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Review

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 ambitions 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 m^2, including 24% of nature reserves. This means that the provision of urban population with public green spaces is almost 15 $m^2.person^{-1}$, which is above the existing Ukrainian standards, which require 10 $m^2.person^{-1}$. 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 "Rampolynå" 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 "Rampolynå" 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 "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).

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). Kamenečki 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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References

Bihuňová, M., Supuka, J., Tóth, A., Šinka, K., & Kuczman, G. (2021). Urban green areas and woody plant composition: Dwelling space quality factor in the Klokočina housing estate. *Ekologia Bratislava*, 40(1), 80–90. https://doi:10.2478/eko-2021-0010

Čibik, M., Back Prochnow, S., Stiles, R. & Štěpánková, R. (2020). Recognising Green Infrastructure as a Part of the Fourth Nature Concept Through University Campuses. *Acta Horticulturae et Regiotecturae*, 23(2) 71–75. https://doi.org/10.2478/ahr-2020-0015

European Commission (2013). Green Infrastructure (GI) – Enhancing Europe´s Natural Capital. Document no. 52013DC0249. COM/2013/0249 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0249

European Commission (2019). The European Green Deal. Document no. 52019DC0640. COM/2019/640 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN

European Commission (2020). EU Biodiversity Strategy for 2030: Bringing Nature back into our Lives. Document no. 52020DC0380. COM/2020/380 final. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0380&from=EN

European Commission (2021). Forging a climate-resilient Europe – the new EU Strategy on Adaptation to Climate Change. Document no. 52021DC0082. COM/2021/82 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

Fornal-Pienak, B., & Bihuňová, M. (2022). Evaluation of current landscape architecture approaches in chosen cities in Poland and Slovakia. *Acta Horticulturae et Regiotecturae*, 25(1), 28–36.

Gutmane, H. (2022). Mythologizing urban project: case of Barona Street in Riga. *Acta Horticulturae et Regiotecturae*, 25(1), 81–91.

Halajová, D. & Halaj, P. (2020). Green Infrastructure Implementation Programmes at National Level: Case Study "National Project – Support of Biodiversity with Green Infrastructure Elements in Municipalities of Slovakia". *Acta Horticulturae et Regiotecturae*, 23(2) 66–70. https://doi.org/10.2478/ahr-2020-0014

Kamenečki, M., Mudronja Pletenac A., Miholić, H., Tomić Reljić, D., Krstonošić, D. & Pereković, P. (2022a). Revitalization and landscape design of the park in Stari Mikanovci, Croatia; role of existing vegetation in generating new landscape solutions. *Acta Horticulturae et Regiotecturae*, 25(1), 68–75.

Kamenečki, M., Tomić Reljić, D., Bogovac, L., Šteko, V., Pereković, P. & Hrdalo, I. (2022b). Landscape values of the Island of Jakljan, Dubrovnik-Neretva County in Croatia. *Acta Horticulturae et Regiotecturae*, 25(1), 21–27.

Karadeniz, N., Şenoz Orsan, E., Akman Taskin, R. & Cetinkaya, Z. (2020). Re-Interpreting the Imrahor Valley (Ankara-Turkey) in Terms of Green Infrastructure Directing Urban and Rural Development. *Acta Horticulturae et Regiotecturae*, 23(2), 87–95. https://doi.org/10.2478/ahr-2020-0018

Kušen, M., Stura, L., Dubravka D. P., Poje, M., & Židovec, V. (2022). Toxic and allergenic plant species in primary school yards of Zagreb´s Lower Town district. *Acta Horticulturae et Regiotecturae*, 25(1), 99–106.

Maksymenko, N., Shpakivska, I., Burchenko, S., & Utkina, K. (2022). Green infrastructure in Lviv – example of park zones. *Acta Horticulturae et Regiotecturae*, 25(1), 37–43.

Marques, B., McIntosh, J., & Chanse, V. (2020). Improving community health and wellbeing through multi-functional green infrastructure in cities undergoing densification. *Acta Horticulturae et Regiotecturae*, 23(2), 101–107. https://doi.org/10.2478/ahr-2020-0020

Pochodyła, E., Jaszczak, A., Illes, J., Kristianova, K., & Joklova, V. (2022). analysis of green infrastructure and nature-based solutions in Warsaw – selected aspects for planning urban space. *Acta Horticulturae et Regiotecturae*, 25(1), 44–50.

Prochnow, S. B., & Čibik, M. (2022). Unconventional interventions on redeveloping unused urban landscapes based on social interactions. *Acta Horticulturae et Regiotecturae*, 25(1), 92–98.

Rózová, Z., Supuka, J., Klein, J., Jasenka, M., Tóth, A. & Štefl, L. (2020). Effect of Vegetation Structure on Urban Climate Mitigation. *Acta Horticulturae et Regiotecturae*, 23(2), 60–65. https://doi.org/10.2478/ahr-2020-0013

Ruda, M., & Boyko, T. (2020). Designing Protective Ecotones to Reduce Acoustic Load on the Railway Lines. *Acta Horticulturae et Regiotecturae*, 23(2) 81–86. https://doi.org/10.2478/ahr-2020-0017

Shchur, A., Lobikava, N., & Lobikava, V. (2020). Revitalization of (Post-) Soviet Neighbourhood with Nature-Based Solutions. *Acta Horticulturae et Regiotecturae*, 23(2), 76–80. https://doi.org/10.2478/ahr-2020-0016

Spajić, M. (2022). Green Infrastructure and planning procedures – experience of creating an unofficial network of green spaces as an NGO. *Acta Horticulturae et Regiotecturae*, 25(1), 76–80.

Tóth, A., & Feriancová, Ľ. (2013). Green Infrastructure in the Context of Rural Space Restoration and Design. *Nordic Journal of Architectural Research*, 25(2), 187–212. https://arkitekturforskning.net/na/article/view/471/419

Tóth, A., Halajová, D., & Halaj, P. (2015). *Green Infrastructure: A Strategic Tool for Climate Change Mitigation in Urban Environments*. In Ecology & Safety. pp. 132–138.

Tóth, A., Štěpánková, R., & Feriancová, Ľ. (2016). *Landscape Architecture and Green Infrastructure in the Slovak Countryside.* Prague: Powerprint, 102 p.

Tóth, A., & Timpe, A. (2017). Exploring urban agriculture as a component of multifunctional green infrastructure: Application of figure-ground plans as a spatial analysis tool. *Moravian Geographical Reports*, 25(3), 208–218. https://doi:10.1515/mgr-2017-0018

United Nations (2015). *Transforming Our World: the 2030 Agenda for Sustainable Development*. Department of Economic and Social Affairs. 35 p. United Nations. https://sdgs.un.org/2030agenda

Williams, F. (2022). evidence of paucity of residential green spaces from the normalized difference vegetation index (NDVI) in Metropolitan Lagos, Nigeria. *Acta Horticulturae et Regiotecturae*, 25(1), 51–59.

Williams, F., & Okedele, O. (2022). Non-adherence to the residential private open space to building footprint coverage regulations in Lagos State: a research evidenced need for introspection. *Acta Horticulturae et Regiotecturae*, 25(1), 60–67.

Yang, Y, Tian, G., Li, H., Ning, D., He, R., & Fekete, A. (2022). Comprehensive zoning scheme for vernacular landscapes of China. *Acta Horticulturae et Regiotecturae*, 25(1), 8–20.

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Research Article

Comprehensive zoning scheme for vernacular landscapes of China

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As China's rapid development has gradually expanded beyond urban areas, vernacular landscape as a significant expression of local conditions receives more and more attention. This paper aims to formulate a comprehensive zoning scheme for vernacular landscapes of China. The zoning applies zoning methods and technical means of the Geographic Information System. Based on the understanding of the vernacular landscape concept, the main factors that determine the feature of the vernacular landscape are identified, including landforms, climate, hydrology, vegetation, land use, settlements, housing, population, economy, and customs. Then, the indicators that can significantly reflect the characteristics of each factor are selected to construct an indicator system for comprehensive zoning. We combine quantitative and qualitative analysis to examine the spatial differentiation patterns of Chinese vernacular landscapes comprehensively. The prior zoning principle is a combination of the principles of relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape. Simultaneously, it considers the combination of the principles of synthesis and dominant factors, the combination of the principles of top-down and bottom-up, the combination of the principles of spatial integrity and continuity, and the principle of hierarchical zoning. Based on indicator evaluation and essential zoning basis, using overlay analysis and comparative analysis methods, the country is divided into two-grade spatial units of vernacular landscapes by two steps: 8 vernacular landscape regions and 56 vernacular landscape sub-regions. It provides theoretical support for protecting and developing vernacular landscape characteristics, and exerting regional advantages to achieve comprehensive development.

Keywords: spatial differentiation, zoning principles, indicator system, Chinese vernacular landscape regions, Chinese vernacular landscape sub-regions

1 Introduction

In recent years, with the implementation of a series of national macro strategies – such as the "Beautiful China" Construction, Regional Sustainable Development, and Rural Revitalization Strategy, China's rapid development has gradually expanded beyond urban areas. Vernacular landscape, as a significant expression of local conditions, receives more and more attention. In addition, it is necessary to identify landscape patterns from a regional and integrated perspective in response to the current national spatial planning.

Geographical zoning or classification is the division of geographical entities based on properties or relationships (Chorley & Haggett, 1967; Johnston, 1968). Synthesis is the basis for the existence of geography and the fundamental way to understand the geographical environment dialectically (Zheng et al., 2005). Besides, comprehensive geographical zoning is compatible with the requirements of socio-economic development. Hence, since the 1990s, in the face of rapid changes in the ecological environment and socio-economic situation, some Chinese scholars have realized the importance of zoning integrating natural and social aspects and have conducted many comprehensive geographical zoning practices, such as the land use zoning scheme of China (Feng, 2001), the comprehensive regionalization of human geography in China (Fang et al., 2017), and the zoning by rural regional system types (Liu, Zhou & Li, 2019b), etc. However, there are only a few comprehensive zoning studies involving cultural features, which may be due to the diversity and complexity of the culture itself.

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So far, most landscape zoning has been carried out from the perspective of landscape ecology based on the theory of landscape heterogeneity (Center, 2008; Fu et al., 2001; Liu et al., 2019a; Long, Nelson & Wulder, 2010). These studies emphasize the spatial differentiation of natural spaces, ecological processes, and landscape functions (Li et al., 2006b) without considering the landscape's socio-cultural attributes. In short, there is still a lack of landscape regionalization studies that integrate natural and human factors, especially vernacular landscapes.

This paper aims to formulate a comprehensive zoning scheme for vernacular landscapes of China, seeking a comprehensive understanding of differentiation patterns of Chinese vernacular landscapes. The research focuses on three main aspects: the stability and differentiation of the natural geographical environment, the inheritance and characteristics of the socio-cultural background, and the combination of the principles of the relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape. Our findings will provide a scientific basis for the development of Chinese vernacular landscapes regarding preserving local styles, inheriting cultural traditions, and protecting the ecological environment.

1.1 Literature review

According to Kwa (2005), the word "landscape" can be traced back to Dutch as a loan word into the English language along with a fair amount of landscape paintings imported from Holland and Flanders, referring to rural settlements with the administrative implication (Ogden, 1955). However, the meaning of the word "landscape" evolved to describe a pictorial representation by the end of the sixteenth century, firstly as the background of a historic piece, then as an independent genre. Since then, "landschap" is an expression representing the land, mostly as inhabited by humans (Fechner, 1986). The roots of "landscape" in Anglophone geographic practice are to be found in the German concept of "landschaft", which means the sense of visual aesthetics, emphasizing people's perception and cognition of natural scenery, without clear space boundaries (Cosgrove, 2004). Humboldt developed the concept of "landscape", transforming it from an aesthetic category into an abstract entity representing the overall characteristics of certain land on the earth (Humboldt, 1969; Pagden, 1993). From a geographic perspective, Schmithüsen (1973) believes that landscape is relative unity, stepwise integrated local systems of factors comprising all realms of nature. Thus, from natural sciences to human sciences, different disciplines have different understandings of landscape (Hersperger et al., 2020). Today, the common understanding of "landscape" is consistent with the definition in the European Landscape Convention (2000): "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors." The landscape represents the imprint of complex physical geographical processes and human historical activities on the earth (Li, 2007). Therefore, the concept of "landscape" can be used to draw connections among people, between people and places, and between societies and their environment (Bloemers et al., 2010).

Jackson earlier applied "vernacular" to landscapes generated by everyday praxes, which are dedicated to stability and history, and elaborated on "vernacular landscape" as a basic form of cultural landscape (Jackson, 1984). Linking the attribute "cultural" to landscape underlines the holistic view of landscapes: humans interact with landscapes in dynamic processes (Naveh, 1995). Vernacular landscape refers to "the adaptation method adopted by local people to the natural process, the land, the spatial patterns for life; the manifestation of the life way of the people here and now on the earth; a regional complex including the land, towns, settlements, dwellings, temples, etc. on the land; a whole system including nature, history, and culture" (Yu, Wang & Huang, 2005). Vernacular landscape reflects the physical geography and humanistic features of a particular area and the interface between time and space, nature and culture, tangible and intangible assets.

1.2 Theoretical framework

The vernacular landscape includes not only the landscape formed by natural processes but also the landscape formed by the transformation of nature by human activities during history, as well as the unique local cultural assets. Therefore, from the comprehensive perspective of the overall characteristics, vernacular landscape is a unity constituted by natural conditions and human production and lifestyle in a particular area.

Natural constituents of the vernacular landscape

The natural environmental factors significantly influence and characterize vernacular landscapes, mainly manifested in tangible landscapes. Out of them, landforms are the critical basis, reflecting the characteristics and boundaries of the regional environment, and the general topography is the main factor constituting the landscape. Climate is a prerequisite for the formation of vernacular landscapes, which provides natural nutrients and energy and is critical for landscape expression. Surface hydrological processes play a significant role in the development of spatial patterns and the appearance of vernacular landscapes. Vegetation is an indispensable part of the natural ecosystem, and it is also an essential

factor that best reflects the degree of human transformation to nature. Diverse vegetation is an important and distinctive factor of vernacular landscapes (Li & Guo, 2015). In summary, the landforms, climate, hydrology, and vegetation are the main factors of the geographical patterns and the vernacular landscape ecosystem.

Human constituents of the vernacular landscape

Throughout history, the human impact on nature has also played a dominant role in developing vernacular landscape. Vernacular landscape includes not only the tangible but also the intangible human heritage. Altogether they provide vernacular landscape a unique appearance. The tangible landscape is characterized by various factors at different spatial levels, including macro, meso, and micro levels. Land use determines the overall image of the vernacular landscape, embodying the law of land evolution, the process of resource utilization, and the way of interaction between man and nature at a macro level. The distribution of villages is a vital characteristic of the vernacular landscape, reflecting the settlement status of diverse concentrations based on geographical conditions at a meso level. The housing style is the fundamental physical representation of vernacular landscapes, reflecting the common humanistic characteristics of a particular area at a micro level. Out of the intangible landscape, the population, that is, the man has always been the base for the formation and existence of vernacular landscapes. The economy is the thing that human beings are engaged in daily life to meet the needs of human society; therefore, it is an essential aspect of vernacular landscape. The traditional custom is the matter formed by historical memory and cultural awareness of local areas and is the spirit of the vernacular landscape. Popular local customs have a robust humanistic colour, rich content, and strong influence, which can be regarded as a critical feature of vernacular landscape (Liu, 2013). In summary, land use, settlements, housing, population, economy, and customs are the main human factors of the vernacular landscape. They reflect the human-landscape relationship in the vernacular landscape and are relatively stable landscape factors (Fig. 1).

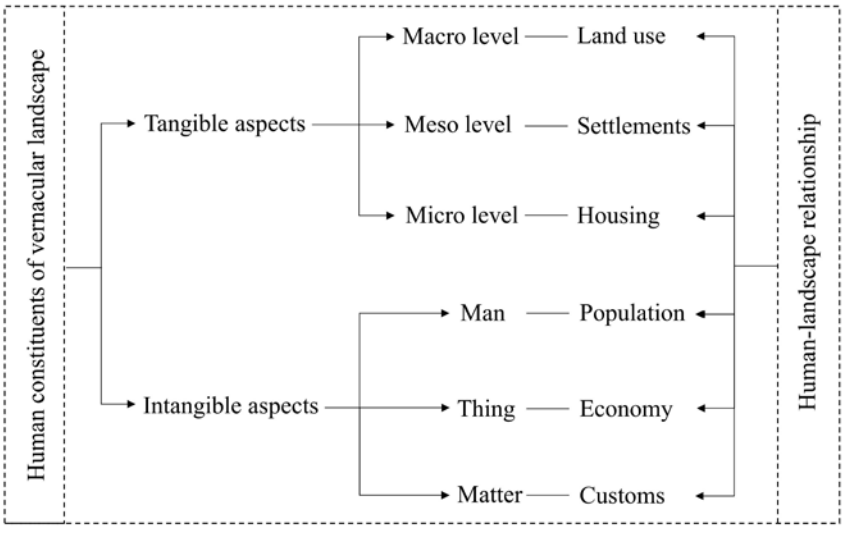


Figure 1 The relationship of the human factors constituting vernacular landscape

Spatial differentiation of the vernacular landscape

The natural environment itself is diverse, and it is also the basis of the diversity of human cultures. The two together form different landscape patterns, leading to an apparent disparity between various areas so that vernacular landscapes show distinctive local characteristics. To clearly and fully understand the differentiation law of vernacular landscapes, it is necessary to introduce the concept of region, that is, to designate spatial units of vernacular landscapes. In this study, the concept of "vernacular landscape region" emphasizes the relativity of the zoning results while highlighting the consistency of the regional natural and human conditions.

2 Material and methods

2.1 Indicator system of Chinese vernacular landscapes

The indicator system is the basis and core of geographical zoning. Based on the research focus, the regionally comparable and easy-to-operate indicators should be selected to construct an effective indicator system to ensure the scientificity, integrity, and non-overlapping of geographical zoning. According to the main factors of natural constituents and human constituents of vernacular landscape, we select the indicators that can significantly reflect the characteristics of each factor to build the indicator system for comprehensive zoning of Chinese vernacular landscape (Table 1).

