Green Infrastructure

Guide for the Municipalities

Ing. Zuzana Hudeková, PhD.

Green Infrastructure
Guide for the Municipalities

Author:
Ing. Zuzana Hudeková, PhD.

Co-authors
doc. RNDr. Peter Mederly, PhD., a Ing. Attila Tóth, PhD.

Graphic lay-out and printing:
Miroslav Zrubák, Bratislava

Bratislava
June 2018

ISBN 978-80-973076-8-4
EAN 978809707307684

Published by: Bratislava, Karlova Ves Municipality, June 2019

The publication was compiled as part of the PERFECT project, which is supported by the European Commission funds, the ERDF, the Interreg Europe operational programme.

More information about the PERFECT project in English are available though the project website: https://www.interregeurope.eu/perfect/ as well as in Slovak on the website: https://www.karlovaves.sk/otvorenyurad/projekty-mestskej-casti/perfectplanning-for-environmental-resourceefficiency-in-european-cities-and-towns/.

Table of Contents

Introduction

Despite the fact that the green infrastructure term is used by the European Commission in several policies, documents and strategies dealing with the protection of biodiversity, adaptation to climate change, protection of water resources and flood prevention, green infrastructure is still a fairly new concept. The reason may lie in the newness of the terminology and its ambiguity, but also in the lack of the clear methodology to accurately define the concept of green infrastructure. The guide that you have in your hands has the ambition to help local municipalities, as well the interested and wider public, to get more familiar with this issue and thus facilitate the introduction of the concept of green infrastructure into everyday practice. The importance of green infrastructure application at the local level is underlined in the position of the European Economic and Social Committee, which states that the crucial responsibility for green infrastructure projects lies within the individual Member States of the EU, and in particular on the bodies responsible for regional and local planning.

Photo 1: Green infrastructure includes the green and blue spaces

1. What is green infrastructure?

1.1 Definition of green infrastructure.

The term green infrastructure reflects a holistic approach of natural, semi/natural and "man-made" greenery and natural areas interlinked together in different levels; from the local level, in the frame of the built environment of cities and municipalities, to the countryside. In general, it is a shift from the perception of areas or elements of urban or rural greenery as being separate, towards the integration of these elements into a coherent system. Several definitions of green infrastructure have gradually been created. Regarding the green infrastructure "official" definition, there is a principal European strategy promoting the use of green infrastructure called „Green Infrastructure – Enhancing Europe's Natural Capital," where the European Commission[1] defines green infrastructure as a "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services". It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, green infrastructure is present in rural and urban settings.[2]

The following definition was proposed within the PERFECT project[3]:
"Green infrastructure is a network of natural and semi-natural elements, green areas and aquatic ecosystems that provide ecosystem services, support biodiversity, offer nature near solutions for problems especially in the built-up areas and ensure the linking of the built-up area with the natural surrounding countryside"

All the above definitions show that green infrastructure is a network/ interconnected system of:

- "man-made" green areas in settlements (e.g. areas with public greenery, parks, green plazas, squares and alleys, the greenery in residential areas, cemeteries, private greenery, such as private gardens, semi-public greenspaces near administrative buildings, etc.)

1 COM/2013/0249 final

2 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0249
3 https://www.karlovaves.sk/wp-content/uploads/Vyhodnotenie-dotaznikoveho-prieskumu-pre-zainteresovanu_verejnost.pdf

- semi-natural and natural areas and a variety of natural ecosystems which are valuable from a nature protection point of view (e.g. forest and wetland areas, protected areas, including NATURA 2000, etc.)
- special greenery elements (often in different levels) like green roofs (intensive and extensive), roof gardens (visual, ornamental, production gardens), green walls (climbing plants on vertical structures or special wall vertical structures with plants) or eco ducts (bridges or flyover structures that enable wildlife to overcome road barriers)
- linear greenery elements, such as biocorridors, alleys, green avenues, greenways and green belts, etc.
- natural and semi-natural water and wetland wetland elements, such as watercourses, surface water, rain gardens, shallow terrains and other features designed for the capture and gradual absorption of rainwater, etc.

The components, types and features of green infrastructure are covered in more detail in Chapter 4.

Photo 2: Green infrastructure makes the stay in public spaces more enjoyable

2. The application of the concept of green infrastructure

2.1 Conventions, strategies and other EU documents as a basis for the application of the concept of green infrastructure

Green infrastructure is included in several important European Union strategies and policies, such as the protection of biodiversity, climate change, the protection of water resources, flood prevention and, in particular, the planning of the urban environment.

Among the first document on the European level that also deals with the protection and the creation of landscape, including green infrastructure in urban environments, is the Landscape Convention. The Landscape Convention highlights the following issues: 1. The importance of the urban landscape and open public urban spaces; 2. The introduction of the public participatory process in the landscape's assessment, which shall be performed through field research by professionals working in conjunction with local inhabitants; and 3. The importance of the exchange of experience and information.

However, the practical application of the Landscape Convention in Slovakia is not implemented at a satisfactory level. The basic concept of "landscape" is defined in the Convention as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors." This definition applies to the urban and as well as the suburban landscape. The Convention applies across the entire territory, as it covers not only the types of landscapes that can be considered as exceptional, but also the ordinary as well as the degraded landscape types. The European Landscape Convention, therefore, defines landscape through mankind, highlighting its significant social and societal dimension.

Photo 3: Examples of green infrastructure - vegetation on the vertical constructions

"EU biodiversity strategy to 2020" was approved in 2011 under the name "Our life insurance, our natural capital: an EU biodiversity strategy to 2020." The strategy defines six principal objectives that complement each other and focus on the root causes of biodiversity loss, as well as on the mitigation of the main pressures on the environment and ecosystem services in the EU. Each objective will be implemented through a set of specific time-bound measures and other related steps[4]. Under the specific objectives of the "EU biodiversity strategy to 2020", objective no. 2 aims to "ensure the conservation and enhancement of ecosystems and their services through the establishment of green infrastructure and restoration of at least 15% of the degraded ecosystems by 2020." Objective No. 6, focuses especially on the green infrastructure promotion, which is described in more detail through the specific goals and tasks. One of the tasks was to draw up the Strategy on Green Infrastructure (which the European Commission prepared and adopted in 2013, see below). There are also concrete proposals to create motivating factors to encourage initial investments in green infrastructure and the conservation of ecosystem services, for example, by more targeted uses of EU funds and public-private partnerships.

4 http://ec.europa.eu/environment/pubs/pdf/factsheets/biodiversity_2020/2020%20Biodiversity%20Factsheet_SK.pdf

The EU Strategy on green infrastructure[5] highlights the importance of green infrastructure, especially in urban environments, as more than 70% of the EU population currently live in an urban environment[6]. Green infrastructure is also understood as an effective measure to mitigate the effects of climate change. It is highlighted that "green infrastructure in major cities, such as green roofs, parks, and alleys, provides benefits to the health of the population, such as clean air and improved water quality, contributes to the protection of human health, energy conservation, and facilitates the management of rainwater."
It is also stated that the "introduction of green infrastructure elements in urban areas creates a greater sense of community, strengthens cooperation within voluntary activities of the civil society and contributes to the fight against social exclusion and isolation. Green infrastructure elements have a physical, emotional, psychological, and socio-economic benefit for the individual and the society. Green infrastructure helps with the possibility of linking urban and rural areas and creates pleasant places for life and work."

Photo 4: Examples of the green infrastructure on the buildings

5 http://ec.europa.eu/environment/nature/ecosystems/strategy/index_en.htm
6 Communication from the Commission to the Council and the European Parliament on the Thematic strategy on the urban environment, COM(2005) 718 in its final version.

The EU Strategy on green infrastructure also deals with newer trends, such as urban agriculture. It literally states that "through urban food production and through community gardens, which are a powerful tool for education and, in particular, for arousing the interest of young people, the issue of separating food production from its consumption is being addressed in the context of green infrastructure and contributes to the increase of its perceived value. Investments in green infrastructure have a great potential to enhance regional and urban development, including the preservation and creation of jobs".

The section on integrating green infrastructure into key policy areas states that it is necessary to ensure that green infrastructure becomes a standard part of the spatial and urban planning and is also fully integrated into all policies of national states.

Another European Commission document entitled "Guidelines on best practices to limit, mitigate or compensate soil sealing" provides examples of how soil has to be protected from the ever-increasing sealing by the means of spatial planning, and how to compensate the negative impacts of soil sealing. Such compensation measures in urban environments could be represented by green infrastructure, sustainable urban drainage systems, the use of permeable surfaces etc.

The EU Strategy on Adaptation to Climate Change[7] also highlights the role of green infrastructure and the provided ecosystem services and nature-based solutions. Support within the LIFE funding mechanism was created to promote such projects.

The European Environment Action Programme to 2020 included the area of green infrastructure among measures to increase resistance to climate change and strengthen the resilience of the environment, which, moreover, can also have significant socio-economic benefits, including public health benefits.

7 http://ec.europa.eu/clima/policies/adaptation/what/documentation_en.htm

3. Main functions of green infrastructure

3.1 Multifunctionality of green infrastructure

Green infrastructure is one of the basic components of the urban and rural fabric and is particularly known for it's positive effects on the quality of the environment. The multifunctionality of green infrastructure is unquestionable since it positively affects a number of areas, including the protection and promotion of biodiversity, adaptation to climate change, health, recreation, promoting of community building and economic aspects.

Photo 5: Social and recreational functions of the green infrastructure

3.2. The basic breakdown of green infrastructure's functions

Environmental and ecological functions of green infrastructure, e.g.:

- Improved air quality and microclimate in urban environments
- Mitigation and adaptation to climate change
- Affecting the hydrological cycle and the outflow ratios
- Promotion of biodiversity, life cycles and processes
- Regulation of soil erosion and other slope processes
- Other regulatory ecosystem services (e.g. supporting the soil-forming processes, decomposition of harmful substances, etc.)

Social, societal, health and economic functions of green infrastructure are, for example:

- Space for contact; learning tolerance and democracy
- Positive impact on the health of the population
- Promotion of recreation and tourism – recreation services
- Crime prevention
- Promotion of safe and sustainable transport
- Economic benefits (an increase in property values, increase in the attractiveness of the environment for investment)
- Promotion of local food production

Structural and aesthetic functions of green infrastructure are, for example:

- Creating the urban structure
- Creation of the spirit of the place, the identity bearer, meanings, and values
- Visual enrichment of the space
- Creation of the landscape character and image – landscaping function.

Detailed information about all the functions of green infrastructure, together with a summary of the existing knowledge and results of the studies is referred to in Appendix 1.

Table 1: Multifunctionality of green infrastructure (drafted according to Magic Matrix Guidelines, the Perfect project[8])

Area	Contribution
Biodiversity	
	Improving the status of wildlife habitats
	Green Eco ducts and bio-corridors
	Reducing the fragmentation and separation of habitats and improving the pass ability of the territory for animals
Climate change and natural hazards	
	Flood risk mitigation:
	Flood risk mitigation (fluvial)
	Mitigating the risk of floods (pluvial) in urban settlements, sustainable management of rainwater, including (infiltration, detention and possible subsequent use)
	Strengthening the resilience of ecosystems
	CO_2 capture and storage (sequestration)
	Mitigating the impact of urban heat islands
	Mitigation and management of natural disasters, prevention of associated risks (such as storms, forest fires, landslides)
Environment/regulatory ecosystem services	
	Noise reduction
	Prevention and/or reduction of soil pollution
	Removal of contaminants from water and water quality assurance
	Removal of pollutants from the air
	Support of insect pollination
	Protection against soil erosion
	Increased pest control
	Improvement of landscape quality
	Mitigation of pressure on the soil surface and soil sealing
Socio-economic area	
	Improved health and well-being of population:
	Mental health
	Physical health:
	Dealing with obesity
	Encouraging physical activity
	Creation of jobs
	Diversification of the local economy
	More attractive and greener cities
	Increased real estate value
	Creation of "genius loci," the character and the look of the landscape
	More integrated energy solutions
	More integrated transport solutions
	Advanced options for tourism
	Advanced options for recreation
	Transport: reduced traffic congestion
	Transport - reducing the number of road fatalities and serious accidents caused by changes in the mode of transport/better protection for cyclists
	Reduced number of criminal offences

8 https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1526373149.pdf

Photo 6: HIstorical parcs - example of the green infrastructure

4. Components and features of green infrastructure

As explained in earlier chapters, green infrastructure requires a holistic approach of linking the various areas and components of greenery in one interconnected system[9]. Since "green infrastructure" is a fairly broad concept, its breakdown and understanding are not always unambiguously clear, the features or elements are not always simple to define, and descriptions of GI can change depending on the stakeholders[10].

