

Planning and designing green infrastructure across landscapes and scales

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Planning and designing sustainable, resilient, and healthy landscapes, cities and communities is anchored in the 2030 Agenda for Sustainable Development adopted by the General Assembly of the United Nations in 2015. Current European strategies, such as the EU Green Infrastructure Strategy, the European Green Deal, the EU Strategy on Adaptation to Climate Change, the EU Biodiversity Strategy for 2030 and other related policy and strategic documents all recognise green infrastructure and nature-based solutions as important planning approaches, as well as design and implementation tools in urban areas and landscapes. This issue of *Acta Horticulturae et Regiotecturae* is dedicated to landscape architecture, landscape planning and green infrastructure at various scales and in diverse landscape settings. It provides original research findings from Chinese, Croatian, Latvian, Nigerian, Polish, Slovak, and Ukrainian cities and metropolitan regions. The issue deals with regional landscape specificities and qualities and shows examples of urban green infrastructure planning and design both at holistic and site-specific scales. At the local scale, it is highly important to involve and engage the public from the very beginning of the planning and design process. This issue introduces various experiences and empirical findings generated by local participatory and co-design actions. The articles show a wide range of ecosystem services provided by green infrastructure and its elements, while also mentioning some of possible ecosystem disservices.

Keywords: green space design, green infrastructure, landscape architecture, open space, urban planning

1 Introduction

The United Nations (2015) have agreed on 17 Sustainable Development Goals (SDGs) within the 2030 Agenda for Sustainable Development. From the perspective of landscape architecture and planning, especially in the thematic context of the paper, the following three SDGs might be specifically highlighted: “Sustainable Cities and Communities” (SDG 11), “Climate Action” (SDG 13), and “Life on Land” (SDG 15). To make cities and human settlements inclusive, safe, resilient, and sustainable (SDG 11), the UN foresees a reduction of adverse *per capita* environmental impact of cities (11.6), as well as a provision of universal access to safe, inclusive, and accessible, green, and public spaces for everyone (11.7). Our UN’s shared aim is to take urgent action to combat climate change and its impacts (SDG 13), including strengthening resilience and adaptive capacity (13.1), and integrating climate change measures into national policies, strategies, and planning (13.2). The UN has agreed upon protecting, restoring, and promoting

sustainable use of terrestrial ecosystems, sustainable management of forests, combating desertification, and halting and reversing land degradation and biodiversity loss (SDG 15) (United Nations, 2015). One of the key strategic documents of the EU in the field of environment and landscape is the EU Green Infrastructure Strategy that was communicated by the Commission already in 2013 (European Commission, 2013). A newer term, which is currently commonly and intensively used in the EU policy terminology is nature-based solutions, which are inspired and supported by nature, cost-effective, simultaneously providing environmental, social, and economic benefits and help build resilience. These solutions bring more and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource efficient and systemic interventions. The European Green Deal (European Commission, 2019) states that lasting solutions to climate change require greater attention to nature-based solutions. It has promised that the European Commission will adopt

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a new and more ambitious EU Strategy on Adaptation to Climate Change that was adopted in 2021 (European Commission, 2021). According to the Green Deal, work on climate adaptation should continue to influence public and private investments, including nature-based solutions. The Green Deal aims at designing a set of deeply transformative policies (2.1), including increasing the EU's climate ambition for 2030 and 2050 (2.1.1), and preserving and restoring ecosystems and biodiversity (2.1.7). The European Green Deal has the ambition to improve the well-being and health of citizens and future generations by providing, among others, fresh air, clean water, healthy soil, and biodiversity. Its actions include climate, environment and oceans, agriculture, and others. The EU Biodiversity Strategy for 2030 states that nature is a vital ally in the fight against climate change. It regulates the climate, while nature-based solutions, such as protecting and restoring wetlands, peatlands, and coastal ecosystems, or sustainably managing marine areas, forests, grasslands, and agricultural soils, will be essential for emission reduction and climate adaptation. Planting trees and deploying green infrastructure will help us to cool urban areas and mitigate the impact of natural disasters (European Commission, 2020). The Biodiversity Strategy includes an EU Nature Restoration Plan on restoring ecosystems across land and sea (2.2), which includes for instance "Bringing nature back to agricultural land" (2.2.2), "Increasing the quantity of forests and improving their health and resilience" (2.2.4), "Greening urban and peri-urban areas" (2.2.8). The key commitments of the EU Nature Restoration Plan by 2030 include that at least 10% of agricultural area is under high-diversity landscape features. To support the long-term sustainability of both nature and farming, The EU Biodiversity Strategy will work in tandem with the new Farm to Fork Strategy and the new Common Agricultural Policy (CAP), including by promoting eco-schemes and result-based payment schemes. Green urban spaces, from parks and gardens to green roofs and urban farms, provide a wide range of benefits for people. They also provide opportunities for businesses and a refuge for nature. They reduce air, water, and noise pollution, provide protection from flooding, droughts, and heat waves, and maintain a connection between humans and nature. The recent lockdowns due to the COVID-19 pandemic have shown us the value of green urban spaces for our physical and mental well-being. While protection of some urban green spaces has increased, green spaces often lose out in the competition for land as the share of the population living in urban areas continues to rise. The EU Biodiversity Strategy for 2030 aims to reverse these trends and stop the loss of green urban ecosystems. The promotion of healthy