Among them, the indicator data of natural factors of vernacular landscape comes from the Resource and Environmental Science Data Center of the Chinese Academy of Sciences (http://www.resdc.cn/) and the National Geomatics Center of China (http://www.ngcc.cn/). The data on the ratio of the non-aging population (under 65 years

Table 1 Indicator system for comprehensive zoning of Chinese vernacular landscapes

Level	Factor	Indicator	Basis
Natural constituents of vernacular landscape	landforms	altitude (m)	– landforms greatly contribute to the spatial differentiation of the natural environment (Cheng et al., 2019). Areas with different landforms show distinct landscape patterns and appearances. The altitude is an intuitive sign of the macro-morphological characteristics of landscapes
	climate	average temperature (°C), average rainfall (mm)	– climate is related to most natural processes, which is crucial for the evolution of landscapes. Besides, the climate phenomenon itself can be taken as a kind of vernacular landscape. Average temperature and rainfall conditions can reveal the differentiation law of natural zones (Zheng & Fu, 1999)
	hydrology	river density ($km.km^{-2}$)	– hydrology is a fundamental element that affects the settlement environment. As one of the essential indicators of the characteristics of the watershed structure (Huang, Xu & Chen, 2001), river network density matters in the regional differences of vernacular landscapes
	vegetation	net primary productivity ($g.C.m^{-2}$)	– vegetation is considered a great indicator of regional natural differentiation, and therefore a necessary feature to identify landscapes. As a critical parameter of the vegetation ecosystem, the average net primary productivity can reflect the overall spatial distribution of vegetation (Piao, Fang & Guo, 2001)
Human constituents of vernacular landscape	land use	land use type	– land use or land cover change is the most closely intersected issue between natural and human processes in global environmental changes (Li, 1996). Under the constraints of specific physical geography, social economy, and human history, diverse types of land use areas have been formed (Feng et al., 2010)
	settlements	administrative village density (per ten thousand km^2)	– settlement distribution is a record of long-term adaptation and interaction between man and land and thus an essential part of vernacular landscape. Administrative village density embodies multiple connections between residents and the environment among regions
	housing	traditional dwelling type	– housing is a fundamental symbol of vernacular landscape and is regarded as its most direct identifying factor. Under the joint effect of natural geographical environment and the socio-cultural background, various traditional Chinese dwellings reveal prominent vernacular characteristics (Sha, 1998)
	population	ratio of non-aging population (under 65 years old) (%)	– population distribution has influenced the formation and existence of diverse vernacular landscapes in the long run. Due to the imbalance of regional resource conditions and social economy, the ratio of non-aging population varies across the country
	economy	ratio of agricultural industry structure (%)	– economy is an essential field constituting human activities as well as vernacular landscape. Agriculture represents the broadest human landscape formed by the interaction between the natural environment and local agricultural production, and hence the ratio of agricultural industry structure changes from region to region
	customs	minority population ratio (%), religious population ratio (%), dialect diversity index	– customs are an indispensable aspect of social life and a critical symbol of human culture (Liao, 2006). Among them, ethnic attributes, religious consciousness, and language traditions are typical representatives, bringing unique and diverse perceptions of vernacular landscapes regionally

old) and minority population ratio is derived from the 2010 National Census (http://www.stats.gov.cn/tjsj/pcsj/rkpc/6rp/indexch.htm). The data on the ratio of agricultural industry structure is taken from the 2017 China County Statistical Yearbook and statistical yearbooks of provinces, municipalities, and autonomous regions. And the data on religious population ratio comes from the 2012 Chinese Family Panel Studies (CFPS) carried out by the Institute of Social Science Survey. Besides, the dialect diversity index, land use type, and traditional dwelling type are learned from experts' research results (Kang, 2019; Peng & Wang, 2006; Xu et al., 2015). The zoning adopts China's counties and merged municipal districts officially designated in 2010 (not including Taiwan Province) as the research units. Moreover, 1 : 4 million basic Chinese geographic information data is used for spatial administrative boundary vectors.

2.2 Principles of comprehensive zoning for Chinese vernacular landscapes

The zoning principle is the primary basis for selecting zoning indicators, formulating zoning methods, and establishing the zoning system, which is also part of the core issues of zoning (Ren & Bao, 1992). The formulation of reasonable zoning principles for vernacular landscapes is a prerequisite to ensure that the zoning process can objectively and truly reflect its differentiation law. Based on the characteristics and zoning objectives set for Chinese vernacular landscapes, the following five principles are determined.

(1) Combination of the principles of relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape: The zoning process considers the spatial similarity of natural constituents of vernacular landscape. The areas with apparent consistency of natural constituents are classified as one type of unit. Simultaneously, we consider areas with similar human constituents of vernacular landscape and classify relatively consistent areas as one type of unit. The two types of various spatial unit layers are then superposed and compared to comprehensively regionalize vernacular landscape based on a combination of relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape.

(2) Combination of the principles of synthesis and dominant factors: Synthesis analysis emphasizes the careful consideration of factors affecting the vernacular landscape. According to the concept of vernacular landscape, it is necessary to combine the natural and human factors of vernacular landscape and comprehensively analyse their interrelationship and combination structure to objectively and accurately reflect the spatial differentiation law of vernacular landscape. However, when faced with the discontinuous and fragmented areas during the zoning process, the factors that dominate spatial differentiation can be selected as the zoning basis to determine the spatial division. Such factors often control and reflect the basic appearance and characteristics of vernacular landscape in a particular area and play a dominant role compared with other factors.

(3) Combination of the principles of top-down and bottom-up: The top-down deductive approach is usually used to divide the higher-grade spatial units, while the bottom-up inductive approach is often applied in dividing the lower-grade spatial units (Zheng & Fu, 1999). The former refers to from the whole to the part, dividing higher-grade spatial units into lower-grade spatial units according to the law of spatial differentiation. The latter means from part to the whole, merging the lower-grade spatial units into higher-grade spatial units according to the law of spatial combination. This study combines top-down and bottom-up zoning approaches. The top-down approach is used for the higher-grade spatial unit division to understand and distinguish areas at a macro level, and the bottom-up approach is used for the lower-grade spatial unit division to identify specific zoning boundaries.

(4) Combination of the principles of spatial integrity and continuity: Given that Chinese vernacular landscapes have apparent spatial differentiation and diversity, comprehensive zoning should ensure relatively independent regions of vernacular landscapes while maintaining spatial integrity and continuity. Combined with the spatial scale and division basis of each zoning grade, necessary areas are merged or separated to avoid excessive fragmentation of zoning units. Overall, zoning units of vernacular landscapes at all grades should be complete and continuous throughout the national geographical space, neither omission nor overlap.

(5) Principle of hierarchical zoning: Zoning by step is popular in comprehensive zoning. Depending on the importance of influencing factors of the research object, different grades of zoning basis are determined in sequence to carry out zoning by step. Since the similarities and differences of vernacular landscape types and spaces are always relative at different scales, hierarchical zoning can ensure the scientificity and rationality of the division result. Simultaneously, for ease of application and limited data, the paper adopts a two-grade zoning system to divide the country into several vernacular landscape regions, and then every region breaks down into multiple sub-regions. From regions to sub-regions, the scale of vernacular landscape units ranges from large to small, the richness of vernacular landscapes usually ranges from multiple to single, and the similarities within vernacular landscape units vary from unobvious to obvious.

2.3 Methods of comprehensive zoning for Chinese vernacular landscapes

With the technical support of GIS (Geographic Information System), this paper mainly draws on four analysis methods related to geography.

(1) Geometric mean method: For the vernacular landscape factors with compound indicators, the n-th power method is used to comprehensively consider the impact of each indicator. Then, we evaluate the vernacular landscape factors by grading the obtained vernacular landscape factor indexes.

$$SS_j = \sqrt[n]{\prod_i^n C_i} \quad (1)$$

where: SS_j – the vernacular landscape factor index of the spatial unit; C_i – the grade value of indicator i classified according to the relative size of its attribute value

(2) Overlay analysis method: The overlay analysis refers to a zoning method that overlays and merges multiple feature layers that affect spatial differentiation to generate a new layer containing the analysis of previous feature layers (Liu, 2008). In this research, all factor layers are first loaded into the GIS to unify the spatial scale. Then, depending on the type of factors, quantitative overlap calculation or qualitative overlap judgment is applied to classify the areas.

(3) Spatial clustering method: Spatial clustering is an important part of spatial data mining, which clusters or classifies entities based on their characteristics (Li, Wang & Li, 2006a). This research uses the GIS grouping analysis method to perform spatial clustering analysis on the administrative village density and overlay index of quantified human factors of vernacular landscape in order to divide their values into distinct groups.

(4) Comparative analysis method: The zoning result is usually affected by personal identification reasons. Therefore, vernacular landscape comprehensive zoning should seriously learn from experts' experience. Through careful comparison and synthesis with existing relevant research results such as rural regional system type zoning, appropriate and reasonable manual corrections are made to avoid excessive fragmentation and potential division errors. In this way, the optimization of the zoning scheme can be realized, and it is also conducive to the formation of a joint planning implementation mechanism in the future.

2.4 Evaluation of Chinese vernacular landscapes

The research framework of comprehensive zoning for vernacular landscapes of China is shown in Fig. 2. We use indicator data to evaluate every natural and human factor of vernacular landscape through GIS technology in order to clarify their spatial distribution. There are two evaluation approaches depending on the types of evaluation factors. For quantified factors, we analyse factor's attribute value based on the corresponding indicator attributes. And according to the relative size of attribute value and previous grading evaluation

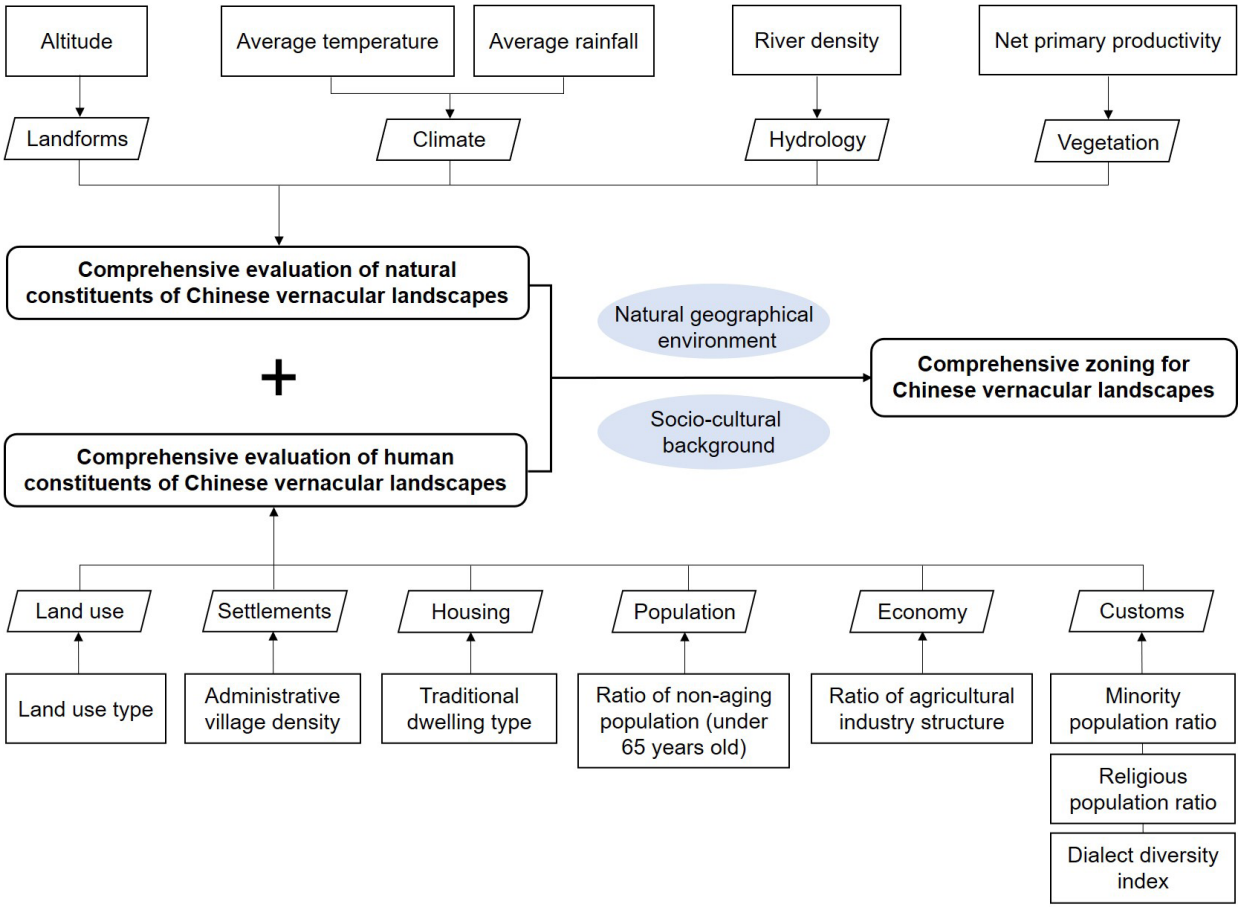
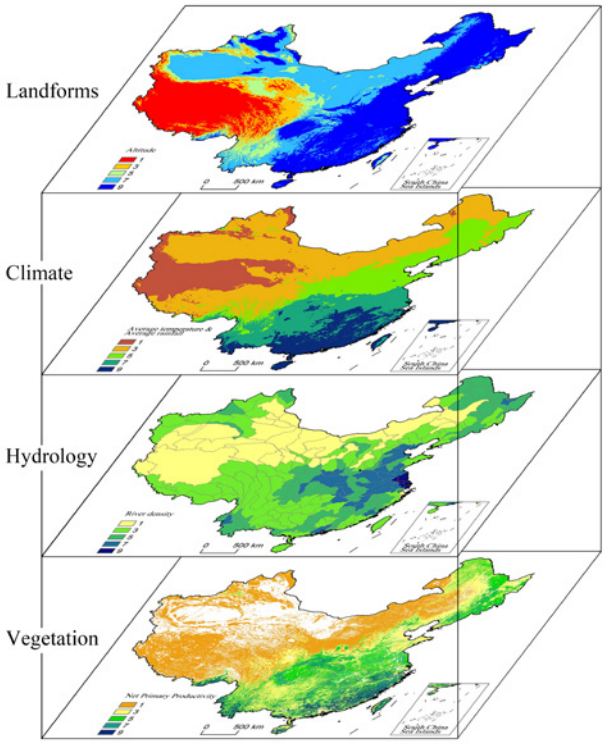


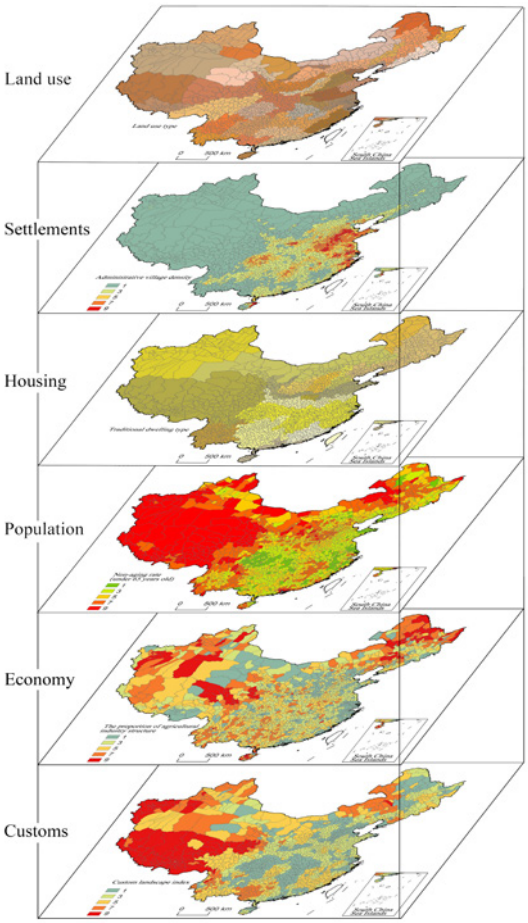
Figure 2 Research framework of comprehensive zoning for vernacular landscapes of China

experience, each factor is classified into five different grades: very small, small, medium, large, very large, and the corresponding assignments are 1, 3, 5, 7, 9. For qualitative factors (land use and housing), combining the characteristics and distribution of the factors, we draw on the experience of relevant zoning studies to clarify various types of regions (Fig. 3a, Fig. 3b).

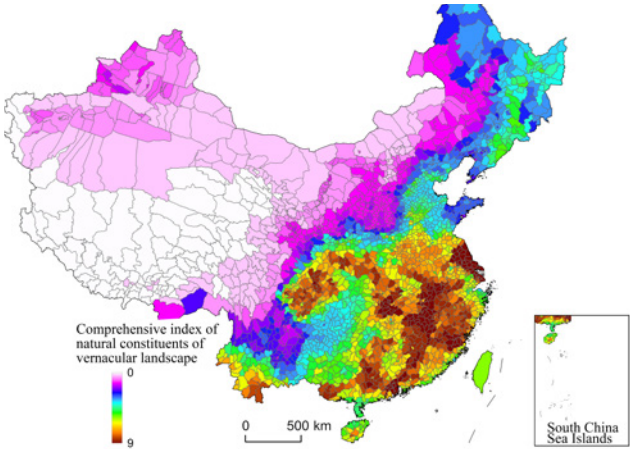
(1) For the natural constituents of vernacular landscape, we comprehensively evaluate it by integrating the grade distribution of landforms, climate, hydrology, and vegetation. With the support of the GIS spatial analysis, the method of the quantitative overlay of equal weight and then averaging is used to calculate the comprehensive index of natural constituents of



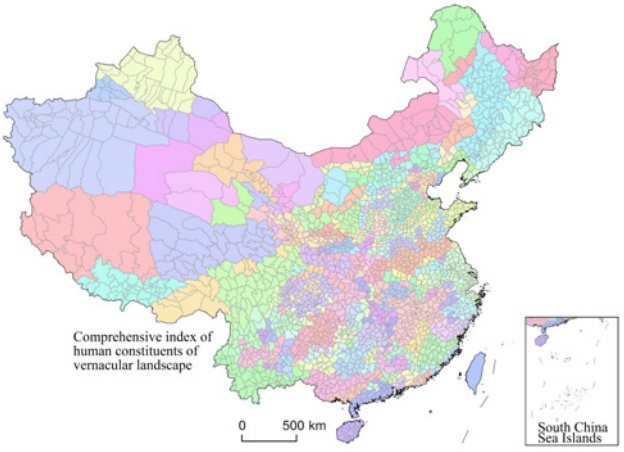
a) Overlay analysis of factors of natural constituents of Chinese vernacular landscape



b) Overlay analysis of factors of human constituents of Chinese vernacular landscape



c) Comprehensive evaluation of natural constituents of Chinese vernacular landscape



d) Comprehensive evaluation of human constituents of Chinese vernacular landscape

Figure 3 Evaluation of comprehensive zoning for vernacular landscapes of China

vernacular landscape in each spatial grid (1,000 × 1,000 m), and then spatially average it to the county-level administrative units. According to the classification of Jenks natural breaks, a comprehensive evaluation map of natural constituents of vernacular landscape is generated (Fig. 3c). It can be seen from the figure that the natural constituents of vernacular landscape are roughly divided by the Hu Huanyong Line, with significant differences between the east and the west. This is consistent with the natural differentiation law between southeast and northwest China and illustrates the rationality and representativeness of the evaluation of natural constituents of the vernacular landscape.