Green infrastructure can be divided according to different criteria. The basic categorisation presents a breakdown into urban and rural green infrastructure, which consists of area, point, and line features.

We can recognize a set of areas (biotopes), lines (bio-corridors) and interaction elements that form the basis for the territorial system of ecological stability in a countryside. Within the concept of green infrastructure, a similar network should also be created in the frame of the settlements. These two networks (countryside and settlement green infrastructure networks) should form a natural unit, since green infrastructure does not know the boundary of built environment and is a rather coherent system that is interconnecting the built environment with the surrounding country.

Features and natural elements in an built environment should form an interconnected network of areas, points, and lines, while also being connected to the system of countryside green infrastructure. The term urban green infrastructure refers to those parts of built and unbuilt urban structures, including roofs, terraces, balconies and even the facades of buildings, which are largely covered by vegetation, or have natural character.
While countryside (rural) green infrastructure is either created naturally (without human intervention) or deliberately implemented or regulated, urban green infrastructure is mainly created by human activity.

9 Forest Research 2010
10 http://ec.europa.eu/environment/nature/ecosystems/docs/Green_Infrastructure.pdf

Green infrastructure is inherently a dynamic system, as the strengthening of natural processes in economic areas, or the introduction of near-nature greenery maintenance in urban areas, can help to expand and enhance green infrastructure areas. Natural processes can have a structural character (in the sense of protection of existing or supplementation of missing natural ecosystems in rural and urban areas) or a functional character (the way how the countryside's ecosystems are exploited, or how the urban green infrastructure is maintained).

4.1 Components of green infrastructure in countryside (rural areas)

Examples of green infrastructure elements in rural areas (drafted according to the "Green infrastructure" leaflet, EC, 2010):

- Protected areas, e.g. Natura 2000; a national network of protected areas.
- Valuable ecosystems and areas of high natural value outside the protected areas, e.g., natural forests and meadows, etc.;
- Restored biotopes that were created with a view to the protection of particular species in order to, for example, expand the protected area; increase the area for grazing, breeding or shelter for different species, and/or; to enable their migration, also referred to as stepping stones for wildlife.
- Areas that contribute to the adaptation and mitigation of climate change, for example, wetlands or alluvial forests and peatlands, which retain water and help prevent flood risks and at the same time absorb and store CO_2.

Examples of green infrastructure elements in rural areas – linear and point elements:

- Natural landscape features, such as small watercourses, small islands and forest boundaries, which can serve as a link between other areas of green infrastructure as bio corridors. As an example, we can further mention: alleys and avenues in the countryside; windbreaks and hedgerow; river systems with shoreline vegetation; and solitary trees, such as those at intersections of roads, by small sacral buildings, such as roadside crosses, wayside shrines, or smaller chapels.
- Artificial features such as eco-ducts or eco-bridges, that are designed to assist species movement across insurmountable technical barriers.

4.2 Elements of green infrastructure in urban areas

Examples of green infrastructure elements in urban areas:

Urban green infrastructure can be created by human activity, or it can be of semi-natural or natural character. In the Slovak standard minimum requirements for municipality amenities[11], the typology of greenery was categorised as follows:

Parks and other types of public green spaces
- central park
- division borough park
- district park

Small landscaped surfaces

Greenspaces in residential areas
- settlement greenspaces between blocks of low residential buildings
- settlement greenspaces in high-rise residential area
- private gardens, allotment gardens, community gardens

Historical greenery
- former private gardens and parks associated with historic buildings
- public historic parks and gardens

Greenery near civic amenities (according to type)
- Pre-school and school facilities and campuses (from kindergarten to university campuses)
- Hospitals and social welfare facilities
- Public and accommodation buildings
- Health and medical buildings
- Recreation centers
- Cultural and educational centers
- Business and shopping centers
- Administrative buildings

11 http://www.telecom.gov.sk/index/index.php?ids=75272

Other greenery
- The greenery of plazas and pedestrian zones
- Botanical and zoological gardens
- Cemeteries
- Campsites

Greenery of industrial zones
- The greenery of industrial areas
- The greenery surrounding the industrial areas (according to type)

Natural and landscape green infrastructure in an urban settlement
- Forests and park forests
- Cultivated and fallow agricultural land
- Other unused areas (covered by vegetation)

In addition to the above mentioned „green" (terrestrial) elements, green infrastructure also consists of "blue" (aquatic) elements, such as water areas, watercourses, wetlands, marshes, waterlogged meadows, rain gardens, etc., (i.e., natural and constructed aquatic and wetland elements).

Examples of green infrastructure elements in urban areas – linear and point:

- Trees, etc.
- Alleys, avenues
- Bushes, groups of bushes and hedges
- Line vegetation nearby transport routes and streets (roadside greenery), rail side greenery, "green" railways

The accompanying vegetation of watercourses and water areas (shoreline vegetation)

- Greenery on buildings - green roofs (roof gardens), greenery on terraces and balconies, green walls and green facades, atrium greenery[12]
- elements of green infrastructure for rainwater infiltration, man-made wetlands and retention ponds, plant root wastewater treatment plants, green infiltration strips, permeable paving infiltration strips.

12 Green Surge, 2017

4.3 Characteristics of selected elements of green infrastructure in urban areas

Green roofs

Green roofs can be divided into two main groups: extensive and intensive. Extensive green roofs only require minimal, almost no maintenance after their establishment. They are composed and planted with durable, mostly xerophytic plants which tolerate extreme environmental conditions, such as dryness and intense sunlight, well. Opposite to this, intensive green roofs are designed to be a space for people to use, thus forming a specific type of open green space. Intensive green roofs are more demanding when it comes to the building's statics, to their construction, and the subsequent maintenance. Bushes and lower tree cultivars are often planted on intensive green roofs as well. In these cases, the projects also consider an irrigation system, since these types of plants struggle to manage with atmospheric precipitation alone. A green roof is an effective means of sustainable rainwater management, and it also has a cooling effect and promotes biodiversity. The main effects of green roofs are water evaporation, shade for the vegetation, the ability to reflect solar radiation and power consumption for the process of photosynthesis. Green roofs influence rainfall retention in several ways. A comparison of the „classic" roof with a green roof highlights not only a significant overall decrease in the water runoff but also the differences in its distribution, with intense rain runoff from the green roof being delayed until the end of the rainfall. Green roofs can also effectively promote biodiversity, for example, to integrate innovative elements and places that will become a haven for the appropriate species.

Photo 7: Examples of green infrastructure - green roof

Green facades and green walls

The first two groups are facades with either vertical vegetation rising on the separate construction or climbing the prefabricated structure or climbing directly on the facade. The third group are "green walls," which are formed not

only by the vegetation but also have a special substrate and irrigation built into the green walls. The effectiveness but also the acquisition and operating costs differ based on this basic breakdown. In addition, the cooling effect varies on the facade itself, particularly if the lower part of the building is naturally shaded (Feng et al. 2010).

Photo 8: Examples of green infrastructure - green facade

Elements of green infrastructure for rainwater infiltration

Infiltration strips, rain gardens, shallow infiltration terrains, gutters, infiltration tanks, etc.
Rain gardens and infiltration and retention areas are particularly used in space-limited locations (e.g. for water absorption by roads or in heavily urbanised environments). Shallow infiltration terrains are surfaces with grass or soil layer planted with different species. An infiltration channel is a hollowed linear system filled with permeable gravel material, with retention and absorption into more permeable soil and rock layers. An infiltration tank is an object with a strong retention function together with the absorption through a grassy/humus layer.

Constructed wetlands
A constructed wetland is often built as a root wastewater treatment plant, in which water flows horizontally or vertically through the porous substrate below the surface of this substrate. The main purpose of water retention is the gradual infiltration and purification, thus promoting the retention of water in the landscape and overall improvement of the microclimate.

Collection ponds and other retention areas
Ponds and other small bodies of water in urban areas help to create a pleasant micro-climate and an attractive environment for people in direct contact with water. Water elements that use captured rainwater, or bodies of water that also serve to capture rainwater or serve for the temporary capture of extreme rainfall, can be considered as particularly advantageous.

5. How to elaborate the Strategy/Action plan on green infrastructure for Municipalities

In the previous chapters, we presented the various functions and types of green infrastructure, as well as the requirement that green spaces and natural elements in urbanised environments should form an interconnected network of areas, points, and lines, while also being connected to the system of surrounding countryside. In order to achieve this, there must be high-quality green infrastructure policy in place (especially in cities and larger towns).

The elaboration of the Strategy for the green infrastructure should consist of several main steps – analyses, reviews, proposal of the vision, targets - followed by the Action plan.

5.1 Analytical part

Gathering information on the quantitative and qualitative indicators of the existing green infrastructure

The sources where the relevant data could be collected and analysed are: different already elaborated strategies and documents (e.g. the Territorial System of Ecological Stability), other documentation for nature and landscape protection (e.g. Document for trees care and maintenance), land-use planning and other sectoral documentation (Greenery Plan, Trees Cadaster, Forest care programs, etc.). If such documentations are not available, it is necessary to carry out an inventory of existing areas and elements of green infrastructure.

The knowledge of the current state is a prerequisite for further planning and creation – for example, the determination of areas for new trees planting, etc. The collected information and documents could also serve the the Municipalities as an excellent information system for the management of urban or municipal greenery.

The mapping of green infrastructure in built environment

The territorial localisation of the green infrastructure elements (e.g. trees) should be processed by the GIS (Geographic Information System) in a digital layer. A prerequisite for the processing of this analysis in GIS is the exact topography of the trees elements so that the creation and management of green areas is as accurate and efficient as possible. The topography of trees, as determined by a topographical surveyor, is an accurate and reliable basis for the inventory of trees and the subsequent planning, creation and design of the green infrastructure. In particular, their health condition, landscaping value, possible damages, and other characteristics should be evaluated from the ecological, landscaping, and aesthetic point of view, as well as from the point of view of the ecosystem services value.

Map 1: An example of tree mapping – point elements of green infrastructure in Bratislava, borough of Karlova Ves

Other kinds of green infrastructure can be mapped in accordance with the typology referred to in Chapter 4. At the same time, it is advisable to focus on:

- areas in which the local government carries out maintenance, for example grassy areas where mowing is being done
- buildings under the municipality's administration (for the purpose of evaluating the options of green infrastructure created on buildings)
- unused areas and land owned by the municipality, which have the potential to create new elements of green infrastructure
- semi-natural areas and elements of green infrastructure (watercourses and areas, hedgerows, lanes, wetlands, unused grasslands).

Map 2: An illustration of green infrastructure areas - mapping grass and lawn areas (Bratislava, borough of Karlova ves)

Mapping of natural green infrastructure

Mapping of natural ecosystems (forest and meadow grasslands), including protected areas and sites

Mapping of non-forest vegetation in the form of roadside and watercourse vegetation, hedgerows, etc.

Mapping of aquatic ecosystems, including wetlands, marshes, and waterlogged meadows.