ecosystems, green infrastructure and nature-based solutions should be systematically integrated into urban planning, including in public spaces, infrastructure, and the design of buildings and their surroundings. To bring nature back to cities and reward community action, the Commission calls on European cities of at least 20,000 inhabitants to develop ambitious Urban Greening Plans. These should include measures to create biodiverse and accessible urban forests, parks, and gardens; urban farms; green roofs and walls; tree-lined streets; urban meadows; and urban hedges. They should also help improve connections between green spaces, eliminate the use of pesticides, limit excessive mowing of urban green spaces and other biodiversity harmful practices (European Commission, 2020).

Sustainable and resilient landscapes at different scales have an integral green infrastructure system, which includes greenways, green belts, ecological networks, green and open spaces, and other natural and semi-natural elements (Tóth, Štěpánková & Feriancová, 2016), including diverse elements such as urban agriculture (Tóth & Timpe, 2017) or green university campuses (Čibik et al., 2020). Green infrastructure can be recognised as an integral component of the fourth nature concept (Čibik et al., 2020), as well as a strategic tool for climate change mitigation in urban environments (Tóth, Halajová & Halaj, 2015), and rural landscapes (Tóth & Feriancová, 2013; Tóth, Štěpánková & Feriancová, 2016). Moreover, green infrastructure can be a reinterpreting and directing concept in urban and rural development (Karadeniz et al., 2020). In intra-urban areas, a significant part of green infrastructure is represented by urban green spaces and green areas, which have a marked impact on the quality of life and well-being of residents (Bihuňová et al., 2021), improve the overall community health (Marques, McIntosh & Chanse, 2020) and serve as an important climate change mitigation tool (Rózová et al., 2020). They provide a wide range of other ecosystem services, such as dust and noise reduction (Ruda & Boyko, 2020). Green infrastructure can be implemented through different programmes and frameworks at the national level, for instance in Slovakia, there has been a national project on the support of biodiversity with green infrastructure elements in Slovak municipalities (Halajová & Halaj, 2020). A concept that thematically builds upon the concept of green infrastructure is nature-based solutions, which can be used to address current challenges and problems in urban environments, such as revitalisation of neighbourhoods and residential areas (Shchur, Lobikava & Lobikava, 2020).

This thematic issue of *Acta Horticulturae et Regiotecturae* deals with different aspects of planning and designing

green infrastructure across landscapes and scales. At the large scale, Yang et al. (2022) present an approach to a comprehensive zoning scheme for vernacular landscapes in China. Kamenečki et al. (2022b) deal with a wide range of landscape values, elaborated on the case study of the Jakljan Island in Croatia. Fornal-Pienak and Bihuňová (2022) evaluate current landscape architecture approaches in selected cities in Poland and Slovakia in a comprehensive comparative study. Unconventional interventions in redeveloping unused urban landscapes are presented by Maksymenko et al. (2022). Pochodyła et al. (2022) analyse green infrastructure and nature-based solutions in Warsaw and elaborate on the aspects of the urban planning practice. The importance of residential green spaces and their vegetation is analysed by Williams (2022), while considering also building footprint coverage regulations in Nigerian Lagos (Williams & Okedele, 2022). Examples of good practices are presented also by interesting Croatian case studies. Kamenečki et al. (2022a) elaborate on the revitalisation and landscape design of the park in Stari Mikanovci, while considering the role of existing vegetation in generating new landscape solutions. Green infrastructure and planning procedures are also evaluated in an empirical case study linked to creating an unofficial network of green spaces by an NGO in Sesvete (Spajić, 2022). Gutmane (2022) provides thoughts on mythologising urban projects by the case study of Barona Street in Riga, Latvia. The last two papers deal with a smaller, site-specific scale. Prochnow and Čibik (2022) present unconventional interventions within redeveloping unused urban landscapes by the example of a small design intervention in an urban park. Kušen et al. (2022) conclude this issue with an analysis of plant species in selected primary school yards in Zagreb, while specifically elaborating on toxic and allergenic plants.