(2) For the human constituents of vernacular landscape, we comprehensively evaluate it by integrating the grade or type distribution of land use, settlements, housing, population, economy, and customs. Since human constituents of vernacular landscape contain quantitative and qualitative indicators, factor evaluation is relatively complicated to quantify uniformly. Therefore, with the support of GIS spatial analysis, the qualitative overlay method is adopted to obtain the regional types of human constituents of vernacular landscape of the county-level administrative units. According to the area of various regional types, combined with data review, map interpretation, and expert judgments, a comprehensive analysis is carried out. The secondary types of areas are classified into the main types of areas based on priority of impact. With reference to certain provincial and municipal administrative boundaries, a comprehensive evaluation map of human constituents of vernacular landscape is generated (Fig. 3d). As can be seen from the figure, there are many types of vernacular landscapes, and most of them are clustered in regions. This is consistent with the characteristic that human constituents of vernacular landscape vary from area to area, and provides a sufficient basis for the detailed zoning of vernacular landscapes.

3 Results

3.1 Strategies for zoning lines in the comprehensive zoning process

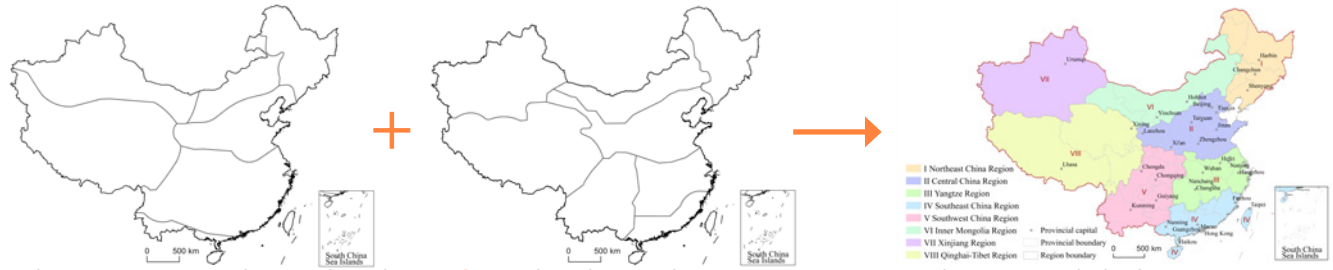
One of the difficulties that have always existed in zoning work is to clarify the boundaries of zoning units (Zhao, Chen & Niu, 1979). This is especially true for the comprehensive zoning of vernacular landscapes. Firstly, because vernacular landscapes are unevenly distributed and transitional, and ambiguous, there is no apparent measurable gradient in space. Secondly, because the spatial boundary is a continuity of points from quantitative change to qualitative change, the boundary is a space where similarities and differences coexist on both sides. Thirdly, the landscape itself mostly depends on intuitive feelings, and border areas are usually more affected by cultural fusion, so the boundaries of vernacular landscapes are blurred.

However, the zoning work requires a clear division without repetition or omission. Therefore, by referencing existing relevant zoning research, such as human geography zoning, rural regional system types, traditional settlement zoning, etc., the basic boundaries of vernacular landscape regions are determined according to the major characteristics and general scope identification of vernacular landscapes. Also, since the division of administrative units is based on various natural geographical environments and socio-cultural backgrounds, it is consistent with the division of vernacular landscape regions. Therefore, this zoning tries to maintain the integrity of provincial and municipal administrative units, which can be of great significance to regional development and management.

3.2 Generating Chinese vernacular landscape regions

First-grade zoning of vernacular landscapes, the division of vernacular landscape regions, is based on the natural geographical environment and socio-cultural background (Western Australian Planning Commission, 2016). It is an effective way to reasonably absorb relevant research results in the study. Hence, the natural geographical environment mainly refers to the 7 natural zones of Zhao Songqiao's comprehensive physical zoning (Zhao, 1983) (Fig. 4a), which are primarily divided according to the combination of temperature and moisture conditions. Each natural zone has consistent climate characteristics, and vegetation, soil, and other landscapes also show some commonalities. The socio-cultural location mainly refers to 8 cultural zones of Wu Bihu's Chinese cultural zoning (Wu, 1996) (Fig. 4b), which are primarily divided based on three significant aspects related to the formation of Chinese cultural zones, including geographic environment, historical development, and relative location, and secondly combined with public fuzzy sensing and recognition of cultural zones. Therefore, according to the general differentiation trend of vernacular landscapes dominated by the natural geographical environment and the socio-cultural background, the country is divided into 8 vernacular landscape regions from top to down using the overlay method of qualitative analysis (the detailed boundary of vernacular landscape regions is clearly defined in conjunction with vernacular landscape sub-regions) (Fig. 4c).

We group and summarize vernacular landscape regions according to 3 natural zones – the eastern zone,



a) Zhao Songqiao's comprehensive physical zoning (Zhao, 1983)

b) Wu Bihu's Chinese culture zoning (Wu, 1996)

c) Chinese vernacular landscape regions

Figure 4 First-grade zoning process of Chinese vernacular landscapes

the north-western zone, and the Qinghai-Tibet zone of Zhao Songqiao's comprehensive physical zoning (Zhao, 1983). The boundary between the eastern zone and the north-western zone is roughly the same as the Greater Khingan Range and the Great Wall of the Ming Dynasty; the boundary between the north-western zone and the Qinghai-Tibet zone is Kunlun Mountain-Altun Mountain-Qilian Mountain, which is also the administrative boundary between Tibet Autonomous Region and Qinghai Province; and the boundary between the eastern zone and Qinghai-Tibet zone is the eastern edge of the Qinghai-Tibet Plateau. Among them, the boundary between the east (the eastern zone) and the west (the north-western zone and the Qinghai-Tibet zone) is a critical geographic boundary across China, which roughly coincides with the 400 mm precipitation line, physical geographic zone boundary, Hu Huanyong line, agroclimatic zone boundary, and population and economic zone boundary.

(1) In the eastern zone, five vernacular landscape regions are divided according to geographical zones and cultural zones, namely Northeast China Region (I), Central China Region (II), Yangtze Region (III), Southeast China Region (IV), and Southwest China Region (V). Among them, Central China Region (II) is bounded by the border of the warm temperate zone and middle temperate zone (near the Ming Great Wall) in the north, next to Northeast China Region (I); it is bounded by the Qinling-Huaihe line in the south, adjacent to Yangtze Region (III) and Southeast China Region (IV). Qinling-Huaihe line is a crucial geographic boundary across China, reflecting the comprehensive differentiation of nature and culture between China's north and south. Southeast China Region (IV) and Yangtze Region (III) are roughly bounded by the boundaries of Guangxi and Fujian administrative units and Nanling belt. And Southeast China Region (IV) contains southern parts of Jiangxi province and a small part of Hunan province. The east boundary of Southwest China Region (V) roughly extends from north to south along the administrative boundaries of Hunan province. And southwest China Region (V) also includes west of Hubei province and northwest of Guangxi province.

(2) In the north-western zone, according to the differences in vegetation, landforms, and ethnic-cultural characteristics, two vernacular landscape regions are divided, taking the boundaries of Xinjiang and Gansu administrative units, namely Inner Mongolia Region (VI) and Xinjiang Region (VII).

(3) In the Qinghai-Tibet zone, according to the special plateau conditions and religious, cultural background, it should be an independent and complete vernacular landscape region, namely Qinghai-Tibet Region (VIII).

3.3 Generating Chinese vernacular landscape sub-regions

Second-grade zoning of vernacular landscapes, the division of vernacular landscape sub-regions, comprehensively considers 10 major vernacular landscape factors, landforms, climate, hydrology, vegetation, land use, settlements, housing, population, economy, and customs. It is mainly based on a combination of the principles of relative consistency of natural constituents of vernacular landscape and relative consistency of human constituents of vernacular landscape to superimpose the comprehensive evaluation of natural constituents of vernacular landscape (Fig. 5a) with the comprehensive evaluation of human constituents of vernacular landscape (Fig. 5b). In addition to the first-grade zoning of vernacular landscapes, the zonings of human geography (Fig. 5c) (Fang et al., 2017), rural regional system types (Fig. 5d) (Liu, Zhou & Li, 2019b), and traditional settlements (Fig. 5e) (Liu et al., 2010) are also used as auxiliary references. Simultaneously, combined with certain provincial and municipal administrative boundaries, 56 vernacular landscape sub-regions are finally divided through complete analysis and comparison (Fig. 6, Table 2).

The methodology used in the zoning process and the definition of vernacular landscape regions in China follows

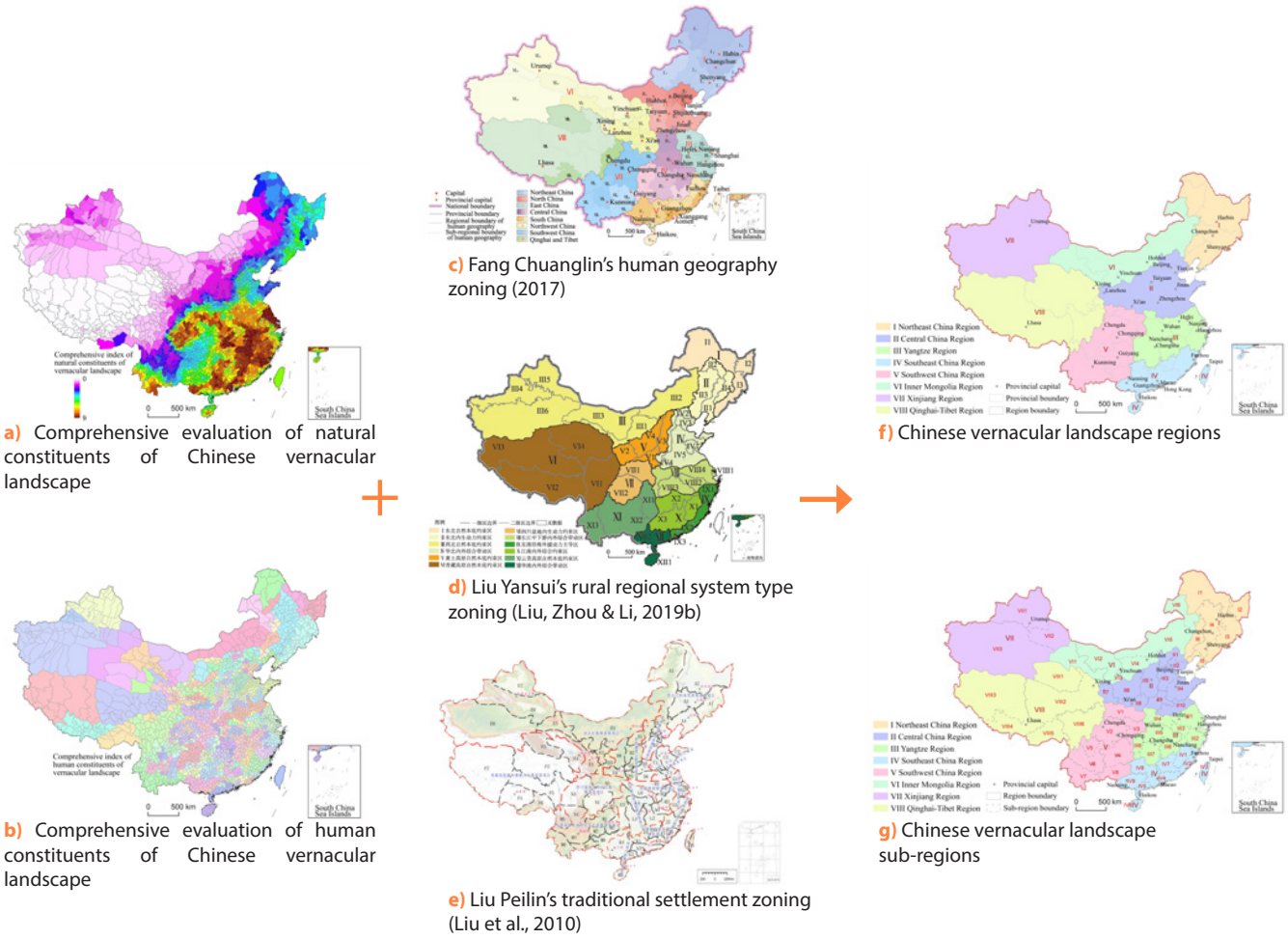


Figure 5 Second-grade zoning process of Chinese vernacular landscapes

Figure 6 Comprehensive zoning scheme for vernacular landscapes of China

the methods and scenarios used at international level. Some examples, case studies and strategies from different European countries (UK, North-Europe, the Mediterranean) and from Middle East shows that the general structure and basic idea in the reservation of vernacular landscapes are everywhere a common basis. The differences are mainly generated by the local natural and cultural conditions and dimensions (Birnbaum, 1994; Saleh, 1998; Palmer & Thérond, 2008; Kingston, 2009; Mitchell, Rössler & Tricaud, 2009; Bourgeau & Vivas, 2018; Altaba Tena & García-Esparza, 2018).

Table 2 Chinese vernacular landscape regions and sub-regions

Coding and naming of vernacular landscape regions	Coding and naming of vernacular landscape sub-regions	Number of sub-regions
Northeast China Region (I)	Greater and Lesser Khingan Range Sub-region (I1), Sanjiang Plain Sub-region (I2), Changbai Mountain Sub-region (I3), Songnen Plain Sub-region (I4), Southern Liaoning Sub-region (I5), West Liao River Basin Sub-region (I6)	6
Central China Region (II)	Northern Hebei Sub-region (II1), Beijing-Tianjin-Tangshan Sub-region (II2), Southern Hebei Sub-region (II3), Shandong Sub-region (II4), Shanxi Loess Plateau Sub-region (II5), Shaanxi-Gansu Loess Plateau Sub-region (II6), Central Gansu Sub-region (II7), Guanzhong Plain Sub-region (II8), Northern Henan Sub-region (II9), Huanghuai Plain Sub-region (II10)	10
Yangtze Region (III)	Lower Yangtze Plain Sub-region (III1), Southern Zhejiang Sub-region (III2), Southern Anhui and Northeastern Jiangxi Sub-region (III3), Hubei-Henan Mountain Sub-region (III4), Hubei-Hunan-Jiangxi Sub-region (III5), Central Jiangxi Sub-region (III6), Central and Southern Hunan Sub-region (III7), Western Hunan Sub-region (III8)	8
Southeast China Region (IV)	Mount Wuyi Sub-region (IV1), Fujian Shore Sub-region (IV2), Taiwan Island Sub-region (IV3), Pearl River Delta Sub-region (IV4), Southwest Guangdong Sub-region (IV5), Hainan Island Sub-region (IV6), Guangdong-Jiangxi-Hunan Hakka Sub-region (IV7), Nanling Sub-region (IV8), Beibu Gulf Sub-region (IV9)	9
Southwest China Region (V)	Qinba Mountain Sub-region (V1), Bashu Basin Sub-region (V2), Western Hubei and Eastern Chongqing Mountain Sub-region (V3), Guizhou Plateau Sub-region (V4), Southwest Sichuan Sub-region (V5), Yunnan Plateau Sub-region (V6), Southwest Yunnan Sub-region (V7), Southeast Yunnan and Northwest Guangxi (V8)	8
Inner Mongolia Region (VI)	Hexi Corridor Sub-region (VI1), Alxa Plateau Sub-region (VI2), Ningxia Plain Sub-region (VI3), Ordos Plateau Sub-region (VI4), Inner Mongolia Northern Plateau Sub-region (VI5), Inner Mongolia Eastern Prairie Sub-region (VI6)	6
Xinjiang Region (VII)	Northern Xinjiang Sub-region (VII1), Tuha Basin Sub-region (VII2), Southern Xinjiang Sub-region (VII3)	3
Qinghai-Tibet Region (VIII)	Hercynian Basin Sub-region (VIII1), Qinghai Plateau Sub-region (VIII2), Western Tibet Sub-region (VIII3), Southwest Tibet Sub-region (VIII4), Southern Tibet Sub-region (VIII5), Western Sichuan Sub-region (VIII6)	6

4 Conclusions

To clarify and distinguish the distribution law and spatial differences of vernacular landscapes, we divide the country into two grades of vernacular landscape spatial units: 8 vernacular landscape regions and 56 vernacular landscape sub-regions. The units are relatively independent and interconnected, and each unit can highlight the typical characteristics of the vernacular landscape in a specific area. Three critical outcomes are obtained in this study, which have both theoretical and practical implications.

1. It argues that vernacular landscape refers to an inseparable complex formed by the interaction between natural constituents and human constituents of vernacular landscape. In this study, while comprehensively considering the similarities and differences of both natural constituents and human constituents of vernacular landscape in different areas, the dominant role of the natural geographical environment and socio-cultural background in influencing the formation of various vernacular landscapes is highlighted, which conforms to the essence of the vernacular landscape.
2. It proposes an indicator system for vernacular landscape comprehensive zoning, which contains the factors of both tangible and intangible vernacular landscapes. We choose two levels of characterizing factors from both natural constituents of vernacular landscape and human constituents of vernacular landscape. Then the indicators greatly reflecting the characteristics of each factor can be determined separately.
3. It provides an approach that integrates quantitative and qualitative analysis with the support of a set of particular principles to evaluate vernacular landscapes. The comprehensive zoning scheme was finally obtained based on indicator evaluation, essential zoning basis, overlay analysis, and comparative analysis methods.

This study reveals a systematic regionalization based on the overall spatial differentiation law of natural constituents and human constituents of vernacular

landscape, which avoids using single and typical rural landscape cases to summarize the entire vernacular landscapes throughout the region. Also, with reference to worldwide experience, the zoning procedure can be seen as a useful tool for formulating corresponding development and planning strategies (Xie, Li & He, 2020; Silva & Acheampong, 2015). And as the focus of landscape research, protected landscapes can be studied deeply on our basis to resolve management conflicts (Hasti et al., 2016; Havrylenko, Shyshchenko & Tsyhanok, 2020). However, due to the limitations of existing data and technical methods, it has not yet been possible to realize dynamic vernacular landscape comprehensive zoning. It is necessary to further improve the zoning means to optimize the vernacular landscape zoning scheme in a timely, accurate, and efficient manner.

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References

Altaba Tena, P., & García-Esparza, J. A. (2018). The heritagization of a mediterranean vernacular mountain landscape: concepts, problems and processes. *Heritage & Society*, 11(3), 189–210. https://doi.org/https://doi.org/10.1080/2159032X.2019.1670533

Birnbaum, C. A. (1994). Protecting cultural landscapes: Planning, treatment and management of historic landscapes. National Park Service.

Bloemers, T., Daniels, S., Fairclough, G., Pedroli, B., & Stiles, R. (2010). *Landscape in a changing world: bridging divides, integrating disciplines, serving society* (No. 41). European Science Foundation ESF-COST.

Bourgeau, F., & Vivas, J. G. (2018). Vernacular landscapes, toward a conceptual and contextual definition. Annual Symposium of Architectural Research in Finland: Global North – Global Challenges and Local Responses in Contemporary Architecture, Espoo, Finland.