5.2 Evaluation section

Quantitative and qualitative evaluation

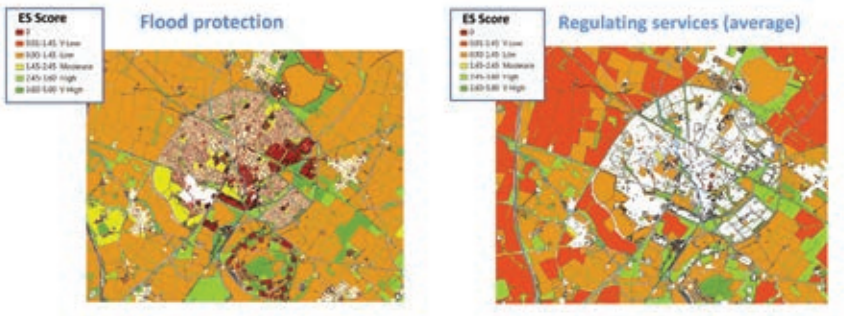
Quantitative evaluation should include a list of the different green infrastructure areas and elements and their spatial projection. Quantitative evaluation will allow the users to identify the options for how to extend the green infrastructure surfaces, as well as the possible interconnection and elimination of territorial fragmentation. Qualitative assessment should focus also to the evaluation of multi-functionality and the ecosystem services of green infrastructure. Individual areas of green infrastructure (also according to their localisation in the urban territory) can have their primary function assigned (e.g. green spaces for recreation of inhabitants, or historical creating the spirit of a place etc.) while maintaining the requirements of multifunctionality (concurrent fulfillment of multiple functions).

One example of a good evaluation of green infrastructure is the British town of Bicester[13], where green infrastructure was evaluated in terms of its ecosystem services provision. This was done by allocating points of functionality in the GIS logical framework matrix with the specified weight score on a scale of 1-5 with respect to what type of green infrastructure (in this case, expressed in terms of the basic habitat types) has the ability to provide services and individual functions[14] (see an example of a database table and individual map layers – recreational function, flood control, regulating ecosystem services).

The evaluation can be processed in different ways. An example from Slovakia is the town of Trnava, where the detailed document about green infrastructure focused on the evaluation of urban and rural vegetation interconnection[15], as well as a detailed evaluation of the functions and ecosystem services of vegetation and undeveloped areas[16]. Another example from the rural environment is the Tvrdošovce municipality, for which the concept of green infrastructure was prepared as a report entitled Green Infrastructure of the Rural Settlement and its Surrounding Landscape[17].

13 "Tools for Planning and Evaluating Urban Green Infrastructure: Bicester and Beyond, Oxford"
14 Burkhard et al. 2012, available at https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1526373803.pdf
15 http://www.trnava.sk/sk/clanok/miestny-uzemny-system-ekologickej-stability
16 http://147.213.211.222/node/6087
17 Tóth, Attila. 2015. Green infrastructure of a rural settlement and adjacent landscape: doctoral dissertation. Nitra : Slovak University of Agriculture. 120 A3 pp.

DESCRIPTION	Recreation	Aesthetic	Spiritual	Intellectual	SensePlace	Wildness	Pollination	PestCont	Habitat	ClimReg	AirQual	FloodPr	WaterPur	SoilErosion	MicroRim	Noise	IntCrop	UrbanFood	Livestock	WaterProv	Provisioning	Regulating	Cultural
Broad-leaved semi-natural woodland	5.0	5.0	5.0	4.5	5.0	5.0	5.0	4.0	5.0	5.0	5.0	4.5	4.0	5.0	5.0	5.0	0.0	2.0	0.5	2.0	2.0	4.8	4.9
Broad-leaved plantation	4.5	4.0	3.0	3.0	4.0	4.0	3.5	3.0	3.5	4.0	4.0	4.0	4.0	4.0	5.0	5.0	0.0	1.0	0.0	1.0	1.0	4.0	3.8
Coniferous plantation	3.0	2.5	1.5	3.0	3.0	3.0	2.0	2.0	2.0	4.0	4.0	4.0	2.5	3.5	5.0	5.0	0.0	0.0	0.0	0.5	0.0	3.4	2.7
Dense/continuous scrub	2.0	2.0	2.0	3.0	3.0	3.0	4.5	3.5	4.0	3.5	3.0	3.0	3.0	3.0	2.0	3.0	0.0	1.0	2.0	1.0	2.0	3.3	2.5
Unimproved acidic grassland	3.5	4.5	3.0	4.0	5.0	5.0	5.0	4.0	5.0	2.0	1.5	1.5	3.0	4.0	1.0	0.0	0.0	0.0	3.0	2.5	3.0	2.7	4.2
Unimproved neutral grassland	4.0	4.0	3.0	4.0	5.0	5.0	5.0	4.0	5.0	2.0	1.5	1.5	3.0	4.0	1.0	0.0	0.0	0.0	3.0	2.5	3.0	2.7	4.2
Possibly unimproved neutral grassland	4.0	4.0	3.0	4.0	5.0	5.0	5.0	4.0	5.0	2.0	1.5	1.5	3.0	4.0	1.0	0.0	0.0	0.0	3.0	2.5	3.0	2.7	4.2
Unimproved calcareous grassland	3.5	4.5	3.0	4.0	5.0	5.0	5.0	4.0	5.0	2.0	1.5	1.5	2.5	4.0	1.0	0.0	0.0	0.0	3.0	2.5	3.0	2.7	4.2
Improved grassland	1.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	2.5	1.0	0.0	1.5	0.0	5.0	1.5	5.0	1.1	1.5
Marsh/marshy grassland	3.0	4.0	3.0	4.0	5.0	5.0	5.0	3.5	5.0	2.5	1.5	2.0	4.0	4.0	2.0	0.0	0.0	0.0	3.5	3.0	3.5	3.0	4.0
Tall ruderal	1.5	2.0	1.5	2.5	2.0	2.0	5.0	4.0	4.0	3.0	2.5	2.0	2.5	3.0	1.0	0.0	0.0	0.0	1.5	2.5	1.5	2.7	1.9
Dry heath/acid grassland mosaic	3.0	4.5	4.0	4.0	5.0	5.0	5.0	3.5	5.0	2.5	2.0	2.0	3.0	3.5	1.0	0.0	0.0	0.0	2.5	2.0	2.5	2.8	4.3
Standing water	4.0	5.0	5.0	4.0	5.0	5.0	2.5	2.0	5.0	2.5	1.0	1.5	3.5	0.5	2.0	0.0	0.0	1.0	1.0	5.0	1.0	2.1	4.7
Standing water - eutrophic	2.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	3.0	2.5	1.0	1.5	1.5	0.5	2.0	0.0	0.0	0.0	0.5	3.0	0.5	1.6	2.8
Arable	1.0	1.0	0.5	1.0	1.0	1.0	1.0	1.0	0.5	1.5	1.0	1.0	1.0	1.0	1.0	0.0	5.0	0.0	1.0	1.0	5.0	0.9	0.9
Amenity grassland	3.0	1.0	1.0	0.5	3.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.5	1.0	0.0	0.0	0.0	1.0	2.0	1.0	1.3	1.6
Bare ground	1.0	1.0	0.0	0.5	0.0	0.0	1.0	1.0	3.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.7	0.4
Urban - hard surfaces	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Map 3: Evaluation of the green infrastructure in Bicester (Great Britain)

5.3 Setting the Target

The following principles are important while setting the targets of green infrastructure in the municipality: quantitative aspects (total surface of the areas, number of elements) of green infrastructure, its quality, availability, its amenities and interconnection.

Quantitative aspect

The evaluation of the quantitative aspect of green infrastructure is based on the sufficiency and adequacy assessment of existing green infrastructure, and the proposal of new green infrastructure areas and creation of an interconnected system.

An ecologically balanced settlement is considered to be one with more than 40-60% ratio/surface share of greenery. Based on various currently known and available sources, it can be concluded that the average requirement for the total surface of green space in the municipalities could be represented by the 75m^2 per inhabitant[18]. It should also be noted that green infrastructure is not only made up by areas of green spaces and water elements in cities. During this step, it is equally necessary to assess the technical options of creating new "unconventional" green infrastructure, for example those aimed at adapting to climate change, such as green walls and green roofs, or elements of sustainable rainwater management.

Some potential areas that can be integrated into the system of green infrastructure in the future are undeveloped territories and brownfields. These are unused areas and fields within the territory of the municipality, which there are plenty of, especially in cities at the moment.

Qualitative aspect

Assessment of the qualitative aspect focuses not just on the evaluation of measures to ensure the proper functionality of the various green infrastructure elements, but also of the entire system. Enhancement of natural processes by fostering nature based solutions and near nature greenspaces management is of great importance for cases where there is any quantitative surface increase of the new green infrastructure areas. As already mentioned in the previous part, functional changes, such as strengthening the natural processes or introducing a near nature greenery maintenance, can help expand and enhance the biodiversity and natural value of green infrastructure. Renaturation and protection of watercourses with functional or shoreline vegetation, diversification of the land cover structure, planting of non-forest solitary trees or groups of trees and alleys, increasing the area of permanent grasslands, greening of agricultural land boundaries (edges of the plots, the boundary between arable land and road), etc., can contribute to the positive structural character of green infrastructure.
For the near nature greenspaces management and maintenance of greenery in urban settlements, the maintenance will be close to nature, with the exclusion of chemical products for weeding, differentiated mowing, support of pollinators by planting species, nectar giving plants, domestic tree species, etc.

[18] *Minimum standards of municipality amenities (Methodological Guide for purchasers and processors of land use planning documentation, MoE SR, 2002)*

Availability/location of green infrastructure areas and elements

The availability of green infrastructure for local inhabitants is not just important for the quality of the environment; itself, but promotes social justice. The availability of green and open spaces for the inhabitants is one of the indicators used to measure sustainable urban development, where green space availability is defined as living within 300 meters of an area of green space. A similar approach is also used in the UK, where the availability of greenery is expressed by either the distance or walking time required to reach an area of green space, or an area of recreation.

A similar example for green space standards is "The Natural England Accessible Natural Greenspace Standards":

- a person should not live at a distance greater than 300 m from the nearest natural green space with an area of at least 2 ha
- at least 1 ha of local nature reserve per every 1000 residents
- at least one 20 ha area of greenery within 2 km away from home
- one 100 ha area of greenery within 5 km
- one 500 ha area of greenery within 10 km

The interconnectedness of green infrastructure elements

The aim of this criterion is to achieve an interconnected green infrastructure network, which enables a continuous movement of residents and species and the proper functioning of the system. Fragmentation of habitats, such as the routing of traffic through natural areas, is one of the main causes of habitat degradation and loss of biodiversity, which can reduce the fulfillment of their functions and the provision of ecosystem services. Valuable ecosystem services may disappear if the natural ecosystems become too small or isolated, because the isolated "islands" of nature, including species, do not allow for genetic exchange between populations of the same species. The interconnection shall be secured by means of bio corridors, and by the eco ducts providing the connectivity in the fragmented landscape. In the urban environment, it is necessary to use other linear elements of green infrastructure, such as alleys and hedges, which allow several smaller species of wildlife to migrate. Mosaic or altered mowing regimes can also help to protect biodiversity (see photo below).

Photo 9: Strips with altered (reduced) mowing regimen provide a shelter, corridor, and food for a variety of animals, including pollinators (photo source: internet[19]), and the added value of such a solution is the increased visual attractiveness of the area for its users.

When designing the elements of green infrastructure, it is appropriate to take into account the interconnections and the needs of the various species. An example would be the creation of "highways for pollinators." In Oslo, Norway[20], they managed this through the targeted planting of nectar-giving species and green roofs to create the conditions for their overpass – flight over the whole city. Another example is the project to facilitate the migration of hedgehogs in London, called the Hedgehog Highway[21].

The promotion of pollinators and maintenance of greenery in a manner close to nature, including the formation of flowering meadows and areas with an altered mowing regime, is the focus of the "Urban bees" program of several initiatives[22]. Examples can be seen in Bratislava, borough of Karlova Ves and other slovak municipalities (Zvolen, Prievidza, and others).

Smaller green surfaces that could be used for interconnection include green roofs, green walls and greenery on terraces and balconies. In addition to improving the microclimate and adapting to climate change, green roofs and walls can also be created to contribute to the promotion of biodiversity. On the roofs, it is possible to integrate elements such as beehives, a wide range of flowering nectar-giving plants and other innovative features to support biodiversity (so called insect hotels, water feeders for bees and birds, etc.).