Regional specificities and qualities of the landscape and its green infrastructure

In rapidly developing and growing urban metropolitan regions such as China, vernacular landscapes are of growing importance. Yang et al. (2022) have identified 8 vernacular landscape regions in China, with 56 sub-regions. A comprehensive and detailed landscape zoning has been carried out from a landscape ecological perspective, based on the principle of landscape heterogeneity. The authors identify the human constituents of vernacular landscapes and categorise them to tangible (land use, settlements, housing) and intangible aspects (population, economy, customs). They come up with an indicator system for comprehensive zoning of Chinese vernacular landscapes, which include natural (landforms, climate, hydrology, vegetation) and human constituents (land use, settlements, housing,

population, economy, customs). Kamenečki et al. (2022b) elaborate on natural, cultural, and visual landscape qualities by the example of island Jakljan in the Dubrovnik-Neretva County in Croatia. Natural qualities of the landscape include biodiversity and perception of “naturalness” of the most dominant landscape patterns. Cultural qualities include agricultural landscapes and cultural and historical heritage. Visual landscape qualities include visually attractive and authentic elements, as well as visual exposure of the landscape. The authors argue that these values must be preserved in order to sustain the character of the landscape, when planning and designing spatial changes.

Planning and designing green infrastructure in urban landscapes

Fornal-Pienak and Bihuňová (2022) analyse strategies and projects that have been implemented and realised in landscape architecture, environmental protection, and sustainable design in selected cities in Poland and Slovakia. They evaluated policy approaches (strategic documents, conceptions, and plans), quality of landscape design (architectural competitions and implemented projects), and public participation (involvement of the public in urban planning, bottom-up initiatives, support of the communities). The authors compared 10 Polish and 10 Slovak cities, while looking at strategic documents and landscape design projects realised within the last 10 years, while looking at the overall design, the selected greenery and the solutions applied for adaptation to climate change. Maksymenko et al. (2022) deal with green infrastructure at the larger scale of park zones by the example of the city of Lviv in Ukraine. Most green areas are owned by the municipality. The total area of parks and squares covers an area of 10,690,000 m², including 24% of nature reserves. This means that the provision of urban population with public green spaces is almost 15 m².person⁻¹, which is above the existing Ukrainian standards, which require 10 m².person⁻¹. Maksymenko et al. (2022) consider parks as objects/cores of urban green infrastructure. The city of Lviv established the position of a gardener for each administrative district of the city, which might potentially contribute to the implementation of nature-based practices in urban parks. Pochodyła et al. (2022) analyse green infrastructure and nature-based solutions in Warsaw. Analysis of urban green infrastructure is used to identify the concepts of its planning, implementation, and management at the level of the whole city as well as its individual parts. They elaborated a spatial analysis of green infrastructure, while focusing on the distribution of main public green spaces at the city scale – forests and parks in the urban fabric and forms of their protection, linear elements of green

infrastructure along communications, implementation of new elements of nature-based solutions in the urban environment such as green roofs, green facades, or rain gardens. The case study has proved that the green infrastructure network is in many parts of the city fragmented, the number and size of green areas are insufficient in the densely built-up areas, and only a few examples of the use of new elements of green infrastructure as green walls, green roofs, rain gardens or plantings along transport corridors were found. The analysis enabled drawing recommendations for the improvement of the conditions of the existing network, while the main recommendations include strengthening the interconnectivity and introduction of nature-based solutions and specific new elements of green infrastructure as green walls, green roofs, rain gardens, or plantings along roads and green tramlines, to improve the environmental conditions in the areas where is not possible to create other types of green spaces.