Center, H. (2008). Landscape pattern indicators for the nation: a report from the Heinz Center's landscape pattern task group. *The H. John Heinz III Center for Science, Economics and the Environment,* 108.

Cheng, W., Zhou, C., Li, B., & Shen, Y. (2019). Geomorphological regionalization theory system and division methodology of China. *Acta Geographica Sinica*, 74(5), 839–856. https://doi.org/10.11821/dlxb201905001

Chorley, R. J., & Haggett, P. (1967). *Models in Geography.* Methuen.

Cosgrove, D. (2004). Landscape and Landschaft. *German Historical Institute Bulletin*, 35, 57–71.

Fang, C., Liu, H., Luo, K., & Yu, X. (2017). Comprehensive regionalization of human geography in China. *Acta Geographica Sinica*, 72(2), 179–196. https://doi.org/10.11821/dlxb201702001

Fechner, R. (1986). *Natur als Landschaft*. Peter Lang.

Feng, Z. (2001). Land use zoning scheme of China based on detailed land surveys. *Journal of Natural Resources*, 16(4), 325–333. https://doi.org/10.3321/j.issn:1000-3037.2001.04.005

Feng, H., Tan, Y., Wang, Q., Chen, J., & Yu, Z. (2010). Review of the research on land use zoning in China. *China Land Science*, 24(8), 71–76. https://doi.org/10.13708/j.cnki.cn11-2640.2010.08.013

Fu, B., Chen, L., Ma, K., & Wang, Y. (2001). *Principles and Applications of Landscape Ecology.* Science Press.

Hasti, F., Rouhi, H., Khodakarami, L., & Mahiny, A. S. (2016). Zoning the protected area of Shahoo/Kosalan using RS and GIS. *Journal of Environmental Science, Toxicology and Food Technology,* 10, 74–81. https://doi.org/10.9790/2402-1008017481

Havrylenko, O., Shyshchenko, P., & Tsyhanok, Y. (2020). Landscape functional zoning of urban protected areas. *Environmental Research, Engineering and Management,* 76(3), 121–136. https://doi.org/10.5755/j01.erem.76.3.24258

Hersperger, A. M., Bürgi, M., Wende, W., Bacău, S., & Grădinaru, S. R. (2020). Does landscape play a role in strategic spatial planning of European urban regions? *Landscape and Urban Planning,* 194, 103702. https://doi.org/10.1016/j.landurbplan.2019.103702

Huang, S., Xu, M., & Chen, D. (2001). GIS-based extraction of drainage network density and it's application to flood hazard analysis. *Journal of Natural Disasters,* 10(4), 129–132. https://doi.org/10.3969/j.issn.1004-4574.2001.04.024

Humboldt, A. V. (1969). *Ansichten der Natur*. Philipp Reclam Jun.

Jackson, J. B. (1984). *Discovering the Vernacular Landscape.* Yale University Press.

Johnston, R. J. (1968). Choice in classification: the subjectivity of objective methods. *Annals of the Association of American Geographers*, 58(3), 575–589. https://doi.org/10.1111/j.1467-8306.1968.tb01653.x

Kang, Y. (2019). A Discussion on Cultural Division of Traditiona Residential Areas in China. *Journal of Shenyang Jianzhu University (Social Science)*, 21(3), 232–238. https://doi.org/10.11717/j.issn.1673-1387.2019.03.03

Kingston, W. H. (2009). *Vernacular architecture and regional design: Cultural Process and Environmental Response*. Architectural Press.

Kwa, C. (2005). Alexander von Humboldt's invention of the natural landscape. *The European Legacy*, 10(2), 149–162. https://doi.org/10.1080/1084877052000330084

Li, D., Wang, S., & Li, D. (2006a). *Spatial Data Mining Theories and Applications.* Science Press.

Li, F. (2007). *The study on vernacular landscape* [Master's thesis, Nanjing Forestry University]. Nanjing.

Li, G., & Guo, R. (2015). Understanding the rural landscape in the United Kingdom from the perspective of planting landscape diversity. *Chinese Landscape Architecture*, 31(8), 20–24. https://doi.org/10.3969/j.issn.1000-6664.2015.08.005

Li, X. (1996). A review of the international researches onland use/land cover change. *Acta Geographica Sinica*, 51(6), 553–558.

Li, Z., Wang, Y., Zhang, X., & Wu, J. (2006b). Principles and systems of landscape ecological regionalization. *Progress in Geography*, 25(5), 10–20. https://doi.org/10.11820/dlkxjz.2006.05.003

Liao, R. (2006). *The tourism planning and design of nonmaterial culture landscape* [Doctoral dissertation, Tongji University]. Shanghai.

Liu, P., Liu, C., Deng, Y., Shen, X., Li, B., & Hu, Z. (2010). Landscape division of traditional settlement and effect elements of landscape gene in China. *Acta Geographica Sinica*, 65(12), 1496–1506. https://doi.org/10.11821/xb201012006

Liu, T. (2013). Memory of villages – an academic path of folklore's participation in cultural development. *Journal of Wenzhou University*, 26(5), 3–12. https://doi.org/10.3875/j.issn.1674-3555.2013.05.002

Liu, X. (2008). *Principles and Methods of GIS Spatial Analysis.* Science Press.

Liu, Y., Li, T., Zhao, W., Wang, S., & Fu, B. (2019a). Landscape functional zoning at a county level based on ecosystem services bundle: Methods comparison and management indication. *Journal of Environmental Management,* 249, 1–11. https://doi.org/10.1016/j.jenvman.2019.109315

Liu, Y., Zhou, Y., & Li, Y. (2019b). Rural regional system and rural revitalization strategy in China. *Acta Geographica Sinica,* 74(12), 2511–2528. https://doi.org/10.11821/dlxb201912007

Long, J., Nelson, T., & Wulder, M. (2010). Regionalization of landscape pattern indices using multivariate cluster analysis. *Environmental Management*, 46(1), 134–142. http://dx.doi.org/10.1007/s00267-010-9510-6

Mitchell, N., Rössler, M., & Tricaud, P.-M. (2009). World Heritage Cultural Landscapes: A Handbook for Conservation and Management. World Heritage Centre UNESCO, Paris.

Naveh, Z. (1995). Interactions of landscapes and cultures. *Landscape and Urban Planning*, 32(1), 43–54. https://doi.org/10.1016/0169-2046(94)00183-4

Ogden, H. V. S. (1955). *English Taste in Landscape in the Seventeenth Century*. University of Michigan Press.

Pagden, A. (1993). *European Encounters with the New World*. Yale University Press.

Palmer, R., & Thérond, D. (2008). The rural vernacular habitat, a heritage in our landscape. *Special edition of the Journal "Futuropa" – For a new vision of landscape and territory,* 1–32.

Peng, J., & Wang, J. (2006). Land Use Zoning in China Based on Kohonen Network. *Resources Science*, 28(1), 43–50. https://doi.org/10.3321/j.issn:1007-7588.2006.01.008

Piao, S., Fang, J., & Guo, Q. (2001). Application of casa model to the estimation of Chinese terrestrial net primary productivity. *Acta Phytoecologica Sinica*, 25(5), 603–608. https://doi.org/10.3321/j.issn:1005-264X.2001.05.015

Ren, M., & Bao, H. (1992). *China's Natural Areas and Development and Renovation*. Science Press.

Saleh, M. (1998). Planning for conservation: the management of vernacular landscape in Asir region, southwestern Saudi Arabia. *Human organization*, 57(2), 171–180. https://doi.org/ https://doi.org/10.17730/humo.57.2.y342908471534875

Schmithüsen, J. (1973). *Das Wesen der Landschaft.* Wissenschaftliche Buchgesellschaft.

Sha, R. (1998). The natural geographical background of Chinese traditional architecture culture. *Scientia Geographica Sinica*, 18(1), 58–64.

Silva, E. A., & Acheampong, R. A. (2015). Developing an inventory and typology of land-use planning systems and policy instruments in OECD countries. https://doi.org/10.1787/5jrp6wgxp09s-en

Western Australian Planning Commission (2016). State Planning Policy 2.5 – Rural Planning Guidelines Version 3.

Wu, B. (1996). Formation and division of Chinese cultural district. *Academic Monthly*, 3, 10–15.

Xie, X., Li, X., & He, W. (2020). A land space development zoning method based on resource – environmental carrying capacity: A case study of Henan, China. *International journal of environmental research and public health*, 17(3), 900. https://doi.org/10.3390/ijerph17030900

Xu, X., Liu, Y., & Xiao, Z. (2015). Dialect and Economic Growth. *China Journal of Economics*, 2(2), 1–32. https://doi.org/10.16513/j.cnki.cje.2015.02.001

Yu, K., Wang, Z., & Huang, G. (2005). Discussion about the vernacular landscapes and their implications to modern landscape architecture. *Huazhong Architecture*, 23(4), 123–126. https://doi.org/10.13942/j.cnki.hzjz.2005.04.039

Zhao, S. (1983). A new scheme for comprehensive physical regionalization in China. *Acta Geographica Sinica*, 38(1), 1–10. https://doi.org/10.3321/j.issn:0375-5444.1983.01.001

Zhao, S., Chen, C., & Niu, W. (1979). Thirty years in integrated physical geography in people's republic of China. *Acta Geographica Sinica*, 34(3), 187–199. https://doi.org/10.3321/j.issn:0375-5444.1979.03.001

Zheng, D., & Fu, X. (1999). A preliminary study on issues of integrated geographical regionalization. *Scientia Geographica Sinica*, 19(3), 193–197. https://doi.org/10.3969/j.issn.1000-0690.1999.03.001

Zheng, D., Ge, Q., Zhang, X., He, F., Wu, S., & Yang, Q. (2005). Regionalization in China: retrospect and prospect. *Geographical Research*, 24(3), 330–344. https://doi.org/10.3321/j.issn:1000-0585.2005.03.002

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Research Article

Landscape values of the Island of Jakljan, Dubrovnik – Neretva County in Croatia

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This paper aims to present an approach to landscape evaluation, on the example of the island of Jakljan, which is a part of the Elaphiti Islands in the Dubrovnik Neretva County. Special emphasis is placed on the evaluation of natural, cultural, and visual qualities, which were identified in order to direct their protection in future development processes taking into account their role in the landscape. After determining the main qualities, the submodels of individual landscape qualities were determined. Next, the relationship between landscape quality and potential quality degradation was analysed, and a database of spatial data was prepared. Natural qualities included biodiversity valuation and perception of naturalness of the most dominant landscape patterns in this area. Cultural qualities included agricultural landscape evaluation and cultural-historic heritage. Finally, based on the evaluation of the visual units and visually attractive and authentic elements of the landscape and the analysis of visual exposure, a final model of visual landscape qualities was carried out. Evaluation maps were obtained using the GIS tools. The paper pointed out the most important values which must not be lost if the existing character of the space is to be preserved.

Keywords: landscape qualities, evaluation, Jakljan island, modelling

1 Introduction

Landscape is not just space and it is not an objective thing; it is an expression of the perception of space that people share, value and use (Olwig, 2007). Landscape can also be defined as a historical document that contains evidence of a long process of interrelationships between society and its material environment (Eiter, 2010). Given that the landscape is a complex system (Jorgensen, 2015), a great deal of effort is needed to simplify this complexity. According to Deming and Swaffield (2011) modelling is a research strategy based on simplification. Namely, most methods of landscape valuation are focused on the qualities of landscape forms, which are determined by geographical methods such as; mapping certain landscape features and attributing importance to these features or transferring analysis results in the form of landscape typologies or value maps (Stephenson, 2010). However, the determination of landscape qualities that are related to a person's relationship to the landscape cannot be conveyed by a geographical approach, and therefore social research that focuses on perception can be used (Stephenson, 2010). In interdisciplinary research, the classical division into quantitative and qualitative research is almost non-existent or completely unclear, which is especially noticeable in landscape analyses that seek to understand different socio-ecological relationships (Tobi & van den Brink, 2017).

The island of Jakljan, the research area, has a predominant natural character of the landscape which, in addition to valuable natural heritage and visual qualities, also has a valuable cultural heritage. Planned construction of tourist and recreational facilities and transport infrastructure will partially or significantly change the area; its completeness will be dissipated. The aim of this paper is to reconcile the interests between landscape protection, cultural heritage and the development of the Island of Jakljan. Therefore, it is necessary to enable the preservation of the existing landscape and cultural values of the research area, with the development of planned contents. An evaluation of the natural, cultural,

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and visual values of the entire island of Jakljan has been made. The paper will propose guidelines for protection and regulation that will be based on evaluation, but will also take into consideration development potentials and needs of the Island. The main goals of this paper are (1) analysis of all natural, cultural and visual features of the subject area, (2) typological classification of visual landscape units in the observed area, and (3) assessment of existing landscape qualities (natural, cultural, visual qualities).

2 Material and methods

2.1 Description of the area

The southernmost county in Croatia, the Dubrovnik-Neretva County, consists of a coastal zone and a sea area with islands and peninsulas. The research area is located on the island of Jakljan, which is a part of the Elaphiti Islands. As one of the northernmost Elaphiti islands, it administratively belongs to the City of Dubrovnik, and the only area built on it is the former summer resort in the main bay, V. Jakljan (Fig. 1).

The design of the structural and visual characteristics of the subject area is conditioned by the pronounced natural features of this abandoned and uninhabited island. Spatial structure of the island of Jakljan is determined by its relief characteristics, since in terms of vegetation, the entire area is now dominated by forest vegetation. Main feature of the island is the division into an undivided, very narrow and steep SW ridge, facing the open sea and the wider, flatter NE slopes of the island facing the end of the Koločep Channel. The observed area of the island of Jakljan is irregular in shape, indented in relief. It includes an area of a more pronounced homogeneity, determined by the dominant forest vegetation. Anthropogenic impact is only slightly more pronounced in recent times, with the clearing of forest vegetation on the slopes in the bay V. Jakljan and the establishment of fig plantations, which significantly changed the visual characteristics of this part of the bay. Other anthropogenic elements, also located and concentrated only in the bay of V. Jakljan, today are slowly being lost within the forest vegetation and enhance the natural character of the rest of the Island. Overgrown area with forest vegetation and the varied relief make it impossible to see the wider area.

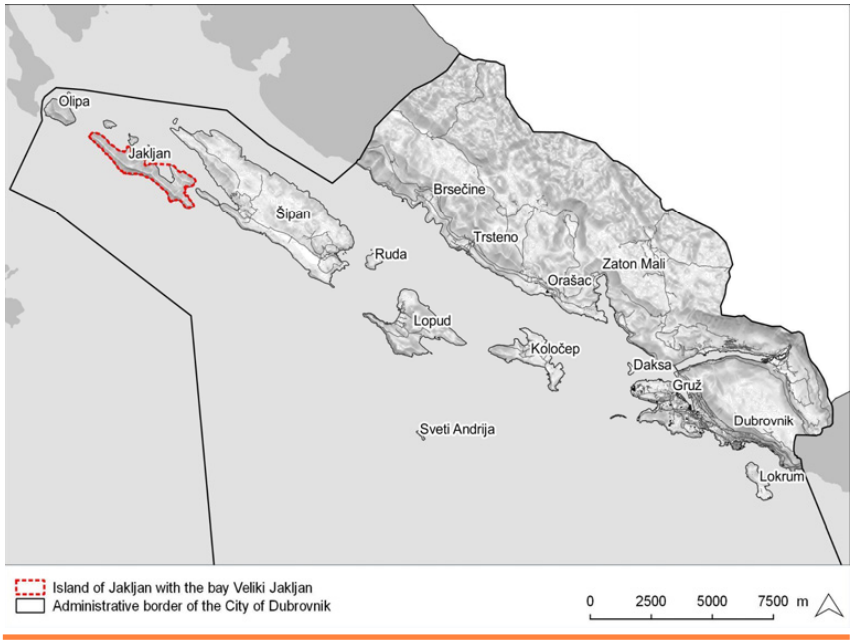

Figure 1 The geographical position of the location within a wider area

Observing the island of Jakljan (Fig. 2), the area under natural forest vegetation dominates (mostly high, mixed vegetation, but also transitional stages of the same), which is significant and the only contrast is the newly established

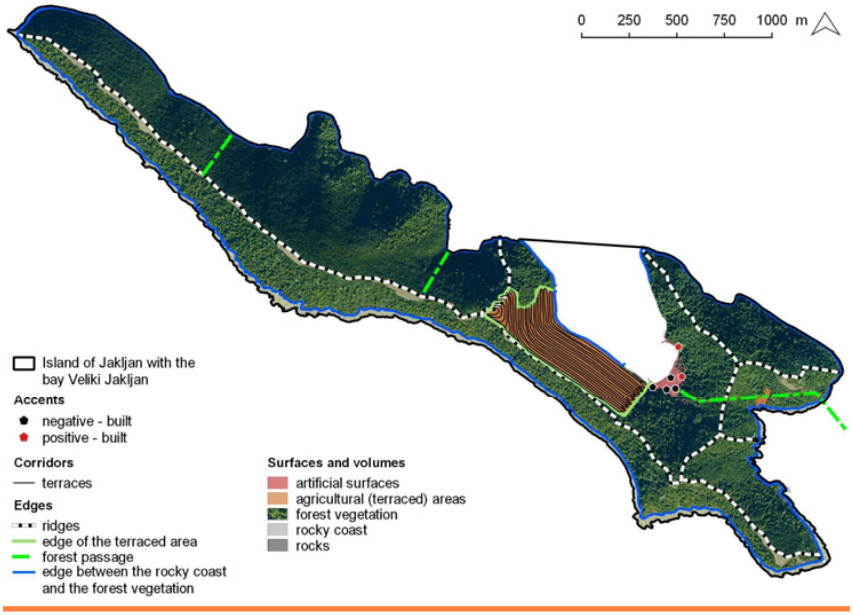

Figure 2 Structural map of the wider coverage area – the island of Jakljan

fig plantation in the bay V. Jakljan, and slightly less built coastal edge/ promenade, beach, piers next to the former resort complex.

Structures that stand out from the environment with their height, shape or purpose are important as structures for navigating space, and they are the accents within the observed area. On the island they are represented by the neglected church of St. Izidore, and in the bay V. Jakljan there are several buildings but all neglected and in ruins.

2.2 *Evaluation of existing landscape qualities*

Evaluation involves identifying the quality and value of the landscape and determining the level of integrity of all components that define and constitute its dominant characteristics.

Methodology of landscape evaluation, the basic issue of this paper, is one of the most frequently used research strategies in environmental design. Marušič (1991) defines it as the recognition of the person´s relationship towards landscape. Modelling is recognized as an appropriate evaluation method because it interprets and simplifies complex systems of environmental quality in the planning context, especially considering their reflection on its future state, which cannot be scientifically verified in the present (Butula et al., 2009). Falconer et al. (2013) believe that the use of modelling in GIS contributes to the accessibility but comprehensibility of a large number of complex issues to the public.