19 *https://www.burgenland.at/fileadmin/user_upload/Downloads/Umwelt_und_Agrar/Umwelt/Umweltanwaltschaft/Handbuch_Pflege_Begleitgruen_2014.pdf)*

20 *https://www.theguardian.com/environment/2015/jun/25/oslo-creates-worlds-first-highway-to-protect-endangered-bees*

21 *https://www.hedgehogstreet.org/help-hedgehogs/link-your-garden/*

22

Photo 10: In addition to supporting biodiversity, the altered mowing regimen also brings a new aesthetic sensation (author: Peter Svitek)

5.4 The action plan for green infrastructure

The formulated green infrastructure targets based on the previous analysis must then be elaborated further in the Action Plan. The role of the Action Plan is mainly to describe the specific steps, activities, projects, responsibilities, timeframes and financial resources for the implementation of the various activities and projects[23]. The described actions in the Action Plan may be oriented to the development of new infrastructure areas or creation of green infrastructure elements (green areas, green walls and green roofs, elements of sustainable rainwater management, planting of alleys and hedges, etc.). Another option for improvement is to propose some qualitative change – i.e. functional changes within the existing areas of green infrastructure, eliminating fragmentation and creating links, increasing the diversity of plant species, resulting in an increase in the diversity of animal species, etc.

The actions included in the Action Plan could be implemented through the land use planning processes, through the generally binding regulations, guidelines and internal directives the municipality uses to govern the territory. There is a possibility within the territorial plans and binding regulations to include the requirements for the new development of "green infrastructure" in general (see the example from Trnava, Slovakia), as well as the requirements for sustainable urban drainage systems (see the example from Prešov, Slovakia).

23 *https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1517933086.pdf*

Examples of applying the concept of green infrastructure and the implementation of the concrete actions from the Action *Plan

Strict and consistent application of the existing technical norms and sectoral standards.

The actions aiming to improve the quality of the green infrastructure could be supported by the consistent application of the existing technical norms and sectoral standards. One example is the Slovak Standard No. "83 7010 Nature protection. Tree care and tree protection," that requires an annual assessment of tree quality (e.g. alleys or trees in public green spaces planted in highly frequented municipality areas). Another example is the Slovak technical norm about the areas for car parking No.736110/Z1, which specifies the requirement for 1 tree to be planted per every 4 parking places. There are also some sectoral standards about tree pruning and the protection of trees during construction works[23] which could positively help to implement some actions aiming on the improvement of the quality of the green infrastructure.

Trnava – generally binding regulations in the Territorial Plan of the city of Trnava, amendments 03/2015

In 2016, the Trnava City Council (Slovakia) approved the proposal for a "Generally binding regulation on the Territorial Plan of the City of Trnava, regulations and limits of land use, and the principles for the further development of Trnava city (03/2015)". Modification of the binding part of regulations was based on the experience and knowledge gained from construction permissions, the need for application of new regulations in relation to the expected negative impact of climate changes and the need for a more precise definition of certain concepts, as well as real needs in the management of urban territorial development.

The approved changes addressed the following requirements in relation to green infrastructure: the increase of green space areas (including public greenery in the city center), the obligation to build green roofs on civic amenities and industrial buildings, the obligation to place bicycle stands next to amenities and industrial buildings, the requirements in the field of sustainable urban drainage systems, guidelines in the field of energy efficiency etc. Some concrete examples in the field of "green infrastructure" that were included among the binding regulations of Trnava city were:
- to apply green rooftops and vertical green walls where possible
- the binding construction of the green roofs in the new buildings construction with a slope of up to 20°, at least to the extent of 50% the newly constructed green roofs shall provide a relaxing stay for residents, visitors, etc.

24 http://www.slpk.sk/eldo/2018/dl/9788055218960/9788055218960.pdf

The regulations from the city of Trnava can serve as a positive example for other Slovak cities. Through these regulations, the building and construction office will be able to require concrete applications of these requirements, and will only issue the building permit if the relevant requirements have been incorporated into the project documentation (blueprint) presented.

City of Prešov - Territorial plan as amended in 2012

Another positive example is from Prešov city (Slovakia), where a Territorial Plan includes a binding regulation about SUDS (regulation 6.5.19), as follows:

«construct the smaller multipurpose rainwater reservoirs in appropriate locations and promote the restoration and the construction of the blue infrastructure with the aim to capture and use the surface runoff from paved surfaces on the spot, or alternatively, to use an appropriate rainwater infiltration method with the aim that the runoff from the locality into the sewage system or water recipient does not increase compared to the status before the construction ,as well as that water quality in the recipient does not deteriorate."

General binding regulation on greenery –example from Bratislava, Slovakia

In 2018, a new general binding regulation (hereinafter GBR) for the capital city of Slovakia, Bratislava, was adopted. The regulation concerned the care of public greenery maintenance and protection of trees that are part of the public greenery of Bratislava.

The GBR Section 4, paragraph 5, is in favour of the preservation of green spaces in cases where a new construction is planned on an area that was previously designated as a "green space". It reads as follows: "In the event of permanent occupation and destruction of a public green space, each person destroying the public green space is required to establish new one in an area designated by the previous green space owner, at least in the same surface area and scope corresponding to the previously destroyed area of green space. If the land or public greenery in the designated location is entrusted to an administrator, the owner of the land will request the administrator's opinion regarding this intent."

6. Funding possibilities for green infrastructure

6.1 Local sources of funding – examples from Slovakia

Fees resulting from the new Development and construction

Since May 2017, there is a possibility for municipalities in Slovakia to charge financial compensation for any new developments and constructions in its territory.

This is enabled by the so called "development fee", which was enacted by "Act No. 447/2015 on local development fee", which municipalities can introduce through their own generally binding regulation. This new fee is the municipality's income and could serve as one of the sources to build up the social and technical infrastructure that would be needed after the new developments are constructed in the territory.

Local governments can use income from fees as capital expenditure for the construction of schools and nurseries, sports facilities, cultural and medical facilities, but also for the construction of transportation infrastructure, and for the new development and maintenance of public greenery.

Data in the building permit issued to the builder can have an effect on the fee amount. It is paid in one lump sum, the rate is set by the municipality on 1 January of the calendar year, and it may vary for different parts of its territory. The law provides for a minimum (10,- Eur) and maximum (35,- Eur) fee amount for each, even partly used square meter (m^2) of floor space of an over ground part of a new construction building.

The fee does not apply to the construction of social and technical infrastructure, minor construction or construction works to eliminate faults and emergencies. The range of structures that are not subject to a fee has expanded and includes, for example, buildings used for the protection of children and social guardianship, as well as state defense buildings.

Other Financial compensation

Amendment to the Slovak Act No. 543/2002 Coll. on Nature and Landscape Protection, which came into force on 1 November 2017, allows the use of financial compensation for tree cutting. The financial compensation shall be used for the planting of new trees and/or for the construction of some elements of green infrastructure, as/or green roofs, green spaces and parks and green Eco ducts. The municipality, as an approval body, determines reasonable new planting in its decision, or an upfront fee based on the trees' social value in financial terms (based on the detailed calculation described in the national Decree to this Act).

Example from the Act No.543/2002 on nature and landscape protection

Paragraph No. 48 - Replacement planting

(1) The nature protection authority imposes an obligation on the applicant to carry out an adequate substitute planting of trees at a predefined location at the expense of the applicant as part of the tree cutting permit; for this, it favors the geographically original and traditional species. If the applicant is not the owner of the land on which the replacement tree has to bee planted, the nature conservation authority may impose the care for the new planted tree to the applicant up to the period of three years. If the substitute planting cannot be implemented, the nature protection authority may impose a financial compensation in the amount equaling the social value of the tree (Sec. 95). The nature conservation authority will impose the obligation to pay compensation up to the social value of the tree also to a person who cuts down trees without the permit.

The financial compensation is the income of the municipality on the territory of which the felling takes place; the municipality is obliged to use these revenues to cover only the costs associated with:

a) the elaboration of the Trees Cadaster and tree care documentation

b) the planting trees (in particular, geographically original and traditional species) and for the care of trees growing on its territory,

c) the building of new green infrastructure , such as parks, green roofs, or Eco ducts.

Example from practical implementation

During the construction of a new railway station in the village of Tvrdošovce (Slovakia), the adequate replacement planting for a single chestnut tree with a trunk circumference of 250 cm was determined at 11 new trees with a root ball – 5 linden trees, 3 maples and 3 oaks with a trunk circumference of 20-25 cm and a height of 2.40 m. The municipality received more earmarked funds as well as compensation for the felling on the outskirt in connection with the construction of new electric wiring. These funds were subsequently defined in the municipality's budget for the planting of new trees and caring for the greenery. It is imperative that municipalities employ or enter into contracts with professionally competent people who know how to make decisions on requests for the felling of trees, determine an adequate replacement planting or financial compensation for the felling and then supervise the technical realization of the replacement planting of trees and shrubs.

Many communities currently do not have a prepared tree care document or other documentation which focuses on green infrastructure. The funds obtained as compensation for the felling of trees are one of the possible sources to remedy this deficiency. Careful design and documentation allows meaningful and sustainable planning and the creation of greenery in the territory of the municipality. Another shortfall is the fact that replacement plantings are often inadequate, poorly made and aftercare is often absent. When implementing replacement planting, the concept and planning, as well as the subsequent care for the trees (cutting, watering, etc., for at least three years) are as important as the performance of the replacement planting.

6.2 National funding sources in Slovakia

Environmental Fund

The Environmental Fund is primarily set up for the purpose of conducting the promotion of state support to care for the environment and the creation of the environment on the principles of sustainable development. The main mission of the Fund is to provide funding for applicants, in the form of subsidies or loans, to support projects within the framework of activities aimed at achieving the objectives of the state environmental policy at a national, regional or local level[25].

25 *http://www.envirofond.sk*

The support of Envirofond in the form of grants can be obtained in connection with green infrastructure in the following areas/for the following measures:

D. Area: Nature and landscape protection

Activity D1: The formation of territorial systems of the ecological stability (further as TSES) and green infrastructure elements on the basis of the agreed TSES documentation

POD. Area: The village restoration program – improving the quality of the environment in rural areas

Activity POD1: The quality of the environment in rural areas – activities aimed at promoting the conservation of aquatic conditions and water resources at the local level – cleaning, restoration and protection of watercourses, pass ability of cross profiles, bridges and culverts, restoration (pass ability) of dead streams, management of floodplain forests
Activity POD2: Green infrastructure and adaptation measures to mitigate the impacts of climate change – activities

- processing of documentation aimed at addressing green infrastructure, a design study of adaptation to climate change (flood control measures, measures aimed at reducing energy consumption and the use of renewable sources of energy, etc.), and local strategy of adaptation to the impacts of climate change;
- activities focused on building green infrastructure elements outside the developed territory (planar, group, linear, solitary): planting, rehabilitation, and care of non-forest tree vegetation (e.g. old and regional varieties and original species, shoreline vegetation, windbreaks, alleys, hedgerows, avenues and scrub, for example, along managed and field roads, at borders of agricultural plots, natural terrain boundaries, isolating vegetation, vegetation strips planted along the contour lines, etc.)
- activities focused on building elements of green infrastructure in urban areas (planar, group, linear, solitary): building and revitalization of public spaces and parks, flowerbeds or herb beds, tree alleys, avenues, mobile greenery, community gardens (including the construction of small architecture elements reflecting the character of the rural landscape in the maximum range of 50% of the requested subsidy budget)
- the protection of the characteristic appearance of the landscape, care of the historical landscape structures and their reconstruction (mining relics, agrarian structures, the rehabilitation of terraces, lines of vegetation, etc.), the care of significant landscape features and attractions (e.g. peatlands, prairie communities, hedgerows, permanent grasslands, deposits of

minerals and fossils, artificial and natural rock formations, wayside shrines, chapels and crosses which form part of the landscape)
- monitoring and disposal of invasive plant species (including disposal of invasive species along the waterways, in agreement with the watercourse administrator)
- activities to mitigate the impacts of climate change, adaptation measures at the local level in accordance with the strategy of adaptation to the adverse impacts of climate change in the Slovak Republic (implementation activities: the establishment of vegetation on the roofs of public buildings, establishment of stable aquatic elements, the collection of rainwater from impervious surfaces (roofs) and its use, for example, as irrigation water for public green areas, the use of shading elements – sun guards in combination with the cooling effects of vegetation, rain gardens, draining of water by building gutters with impermeable surfaces by the roads, sidewalks, parking lots, public areas, etc., flood control carried out on the watercourses in collaboration with the watercourse administrator and promotion of bicycle transport on the basis of a professionally processed project documentation)
- the exchange and the development of public water-permeable areas in the max. the range of 50% of the requested grant, and in combination with the planting of public greenery (e.g. in the form of tiled paving stones, interlocking pavement using a permeable/semi-permeable substrate (bed) and maintaining 2-3 mm spaces filled with silica sand)

Other non-EU funding could be represented by governmental funds, private banks, developers and civil society, Visegrad Fund, etc.

