GREEN INFRASTRUCTURE: A STRATEGIC TOOL FOR CLIMATE CHANGE MITIGATION IN URBAN ENVIRONMENTS

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Abstract

The changing climate has a significant negative impact on urban environments, influencing thereby the quality of life of urban residents and causing a range of problems in urban areas worldwide. There is a need for efficient urban planning and design tools, which can mitigate these negative effects. Green infrastructure represents a tool to create more resilient and sustainable urban environments by greening open spaces in our cities. Green structures and greenery elements improve the urban microclimate and reduce noise, dustiness, the heat island effect and help to manage urban stormwater. Therefore, it is crucial to protect and improve existing green spaces, enhance their connectedness and utilise unconventional areas for creating new green spaces which would improve the health of urban landscapes. Here, greening of roofs, walls, brownfields and other empty spaces comes into play. They still represent an unutilised potential of contemporary urban landscapes. Landscape Architecture as a field of research and design practice plays a crucial role in developing innovative tools, planning and designing green infrastructure which will contribute to creation of sustainable and multifunctional urban landscapes of the future.

Keywords: *climate change, green infrastructure, landscape architecture, urban environments*

INTRODUCTION

One of the main issues in contemporary global development is the changing climate which has a significant impact on our present urban environments. The consequences of climate change, global warming and dynamic urban development (including intensified transportation or massive housing and industrial constructions) are surely the most perceptible in urban environments. These are e.g. heat island effect and generally higher temperature in urban areas, air pollution and aridity, problems with the stormwater management, smog and dustiness, noise or empty spaces and brownfields. It is a great responsibility of governments, planners and architects to come up with sustainable solutions with a potential to improve the resilience of urban environments towards urban development and global environmental changes. For mitigation of these impacts, green infrastructure seems to be a suitable strategic tool of urban planning and landscape architecture at local, regional and national level (Kilbane, 2013). According to Roe and Mell (2013), green infrastructure has a value for landscape enhancement for multifunctional aims as increasing the adaptive capacity of the environment for climate change and long-term sustainability whilst protecting its ecological and social values. Urban green infrastructure should be understood as an interconnected system of all green spaces, areas and structures in the urban area. These will according to Taylor Lovell and Taylor (2013) have a critical role to play in conserving biodiversity, protecting water resources, improving microclimate, sequestering carbon, and even supplying a portion of the fresh food consumed by urban dwellers in the context of environmental issues we will face in the coming years or decades. We can divide the elements of the urban green infrastructure into several categories according to their features, functions, ownership or affiliation to special objects. According to the character of green spaces, we can distinguish between conventional and unconventional components of the green infrastructure: the most conventional elements of the urban green infrastructure are public parks and gardens including garden heritage sites, green squares, street greenery, green spaces at housing estates, greenery accompanying or complementing transport structures and other green spaces or greenery elements (Supuka, Feriancova et al., 2008); the unconventional components have arisen more frequently during the last twenty years. These are for example rooftop gardens or green roofs; vertical greenery or green walls; greened brownfields turned into semi-natural green areas or so called rain gardens etc. According to

the ownership, we can distinguish between private, semi-public and public green spaces. Private green spaces are represented mainly by family gardens or allotments; public green spaces by publicly accessible green spaces like parks and semi-public spaces are for instance privately owned green spaces that are accessible for the public, while the accessibility is often limited by a programme. Some urban green areas can be adjacent to diverse institutions like universities and schools, hospitals, churches and cemeteries, sports grounds etc. These objects are designated as institutional green spaces. Other green areas or greenery components can be affiliated to exhibition or collection sites, spiritual sites or other special types of greenery.

The following chapters will be dedicated to urban green infrastructure and its diverse components, mainly in terms of their significance for climate change mitigation in urban environments. Green infrastructure will be defined as a physical component of urban areas and a strategic planning tool for building sustainable and resilient urban landscapes as stated by Antrobus (2011) and in the Europe 2020 development strategy of the European Commission. Those features of urban greenery solving contemporary environmental problems and consequences of the changing climate will be defined and emphasised, furthermore innovative and unconventional elements of the urban green infrastructure will be introduced, while emphasising their environmental benefits and climate change mitigating potential.