After determining the main qualities, the submodels of individual landscape qualities were conceptually determined. Next, the relationship between landscape quality and potential quality degradation was analysed, and a database of spatial data was prepared. It was used for modelling three specific landscape qualities; natural, visual and cultural. Evaluation modelling was performed in GIS applications ProVal2000 and QGIS, and the homogeneous spatial unit was 5 × 5 m in size. Polygonal spatial data were evaluated directly through value matrices, while other spatial data were evaluated through distance buffer zones. The obtained matrices are connected by arithmetic functions Multi sum and Multi max (ProVal2000) which, after overlapping, calculate the value of each spatial unit with respect to the values of all input matrices. When using the arithmetic function Multi sum (ProVal2000) to connect two or more matrices, depending on the need, weighting factors were used. By including a weight, all values are multiplied by the value of the same, which increases their value in the further process of merging and overlapping. Weights were used in the evaluation of terrestrial and marine habitats for natural and ecological qualities and cultural heritage sites (churches, fortifications and archaeological sites in the sea) for cultural and historical qualities.

3 Results and discussion

3.1 *Natural landscape qualities*

Values of natural landscape qualities are defined primarily with regard to the (a) biodiversity (Fig. 3a) and (b) perception of naturalness of the most dominant landscape patterns in this area (Fig. 3b): the sea with associated rocky and pebble shores, and forests and forest vegetation. In the evaluation of the area from the aspect of biodiversity, terrestrial and marine habitats were evaluated. Maps of terrestrial and marine habitats of the coverage area served as the basis for the evaluation. The evaluation criteria are based on the quality of the present habitat types and their importance for the overall biodiversity of the island of Jakljan. Diversity of the shores of this area is an important element of the naturalness of the landscape, and is therefore taken into account when making submodels. Vegetation of macchia

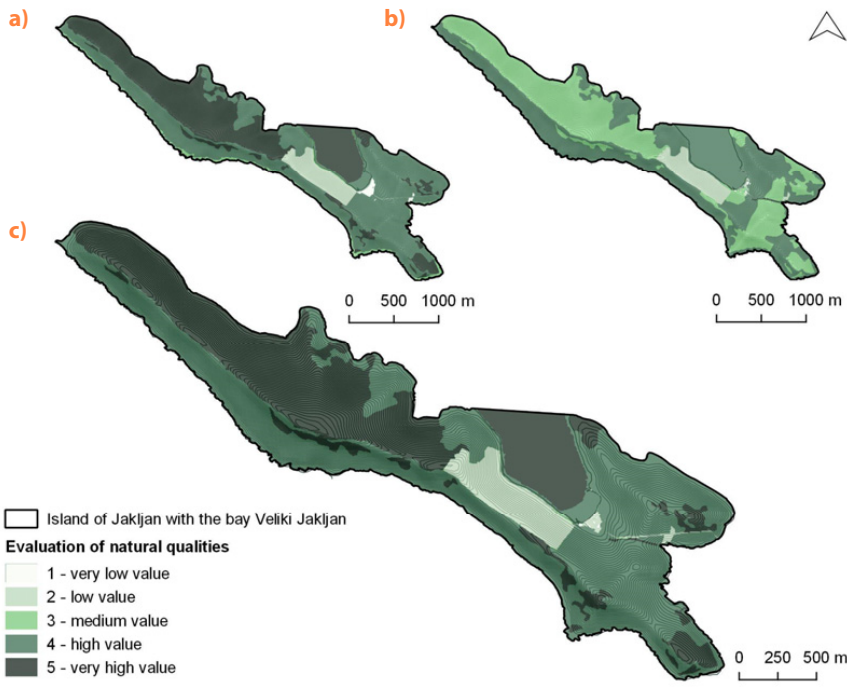

Figure 3 Overview of natural qualities of the wider observed area

and forests, and rocks and rocky shores are valued mainly because of their naturalness, but also their role in the structure and perception of the landscape. Furthermore, the values are determined by the distances from the water elements – springs and torrents, where the value decreases with distance. An important component of the natural qualities of the landscape of the researched area are the relief forms that significantly contribute to the perception of the natural structure of the island space. Therefore, rocky shores are defined as the highest quality of the relief structure of the natural landscape. The final model of natural qualities was obtained by overlapping and merging the sub-model of natural qualities from the aspect of biodiversity (Fig. 3a) and from the aspect of natural qualities of the landscape (Fig. 3b). The final result is an evaluation model of natural qualities, on a scale of one (1) to five (5) (Fig. 3c).

3.2 Cultural landscape qualities

Agricultural landscapes in the investigated area were evaluated from the aspect of structure and from the aspect of the existing and historical way of land use. The first aspect was evaluated by a direct approach based on the criteria of the importance of agricultural land in spatial integrity, readability of structural features, which included terraces and canals. The second aspect was evaluated on the basis of the potential for future use in the case of restoration of now neglected and overgrown areas that according to the interpretation of orthophotos from 1968 and the Austro-Hungarian cadastre from 1837 were once used as olive groves and vineyards. Furthermore, due to the possibility of expanding these zones, agricultural areas in today's land use (orchards) and partially neglected agricultural areas that are still read in the area were taken into account.

Although it was not permanently inhabited, the island of Jakljan contains historical physical structures and archaeological remains that testify to the continuity of living and using this area in close connection with the neighbouring island of Šipan. The mentioned historical architectural structures have been preserved in the bay of V. Jakljan, in the northern part of the island (remains of the fort) and in some southern parts of the island, which has preserved traces of intensive agricultural cultivation.

The final model of cultural qualities was obtained by overlapping and merging the sub-model of quality and potential of the agricultural landscape and the sub-model of cultural heritage. The final result of the association is a value map with rated areas of overall cultural and historical qualities, on a scale of one (1) to five (5). (Fig. 4)

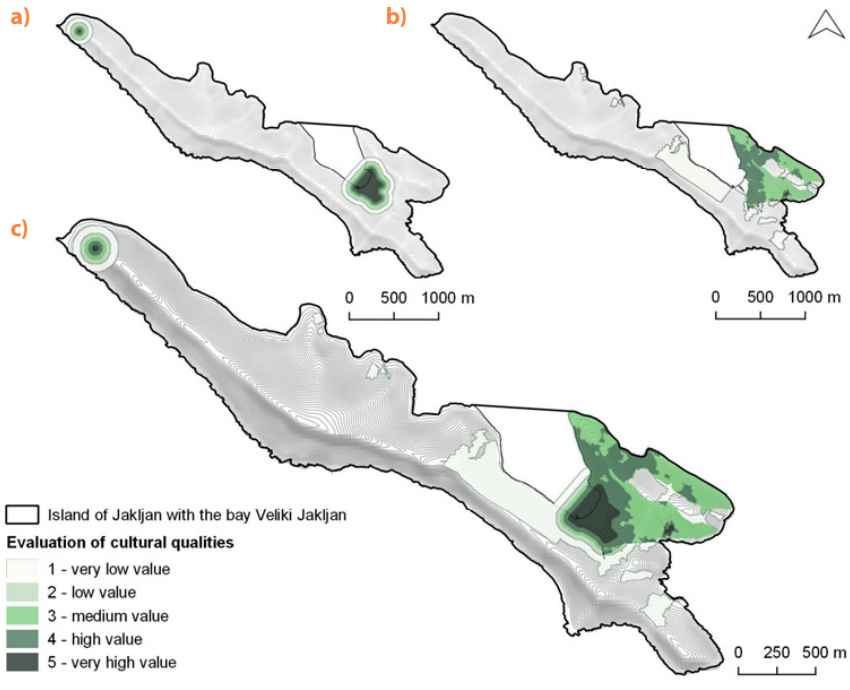

Figure 4 Overview of cultural qualities of the wider observed area

3.3 Visual landscape qualities

Values of visual qualities of landscape are modelled through the function of observation intensity and quality of observed; intensity is determined through frequency of observation (visual exposure), and quality of observed through landscape elements, their interrelationships and evaluation of visual units:

$$(Vij = ƒIij, Kij) \qquad (1)$$

where: V – visual quality; i – object of observation; j – observer; I – observation intensity; K – quality of observed

Therefore, (1) visual completeness of the whole space was evaluated according to the criteria of representativeness/typicality, visual integrity, coherence, complexity, overall impression that represents a complete experience of the visual whole regardless of individual criteria (Bogovac et al., 2021) and (2) visually attractive, authentic elements such as rocky shores, beaches, rocks, forests, and spatial accents

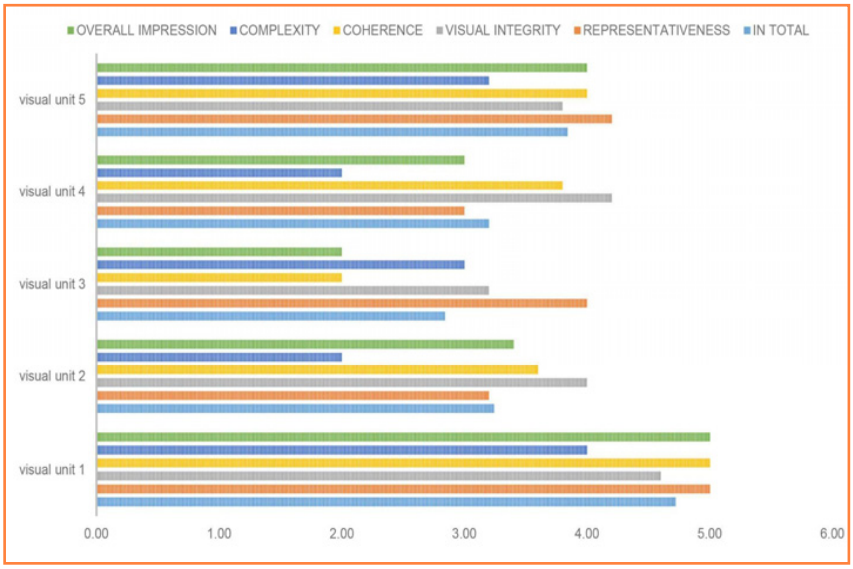

Figure 5 Evaluation of visual units according to different criteria

such as the church of St. Izidor. The mentioned submodels were then combined with the model of visual exposure by the folding technique in order to obtain a complete value map of the visual qualities of space. Identification of visual units is an analytical procedure which, on the basis of visual boundaries, determines spatial units which are later qualitatively evaluated on the basis of visual criteria. Visual units were determined on the basis of field research, interpretation of photographs, and digital elevation model. In the mainland, the boundaries have been determined in the areas of the ridges of the highest relief forms or cuts that represent a visual barrier.

Interpretation identified five visual units that were directly evaluated by several experts for the purpose of creating value models of visual qualities of the landscape (Fig. 5). The criteria taken into account were as follows:

a) Representativeness/typicality – number of combinations of common and essential features that make the area representative in the region to which it belongs; the landscape may contain certain character and/or features and elements that are considered representative by stakeholders.

b) Visual integrity – includes assessment of visual integration of space, character and number of different views that open from individual points in space, visual relationships of elements that make up space, visibility of the wider island space, the existence of visual corridors, barriers and edges.

c) Coherence – a measure of the harmony of the organization of space; the degree to which different factors are interrelated in space and time, the consistency of the alternation of one or more anthropogenic and/or natural patterns.

d) Complexity – a measure of the richness of a scene is manifested in the diversity of spatial patterns of some and/or individual elements within a particular pattern. It may be due to the complexity of natural conditions (relief, combination of different units of the ecosystem, etc.) and/or specific cultural and historical context.

e) Overall impression – refers to the overall experience of the visual whole regardless of individual criteria.

The highest value of visual units was obtained by visual unit 1 (4.60), while the lowest value was obtained by visual unit number 3 (2.44 small value). Visual units 2 and 4 were also rated with moderate values (3.20 and

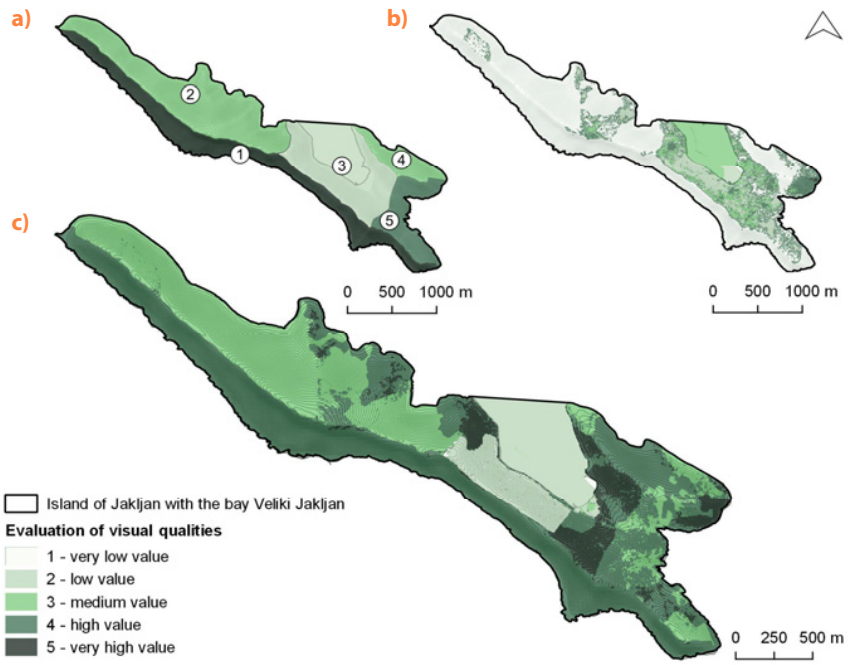

Figure 6 Overview of evaluating the visual quality of visual units

3.24), while visual units 5 were rated as highly valuable (3.8). Visual unit 1 received the highest values (5.0) on the basis of the criteria of overall impression, representativeness/ typicality and coherence, while on the basis of the criteria of complexity it was evaluated on average by the lowest score (4.0) of all criteria.

Based on the evaluation of the overall visual potential, which included the evaluation of visual units and visually attractive and authentic elements of the landscape and the analysis of visual exposure, the final model of visual landscape qualities of the wider area was obtained (Fig. 6). Value of visual qualities grows with the increase of visual potential, i.e. visual qualities and visual exposure. The most visually exposed areas are those that are visible from the highest points of observation (pedestrian and waterways, roads, settlements), i.e. from places where people reside and constantly passing. The range of values is determined by the scale of values from one (1) to five (5), with value 5 representing the areas of the highest values of visual qualities of the landscape, and value 1 the lowest values.

From the map of combined visual qualities, it can be seen that the most valuable areas (value 5) are those that belong to the wider area of V. Jakljan Bay and its wooded slopes. Large homogeneous area, visual unit 1, primarily of natural character defined by steep rocky shore and rocks above which forest vegetation (coniferous and mixed forest, macchia), has a high value (4) due to exposure from waterways and very high visual quality of the unit. Areas of high mixed vegetation on slopes and neglected agricultural areas, which extend above the bays V. Jakljan and M. Jakljan with high exceptions of anthropogenic elements within the same and neglected tourist settlement, are also of high value (4). Visual qualities of the observed parts of the island are emphasised mainly due to the visual exposure of the most frequent observation points. Larger areas of the northern part of the island have a moderate value (value 3) of visual qualities, mostly covered with macchia, without spatial accents that would add value to the space. Only smaller areas in V. Jakljan Bay have a low value (value 2) of visual qualities, which are not observable from many points due to their position, and therefore their value of visual exposure is lower. The area of fig plantations was assessed as low and very low (1 and 2).

3.4 Final model of landscape qualities

The final model was obtained by overlapping and merging sub-models of natural, cultural and visual qualities of the landscape (Fig. 7). By overlapping all the above sub-models of landscape quality, a joint model of landscape quality for the area of the island of Jakljan was obtained.

The most valuable areas are those that are characterised by high natural, cultural and visual qualities. The final result of the association is a value map with estimated areas of total quality value in the rating scale from one (1) to five (5), where the association method uses a multi max function which retains the highest values of all input submodels.

The final model of landscape quality indicates that almost the entire island belongs to the most valuable (44.28%) and highly valuable areas (50%) (grades 4 and 5), with the exception of low value (grade 2) active fig plantations on the slopes of the bay V. Jakljan (5.33%). Most valuable areas are those covered with macchia in the northern part of the island, and visually exposed areas of mixed forests that surround the bay. The coasts are recognized as the most valuable zones, as well as the sea part of the coverage area, which covers the Posidonia habitat. Areas of cultural and historical heritage that include the historical complex around the church of St. Izidore and utilitarian buildings and coastal infrastructure (the remains of a pond built by the Benedictines, and an old pier located on the north side of the bay made of stone), are also recognized as the most valuable.

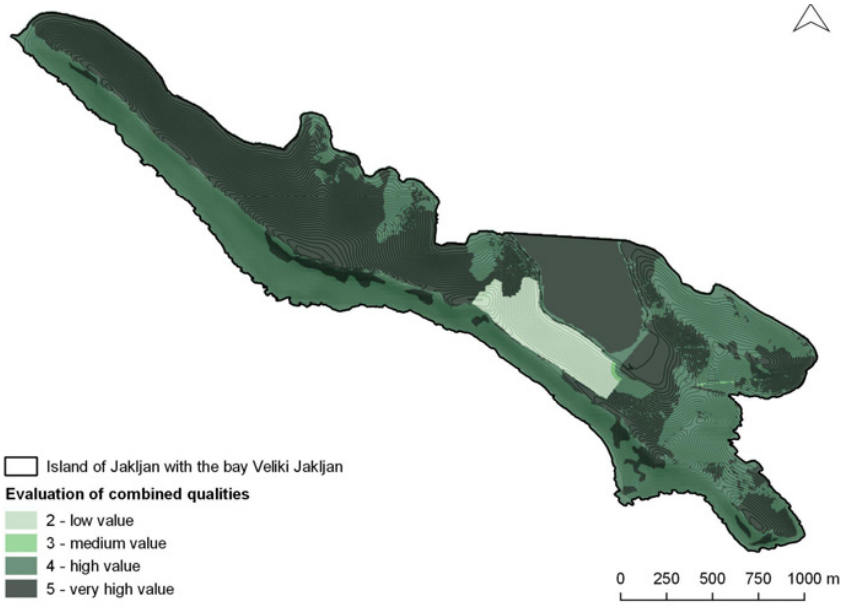

Figure 7 Final model of combined landscape qualities

The entire southern side of the island, which includes rocky shores and rocks, is a high value area (value 4), based on the identified visual and natural qualities. Highly valuable is the area above the bay M. Jakljan, which in addition to these qualities, also has pronounced cultural and historical qualities due to the pronounced agricultural character, or exceptional potential for the restoration of former olive groves identified in orthophotos from 1968 and the Austro-Hungarian cadastre from 1837.