Green infrastructure in urban residential areas and zones

Williams (2022) elaborates on the paucity of residential green spaces using the Normalised Difference Vegetation Index (NDVI) in the urban residential fabric of the metropolitan city of Lagos in Nigeria. Residential areas cover approximately 52% of the total land use, while urban open space covers only 2.8%. Williams (2022) investigates the NDVI on three selected residential estates of variable densities (low, medium, high). The results show low NDVI values, which reveal that residential areas have negligible vegetation. Therefore, it is important to consider actions to improve the greenness index of the city and to ensure that rapidly developing peri-urban settlements do not neglect public green spaces. Williams and Okedele (2022) evaluate the non-adherence to residential private open spaces to building footprint coverage regulations in Lagos. Residential private open spaces are instrumental to the creation of pleasant residential environments, contributing to the individual character, identity, and appearance of the residential area. Therefore, the problem of inadequate percentage of the residential private open spaces prevents the urban residential environment from attaining city sustainability. This problem is rooted in the non-adherence to building regulation standards especially in Nigerian cities. The results of the study reveal that in the medium density residential estates, which represent a typical spatial pattern, 70% of the residential lot is covered by building footprint, while 30% is reserved for private open space. This is not in line with specifications of the Lagos state building regulation, which specifies that 60% should be reserved for building footprint coverage and 40%

for private open space. Thus, there is a need for better control of building regulation adherence.

From green space design to green infrastructure enhancement

Kamenečki et al. (2022a) present diverse procedures and indicators of systematic inventory and analysis of existing vegetation in urban landscapes, using the Visual Tree Assessment (VTA) method by the example of the park in Stari Mikanovci in Croatia. Based on this evaluation, four different conceptual design solutions were elaborated. The authors conducted a multi-criteria descriptive analysis of different design solutions by different authors with the same assignment. They found that existing vegetation is not a limiting factor for the typology, diversity, disposition, and degree of intervention in the creative phase of the design process. Spajić (2022) highlights the importance of the nongovernmental sector for enhancing local green infrastructure, based on the experience of the NGO “ZIPS” (Zelene I plave Sesvete) in Croatia. He introduces the “quad helix” approach, which was the basis for defining relations among various stakeholders throughout many of the projects that have been conducted so far by the NGO ZIPS. The role of NGOs is according to Spajić (2022) to lobby, point out problems, promote, disseminate and co-design space, while final decisions are usually made by democratically elected representatives. The strategic approach to spatial development is presented at different acting levels/steps from “base” (creating thematic maps) through “planning” (strategic placing of new green elements, involving the public) to “implementation” (involving private owners and the public). The ZIPS NGO has managed to develop a central triangle of publicly available open spaces in the central part of the municipality, which contribute to the well-being of citizens and the quality of their environment. The experience of ZIPS shows how important it is to build partnerships at local, regional, national, or even international level, especially within research, innovation, and educational projects. According to Spajić (2022) to enhance green infrastructure locally, it is important to act in different fields before an official plan gets adopted. Making small steps and fulfilling simple tasks can lead to greater achievements in time. In Lviv, a community garden was created as the initiative of the NGOs Permaculture, EkoTerra and PLATO, to arrange the public space of the City Gardening “Röring’s Greenhouses” with the consent of the city administration (Maksymenko et al., 2022). In the case of the small wooden design objet Rampolynå, the cooperation with the local NGO Fabrika Umenia (meaning Art Factory) was of added value, as they can use the added element for organising and hosting events (Prochnow and

Čibik, 2022). Gutmane (2022) elaborates on the issue of mythologizing urban project on the case study of Barona Street in Riga's historical centre. During and after the reconstruction of Barona Street, it was widely used as a public image of street renovation failure. Both, professionals, and civic associations criticised ad hoc planning, unsuitable traffic organisation, inappropriate design, and poor construction quality. Built on the analysis of the related reflections and criticism in media and public discussions, the thick description of the Barona Street project's events attempts to show how socially and emotionally shaped perception of design and implementation process by involved social groups has contributed to the mythologising the renovation of Barona Street. The conclusions emphasise socio-psychological framing of urban analysis. The emotional implication of Barona Street myth induces reattribution of the responsibility for failed design to individual political leaders, designers and involved municipal workers, shifting public attention away from structural and governance inability to engage with public spaces and creating preconditions for involving urban projects as a tool in political power games. Gutmane (2022) concludes that there is an inadequate public space policy, an absence of appropriate management and collective perception of the street as a public space. She identifies myth as a tool for creating and strengthening social identity.