6.3 EU and Trans-national funding sources

States can support Green Infrastructure through different EU funds and programs. Here are some of the co-financing opportunities currently available:

- Structural Funds (European Regional Development Fund (Chapter 4) and European Social Fund)
- Cohesion Fund,
- European Maritime and Fisheries Fund
- European Agricultural Fund for Rural Development,
- LIFE+
- Research funding programmes
- European Fund for Strategic Investment
- Horizon 2020

Operational programmes

National level allocation is possible based only on GI inclusion in the Member State's Operational Programme. In Slovakia, there is the Operational Programme "Quality of the environment", in which the green infrastructure could be supported in the framework under the 2 priority Axes. The first specific objective is the No. 1.3.1: Improving conservation status of habitats and species and strengthening of biodiversity mainly in Natura 2000 network. Within this specific objective the financial support will go to the:

- Maintaining and restoration of biodiversity and ecosystems outside the protected areas. The activity includes mainly the implementing measures (removal and opening of barriers and creation of migration corridors outside the watercourse, revitalisation and optimisation of the hydrological regime of habitats, conservation and restoration of a favourable status of wetlands) contributing to the improvement of habitats and species status, restoration of degraded ecosystems and their services.

- Elimination of invasive plant species according to the Ministry of Environment Decree No. 24/2003 Coll. and according to the strategic priorities at the national level, provided the national legislation and downstream concept document will define specific cases which can be financed through the use of EU funds.

- Support for green infrastructure elements at the local level (municipalities) which leads to the creation of strategically planned network of natural and semi natural areas with environmental characteristics, that are created and managed in such way, that they provide a wide range of ecosystem services87. Support will also go to the elaboration of the documentation of territorial system of ecological stability at regional (RTSES) and local (LTSES) level that will create the basis for the regulation of green infrastructure construction concept at lower levels of implementation.

The second investment priority under which green infrastructure could be supported is the specific objective 2.1.1: Reducing the risk of flooding and negative effects of climate change. This OP specific objective is implemented through the different activities, e.g. preventive flood protection measures implemented outside the watercourses and water retention measures in the urbanised landscape (residential areas of municipalities).

Within this specific objective, the financial support will go to the water retention measures in the urbanised landscape (residential areas of municipalities). The water retention measures (the activities for capturing and retention of rainwater in urbanized landscapes) will be supported either through green infrastructure elements, or elements of technical character. In particular, these measures

encompass creation of bio-retention systems for rainwater retention (rain gardens, collection ponds, etc.), further on so-called green roofs or surface or underground reservoirs for rainwater retention (for other potential rainwater use, e.g. for watering). The support will be targeted towards measures for soaking of rainwater, i.e. soaking elements (e.g. soaking strips, infiltration trenches, etc.) or utilization of grassing blocks.

LIFE 2014 – 2020 Programme

The LIFE Programme is a specialized funding program for the environment and climate protection, under the authority of the European Commission[26]. Projects that improve the functional interconnectedness of green infrastructure and facilitate the movement of species between protected areas, such as Natura 2000, can be co-financed under this financial instrument. The LIFE Programme also offers funding opportunities for the construction of green infrastructure elements in urban areas and their outskirts, as well as funding projects that promote an ecosystem approach to fragmentation, multipurpose soil use and other.

The EEA Financial Mechanism and the Norwegian Financial Mechanism for 2014 – 2021

The EEA and Norway grants are resources from the countries of Iceland, Liechtenstein and Norway to reduce economic and social disparities, and to strengthen cooperation with the 15 EU countries in central and southern Europe and the Baltics. This financial mechanism offers a total of EUR 2.8 billion for the 2014-2021 period in 5 priority areas and a total of 23 programs. The priorities also include theme no. 3 – Environment, Energy, Climate Change and Low-carbon Economy, also covering an theme no. 13 – Mitigation and Adaptation in the Context of Climate Change. Green infrastructure is cited as one of the green adaptation measures.
As an example, the national allocation for Slovakia for the 2014 – 2021 period is EUR 113.1 million (of which EUR 54.9 million is from the EEA Financial Mechanism and EUR 58.2 mil. is from the Norwegian Financial Mechanism).

Horizon 2020 is the EU funding program for research and innovation

The Horizon 2020 program is running from 2014 to 2020, with a €80 billion budget. It provides research and innovation funding for multi-national collaboration projects, as well as for individual researchers, and supports SMEs with a special funding instrument.

26 *http://ec.europa.eu/environment/life/index.htm*

Natural Capital Financing Facility (NCFF)

The Commission and the European Investment Bank (EIB) have established a Natural Capital Financing Facility. The NCFF will finance investments in natural capital projects, including green infrastructure, which generate revenues or save costs and contribute to nature, biodiversity and climate change adaptation objectives. The NCFF is open to public and private entities, including partnerships where appropriate. Investments could for example focus on ecosystem restoration projects as insurance against floods or draughts or to improve water quality.

Cross-border and transnational cooperation programmes for 2014-2020

Interreg is one of the two goals of the EU Cohesion Policy in the 2014-2020 period and it is funded by the European Regional Development Fund (ERDF). It has a budget of EUR 10.1 billion invested into several cooperation programmes responsible for managing project funding.

Interreg has three types of programmes:

- Cross border (60 programmes)
- Transnational (15 programmes)
- Interregional (4 programmes)

BiodivERsA ERA-Net

Research on biodiversity is also supported through the BiodivERsA ERA-Net, which works to coordinate national research programmes on biodiversity across Europe and to organize international funding for research projects in this field on a competitive basis.

Conclusion

Green infrastructure is one of the main preconditions for the sustainable development of a resilient urbanized environment. It is not just an obligation, but also a great opportunity of the municipalities to develop and enhance their local green infrastructure.

Great potential also lies in micro regional cooperation at the level of Local Action Groups (LAGs), which have a prerequisite for the making of common micro regional green infrastructure.

Towns and cities should have a clear concept for the creation and management of their green infrastructure as a whole, as well as its individual elements, such as green areas and new and replacement planting of trees. This should be facilitated by the conceptual documents (e.g. local territorial systems of ecological stability, General greenery plan, Tree care document), but mainly a comprehensive Green infrastructure Strategy, including an Action Plan.

Green infrastructure can be the solution to two major challenges that mankind will face in the coming years – the loss of biodiversity and climate change. It is therefore of extreme significance and urgency that green infrastructure is promoted and delivered to a much greater extent. We hope that this guide will help to achieve this.

Appendix 1

Environmental and ecological functions of green infrastructure

Improvement of microclimate in urban environments

Mitigation of summer heat through green infrastructure

The cooling effect of vegetation has been confirmed by a number of studies, but the extent of this effect depends not only on the size of public space and the service and quality of the vegetation, but also on the location of the green space within the city, as well as the nature of the surrounding buildings, terrain and other. On the basis of multiple sources, it can be said in general that the difference in temperatures between, for example, parks and built-up areas, averages from 0.94°C to 2.26°C. Increasing the proportion of greenery by 10% can reduce the temperature in the urban area by 3%. Research undertaken in Manchester shows that the increase in the proportion of vegetation by 10% in those parts of the city where the proportion is very low, will maintain the temperature at the level from 1961-1990, even in 2080.

The cooling effect of vegetation on the surroundings is reflected only in parks with a sufficiently large area. This effect is noticeable at a distance of 500 m, depending on the nature of the surrounding buildings; near parks with an area of more than 150 hectares, it can be up to a distance of 1 km. Put simply, it can be said that large areas of greenery cool down their environment and this effect is noticeable from the edge of the park to a distance corresponding approximately to its size.

When discussing the efficiency of green areas, it is necessary to also focus on the qualitative side, and specifically on the representation of trees, which have a significant impact not only on the temperature of that area but also on the possibility of cooling down the surroundings. Potscher et al. (2006) confirmed that in the case of parks with only a small proportion of trees or just low decorative plants, the temperature is the same or can even be slightly higher than in their surroundings.

In terms of the effectiveness of greenery on heat reduction, we can refer to studies that have been carried out on grassy areas. Separately, it also depends on whether the parking lot is shaded or not and on the condition of the soil moisture in the substrate. If the area is shaded and has enough moisture, the effect is significantly higher. Ca et al. (1998) measured a 2 degree Celsius difference between asphalted parking and a grassy area.

As mentioned above, active cooling is mainly based on the principle of water evaporation. Vegetation cools down the environment thanks to its low albedo (degree of reflectivity), energy consumption in the process of photosynthesis, and also thanks to the shade in the case of taller trees.

The cooling effect of the vegetation can be explained relatively easily with the help of physics: approximately 2.5MJ is needed to transform one liter of water into vapor, which is 0.69kWh. Trees transpire water through their stomata, which they then convert to vapor by taking heat energy from the environment. Their „cooling power" reaches values as high as a few hundred watts per m^2. It can thus be clearly confirmed that a grown tree, well supplied with water, cools its surroundings with power comparable with some air conditioning units. However, this also depends on the air flow; a breeze mixes the ambient overheated air with the air cooled with the aid of vegetation.

According to research, transpiration by vegetation recycles a high proportion of water into the air (an adult deciduous tree releases around 300 litres per day). For example, an adult apple tree creates 65-140 gallons of water vapor during a summer day, while an adult birch can evaporate up to 7000 litres of water per season. In accordance with the described effect of cooling, this does not only include air humidification, but also rich and active cooling.

However, the above described phenomenon occurs only provided that the trees have enough moisture; otherwise, gas exchange stops and the cooling effect happens only thanks to the shading, especially for species that handle drought well. Closure of the stomata on the leaves causes an increase in leaf temperature (Leizinger et al. 2005). In this respect, trees planted in paved surfaces or those that have compacted soil in the root area exhibit differences in the effectiveness in this context, compared to trees in the terrain or in the lawn. This difference is given by the fact that the increased ambient temperature above the paved surfaces leads to increased transpiration.

The research of growth of chanticleer ornamental pear (Pyrus calleryana) that took place for a period of 6 years in the British city of Manchester (Rahman et al., 2011) is worth mentioning in this context. Not only did the trees in the unpaved ground or planted in a special tree „substrate" („Amsterdam soil") grow 2 times faster than trees in paved surfaces with a compacted substrate, but their cooling effect was also about five times higher (evapotranspiration potential was up to 7kW).

However, not only a tree itself can be thought of as a separate „air conditioner unit". The transformation of the country, i.e. the change of an undeveloped territory to a developed one has a similar effect. Development on one hectare of high-quality land with a high retention clip capacity of approx. 4 800 m^3

leads to a significant decrease in evapotranspiration. The energy needed for the evaporation of such a quantity of water is equivalent to the energy consumed by approximately 9,000 freezers per year, which is about 2.5 million kWh.

From the point of view of effectiveness regarding the summer heat mitigation, it is still necessary to add that trees with all of their leaves absorb 70-90% of solar radiation in the summer and 20-90% in the winter (the difference is mostly in deciduous trees). Properly planted trees by buildings represent about 2% savings on heating. Green areas increase air humidity (average given value is 5 to 7%).

Leizinger et al. measured the temperature among a group of trees at 24 – 29°C, while the temperature on the street was 37°C, and 45°C on the roofs of buildings.

In the cities of Bratislava and Piešťany, temperature measurements 2m above the ground were made using a drone thermal imaging camera (see Figure 3).