4 Conclusions

The paper showed that the approach used in this paper can be adjusted according to (1) site specificity and (2) spatial problems and conflicts to be resolved before deciding on spatial changes. Such an approach contributes to solving practical problems in the protection of landscape qualities that are essentially a public good and a link between nature and culture and biophysical, experiential, social and developmental elements in space. Such evaluation process can be carried out in the framework of EIA, SEA or spatial planning preparation. At the same time, the disadvantage of these assessments is that the landscape is mostly analysed through the prism of structural features and visual qualities, while neglecting public attitudes and other landscape qualities that may be degraded by future development.

References

Bogovac, L., Butula, S., Andlar, G. & Tomić Reljić, D. (2021). Approaches to landscape evaluation questioning examining landscape vulnerability and sensitivity of the Island of Rab. *Geoadria*, 26(1), 35–58. https://doi.org/10.15291/geoadria.3409

Butula, S., Andlar, G., Hrdalo, I., Hudoklin, J., Kušan, T., Kušan, V., Marković, B., & Šteko, V. (2009). *Projekt COAST: Inventarizacija, vrednovanje i planiranje obalnih područja Dalmacije,* Oikon d.o.o. – Institut za primijenjenu ekologiju, Sveučilište u Zagrebu Agronomski fakultet – Zavod za ukrasno bilje, krajobraznu arhitekturu i vrtnu umjetnost, Urbanistički institut Republike Slovenije, Zagreb.

Deming, M. E. & Swaffield, S. (2011). *Landscape Architecture Research; Inquiry, Strategy, Design.* John Wiley and Sons. Hoboken, New Jersey

Eiter, S. (2010). Landscape as an Area Perceived through Activity: Implications for Diversity Management and Conservation. *Landscape Research*, 35(3), 339–359. https://doi.org/10.1080/01426391003746531

Falconer, L., Hunter, D., Telfer, T. C. & Ross, L. G. (2013). Visual, seascape and landscape analysis to support coastal aquaculture site selection. *Land Use Policy*, 34, 1–10. https://doi.org/10.1016/j.landusepol.2013.02.002

Jorgensen, A. (2015). Editorial: Is landscape an oxymoron? Understanding the focus of Landscape Research. *Landscape Research*, 40(1), 1–4. https://doi.org/10.1080/01426397.2014.998012

Marušič, J. (1991). Oblike vrednotenja v krajinskem načrtovanju. *Urbani izziv*., 18, 37–45.

Olwig, K. R. (2007). The practice of landscape 'Conventions' and the just landscape: The case of the European landscape convention. *Landscape Research*, 32(5), 579–594. https://doi.org/10.1080/01426390701552738

Stephenson, J. (2010). The Dimensional Landscape Model: Exploring Differences in Expressing and Locating Landscape Qualities. *Landscape Research*, 35(3), 299–318. https://doi.org/10.1080/01426391003743934

Tobi, H., & van den Brink, A. (2017). *Research in Landscape Architecture: methods and methodology* (1st ed.). In: van den Brink, A., Bruns, D., Tobi, H., Bell, S. (Eds.). Ch.2: A process approach to research in landscape architecture. Routledge. New York. 24–34.

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Research Article

Evaluation of current landscape architecture approaches in chosen cities in Poland and Slovakia

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The Paper presents analyses of the strategies and projects that have been implemented and realised in landscape architecture, environmental protection, and sustainable design in the chosen cities in Poland and Slovakia. There are several levels of evaluation: the first one is policy approach (which includes strategic documents, conceptions, plans which have been elaborated), the second one is the level of landscape design and sustainability (including architectural competitions and project realisation) and the third one is public participation (involvement of the public in urban planning, bottom-up initiatives, support of the communities). Ten cities in Poland and ten cities in Slovakia have been chosen. (The Paper brings an overview what are the current topics, with a great emphasis on what are the trends in landscape architecture and what are the obstacles, which need to be overcome.

Keywords: landscape architecture, climate change adaptation, well-being, trends, sustainability

1 Introduction

Increasing human development and concentration of population in the urban areas is closely related to the quality of citizens´ lives, safe and clean environment, and adaptation to extreme climate conditions in the cities. During the 20th-century strategies related to greenways, ecological design, sustainable development of cities have been elaborated (Supuka, 2008; Mandziuk et al., 2021a). Sustainable shaping of green areas in cities is supported by scientific research, connected with the current policy of the European Union and supported by the local governments and residents of cities. Adaptation measures for climate changes have been emphasized in the last decades of the 21st-century. An increasing number of days with tropical temperatures, urban heat islands, floods in the urban and rural areas (Kousis, Pigliautile & Pisello, 2021) caused the necessity of different approaches also in the landscape architectural projects (Seckin, 2018; Mabon and Shih, 2021). In recent years water in the city has been attracting increasing attention from the urban planning point of view. Water in all its forms and types has been brought into the city to improve the quality of urban life. Rivers are being redesigned to become an interplay between ecology, flood protection and amenity (Prominski, 2017). Green roofs and vertical gardens also help to manage the rainfall run-off. Over the past decades, the development of new materials and construction technologies has helped to maximize the benefits of these systems (Hubačíková, Marková & Dimitrova, 2020).

Materials and products for sustainable sites are those that minimize resource use, have low ecological impacts, have no or low human and environmental health risks and assist with sustainable site strategies (Calkins & Ap, 2009; Mandziuk et al., 2021b).

Grimm-Pretner (2018) underlines incorporating innovative solutions, design with nature-based solutions and multifunctionality for open urban spaces, with highlighting follow-up of realised projects.

When we look at the popular landscape design approaches, every decade has its own style, rooted in the social and economic status of the world. The following topics could be considered as trends in Landscape Architecture design during the last few years.

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Flemming (2021) has published the following list of trends in landscape architecture design for the year 2021:

1. Well-being landscapes – the impact of the Covid-19 pandemic on our mental and physical health during the last 2 years clarified that open green spaces are the most valuable and safe places to meet family and friends.
2. Re-designing the street – prioritizing the pedestrian movement over the vehicular traffic and also due to climate changes, the streets have the potential to become greener and safer.
3. Outdoor living – the creation of outdoor living spaces as an extension of the indoors.
4. Planting to reduce air pollution – trees can clean the air and absorb harmful airborne particles, gaseous pollutants and toxins through their leaves, bark and roots.
5. Investment into local public parks – local public parks and their accessibility to vulnerable groups of the population, have never been as important as during the last 2 years.
6. Smart use of space – the space should be designed wisely to fulfil the required functions, it should have appropriate aesthetic qualities and it should be easily accessible.
7. Grow your own initiatives – many people became interested in growing their own food.
8. Stormwater management – can reduce run-off of rainwater into streets sewerage and keep it where it drops in order to slowly infiltrate or evaporate or for other uses.
9. Nature-based solutions – bioecological network supporting biodiversity.
10. Smart technology in the landscape – applying smart technologies in the cities and open spaces.

Smart cities are green, innovative, friendly, inspiring and digital. Smart cities properly use modern technologies to invoke the synergic effects between various subsystems regarding energetic intensity and quality of life of the citizen (Svítek & Postránecký, 2018). In 2017 and 2018 there was an international project supported by the Visegrad fund which evaluated chosen cities in the Czech Republic, Hungary, Poland and Slovakia in terms of smart solutions in the spheres of governance, environment and alternative energy and public involvement (Óhegyi et al., 2017).

The Paper aims to bring an overview of the importance of urban greenery development and improvement of the quality of urban open spaces from the point of view of the city municipalities. We have evaluated what kinds of strategic documents, guidelines and standards have been elaborated by the City Hall and what types of landscape architectural projects have been realised. This research also brings an overview of the trends in the field of landscape architecture in Poland and Slovakia. We have tried to find some similarities and differences.

2 Material and methods

The selection of cities in both countries was based on differences in numbers of the population, so that it would be possible to make a cross-section of implemented landscape architecture projects, of existing strategic documents or active approach of the city government to improve the living conditions of the inhabitants of their city. We have also tried to represent various environmental and natural conditions in Poland and Slovakia.

In the first step, the evaluation took place at the level of self-government management (evaluation of the presence of relevant departments dealing with urban planning, landscape architecture or strategic greenery management.) We have also searched for documents related to improving the lives of the city's inhabitants, strategies on adaptation to climate change, or published guidelines, standards and manuals regarding designing of the public open spaces and greenery management (Table 1a, b).

The next step was a field survey of implemented projects (Table 2a, b). One realised project has been selected and assessed from the following points of view:

1. Quality of landscape architectural design, with taking into account the functional and spatial possibilities and needs of the inhabitants.
2. Suitability of the solutions in the area, support of the *genius loci* of the space.
3. Technical realisation of the project.
4. Selection of materials, mobiliary and other elements.
5. Greenery (species and cultivars of trees, shrubs and flower compositions).

We have collected the data from the official web pages of the cities, from social networks platforms and the interviews with the city representatives. The evaluation has been done between June 2021 to November 2021. Chosen landscape architectural projects, which were evaluated, have been realised during the last 10 years.

3 Results

3.1 Evaluation of chosen cities in Poland

Warsaw consists of 18 city districts. Each district has its own self-government which means that also way of development of the districts varies. There is almost 110 m^2 of green areas per one inhabitant of Poland's capital. The Old Town of Warsaw is listed in the UNESCO World Heritage List. Warsaw is one of the most dynamically

developing European cities with great potential and extraordinary vibe, its inhabitants often refer to its history and are very skilfully able to combine tradition with modernity. Green areas cover almost half of the city's area. There are as many as 95 parks, a lot of squares, gardens, pocket parks, parklets, green tram lines. Some buildings have gotten vertical, green walls, roof gardens, which are very important for the microclimate of the city. Revitalization of green areas and projects of new green areas were realised every year in Warsaw.

Wrocław – is also rich in green areas, from parks to forests and Natura 2000 areas. Green areas in the city accounted for 4.8%, and forests for 7.6%. There are many small areas of greenery, such as the Japanese Garden nearby the University of Technology. There are also many larger valuable areas such as the Bystrzyca Valley Landscape Park, Las Pilczycki, Strachociński or Rędziński. Not only are these areas beautiful in terms of nature, but they are also a habitat for many species of plants and animals. New squares, parks, pocket parks are established every year.

Kraków – a lot of types of green areas occupy about 150 hectares of the city. Other green areas include road lanes, green areas, water greenery, greenery accompanying sports grounds and fortress greenery with a total area of approximately 3.111 hectares. Nowadays many pocket parks, parklets and green walls, which are all very important to minimize the negative impact of urbanization/ anthropogenic impacts, can be found in Kraków.

Rzeszów – In the ranking of green cities prepared by the portal rynekpierwotny.pl Rzeszów came second among

Table 1a Chosen cities in Poland and Slovakia and the list of strategies, methodologies, documentation and realised projects

Poland																			
City	Number of inhabitants	Density (inhabitants.km^2)	Strategic documents						Landscape design projects realised within last 10 years								Specific department at city hall related to landscape architecture	Participation in the national and international projects	Public involvement	Bottom-up activities (activities of the people or NGOs)
			urban city plan	spatial system of ecological stability	register of the greenery	smart city strategy	adaptation strategy for climate changes	public spaces design manual	central city zones (squares)	city parks and recreational zones	open spaces in housing estates	pocket parks or small interventions	special types of greenery (schools, hospitals, senior houses...)	rainwater management projects	biodiversity support	urban development				
Warsaw	1,765,000	3,800	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Wrocław	638,659	2,192.23	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Kraków	766,683	2,386	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rzeszów	183,901	1,528.5	x	x	x	x	x	x	x	–	x	x	x	–	x	x	x	x	x	x
Olsztyn	173,718	1,938.7	x	x	x	x	x		x	–	x	–	–	–	x	x	x	–	x	x
Przemyśl	60,442	1,294.4	x	x	x	x	–	–	–	–	x	–	–	–	x	x	–	–	x	–
Jelenia Góra	78,335	717.2	x	x	x	–	–	–	–	–	x	–	–	–	x	x	–	–	x	–
Tarnów	107,045	1,474.8	x	x	x	x	x	–	x	–	x	x	–	–	x	x	x	–	x	x
Łódz	696,708	2,278	x	x	x	x	x	x	x	–	x	x	x	–	x	x	–	–	x	x
Kalisz	101,307	1,427.6	x	x	x	–	x	–	–	–	x	–	–	–	x	x	–	–	x	–

the 66 largest cities in Poland. The main criterium of the evaluation was the share of parks and green areas (13.4%) in the city's total area, excluding forests.

Olsztyn – is not a "City-Garden" but it could be changed. The real importance of greenery should be recognized and its planning, maintenance and continuous development should be systematically arranged.

Przemyśl – many different types of greenery have been developed here, for example: protecting green belts allotment, recreation parks, remediation greenery, green areas nearby hypermarket and adjacent to housing estates.

Jelenia Góra is characterized by the large diversity of green areas, resulting mainly from the specificity of its location among the surrounding mountains and hills. Currently, the area of the maintained urban greenery of Jelenia Góra covers almost 100 hectares, including 8 city parks and numerous squares, and also small green areas. A specific group of green areas are municipal playgrounds (currently 29). Parklets are also used as a new type of green areas in the city centre.

Tarnów – green areas in Tarnów accounted for 6% of the city's area (i.e. 55 m^2 of greenery per one inhabitant of Tarnów). Revitalization of Strzelecki, Sanguszki and Piaskówka parks has been realised. Sensory gardens with herbs and natural plants were created last year. A new project was done in the city centre. Now we can use new parklets along the promenade.

Table 1b Chosen cities in Poland and Slovakia and the list of strategies, methodologies, documentation and realised projects

Slovakia																			
City	Number of Inhabitants	Density (inhabitants.km^2)	Strategic documents						Landscape design projects realised within last 10 years								Specific department at city hall related to landscape architecture	Participation in the national and international projects	Public involvement	Bottom-up activities (activities of the people or NGOs)
			urban city plan/masterplan	spatial system of ecological stability	register of the greenery	smart city strategy	adaptation strategy for climate changes	public spaces design manual	central city zones (squares)	city parks and recreational zones	open spaces in housing estates	pocket parks or small interventions	special types of greenery (schools, hospitals, senior houses...)	rainwater management projects	biodiversity support	urban development				
Bratislava	440,948	1,199	x	x	–	–	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Košice	238,138	1,004.59	x	x	–	x	x	–	–	–	x	x	x	x	x	–	–	x	x	–
Prešov	87,886	1,247.85	x	x	x	–	x	x	–	x	x	–	x	–	–	–	–	–	x	–
Žilina	80,386	1,004.45	x	x	x	x	–	–	–	x	–	–	x	–	–	–	x	–	x	–
Nitra	76,028	756.65	x	x	x	–	x	x	x	–	–	–	–	–	x	–	x	x	x	x
Trnava	64,735	904.88	x	x	x	–	x	–	–	–	x	x	x	x	x	x	x	–	x	–
Trenčín	55,416	675.8	x	x	–	–	x	–	x	–	x	x	x	x	–	–	–	–	x	–
Martin	53,763	793.67	x	x	–	–	–	–	–	–	–	–	–	–	–	–	x	–	x	–
Zvolen	42,092	426.33	x	x	x	–	x	–	x	–	x	x	x	x	x	–	–	–	x	x
Brezno	20,736	170.02	x	x	–	–	–	–	–	x	–	–	x	–	–	–	–	–	–	–

Łódz – there are many parks, green areas, as well as the largest forest complex there. There are over 30 city parks in Łódź with a total area of nearly 500 hectares, 13 of which are historical parks under conservation protection. In addition, the areas of a park nature include the Botanical Garden, the Municipal Zoological Garden, several sports and recreation centres, as well as numerous squares and lawns. One of the favourite walking places for the inhabitants of Lodz is the largest forest complex within the city limits, Łagiewniki Forest with an area of approx. 1.250 hectares. Such a great variety of green areas and the constant development of Łódź parks are appreciated by the inhabitants of Łódź, who are more and more willing to use these places for everyday recreation.

Kalisz has compact development build-up areas, which makes it difficult to plan large green areas. That's why parks and squares are densely interspersed with canals, alleys and streets. Recently, bus stops overgrown with vegetation have been designed in the city.

3.2 Evaluation of chosen cities in Slovakia

Bratislava – the capital of Slovakia consists of 17 city districts; each district has its own autonomy. The most active districts are Old City (revitalisation of squares and pocket parks, new technologies in tree planting – using the structural substrate in root open cells), Karlova Ves (nature-based solutions, establishment of rain gardens and stormwater collection, flower meadows, education of the public), Rača (flower meadows, support of the community gardens), Záhorská Bystrica (revitalisation of the district park), Petržalka (establishment of the orchards, new tree plantation, high quality of the open spaces of new housing estates). The main central organisation which elaborates the standards and documents for the whole municipality is the Metropolitan Institute of Bratislava, where architects, landscape architects, ecologists and sociologists are employed.

Košice is the second-largest city in Slovakia. There are plenty of projects, which have been realised within the urban structure of the city and also in the recreational landscape. Several sites have been reconstructed – Kulturpark cultural centre of Košice (brownfield revitalisation), city park revitalisation, Park Moyzesova. There is an active NGO Carpathian Development Institute in Košice. The city Climate Adaptation Strategy is under preparation. One of the 22 districts – KVP – is testing out an environmentally-friendly philosophy in designing spaces in between apartment buildings, especially in densely-populated areas with pre-fabricated panel houses. Many of the primary schools started to create rain gardens as a part of environmental education. The city gained the title of European Capital of Culture in 2013 after a five-year preparation. During the preparation period, small technical buildings within the city (called "výmenník") have been transformed into the modern centres of art and culture which are very popular among inhabitants up till now. In June 2020 the City of Košice was awarded an international grant Urban Innovative Action. Only 11 from 222 projects across Europe were selected.

At the City Hall, there is a Department of the Main Architect of the City with a Section for Urbanism and Section for Architecture. These offices have organised several official architectural competitions. The last one was focused on the revitalisation of the former water mill canal in the centre of the city.

Prešov – the main projects that have been realised here are the revitalisation of the open spaces of the housing estates and small city parks which have been supported by EU funds. Manual for the design of open spaces has been prepared which is a guideline for further development and equipment of open urban spaces.

In Prešov, there is a Department of Spatial Development, Architecture and Construction with Sections of Territorial Development and City Architecture within the City Hall.

Žilina has prepared several projects of Landscape design revitalisation within the last 3 years. Sites to be revitalised (i.e. urban studies or projects of the redesign of open spaces have already been elaborated) are the following: the housing estates Solinky-Centrum (2021), Hliny V–VI (2021), Vlčince I and IV (2021), housing estate near the Hospital (2020), Hliny I, II, VII (2020), Hliny II–IV, VIII (2019), Hájik – Hradisko (2014). In 2013 three community gardens were established. The project of revitalisation of the City Park Ľudovíta Štúra won the 1st price in the Park of the year 2020 competition.