1. GREEN INFRASTRUCTURE AND EUROPE 2020

Green infrastructure represents a complex system of natural and semi-natural areas and elements in rural and urban areas providing a wide range of valuable ecosystem functions and services for human environments. Components of the green infrastructure provide health-improving benefits like fresh and cleaner air or better water resources. In urban landscapes, most of the green infrastructure components are anthropogenic elements like parks, rooftop gardens, green walls, greenways or restored natural areas. Components of the green infrastructure support biodiversity and enable ecosystems to provide functions like interlinking urban, peri-urban and rural areas. Implementation of green infrastructure components in urban environments has also a significant social dimension as it improves the community, initiates volunteering activities of the public and helps to avoid social isolation. Green infrastructure represents a physical, psychological, emotional and socio-economic benefit to individuals and the community as a whole (Benedict and McMahon, 2006; European Commission, 2013). It is a successfully verified tool to ensure ecological, economic and social benefits through natural solutions which usually is a high-return investment. Thanks to green infrastructure, we understand the importance of nature for the human society and for mobilisation of investments for sustaining and strengthening the natural systems. The urban green infrastructure includes also areas and elements with productive or utilitarian functions. These production areas within and around urban areas in the peri-urban contact zones serve as a proximity food resource improving the food resilience of urban areas. Besides the productive functions of these components, their social, environmental and ecological functions are similarly significant. Agriculturally used components of the urban green infrastructure are contemporarily designated as urban agriculture.

Concerning a further sustainable development of urban landscapes, there is a need for innovative strategic planning tools which can respond to contemporary issues of the changing climate and dynamically developing urban areas. The Europe 2020 is a development strategy of the European Union issued by the European Commission in 2010. One of the priorities of the European Union defined in this strategy document is to achieve a smart, sustainable and inclusive growth. Within the main objectives of the Union, we can find innovation, education, social inclusion and climate/energy. The Europe 2020 strategy defines green infrastructure as one of the tools to achieve the main objectives. It is an important step towards protection of the European natural capital and sustainable regional and spatial development. The EU Biodiversity Strategy to 2020 binds the European Commission to develop a green infrastructure strategy. The Europe 2020 deals with global environmental challenges like reduction of greenhouse gas emissions, increasing the share of renewable energy in final energy consumption in order to achieve an increase in the energy efficiency (European Commission, 2013).

2. CONTEMPORARY ENVIRONMENTAL PROBLEMS IN URBAN AREAS

The global environmental challenges and consequences of the changing climate are very much present even at the local scale in urban areas. We can perceive an overheating of urban environments and the presence of the so called heat island effect and also a significant aridity of the urban microclimate. In association with the local impact of these environmental issues, the consequences of the contemporary urban development have also a negative impact on the quality of life of urban populations. These are the air, soil and water pollution by emissions from transportation and industry, dustiness and noise caused mainly by traffic. The following chapter defines possible solutions for these problems provided by the urban green infrastructure and its components.

3. GREEN SOLUTIONS FOR IMPROVEMENT OF URBAN ENVIRONMENTS

The environmental problems in urban areas mentioned in the previous chapter can be solved or mitigated through green infrastructure and its components which enable to avoid our dependence on gray infrastructure solutions that are more expensive and less sustainable compared to natural solutions. Green infrastructure is based on the principle that protection and supporting nature and natural processes is accompanied by several benefits for human society if they are intentionally integrated into spatial planning and development. Compared to the single-purpose gray infrastructure, green infrastructure is not limited to spatial development; it supports natural solutions if they represent the best alternative. Green infrastructure can sometimes offer alternative or comparable solutions to standard forms of gray infrastructure (European Commission, 2013). Green infrastructure can improve life in different ways, through its environmental, social and economic potential based on the multipurpose utilisation of the natural capital. By an efficient utilisation of green infrastructure at local level, we are able to reduce energy consumption through passive heating and cooling; filtrate air and water pollutants; create clean and temperate air, lower the heat island effect; lower the costs for stormwater infrastructure management; ensure flood protection and food resources; stabilise the soil through preventing or reducing erosion. Rooftop gardens, green roofs and vertical greenery can reduce energy consumption and overheating of buildings and houses. Greenery elements, mainly trees, produce oxygen, filtrate and clean the air, e.g. through adsorbing dust and improve the urban microclimate. In order to deal with the problem of aridity of urban microclimate, green infrastructure solutions managing stormwater like rain gardens and rainwater reservoirs with hygrophilous and hydrophytic plants play a crucial role as they retain the water in urban areas. These solutions can enrich the urban microclimate through increasing the air humidity and moreover, rainwater can be utilised e.g. for watering trees, perennials and other urban green areas.