Small design interventions to improve the quality of local green infrastructure

In some cases, even green belts, or other elements of urban green infrastructure such as parks can have unused zones and parts, where even a small design intervention can enhance the overall open-space quality. Sometimes an interesting small architectural element or a site furniture can revive nonfunctional open spaces and make users stop, think, relax, interact, and socialise. The case study of "Rampolynā" shows that unconventional interventions can be used as efficient tools for redeveloping unused/forgotten/abandoned sites and "places without function" in urban landscapes. Landscape architecture has the potential to re-create such areas and provide them with a new, meaningful function. Prochnow and Čibik (2022) show, how a small design intervention in the form of a small wooden object of site furniture entitled "Rampolynā" has had a place-making effect in a part of the Milan Rastislav Štefánik Park in Partizánske (western Slovakia), which was used mainly as a passage, offering no quality for staying. The object, besides serving the most obvious function of sitting and staying is open for various interpretations by users. It has been developed within the 2019 volume of the [1:1] Workshop series,

which was implemented in a participatory planning and co-design process. The integration of the public, e.g., through local NGOs can be of added value. In the case of "Rampolynā", the cooperation with the local NGO Fabrika Umenia (meaning Art Factory) was of added value, as they can use the added element for organising and hosting events (Prochnow and Čibik, 2022).

Trees matter: trees as "construction material" of urban green infrastructure

The NGO ZIPS organises regular tree plantings with the citizens. For instance, it aims at preserving two 500-year-old lime trees and their genome by cloning them and replanting a hundred of their clones all over the municipality of Sesvete, especially in kindergartens, schoolyards, churchyards, public spaces, and other places. The certified seedlings will be delivered by the Croatian Forestry Institute (Spajić, 2022). Kameněčki et al. (2022a) found by a systematic inventory and analysis of existing vegetation, using the Visual Tree Assessment (VTA) method in the park in Stari Mikanovci in Croatia that existing vegetation, especially trees are not necessarily a limiting factor for the typology, diversity, disposition, and degree of intervention in the creative phase of the design process. As pointed out by Kušen et al. (2022), trees stand for elementary components of urban green infrastructure. For instance, in Zagreb's Lower Town, it is mainly row-planted trees and green spaces around building blocks, as well as schools. Kušen et al. (2022) focus on the potential ecosystem disservices delivered by green spaces, with a particular focus on toxic and allergenic species with a potentially hazardous effect, especially in schoolyards. They conducted field research in 7 primary school compounds and documented 34 herbaceous and geophytic species, 38 shrub species and 36 tree species. They found 35 poisonous and 28 allergenic plant taxa in green spaces surrounding primary schools, including *Hedera helix*, *Taxus baccata*, and *Ilex aquifolium*. Species with high pollen production such as *Betula pendula* or *Robinia pseudoacacia* represented only a low proportion in the species composition. They suggest that species should be chosen more carefully, avoiding species that are moderately and strongly allergenic or poisonous, however, this should not result in repeatedly planting just a few "safe" plant species, an effort should also be made to preserve and increase biodiversity in cities. Poisonous trees and shrubs should be surrounded by other plants that are not poisonous in a way (e.g., impenetrable hedges) that prevents contact with the children. Growing of poisonous annuals, biennials and perennials should be avoided. The authors conclude that children should be more informed about plant species, their value, and characteristics.

2 Conclusions

Green infrastructure planning and design takes place at various scales and in diverse landscape settings. It is a strategic concept that is well integrated in international, EU-wide, national, regional and local policies and concepts. It can be considered an effective tool to mitigate the negative impacts of climate change and in creating healthy and sustainable human environments. In urban landscapes, green infrastructure must be approached both from a more holistic perspective that covers the entire urban area, such as green belts, green grids, greenways and similar. At the local scale, it is important to deal with each green space element as a unique open space with its own values and qualities, while actively involving and engaging the public in participatory planning and co-design processes. Sometimes even small design interventions can significantly improve the open space quality of green infrastructure elements. While vegetation elements are normally of added value for green spaces, it is important also to consider their potential ecosystem disservices when selecting the tree species composition.

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