At the City Hall, there is a Department of Environment with a Section for Urban Greenery Management. There is also a Department of the Main Architect of the City, in which a landscape architect is employed. Several official architectural competitions for public open spaces revitalisation have been organised in Žilina.

Nitra – has prepared several projects for the revitalisation of the city parks, open spaces and squares. The City Hall actively involves inhabitants in discussions (e.g. Hackathon – public discussion about new master plan preparation, establishment of community gardens, application of suggestions for tree planting and urban interventions). Only small projects have been realised – supporting the biodiversity in the city and planting of single trees within the urban structure of the city. A new

Table 2a Evaluation of open spaces in chosen cities

Poland																												
City	**City district**	**Evaluated site/realised project**	**Landscape architectural design**							**Chosen greenery**								**Solutions for adaptation to climate changes**										
			concept of the project	**functional zones of the site and communications**	**connection to the surroundings**	**chosen mobiliary and equipment**	**art, sculptures, innovative, creative solutions**	**solutions for supporting the community and social life**	**precision of the realisation, detail completion**	**trees**	**trees/shrubs with edible fruits**	**shrubs**	**flower beds**	**flower meadows**	**lawn – intensive management**	**lawn extensive management**	**greenery on constructions, roof top gardens**	**rain gardens**	**swales**	**different management of the grass areas**	**permeable materials (parking plots, paths, roads)**	**water (jets in the pavement, fountains, pools,…)**	**drinking water**	**shadowed places**	**using structural substrates for tree planting**	**brownfield revitalisation**	**places for biodiversity: plants, insects**
Warsaw	Ursynów district	Zielony Służew Nad Dolinką (green area for recreation along Służew River)	3	3	3	3	2	3	3	3	3	3	3	3	2	3	0	0	0	3	3	3	0	3	0	0	3
Wrocław	area in a part of the New city	square – 26 Marca, Armii Krajowe Str.	2	3	3	3	0	3	3	3		3	3	3	3	3	0	0	0	3	0	0	0	3	0	0	2
Kraków	Zabłocie district	verical garden in park in "Stacja Wisła" Park	3	3	3	1	0	2	1	0	0	0	3	3	0	0	3	0	0	0	3	0	0	0	0	0	2
Rzeszów	centre	revitalization of Biały Ogród as pocket park (Farna Place)	3	3	3	3	2	3	2	2	2	3	3	0	2	2	0	0	0	2	3	3	0	2	0	0	2
Olsztyn	Zator district	recreation square	2	3	2	2	0	3	2	3	3	2	2	0	2	0	0	0	0	2	2	3	0	2	2	0	2
Przemyśl	centre	park	2	2	2	2	2	2	2	2	3	2	2	2	2	2	0	0	0	2	2	3	0	3	2	0	3
Jelenia Góra	centre	pocket park	2	2	2	2	2	2	2	2		2	2	0	0	0	0	0	0	0	0	0	0	2	2	0	3
Tarnów	centre	pocket park	2	3	2	0	0	3	2	0	0	2	2	2	0	0	0	0	0	2	0	0	0	0	0	0	3
Łódz	Górniak district	ogrody geyera (square)	3	3	3	3	3	3	3	3	0	3	3	0	2	0	0	0	0	2	2	0	0	3	3	3	3
Kalisz	in the whole city	green bus stops	3	3	3	0	3	3	2	0	0	0	3	0	0	0	3	0	0	0	0	0	0	3	0	0	3

The evaluation criteria were: 3 – creative and innovative solution, 2 – appropriate, ordinary solution, 1 – inappropriate solution, 0 – without a solution for supporting biodiversity or adaptation to climate change

Table 2b Evaluation of open spaces in chosen cities

Slovakia																										
City	**City district**	**Evaluated site/realised project**	**Landscape architectural design**							**Chosen greenery**								**Solutions for adaptation to climate changes**								
			concept of the project	**functional zones of the site and communications**	**connection to the surroundings**	**chosen mobiliary and equipment**	**art, sculptures, innovative, creative solutions**	**solutions for supporting the community and social life**	**precision of the realisation, detail completion**	**trees**	**trees/shrubs with edible fruits**	**shrubs**	**flower beds**	**flower meadows**	**lawn – intensive management**	**lawn extensive management**	**greenery on constructions, roof top gardens**	**rain gardens**	**swales**	**different management of the grass areas**	**permeable materials (parking plots, paths, roads)**	**water (jets in the pavement, fountains, pools,…)**	**drinking water**	**shadowed places**	**using structural substrates for tree planting**	**brownfield revitalisation**	**places for biodiversity: plants, insects**
Bratislava	Nové Mesto	Park Jama	2	3	3	3	2	3	2	2	0	0	2	2	3	0	3	3	0	3	3	3	3	3	0	3	3
Košice	Staré Mesto	Park Moyzesova	3	3	3	3	3	2	3	0	0	0	0	0	3	0	0	0	0	0	3	3	3	3	0	0	2
Prešov	City	planting the trees in the city	3	3	3	0	0	0	2	3	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	2
Žilina	Bôrik	Park. Ľ. Štúra	3	3	3	3	3	3	2	3	0	3	3	3	3	2	0	3	0	2	3	3	3	3	0	0	3
Nitra	–	supporting biodiversity	3	0	3	0	0	0	3	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Trnava	Zátvor	housing estate Zátvor	3	3	3	3	3	3	3	3	3	3	3	0	3	0	0	3	3	3	3	3	3	3	0	0	3
Trenčín	Biskupice	children playground Karpatská	3	3	3	3	3	3	3	3	3	3	3	0	3	3	0	0	3	0	3	3	3	3	0	0	3
Martin	Malá Hora	Jessenius Faculty of Medicine	2	3	3	2	0	0	2	2	0	3	3	0	3	0	0	0	0	0	0	0	0	0	0	0	2
Zvolen	CMZ	Technical University in Zvolen	3	3	3	3	2	3	1	2	0	0	2	2	2	0	0	3	0	2	3	3	0	3	0	0	3
Brezno	CMZ	Margitin City Park	2	2	1	3	1	2	1	2	3	1	1	0	0	0	1	0	0	2	3	3	3	3	0	0	1

The evaluation criteria were: 3 – creative and innovative solution, 2 – appropriate, ordinary solution, 1 – inappropriate solution, 0 – without a solution for supporting biodiversity or adaptation to climate change

greenway/cycle road/which will connect the city with the surrounding areas is under construction.

The City Hall includes the Department of Environment with Section for Urban Greenery, the Department of the Urban planning and Architecture and the Department of the Main Architect of the City.

Trnava – is one of the most active cities in Slovakia, thanks to its mayor, who is very ambitious and has long-term visions. Plenty of projects have been realised and a lot of architectural competitions for different types of green open spaces have been organised. Development of the city with regards to landscape architecture happens not only within the urban areas but also in the surroundings of the city where new recreational zones have been established. For example, edible forest with recreational, climatic functions and also for the protection of the agricultural fields. The public is actively involved in discussions with landscape architect, as a result, high-quality projects are being created. There are plenty of other activities in Trnava, for example, Urban Intervention, Free Trees for Your Garden, 10.000 Trees Within the City, construction of the greenways and connection of the city with the surroundings. Projects completed are reconstructions of city parks, revitalisation of open spaces in housing estates (Tehelná, Gejzu Dusíka, Na Hlinách), new urban development Arboria, revitalisation of the forest park.

There is the Department of Territorial Development with Section for Urban Greenery and Concepts and the Department of Construction and Environment with Section for Landscape and Natural Protection within the City Hall structure.

Trenčín – several projects that stem from architectural competitions (revitalisation of part of the central zone) have been realised here. Other successful projects are pocket parks in the centre of the city, revitalisation of open spaces in the housing estates, revitalisation of the children's playgrounds, revitalisation of the university park and city park.

There is the Department of Construction and Development and also the Department of the Main City Architect within the City Hall.

Martin – one official architectural competition for Slovak National Uprising Square has been announced, and plenty of urban studies for various sites (parks, housing estates, streets, cemetery) have been realised.

At the City Hal, there is a Department of Environment with a Section for Urban Greenery. There is also the Department of Urban planning and Architecture as well as the Department of the Main City Architect with a landscape architect working there, too.

Zvolen – The City Hall is actively cooperating with the local Technical University in Zvolen as well as with several NGOs. Several interesting projects have been realised here: support of biodiversity through establishing of flower meadows, Urban Bees, establishing of the rain gardens in the housing estates and school gardens, collection of rainwater in school grounds and City Hall buildings and also in the open landscape.

Department of Construction, Environment and Traffic and Department of Urban Development are included in the City Hall structure.

Brezno – There are several projects for open spaces revitalisation (e.g. revitalisation of streets ŠLN, 9. mája, ČSA, F. Kráľa and of Margitin Park which are supported by EU funds. Department of Environment and Construction with Section for Waste Management and Management of the Public Open Spaces is working within the City Hall.

4 Discussion and conclusion

Vegetation in the city provides shade, lower local temperature, better condition of the air, reduces damage caused by flooding, reduces noise, supports water retention, improves the aesthetics and creates identity of the place. It also creates a habitat for numerous animals and other plants. Other elements of urban greenery, i.e. lawns, squares, flower meadows, green roofs of buildings, green stops, street greenery, rain gardens, cemeteries, retention reservoirs and parks are equally important, and even irreplaceable (Kousis, Pigliautile & Pisello, 2021).

The whole newly designed types of green areas big and small in Polish and Slovak cities are very important for improving human well-being in the cities. This is a positive aspect, because as it is observed new green areas are helping to improve the environment and to minimize the negative impact of the urbanisation process and climate change.

Many landscaping trends are about coming back to nature with low-maintenance, water-smart and eco-friendly designs, and using outdoor spaces more also for typically-indoor activities. The trends in landscape design projects vary a little bit due to different levels of economic and social standards of the society (we can consider worldwide differences, differences between the states and also differences in the regions).

In the USA the highlighted topics are Going Native, Outdoor Living Areas, Eco-Conscious Elements, Multi-Season Green, Getting Creative with Food Plants, Setting up a Pollinator Garden, Growing up With Vertical Gardens,

Smart Technology, Keeping Pests Out, Composting For Healthy Soils, Intricate Touches, Food Out Front, Secluded Spaces, Low-Maintenance Landscapes, Unique Outdoor Lighting, Xeriscaping, On-Site Water Collection, More Potted Plants, Front Porch Living, Blue Gardens (JMF Landscaping, 2020).

Shchur, Lobikava & Lobikava (2020) from Belarus consider the following as crucial to implement in the projects: community gardens, educational green space for children, recreation and exercise space for older people, café and recreation area, sports facilities, safety & security, biodiversity, car-free zone.

Ring, Reinwald & Damyanovic (2020) agreed that the function of the green infrastructure is not only ecological but also social and economic. A new and innovative project is the Biotope City in Vienna – the city as nature with its innovative approach in an urban planning model. It represents the modern way of industrial area revitalisation which was proposed by the interdisciplinary planning team. There is also a new approach seen in the revitalisation of the former airport in Oslo (Fornebu), in Vienna (See Stadt Aspern) and in Prostejov (CZ) where the greenery was established before the construction of the building or at least at the same time. Stormwater management and supporting the green-blue infrastructure is an important topic in the Nordic countries and countries of Western Europe. In the Czech Republic, there is a competition Adapterra Awards which collects great examples of landscape architectural projects with emphases on rainwater collection and supporting the biodiversity.

The cities in Slovakia and Poland have their Master plans ready, many of them have strategic documents for urban development, but only some of them have adaptation strategies for climate changes and guidelines for open spaces design. Many of the cities have urban studies or landscape design projects for chosen areas prepared (housing estates, school premises, parks, hospitals, forest parks) but due to lack of financial resources, they have not been realised yet. The city halls are prepared for external or EU sources of financing.

The landscape design studies and proposals in Slovakia and Poland were elaborated by landscape architects or a landscape architect was part of the project team. However, a big number of projects are still elaborated by architects only. In our opinion, the revitalisation of open public spaces should be designed in cooperation of professionals from various fields such as architects, landscape architects, engineers and ecologists.

References

Calkins, M. (2009). *Materials for sustainable sites*. New Jersey: John Wiley and Son, 2009. 453 p.

Flemming, V. (2021). *Top 10 Landscape Trends for 2021*. https://www.asalandscapearchitects.co.uk/articles/top-10-landscape-trends-for-2021/

Grimm-Pretner, D. (2018). Contemporary issues in landscape architecture the challenge of designing green infrastructure. *Plants in Urban Areas and Landscape.* Conference proceedings Nitra: SPU, 2018, pp. 3–6. DOI:10.15414/PUAL/2018.3-6

Hubačíková, V., Marková, J., & Dimitrova, A. (2020). *Green roofs and vertical gardens as part of the urban green space.* Public recreation and landscape protection, 194.

JMF Landscaping (2020, October 26). 20 Landscaping Trends for 2021. https://jmflandscaping.com/20-landscaping-trends-2021/

Kousis, I., Pigliautile, I., & Pisello, A. L. (2021). A Mobile Vehicle-Based Methodology for Dynamic Microclimate Analysis. *International Journal of Environmental Research*, 15(5), 893–901. DOI: 10.1007/s41742-021-00349-7

Mabon, L., & Shih, W. Y. (2021). Urban greenspace as a climate change adaptation strategy for subtropical Asian cities: A comparative study across cities in three countries. *Global Environmental Change*, 68, 102248. DOI: 10.1016/j.gloenvcha.2021.102248

Mandziuk, A., Fornal-Pieniak, B., Stangierska, D., Parzych, S., & Widera, K. (2021a). Social Preferences of Young Adults Regarding Urban Forest Recreation Management in Warsaw, Poland. *Forests*, 12(11), 1524. DOI:10.3390/f12111524

Mandziuk, A., Fornal-Pieniak, B., & Ollik, M. (2021b). The willingness of inhabitants in medium-sized city and the city's surroundings settlements to pay for recreation in urban forests in Poland. *iForest-Biogeosciences and Forestry*, 14(5), 483. DOI:10.3832/ifor3758-014

Óhegyi, E., Bihuňová, M., Dostál, P., Weber-Siwirska, M., & Zaryn, M. (2017). Smart and Green, The Future of Visegrád Cities. *CEEweb for biodiversity and APU in Nitra*, 2017. 50

Prominski, M., Stokman, A., Stimberg, D., Voermanek, H., Zeller, S., & Bajc, K. (2017). River. space. design: planning strategies, methods and projects for urban rivers. *Birkhäuser*.

Ring, Z., Reinwald, F., & Damyanovic, D. (2020). Biotope city – Vienna as a contribution to sustainable, climate-sensitive urban open spaces. *Urban areas and Landscape*, 10–18. DOI:10.15414/PUAL/2020.10-18

Seçkin, N. P. (2018). Environmental control in architecture by landscape design. *A/Z ITU J. Fac. Archit*, 15, 197–211.

Shchur, A., Lobikava, N., & Lobikava, V. (2020). Revitalization of (Post-) Soviet Neighbourhood with Nature-Based Solutions. *Acta Horticulturae et Regiotecturae,* 23(2), 76–80. DOI 10.2478/ahr-2020-0016

Supuka, J. (2008). Novodobé trendy v tvorbe prírodných parkov a ekologických sietí v mestách. In Vegetačné štruktúry v sídlach, 81–91. Nitra: SPU.

Svítek, M., & Postránecký, M. (2018). Města budoucnosti. Nadatur.

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DOI: 10.2478/ahr-2022-0005
Acta hort regiotec, 25, 2022(1): 37–43

Research Article

Green infrastructure in Lviv – example of park zones

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The combination of negative effects of urbanization and climate change in large cities poses a real threat to environmental, economic, and social stability in the world. The intensification of climate change and the analysis of its negative effects in cities show that climate change causes special threats in cities that are not specific to other types of human settlements. Assessing the vulnerability of urban ecosystems to climate change and planning measures to adapt cities to climate challenges is an important element of spatial infrastructure planning. The goal was to analyze the green infrastructure spatial arrangements on the example of green zones in Lviv. According to the results of field research and analysis of cadastral data, it was determined that most of the green areas are in the municipal property of the city, the only exceptions are the sites of the nature reserve fund of national importance. The total area of parks and squares of the city is more than 1,069 ha, of which 24% are areas of nature reserve. The provision of the urban population with public green spaces is about 14.82 m^2.$person^{-1}$. The green infrastructure is based mainly on objects – cores (e.g. parks and squares). There is also a reserve in the city to expand the boundaries of green areas. The combination of "cores" with green corridors and the use of point objects of green infrastructure will contribute to the continuity of the green spaces network, which in turn will provide more environmental and socio-economic benefits for the population.

Keywords: green infrastructure, parks, nature reserve fund, greening

1 Introduction

Landscaping is an integral part of sanitation and spatial planning. In large cities (population over 700,000), proper landscaping is a problem due to continuous construction, which occurs with violation of relevant requirements and reduction of urban green areas, due to the expansion of the road network. Other problems are old trees in cities, improper structure of green areas, and outdated approaches to green areas planning and management. The main governing documents for urban green areas management are the Law of Ukraine "On Settlement Improvement" (Verkhovna Rada of Ukraine, 2005), DBN (State Norms for Constructions) B.2.2-12 "Planning and Development of Territories" (Ministry of Regional Development, Construction and Housing of Ukraine, 2019) which replaced DBN 360-92 (State Committee of Ukraine for Urban Planning and Architecture,1992) and also DSTU-N (State Standard of Ukraine) B B.1-1-12 "Guidelines on the structure and content of the zoning plan." (Ministry of Regional Development, Construction and Housing and Communal Economy of Ukraine, 2011). Management of green areas in cities is usually carried out by specialized municipal company working under city councils. In turn, at the legislative level a document "Instructions on technical inventory of green areas in cities and towns of Ukraine" (State Committee of Construction, Architecture and Housing Policy of Ukraine, 2001) was approved for the inventory of green areas, however in most cases the inventory data are no opened for public, i.e. the local population cannot participate and influence on the decision-making process on sanitary felling of trees, landscaping of urban zones, etc. In other cases, the inventory is carried out either according to approved local rules, technical regulations or even not performed at all.

Issues of landscaping in UA cities were studied in (Tsaryk & Poznijak, 2016; Nazaruk & Zhuk, 2013; Stolberh, 2000; Kucheriavyi, 2005). An overview of the development of green infrastructure projects, landscape and environmental planning was performed and results are

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demonstrated in previous works (Klieshch & Maksymenko, 2020; Maksymenko et al., 2021b; Maksymenko et al., 2021c). Some effects of green areas of the city on the natural components of the environment were studied in (Maksymenko et al., 2021a; Maksymenko & Burchenko, 2019; Maksymenko et al., 2021d; Shpakivska, 2001).