4. GREEN INFRASTRUCTURE FOR STORMWATER MANAGEMENT IN URBAN AREAS

Stormwater management causes problems in many cities. Green infrastructure offers a sustainable solution of this issue while providing also environmental benefits and mitigating the consequences of the changing climate at the local level. Why not to collect rainwater from roofs, roads, footpaths and car parks to local streams and reservoirs, clean it using water plants and hygrophytes and provide a biotope for a range of fauna, improving thereby the local biodiversity? Such a project has been successfully implemented in the campus of the University of Canterbury in Christchurch, New Zealand, *see figure 1 on the left*. In Paris, France, there are two new urban districts, where stormwater management using green infrastructure is integrated into the public space. One of these projects is the Parc Clichy-Batignolles, where rainwater canals with hygrophytes collect and clean the rainwater and terminate in a huge rainwater reservoir with water plants and hygrophytes which besides environmental benefits, improve also the aesthetic quality of the public space, *see figure 1 on the right.* There are diverse technological solutions for green infrastructure application in surface runoff management during extreme rainfall events. The priority is retention, accumulation or detention of surface runoff of stormwater and reduction of the load factor of uniform sewer networks, *see figure 2*.



Figure 1: On the left: The Okeover stream in the campus of the University of Canterbury, Christchurch (New Zealand) collects water from roofs, roads, footpaths and car parks; on the right: Stormwater management in the Parc Clichy-Batignolles, Paris (France). Photos: Attila Tóth, 2014, 2012.



Figure 2: On the left: Dry retention basin with a spillway in the urban area; on the right: Drainage ditch in the urban area. Photos: Peter Halaj, 2012.

5. GREEN INFRASTRUCTURE AND WATERS

Green infrastructure can be also utilised for improvement and of the overall ecological condition of watercourses and bodies of water. It can reduce the transport of harmful substances to watercourses and bodies of water through riparian buffer zones, which positively contribute to the improvement of qualitative parameters of waters. These green infrastructure elements support the infiltration of surface water runoff, its retention and utilisation of the contained nutrients in the soil profile. Green infrastructure elements help to decrease the contamination of waters and provide useful shading of the

water surface in the form of bank vegetation, which leads to water temperature reduction and an increase in the self-purification capacity of waters.

6. ROOFTOP GARDENS, GREEN ROOFS AND VERTICAL GREENERY IN URBAN AREAS

Future urban areas will be even denser than we know them in our contemporary cities. Therefore, there will be less space and area available for components of the green infrastructure. Conventional greenery types like public parks will have no more space and we will have to look for alternative green spaces. To reduce the energy consumption of buildings and improve the urban microclimate by reducing dustiness and aridity, rooftop or elevated green constructions and green walls or vertical greenery seem to be one of the strategic urban planning and design tools for future urban green spaces. The following figure depicts two alternative forms of urban greenery: elevated green spaces of the Promenade Plantée in Paris (on the left) and green walls at the Caixa Forum in Madrid (on the right), *see figure 3.*



Figure 3: On the left: Promenade Plantée in Paris (France) is an elevated urban green space on the top of a former elevated railway; on the right: Green walls at the Caixa Forum in Madrid (Spain) represent a modern alternative urban green space. Photos: Attila Tóth, 2012, 2011.

7. GREENING OF BROWNFIELDS IN URBAN LANDSCAPES

In many urban areas, mainly of industrial cities, there are huge former industrial sites or other abandoned areas with no contemporary use. These areas represent potential green spaces as alternative components of the urban green infrastructure improving the resilience of urban environments towards negative impacts of the changing climate. There are several good examples of such developments in Nordrhein-Westfalen - the most industrial region in northern Germany. One of the best known greened brownfields is the Landschaftspark Nord in Duisburg *(figure 4, on the left)*, another similar project is the Zollverein located in Essen *(figure 4, on the right).*



Figure 4: On the left: Landschaftspark Nord in Duisburg (Germany); on the right: Zollverein in Essen (Germany) - two examples of urban green infrastructure improvement by greening brownfields at former industrial sites in Germany. Photos: Attila Tóth, 2012.

CONCLUSION

The concluding thought of this paper is that natural and semi-natural areas forming the urban green infrastructure play a crucial role in mitigating the impact of the changing climate on human environments. Therefore, it is important to preserve, maintain and improve the existing components of the urban green infrastructure and to develop new alternative forms of urban greenery such as rain gardens or other green forms of urban stormwater management or to use also unconventional spaces or abandoned areas to extend the existing urban green infrastructure, such as walls, roofs (or other elevated spaces) and brownfields to improve the urban green infrastructure and develop a strategic tool for mitigation of negative consequences of urban development and climate change. This approach has a potential to develop smart, sustainable and resilient future urban areas as stated in many development strategies, such as the Europe 2020.

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