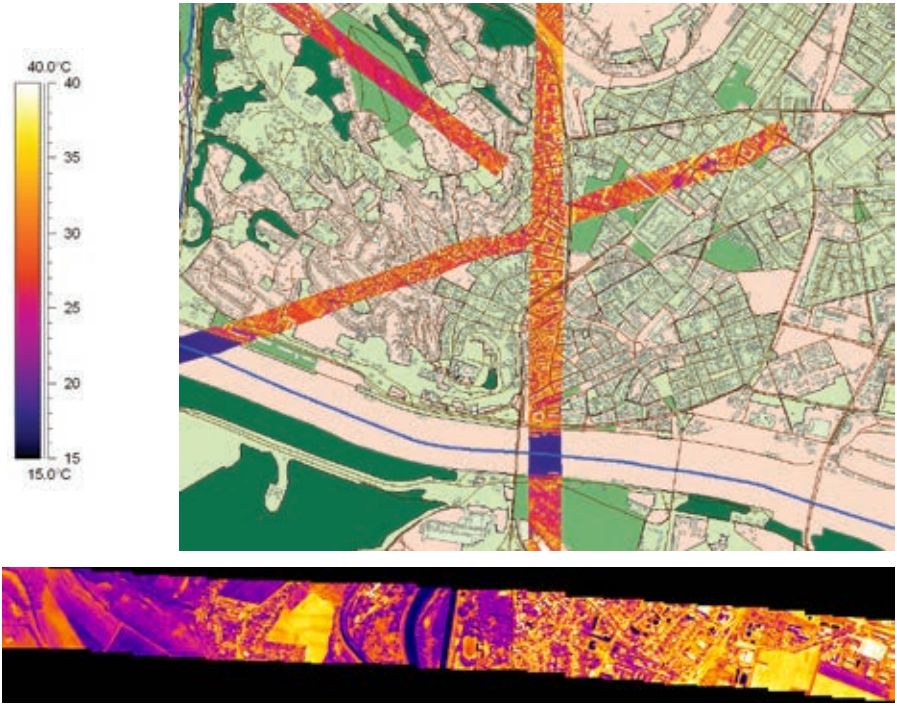


Fig. 1: Areas mapped by drones with the help of a thermovision camera – an illustration of the temperature differences depending on the type of urban landscape structure, surface, and the amount of greenery (source: REC Slovensko, 2007, personal communication)

Measurements showed an already proven fact; that the difference in temperature in Bratislava is really striking, from 29.87°C in a floodplain forest to 42.06°C in the commercial area by the Aupark shopping center[27].

Several papers from abroad and Slovakia have found big differences in temperature on various vegetation's areas, depending on the amount of woody plants, especially trees. For example, measurements from 2006[28] detected the maximum temperature difference between the air above a lawn and under a solitary tree (measurements at ground level) to be 14.6°C. Cooling effect was manifested in this measurement in all areas with trees and shrubs. Surprisingly high air temperature values were detected on the grass, which in some cases were comparable to air temperatures measured on asphalt areas (roads and parking lot).

Evapotranspiration requirements for water are increasing with an increase in the average annual air temperature. Periods of drought in the summer months are becoming longer, so trees often suffer from a lack of water in the urban environment. The stress brought by drought is becoming the primary abiotic stressor, limiting not only the growth and development of the trees but also their ability to cool the area through evapotranspiration. For this reason, it is very important to ensure enough moisture at the time of the summer heat. Obviously, the best solution would be the infiltration of rainwater at the point of contact or its capture and subsequent use for the watering of vegetation.

This measure is part of the increase of the population's adaptive capacity, that is, the ability to find a temporary „refuge" from extreme heat, especially at the peak time. Although these parks are mainly available for residents living or working in their vicinity (within 500 m, or 10 min walk), they can often be used by residents from greater distances, e.g. pensioners and mothers on maternity leave.

Mitigation of summer heat through an aquatic element

Water in an urban area is not only very attractive but also has great importance in several respects. The use of an aquatic element in the cooling of the environment is already known from the past (e.g. Moorish architecture in Granada or Alhambre). Aquatic areas that also serve to capture rainwater are particularly advantageous.

Water efficiently cools down the environment and creates a pleasant microclimate. Based on some studies, the temperature on the leeside is greatly reduced, and the cooling effect reaches up to 35 m from the aquatic element[29].

27 *Hudeková, 2011*
28 *Reháčková, Pauditšová, 2006*
29 *Nishimura et al.,1998*

Pond, small bodies of water

Ponds and other small bodies of water in the urban environment help create a pleasant microclimate. Water elements that use captured rainwater or bodies of water that also serve to capture rainwater or serve for the temporary capture of extreme rainfall can be considered particularly advantageous. In the context of the described water evaporation phenomenon, it is very useful to replace the evaporated water with rainwater in areas of water bodies.

In the case of a water element without water circulation, the cooling effect is based on a combination of water vapor, for which energy is taken from the surrounding environment and the water in the form of heat. The cooling effect of evaporation is proportional not only to the quantity of evaporated water but is also based on the principle of equalizing the different temperatures of the cooling water and the ambient air.

Wetlands, wet habitats

Wetlands are defined as areas with marshes, moors, peat bog and natural or artificial, permanent or temporary, standing and flowing water. Often in the past, these territories were assessed as „useless" areas, which need to be dried out, covered, or otherwise adapted to other purposes. This is probably the reason why more than 60% of the wetlands in the world have disappeared since the beginning of the 20th century. However, the importance of wetlands is immense, not only from the point of view of adaptation to climate change, but also from the perspective of mitigation

Studies, as well as practical experience, show that vapor from wetland and other hydrophilous (water-pollinated) vegetation with sufficient water supply has a beneficial effect on climatic conditions. In addition, as has already been described in previous clauses, this is cooling with the assistance of vapor from the water surface, because water consumes 2500 kJ/m^2 to evaporate 1 mm of water. Currently, there is not much known research that would address the combined cooling effect of water evaporation and evapotranspiration from wetland and other vegetation. In his research, Hammel et al. (2012) pointed to the favorable state of moisture in the surrounding soil, which also has a positive impact on the cooling of the environment.

Green roofs

Green roofs decrease the temperature of buildings by several °C under the roofs. The green roof can reduce heat transfer through the roof from the external to the internal environment by more than 90%. Measurements from the summer days of recent years in Germany have shown that if the outside temperature is 25-

30°C, reduction of the temperature inside a room under the green roof is 3-4°C. Measurements have shown that 20-40 cm vegetation which grows on a 20 cm substrate has characteristics comparable with a 15 cm mineral wool insulation. A number of studies have shown that buildings with green roofs overheat less, which leads to significant savings in the use of air conditioning. Any reduction of internal temperature by 0.5°C leads to savings in electricity for air conditioning by 8%. The assumption is that green roofs absorb 150W/m^2 of thermal energy. Based on several studies, green roofs (depending on the thickness and quality of the substrate, plants, the season, etc.) hold about 60-80% of rainfall. Based on research and situation modeling in Brussels, the creation of green roofs on 10% of currently existing roofs would result in drainage reduction by 2.7%, while the largest proportion in the reduction would be directly in the most densely built-up parts of the city.

In particular, it is necessary to emphasize the positive effect of green roofs on water quality.

Green facades

The walls of the house are exposed to sunlight throughout the year and have relatively large fluctuations in temperature. A facade with no shade can heat up to 40°C on a hot summer day, while the temperature of the wall under the green cover is lower by as much as 15°C (Perez et al. 2011), which has a positive effect on the temperature in the interior. Coverage of the walls with vines moderates the extremes between the exterior and interior. Solar radiation is captured by the leaves on the green facade, which release water vapor into the environment, thus efficiently cooling the space thanks to „transpiration."

In addition to the influence on the temperature in the interior, green facades also have an effect on the temperature of its surroundings separately in the narrow street areas. According to research in southern Europe, this difference in temperatures can be up to 9°C (Alexandrie et al. 2008).

The amount of research papers on green walls is still relatively low, but their cooling effect has been confirmed up to 60 cm from the green wall (Wong et al. 2010). Professional literature sometimes talks about a 10-30% energy cost savings for the season. Just a fraction of solar energy reaches the outside wall thanks to the vine facade. Therefore, if an uncovered wall heats up to, for example, 42°C in the sun, the same wall under a green facade reaches only about 22°C.

Vines significantly reduce the temperature of the wall, not only depending on the climatic zone but mainly on the areas that they cover. Reduction in temperature ranges from 10°C to 30°C.

It has been calculated that the reduction of the walls temperature by about 5.5 °C will save about 50% of power expended on air conditioning. When we take into account that 1/3 energy for heating in winter is spent on the wind-cooled walls, vines (particularly evergreens such as ivy) bring energy profits.

Improving the quality of urban air through green infrastructure

Air quality in urban areas varies, depending on the activities, used fuels, and industrial technologies. Dust and solid particles, gaseous chemical compounds such as carbon oxides, sulfur oxides, nitrogen oxides, fluorides, chlorides, ammonium substances, hydrocarbons, etc., get into the air from a variety of technological processes, transport, and housing. According to the comparison of the urban atmosphere with open countryside, the urban ambient air has 10 times more dust particles, the SO_2 concentration is 5 times higher, the CO_2 concentration is10 times higher, and the CO concentration in the urban ambient air is 25 times higher than in the open countryside. According to the World Health Organization, the value of pollutants was exceeded at least once in 70-80% of the monitored sites[30]. For example, the SO_2 developments were different in Western and Eastern Europe. Positive trends are associated with strict emission standards and industrial restructuring.

It is proven that greenery can improve the quality of urban air.[31] Filtration effects of greenery are widely known. Trees and bushes have a beneficial effect on the purity of air, serve as a filter for dust particles (indicated value of 20 g of dust particles per m^2 of leaf area. Researchers from Columbia University found that the ratio of asthma in children was 4 to 5 times lower in children living in an urban environment with tree avenues. For example, a 50-year-old maple (*Acer platanoides*) absorbs 0.0295 kg of sulfur, 0.0860 kg if chlorine and 0.0039 kg of fluorine per vegetation period. Trees on the streets are able to remove sulfur dioxide and reduce particulate matter by up to 75%[32]. The biggest effect of dust capture and absorption of the contaminant was found in a double-row of trees with a relatively high planting density[33]. But even solitary trees capture 15-20 % of dangerous particulate matter PM 10[34]. The capture of PM in an urban area seems to be very significant, as these greatly threaten the health of the inhabitants of the cities. In accordance with the report of the World Health Organization, hazardous dust particles reduce the average life of the inhabitants of European cities by roughly one year[35].

30 *World Health Organisation ,WHO*
31 *Nowak et al 2006*
32 *TCPA, 2008*
33 *Jim, Chen, 2008*
34 *Bealey et al., 2007; Mitchell and Maher, 2009*
35 *Lagner, 2011*

Photo 11: The flowering meadows are promoting pollinators

A number of works deal with the effectiveness of capturing volatile organic compounds and dust according to the type of trees. Several authors evaluated the trees in this regard on the basis of the urban tree air quality score "UTAQS"[36]

Noise reduction and an increase of humidity through green infrastructure

The function of greenery in terms of noise level reduction in the urban environment and wind speed reduction is non-negligible. Noise reduction may be up to 30 dB per 100 feet. Green areas increase air humidity (the average value is 5 to 7 per cent); mature birch (*Betula pendula*) can evaporate up to 7000 liters of water per season.[37]

Promotion of biodiversity and ecosystem services

The United Nations Environment Programme has drawn up a report, stating that biodiversity at the global level is currently falling faster than at any time in the past[38]. The importance of biodiversity in urban areas continues to grow due to the fact that 2007 was the first year when more people resided in

36 More information, together with a more detailed evaluation of individual tree species, can also be found in the Urban air quality Report, 2012
37 Hudeková, 2007a
38 MEA, 2005

urban areas than in rural areas. We often encounter the view of cities as the opposite of the countryside, where the environment modified by people does not play an important role from the perspective of biodiversity. But the opposite is true – the level of biodiversity, a number of species in the urbanized environment, whether of animals or plants, often exceeds even the surrounding rural areas. Natural elements, parks, forests, gardens, cemeteries, open spaces and even buildings and their roofs provide a great diversity and create a unique environment for the various species. Contact with nature and the natural environment is also very important for the city residents and is one of the indicators of the quality of their lives.[39]

It is, therefore, necessary to create suitable conditions for the promotion of biodiversity, not only on the citywide level but also in the design and creation of various public spaces at the local level[40]. The quantity and spatial relationships between different areas of greenery have a direct impact on the status of biodiversity in the urban environment. The fragmentation of natural elements therefore raised the request for the inclusion of public spaces in the local system of interconnected areas on the citywide level. Development of a green network is important not only in terms of the movement of species but also from the point of view of feasibility by the residents.

There are a lot of options for the protection of biodiversity at the local level. These include, for example:

- increasing the proportion of vegetation, especially in developed city centers
- including biodiversity conservation into land-use planning
- establishing landscaping close to nature
- caring of public greenery in a manner close to nature
- protecting habitats and species and creating corridors linking the various habitats

The area of ecosystem services is closely linked to the issues of greenery functions in public areas. Ecosystem services have various benefits, such as the provision of regulatory services, climate, disease control, water purification, a recreational and educational function for residents, and others[41]. Ecosystem services have a direct link not only to the protection of biodiversity but also to the modification of the microclimate and other regulatory functions of the vegetation in the country.

39 Hudeková, 2012b
40 Werner et al. 2009
41 Eamus, 2005

Influence on the hydrological cycle, damping of the flood waves

Appropriately designed public spaces with plenty of greenery can have a significant positive impact on the hydrological cycle in an urbanized environment because they can provide an important space for the temporary capture of surface water during storms until it is removed by the drainage system. Public spaces with permeable surfaces can, in addition to capturing rainfall, enable direct infiltration of precipitation into the soil, thereby lowering the requirements for traditional drainage systems and at the same time, the greenery captures additional significant quantities of precipitation on its surface. This precipitation can then evaporate into the atmosphere, thus increasing atmospheric humidity, or slowly seep into the soil.

Overall, vegetation in public urban areas is involved in the management of rainwater at several levels in many ways:

Trees capture rainfall very efficiently, depending on the size and type. Studies indicate that while massive trees capture 80% of rainfall, saplings capture only 15%. Coniferous trees are more efficient at capturing rainfall because deciduous trees capture only 10% to 30% in their leaf-free state[42]. The capture of water while "above the surface" reduces the amount of water which is then absorbed into the soil.

Thanks to its root system, vegetation aids the infiltration of rainwater to the lower layers of soil[43] and into groundwater.

Photo 12: Example of green infrastructure - watercourse with accompanying greenery

42 Q. Xiao and E. McPherson,2009, Calder, J. et al. 2008

43 H. Bramley In J. Bartens and The Mersey Forest Team 2009

With the help of transpiration (the evaporation of water by the plant's surface), plants draw water out of the ground by the roots. And finally, when rainwater gets accumulated in temporary polders, it can be very effectively drained by trees that tolerate waterlogging well.

Maintenance of the ground's permeability in an urbanized environment is of particular importance in addition to the greenery. The study shows that a 10% increase in the proportion of greenery in the cities would help reduce the rainwater runoff by 5%.[44]

Minimization of impervious surfaces in public places can very effectively help prevent and avoid torrential flooding during the rainy season when the sewer network capacity is not able to divert the amount of rainfall in the short interval. Permeable surfaces in public areas enable the infiltration of rainwater and help maintain the effectiveness of the water cycle in the urban environment, but also help reduce the increased volume of drained water and contribute to reducing the potential for a flood wave.

Terrain modeling of natural or artificially created shallow depressions, which drain excess water from the surrounding terrain, roofs, parking lots, or the landscape through dry polders in public areas, can be used to capture rainfall.

In the hinterland of municipalities, forests and park forests on slopes are of utmost importance in this respect.

Social, societal, health and economic functions of green infrastructure

Several authors point to the social aspects of greenery and public spaces as a basis for social contacts and community forming. Public spaces with greenery work as a social platform[45]. Green and public urban spaces are a key part of the public domain and provide an important platform on which people from a variety of social, cultural and demographic groups come together[46].

The optimal social interaction requires a range of different, hierarchically arranged green areas of various character, from the public to private. Semi-private areas that are only available to a clearly defined group of people, for example, residents of a particular residential block, are particularly important in this context.

The contact areas between the areas of greenery with various availability also offer important means of social control.

44 *Handley, 2010*
45 *Partnerství Foundation, 2011*
46 *Stiles, 2010*

Influencing the physical and mental health of people and their well-being

More and more evidence points to the fact that there are measurable health benefits, which have their roots in the availability of green areas close to where people live and work.

Public spaces and green areas are important for health because they:

- allow contact with nature, promote regeneration from stressful situations, are beneficial to mental health and help improve behavior and attention of children
- promote the physical activity of people[47]

Several studies have shown a direct influence between public health, level of physical activity and the availability of public spaces - e.g. studies of eight European cities show that people who live in areas with abundant greenery are three times more likely to be physically active, with a 40% lower probability

Photo 13: Examples of green infrastructure -green spaces of the civic amenities (business and shopping centers)

47 EEAc, 2009

Photo 14: Examples of green infrastructure -green spaces of the housing districts

of becoming overweight or obese. Students who have access or a view of the natural environment show a higher level of attention than children who do not have this option. Researchers from the Research, Landscape and Human Health Laboratory at the University of Illinois carried out interesting research, concluding that a view of foliage from the window helps girls in puberty with self-discipline.

The provision of space and buildings for leisure and recreation

This is probably the best known function of greenery, which involves the direct use for games, sports, and recreation, both organized and informal, active and passive.

- The provision of space for games for children of different age groups
- Providing options for various organized team sports
- Providing options for informal recreation, which does not require special equipment

Access to nature and its use

It is stated that, since humans are a part of nature, and due to the fact that species have evolved over millions of years in the interaction with their natural surroundings, we still need to be in close contact with the world of nature, even though we now mostly live in urban environments. This idea is perhaps best expressed by the biophilia hypothesis, developed by E. O. Wilson. The theory of "biophilia" and the biophilic design strives to reunite the value system of humanity with nature, which will also increase the environmental values and the health of urban residents, thus promoting a sustainable way of life.

Economic benefit

The economic benefit resulting from high-quality public spaces is undeniable and established by a number of studies. For example, CABE (2004) showed in their study „Does Money Grow on Trees?" that green areas increase the value of the other property.

In addition, the production functions of greenery (in particular, community gardens, but also private gardens) also bring economic benefits. It is also important to note that regulatory and environmental functions of green infrastructure have relatively high economic benefits.

Crime rate

A number of studies have shown a direct link between neat public spaces specially with planted vegetation and trees and a decrease in criminal activity.

Structural and aesthetic function

Breakdown, division and merger into an urban structure

Each settlement has its own unique spatial urban structure. More complex structures, such as street networks, building blocks, and urban district, are created from the essential elements made up by plots.

The layout of a developed and undeveloped area is referred to as the form. The traditional form, where individual buildings create a continuous built-up area and streets define the blocks of buildings in the urban structure, is often replaced by the modern form, where solitary buildings are constructed freely in the space. Green infrastructure can play an important role in the division of urban structure, but also in the interconnection the various parts of the municipality and when establishing a settlement with a free landscape.

The role of green infrastructure in ensuring the structure and organization of the settlement is well defined. A municipality may be separated from the surrounding countryside and industrial areas in this way, and different ways of using the land can also be separated from each other. Such structural open spaces include green strips and concentric green circles, wedged areas of greenery and green corridors, as well as smaller linking areas of greenery, which may take the form of tree-lined streets with a low density of traffic.

In his classic urban planning publication entitled „Image of the City," Kevin Lynch (1960) stated that orientation is important for reasons of efficiency, but also for securing a sense of well-being on the part of the population. Five structural components of the urban environment identified by Lynch (significant elements, nodes, road network, outskirts and boroughs) can be adjusted to a different scale, so that they can be used at different levels of spatial hierarchy on the local/zonal level, at the level of districts or the entire city, and they can also be applied in the design of green infrastructure.

Creation of the spirit of the place, the identity bearer, meanings, and values

Green infrastructure, as well as the whole of the urban landscape, is often an important carrier of the „genius loci" of local history and other values. Open areas in municipalities are important carriers of meanings and values and help to create and reinforce the identity of the individual and the community.

The function of the area's visual enrichment

This function is largely influenced by the quantity and quality of the green infrastructure and the design of the green areas. However, it is important to note that public participation in the planning process also plays a very important role this the context, not just the way the greenery is designed.

Creation of the landscape character and image – landscaping function

Green infrastructure plays an important role in creating the landscape character and image. Landscape image is readable thanks to the arrangement of the components of the landscape's structure. The structure of the landscape itself, which helps create its character, is given by the terrain and important landscape features. Major landscape features are associated both with the look of the landscape and its functioning. Green infrastructure is undoubtedly an important basic land element – whether in the form of forest plants, avenues, solitary trees, non-forest trees, lanes, hedgerows in agricultural land, watercourse greenery, etc.

Bibliography:

Alexandrie, et al. Temperature decreases in a urban canyon due to the green walls and green roofs in different climates. Building and Environment. 2008, 43(4), 480-496.

AŽ PROJEKT s.r.o, : Vytvorenie podmienok pre stanovenie zásad a pravidiel územného plánovania, 2013, Dostupné na internete: http://www.azprojekt.sk/data/v-zasady-pravidla/ZP%203%20N%C3%A1vrh%202013.pdf

AŽ PROJEKT s. r.o. Štandardy minimálnej vybavenosti obcí. [Online] 2009. http://www.telecom.gov.sk/index/index.php?ids=75272.

BRAMLEY, H., HUTSON, J., TYERMAN S.D.,. 2003. Floodwater infiltration through root channels on a sodic clay floodplain and the influence on a local tree species Eucalyptus largiflorens. Plant and Soil. 253(1): s. 275-286. In Bartens, J., The Mersey Forest Team, 2009. Green Infrastructure and Hydrology, jun 2009.

BEALEY, W.J. et al. 2007. Estimating the reduction of urban PM10 concentrations by trees within an environmental information system for planners, Journal of Environmental Management

85, s. 44–58.

BOWLER, D. et al. 2010. Urban greening to cool towns and cities: A systematic review of the empirical evidence In Landscape and Urban Planning, Volume 97, Issue 3, 15 September 2010, s. 147–155

Barcelona City Council, 2010. Parks and Gardens database [online]. In EEA, 2010. The European environment | State and outlook 2010, Thematic assessment, Urban environment, s.16.

[cit. 2012-03-20] Dostupné na internete: http://w3.bcn.es/XMLServeis/XMLHomeLinkPl/0,4022,375670355_376776313_3,00.html

BUILDING NATURAL VALUE FOR SUSTAINABLE ECONOMIC DEVELOPMENT : The green infrastructure valuation toolkit user guide [online]. s. 23 [cit. 2012-01-18] Dostupné na internete: http://www.greeninfrastructurenw.co.uk/resources/Green_Infrastructure_Valuation_Toolkit_UserGuide.pdf,

CABE (Commission for Architecture and the Built Environment and the Greater London Authority), 2004. Does Money Grow on Trees? [online]. [cit. 2011-04-10]

Dostupné na internete:

http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/files/does-money-grow-on-trees.pdf

CABE (Commission for Architecture and the Built Environment and the Greater London Authority), 2009. Open space strategies - Best practice guidance Published in 2009 [online]. [cit. 2010-04-18] Dostupné na internete: http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/files/open-space-strategies.pdf

CALDER, I., et al. 2008. Woodland actions for biodiversity and their role in water management. Woodland Trust. In Bartens, J., The Mersey Forest Team, 2009. Green Infrastructure and Hydrology, jun 2009.

CARR, S., A. LANE 1993. Practical Conservation: Urban Habitats. The Open University, Hodder and Stoughton, London, UK

CERMÁK, J., et al. 2000. Urban tree root systems and their survival near houses analyzed using ground penetrating radar and sap flow techniques. Plant and Soil. 219(1/2): s. 103-116. In Bartens, J., The Mersey Forest Team, 2009. Green Infrastructure and Hydrology, jun 2009.

CHANG et al, 2007. „A preliminary study on the local cool-island intensity of Taipei city parks, in " Landscape and Urban Planning 80(4): 386-395.). In Building natural value for sustainable economic development : The green infrastructure valuation toolkit user guide [online]. [cit. 2011-03-10] Dostupné na internete: http://www.greeninfrastructurenw.co.uk/resources/Green_Infrastructure_Valuation_Toolkit_UserGuide.pdf

DONOVAN, R., et al 2005. Development and application of an urban tree air quality score for photochemical pollution episodes using the Birmingham, United Kingdom, area as a case study. Environ. Science Technology 39, 673–6738.

EAMUS, D. et al. 2005: Ecosystem services: an ecophysiological examination, Turner review No. 9 Australian Journal of Botany 53(1) 1–19

EEA, 2009: Ensuring quality of life in Europe's cities and towns, Tackling the environmental challenges driven by European and global change

EEA, 2010a. The European environment | State and outlook 2010, Thematic assessment, Adapting Climate Change p. 4.

EEA, 2010b. The European environment | State and outlook 2010, Thematic assessment, Urban environment, s.12.

EEA, 2010c. EEA Fast Track Service Precursor on Land Monitoring — Degree of soil sealing 100m (reference year 2006). In EEA, 2010. The European environment | State and outlook 2010, Thematic assessment, Urban environment, s.16.

EEA, 2010d. The European environment – State and outlook 2010, Synthesis, s. 39.

ELLAWAY, A et al., 2005. Graffiti, greenery and obesity in adults: secondary analysis of European cross sectional survey'. In British Medical Journal,331: s. 611–612.

EDINBURGH OPEN SPACE STRATEGY, 2010 [online], [cit. 2011-01-20] Dostupné na internete:

http://www.edinburgh.gov.uk/downloads/file/2016/open_space_strategy

Feng, et al. Theoretical and experomental analysis of the thermal balance of extensive green roofs. Energy and buildings. 2010, 42(6),959-965 .

FOREST RESEARCH, 2010: Benefits of green infrastructure, Report, [online], [cit. 2012-01-20] Dostupné na internete:

http://www.forestry.gov.uk/pdf/urgp_benefits_of_green_infrastructure_main_report.pdf/$FILE/urgp_benefits_of_green_infrastructure_main_report.pdf

GILL, S.E. et al, 2007. Adapting Cities for Climate Change: The Role of the Green Infrastructure. In Built Environment vol. 33 No. 1.

GREEN INFRASTRUCTURE AND HYDROLOGY, 2009 [online], [cit. 2012-01-20] Dostupné na internete:

http://www.ukcip.org.uk/wordpress/wp-content/PDFs/LA_pdfs/GI_Hydrology.pdf

HANDLEY, 2010. University of Manchester workshop w/ Handley, Gill et al, April 2010. In Building natural value for sustainable economic development : The green infrastructure valuation toolkit user guide [online]. [cit. 2011-03-20] Dostupné na internete: http://www.greeninfrastructurenw.co.uk/resources/Green_Infrastructure_Valuation_Toolkit_UserGuide.pdf, p. 24.

HEISLER, Energy savings with trees, 1986 and Jones (2003) cited in Landscape consultants (2004). In Building natural value for sustainable economic development : The green infrastructure valuation toolkit user guide [online]. [cit. 2011-03-20] Dostupné na internete: http://www.greeninfrastructurenw.co.uk/resources/Green_Infrastructure_Valuation_Toolkit_UserGuide.pdf.

HUDEKOVÁ, Z., 2012a. Ochrana biodiverzity vurbanizovanom prostredí In Urbanita, [online]. [cit. 2012-04-22] Dostupné na internete:http://www.urbion.sk/ochrana-biodiverzity-v-urbanizovanom-prostredi/

JIM, C.Y. ,CHEN, W.Y. 2003. Assessing the ecosystem service of air pollutant removal by urban trees in Guangzhou, Journal of Environmental Management 88, 665–676

KOHÉZNA POLITIKA NA PODPORU RASTU A ZAMESTNANOSTI, Strategické usmernenie Spoločenstva na roky 2007-2013, ISBN 92-79-03489-8, str.29

Köhler, M. Green façades-a view back and some vision. Urban Ecosyst. 2008, 11, 423-436.

KRATOCHVÍL, P. 1996. Město jako kulturnífenomén In Halík, P. et al. Architektura a město. Academia, Praha 1996

KUO, F et al. 2001. Views of nature and self-discipline: evidence from inner city children , Press University of Illinois Urbana-Champaign, U.S.A, Journal of Environmental Psychology (2001) 21 [online]. [cit. 2012-02-10] Dostupné na internete: http://lhhl.illinois.edu/girls_self-discipline.htm

KUO, F et al. 2001: Does Vegetation Reduce Crime? In ENVIRONMENT AND BEHAVIOR, Vol. 33 No. 3, May 2001 343-367 [online]. [cit. 2012-02-10] Dostupné na internete: http://www.outdoorfoundation.org/pdf/EnvironmentAndCrime.pdf

LANGNER, M. 2011. Measurement of particle deposition to urban vegetation In ELCA [online]. [cit. 2011-10-10] Dostupné na internete: http://www.elca.info/elca-forschungsworkshop-2011.aspx#

Leizinger et. al., :Tree surface temperature in urban environmemt. Agriculture and forest Meteorology. 2005, 150, p. 50-60. 3.

LYNCH, K.,1960. The image of the city, MID Press, Cambridge MASS

LOVASI, G., QUINN, J., NECKERMAN, K., PERZANOWSKI, M. & RUNDLE, A. (2008) Children living in areas with more street trees have lower prevalence of asthma. Journal of Epidemiology & Community Health, 62(7), pp. 647

MITCHELL, R., MAHER, B.A. (2009) Evaluation and application of biomagnetic monitoring of traffic derived particulate pollution. Atmospheric Environment 43, 2095–2103.

MEA, 2005. Ecosystems and human well-being: Synthesis, [online]. [cit. 2010-02-10]. Dostupné na internete:http://www.millenniumassessment.org/documents/document.356.aspx.pdf

NADACE PARTNERSTVÍ 2003: Utváření místa, Príručka k vyvtáření kvalitních veřejných prostranství, Project for Public Spaces, Inc., s.12

NISHIMURA, et al., 1998. Novel water facilities for creation of comfortable urban micrometeorology.Solar Energy 64, 197–207

NORTHWEST, 2010. Green Infrastructure: How and where can where it help the Northwest mitigate and adapt the climate change, June 2010, s. 16

NOWAK, 1994. Chicago's urban forest ecosystem: results of the Chicago urban forest climate project. In Building natural value for sustainable economic development : The green infrastructure valuation toolkit user guide [online]. [cit. 2011-02-10]. Dostupné na internete: http://www.greeninfrastructurenw.co.uk/resources/Green_Infrastructure_Valuation_Toolkit_UserGuide.pdf, s. 22.

NOWAK, D.J. 1994. Air pollution removal by Chicago's urban forest. In: McPherson, E.G, D.J.

Nowak and R.A. Rowntree. Chicago's Urban Forest Ecosystem: Results of the Chicago

Urban Forest Climate Project. USDA Forest Service General Technical Report NE-186.s. 63-81

Peck, S. W., M. Kuhn, et al. Design Guidelines for Green Roofs. s.l. : Ontario Association of Architects; CMHC, 2003.Mentens, J., D. Raes, et al. Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? Landscape and Urban Planning. 2006, 77(3): 217-226.

Perez, et al. Behavour of green facades in Mediteranian continental climate. Energy conversion and management. 2011, 52(4), 1861-1867.

Perini, Katia. The Integration of Vegetation in Architecture, Vertical and Horizontal. International Journal of Biology. 2012, Zv. 4, 2.

Perini K., Ottelé M., Haas E. M., & Raiteri R. Greening the building envelope, façade greening and living wall systems. Open Journal of Ecology. 2011, 1(1), 1-8.

Rahman et.all: Efect of cooling condition of the growth and cooling ability of Pyrus calleryana. Urban forestry and Urban greening. 2011, 10(3), 185-192.

REACHER, M. et al, 2004. Health impacts of flooding in Lewes : a comparison of reported gastrointestinal and other illness and mental health in flooded and nonflooded households. In EEA 2010, | State and outlook 2010, Thematic assessment Urban environment s.13.

REBSTOCK, M., et al. 2011. Methodology Action Plan for good planning and designing of urban open spaces, REC Slovakia, ISBN 978-80-89320-06-6

REHÁČKOVÁ, T.,- PAUDITŠOVÁ, E.2006. Vegetácia v urbánnom prostredí. 1. vyd. Bratislava: CICERO, s.r.o., 2006, ISBN 80-96914-1-1

SHAFTOE, H. 2008: Convivial urban spaces:creating effective public space, Earthscan London, ISBN 978-1-84407-388-7

Šteiner, A. et all:: "Katalóg adaptačných opatrení miest a obcí BSK na nepriaznivé dôsledky zmeny klímy on-line http://www.region-bsk.sk/koncepcne-materialy.aspx

TOWN AND COUNTRY PLANNING ASSOCIATION, 2008: The essential role of green infrastructure: eco-towns green infrastructure worksheet Eco-towns Green Infrastructure Worksheet, Advice to Promoters and Planners, September 2008, [online]. [cit. 2010-10-10] Dostupné na internete: http://www.tcpa.org.uk/data/files/etws_green_infrastructure.pdf

THE SCOTTISH EXECUTIVE CENTRAL RESEARCH UNIT, 2001: Rethinking open space open space provision and management: a way forward,. Kit Campbell Associates. Edinburgh

[online]. [cit. 2009-11-10] Dostupné na internete: http://www.scotland.gov.uk/Resource/Doc/156814/0042172.pdf

THOMAS, P., 2000. Trees: Their Natural History. Cambridge, United Kingdom: Cambridge University Press. In Bartens, J., The Mersey Forest Team, 2009. Green Infrastructure and Hydrology, jun 2009.

United Nations, Department of Economic and Social Affairs, Population Division

2008. online version [online]. [cit. 2012-02-10] Dostupné na internete: http://www.un.org/esa/population/publications/wup2007/2007wup.htm.

URBION, 2010. Štandardy minimálnej vybavenosti obcí : Metodická príručka pre obstarávateľov a spracovateľov územnoplánovacej dokumentácie. AKTUALIZÁCIA. Bratislava. 2010.

URBAN AIR QUALITY, REPORT, april 2012, The Woodland Trust, Kempton Way, Grantham, Lincolnshire NG31 6LL, [online]. [cit. 2012-5-15]. Dostupné na woodlandtrust.org.uk

VELARDE, M. D.; FRY, G. AND TVEIT, M., 2007. 'Health effects of viewing landscapes: landscape types in environmental psychology'. Urban Forestry & Urban Greening 6: s. 199–212

WERNER,P. ZAHNER, R.: Biologische Vielfalt and Stadte, 2009

Williams, Dave. Why Green Roofs? [Online] https://tcugreenroofs.wordpress.com/green-roof-benefits/.

Wong, et al. Thermal Evaluation of the vertical greenery system for bulding walls. Building and Environment. 2003, 45(3), 663-672.

WORPELE, K., GREENHALGH L.,1996. The freedom of the city.Demos, London

XIAO, Q., MCPHERSON, E., 2002. Rainfall interception by Santa Monica's municipal urban forest. Urban Ecosystems. 6: p. 291-302. In Bartens, J., The Mersey Forest Team, 2009. Green Infrastructure and Hydrology, jun 2009.

Informácie z web-stránok:

http://www.greeninfrastructurenw.co.uk/liverpool/Action_Plan.pdf

http://www.trameverteetbleue.fr/sites/default/files/fiches-territoires-tvb-roubaix-etd-2012.pdf

https://www.cbd.int/sp/targets/

https://www.asla.org/ContentDetail.aspx?id=43535

https://www.alexandriava.gov/uploadedFiles/tes/oeq/info/GI%20Strategy-FINAL.pdf

Zelená infraštruktúra: Fenomén súčasnosti a prírode blízke riešenie pre udržateľnú budúcnosť (PDF Download Available). Available from: https://www.researchgate.net/publication/305347625_Zelena_infrastruktura_Fenomen_sucasnosti_a_prirode_blizke_riesenie_pre_udrzatelnu_buducnost [accessed Jan 18 2018].


Green Infrastructure Guide for the Municipalities