Historically, the idea of green infrastructure (GI) planning or an ongoing network of green spaces is not a new one. At the beginning of the 19th century, Frederick Low Olmsted proposed a landscape-architectural concept that combines systems of parks and green corridors, which was more comprehended than isolated greenery and had more benefits. Edward T. McMahon (Benedict & McMahon, 2006) proposed one of the first definitions of green infrastructure as an interconnected network of protected lands and waters that supports local species, natural ecological processes, air and water resources, and promotes human health and quality of life. In 1995, the European Commission provided definition, which is currently the most acceptable in Ukraine, including in view of the Association Agreement between Ukraine and EU (Verkhovna Rada of Ukraine, 2014). According to the EC (European Commission, 2013) "green infrastructure is 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, GI is present in rural and urban settings". List of ecosystem services includes water treatment, air quality, recreation and climate change mitigation and adaptation. It should be noted that in our opinion it is advisable to separate approaches to the organization and development of green infrastructure of urban systems and rural areas, as land use has different characteristics – a higher percentage of agricultural land use, nature reserves, recreational areas (sanatoriums, health resorts, etc.). However, urban areas together with rural ones should form a single, mostly continuous ecological network.

2 Material and methods

Lviv has a very long history of green areas traditions. Hundreds of calm green streets, dozens of squares, boulevards; there are about 30 parks in each city district, the total area of green zones is about 1,000 ha, or about 15 m^2.$person^{-1}$, these figures do not include various types of forest-parks and expansion of agglomeration boundaries (Resolution of the Lviv City Council, 2018). The rich, diverse and ancient heritage of gardens and parks is a direct merit of the great gardeners living in the XIX century. The most prominent of them is the inspector of Lviv city plantations Arnold Röhring. He arranged the most of Lviv's parks and squares: Striyskyi Park, Park "Zalizna Voda", Lychakiv Park, boulevards on Shevchenko and Svobody avenues, green area on the St. Yura Square (St. George Square), tree areas on Halytska and Soborna Squares, the park in Kulpark, the lower terrace of the High Castle Park with a gardener's house, arboretum of the National Forestry University located on O. Kobylyanska Street, Resort Park in Bryukhovychi and dozens of gardens.

The researches were carried out through field trips, communication with stakeholders, cartographic study, including open cadastral register data, analysis of historical approaches to green infrastructure management.

3 Results and discussion

A feature of the organization and development of GI in Lviv is the large number of parks, which belong to the nature reserve fund and cover an area of 654.57 he. At the same time, they form a network with other green areas for general use, as well as smaller GI objects with limited and special use, such as linear plantings along roads, green roofs, green walls, and rain gardens.

The area of green spaces is about 15 m^2.$person^{-1}$, which is much higher than existing standards 10 m^2.$person^{-1}$ (Ministry of Regional Development, Construction and Housing of Ukraine, 2019). Also, there is a natural reserve of about 100 ha, which is very promising for landscaping.

An example is the inclusion of a land plot of about 1 hectare to the territory of Park "Zalizna Voda" – the park site of landscape art having local significance (Fig. 1). The restored area will be a community garden, which is one of the types of GI. This was an initiative of NGOs

Figure 1 Park "Zalizna Voda" (area for restoration is marked by black colour)

Figure 2 Landscape of the park «Zalizna Voda»

Permaculture, EkoTerra and PLATO to arrange the public space of the City Gardening "Röhring's Greenhouses" with the consent of the city administration. Previously, a large greenhouse area was located in this area, which is still in an abandoned state. This area is intended for the preservation and use of parks, monuments of landscape art and for the maintenance of the Park "Zalizna Voda".

The territory of Park "Zalizna Voda" has an area of 19.50 ha. There was no re-planning of the natural landscape in the park (Fig. 2); currently works are on-going for the arrangement of pedestrian zones and preservation of forest systems, the formation of a system of surface runoff.

Next to the Park "Zalizna Voda" there is a park-monument of landscape art with local significance named "Snopkivskyi Park". The area is 47.6 ha, the territory of the park is subordinated to the Lviv Municipal Company "Green Lviv" and is in the municipal property of the city. The problem with these two parks is the lack of a natural system of connectivity between them. Park areas are separated with a highway with a tram track, which contradicts the idea of continuity of green infrastructure.

Stryiskyi Park is a central park classified as the city's national landscape art park. It can be considered as an analogue of the Gorky Central Park in Kharkiv. The area of the park is 56 ha and it is a separate legal entity.

Regional Landscape Park "Znesinnya" of local significance is also located in Lviv. The area is 312.1 ha and it is subordinated to the Lviv City Council. It is one of the first parks of this type in Ukraine, established within the city, and one of the few that emerged through a public initiative (as a result of the struggle to preserve the old cemetery). Its territory is divided into the following zones: protected, regulated recreation, stationary recreation, and economic zones. One of the most interesting objects in the park is the historical and cultural open-air museum "Shevchenkivskyi Gai" that is located on the territory of the Klimentyi Sheptytskyi Museum of Folk Architecture and Life. In addition, there is an Information and Education Center on the territory of "Znesinnya".

The park of the Holy Pope John Paul II was called the Forest Park "Zubra" in the past. Park "Zubra" or "Zubrivskyi Forest" was renamed in 2011. Behind the forest in the tract there was Lake "Pioneer", but in 1982 due to industrial pollution the lake was lowered. In 2019, the first eco-trail "Zelena Stezhka Sykhova" (Fig. 3) was opened in Lviv, which runs through the park, and it has many information boards telling about the biota of the park and environmental issues. The Park does not belong to the nature reserve fund; the area is 97.90 ha. One of the features is that the park, namely forest part, is closely located with the site of the Armed Forces of Ukraine.

Ivan Franko Park is a park-monument of landscape art of local significance; it is subordinated to the Lviv Municipal Company "Green Lviv" and its area is 10.6 he. This is the oldest park in Lviv and Ukraine, one of the oldest municipal parks in Europe. Four hundred years ago, the Ivan Franko Park was replaced by urban fields, but later the land passed into private hands. At the end of the 16th century, a rich Lviv burgher, Jan Scholz-Wolfowicz, established a park here. Over time, the park was rebuilt by the owners in the Italian style, redesigned for the entertainment of the local population. In 1855, the park became the property of the city again, thus becoming one of the oldest municipal parks in Europe. The famous Lviv gardener Bauer undertook its arrangement. He reconstructed the park in the English landscape style. At the same time, almost all the old trees were cut down and most of the trees we have today were planted.

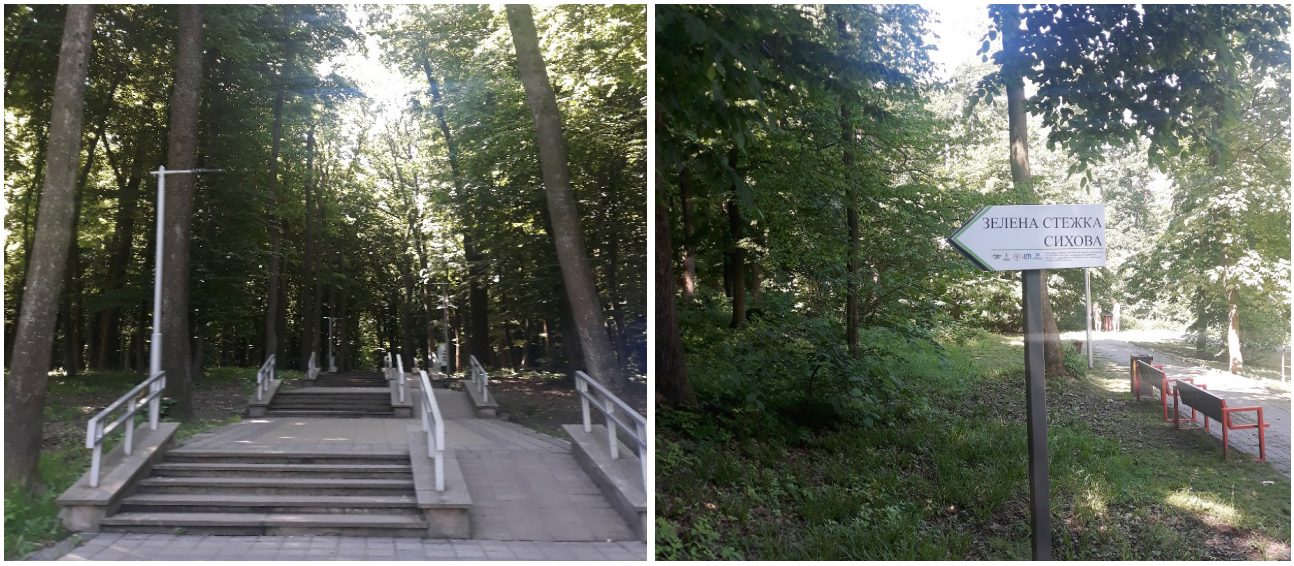

Figure 3 The Park of the Holy Pope John Paul II. Start of the eco-trail "Zelena Stezhka Sykhova"

The High Castle Park was founded in 1835. It got its name from the fortress, the remains of which have been preserved on the territory. The area of the park is 35.38 ha; it is subordinated to the Lviv Municipal Company "Green Lviv". The structure of the park is focused on the landscape park model. It has lower and upper terraces. In the 1950s, the Lviv TV tower was built on the upper terrace and the TV center building was constructed next to it. These objects somewhat disturb the historical and cultural landscape of the area.

Park-monument of landscape art of local significance B. Khmelnytskyi Park of Culture and Recreation is located near Striyskyi Park, from which it is separated by a highway and has an area of 26 ha. It is subordinated to its own directorate. The park was founded in 1951.

"Forest Park Pohulyanka" – botanical monument of local significance – is subordinated to the Lviv Municipal Company "Green Lviv" and its area is 100.33 ha. The park is located in the southeastern part of Lviv, in the valley of the Pasika stream and in the surrounding hills. The Pasika stream merges in an underground collector with the Soroka stream and gives rise to the Poltva river. Pohulyanka hills form a part of the Lviv upland.

City Park "Pohulyanka" was established in 1940. At that time, work began on clearing and arranging the territory of the park area, and reservoirs appeared along the main line. The compositional axis of the forest park is the central alley, along which artificial ponds are arranged. This alley goes through the valley, which divides the park into two parts – northeast and southwest ones. The slopes of the park hills are paved with walking routes, inscribed in relief. Trails can be walked around the perimeter of the park, to the observation decks and several entrances located on different sides of the "Pohulyanka".

Lychakiv Park, a park-monument of landscape art of local significance – is subordinated to the Lviv Municipal Company "Green Lviv" and its area is 8.8 ha. It is a small city park on the heights of the north-eastern district of Lviv. By the nature of the composition it belongs to the landscape parks. It was created in 1892 according to the project of the outstanding master of Lviv garden and park architecture Arnold Röhring. A feature of the stand in Lychakiv Park is the dominance of black pine. There are also maples, lindens, chestnuts, there are several species of shrubs (Zhuk, 2012).

The geological natural monument of local significance "Kortumova Gora" is subordinated to the Lviv Municipal Company "Green Lviv" and has an area of 21.4 ha. The park is located in the northwest of Lviv, on the slopes of the mountain of the same name, which is part of the tract of Roztocze hills. From the highest point of Lviv (Castle Hill), Kortum Mountain is separated by the valley of the Poltva River. Currently, part of the territory is occupied by a penitentiary institution. The territory of the historical park is in an abandoned state, although it continues to attract local people by panoramas of its unique landscapes. Kortumova Mountain is separated from the territory of the Bryukhovytsia Forest Park by railway tracks. The park is a place where scientists finds fossil flora, which are important for the reproduction of the geological history of the Central Europe. The green zone of Kortumivka is formed by plantings of maple, ash, birch, black alder, chestnut, pine and other trees.

Park "Na Valakh" is the second oldest park in Lviv. It is a park-monument of landscape art. The total area is 2.32 ha.

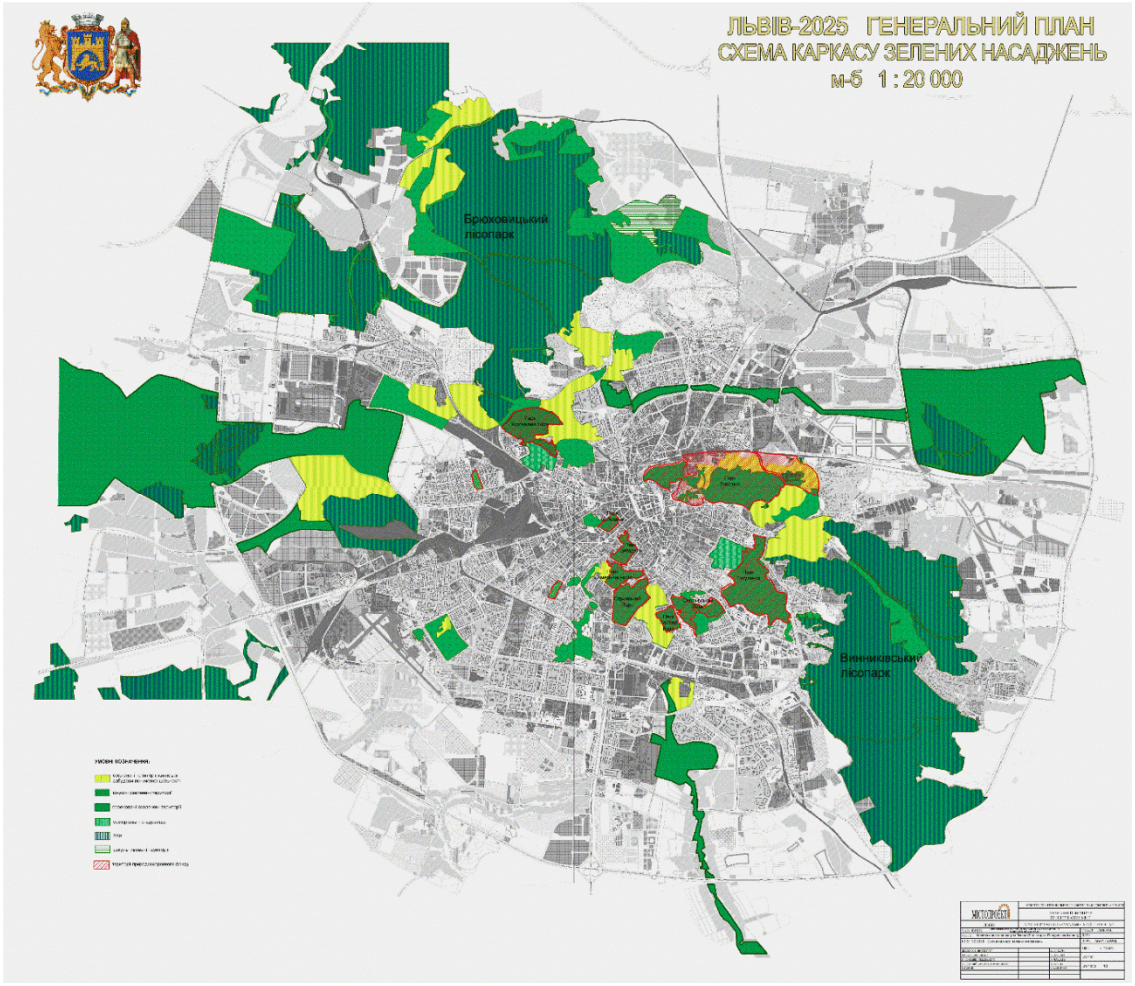

Figure 4 Green areas in Lviv (as from Master Plan for Lviv)

Sknylivskyi Park was established in 1974 and is intended for recreational purposes. The area of the park is 38.46 ha. The park was created in a landscape style on a plain that belongs to the Lviv Plateau and is currently in an abandoned state.

A highway passes through the Ivan Vyhovskyi Park. It was created to preserve and use the lands of the nature reserve fund, as the park is home to botanical monuments of nature. The area of the park is 5.18 ha.

Lewandowski Park is subordinated to the Lviv Municipal Company "Green Lviv" and has a purpose to preserve and use the lands of the nature reserve fund. The area of the park is 5.89 ha.

In addition to the above green areas, in the city under the authority of Lviv Municipal Company "Green Lviv" are (Lviv City Council, 2021):

- the green zone of Mayorivka, which is planned to be included to the geological natural monument of local significance "Medova Pechera", the area of which is currently 1.2 ha;
- Students' Park, area – 6.15 ha;
- Park "Piskovi Ozera", area – 5.9 ha;
- Park "Zamarstynivskyi", area – 32.58 ha;
- Park "The 700th anniversary of Lviv", area – 20.21 ha;
- Park "Gorikhovyi Gai", area – 40.61 ha.

The city's green spaces, which are parts of the nature reserve fund of national importance, are also the territory of botanical gardens – the Botanical garden of Ivan Franko National University of Lviv (area – 18.5 he) and the Botanical garden of National Forestry University of Ukraine (area – 22.7 he).

For each city district there is a position of a gardener, he/she reports to the Department of Ecology and the Natural Resources of the Lviv City Council.

The Master Plan of the Lviv City Council (Lviv City Council, 2006) also contains a scheme of landscaping for Lviv (Fig. 4).

The scheme of green sites of the city also includes green areas (in particular, forests) of the adjacent, suburban areas. Yellow colour indicates green areas of low-density

housing, which also form a network of green areas, but are not public and do not meet the needs of recreation. The objects of the nature reserve fund are highlighted in red. As of 2021, 24 parks, i.e. 70% of city parks, have established and demarcated boundaries that protect them from construction works.

The forest park part of the green zone of the city, which is subordinated to the Lviv Forest Park Company of the State Forestry Association "Lvivlis", occupies 28,867 ha. The area of forests within the city (Vynnykivske, Bryukhovytske, Zavadivske forestry) is 3,447 ha. That is, the area of green spaces in Lviv of various categories is 33,286 ha, including 4,419 ha within the city, or almost 26% of the city area. In total, there are about 54 m^2 of urban green space per person in Lviv.

Generalized data on the park areas of the city of Lviv are presented in Table 1.

Table 1 Park zones in Lviv

No	Name	Area (he)	Nature reserve fund
1.	Park "Zalizna Voda"	19.50	yes
2.	Snopkivskyi Park	47.6	yes
3.	Stryiskyi Park	56.0	yes
4.	Regional Landscape Park "Znesinnya"	312.1	yes
5.	The park of the Holy Pope John Paul II	97.90	no
6.	Ivan Franko Park	10.60	yes
7.	The High Castle Park	35.38	yes
8.	B. Khmelnytskyi Park of Culture and Recreation	26.0	yes
9.	"Forest Park Pohulyanka"	100.33	yes
10.	Lychakiv Park	8.80	yes
11.	Kortumova Gora	21.4	yes
12.	Sknylivskyi Park	38.46	no
13.	Ivan Vyhovskyi Park	5.18	yes
14.	Park "Levandivskyi"	5.89	no
15.	Students' Park	6.15	no
16.	Park "Gorikhovyi Gai"	40.61	no
17.	Park "Na Valakh"	2.32	yes
18.	Park "Piskovi Ozera"	5.90	no
19	Park "Zamarstynivsky"	32.58	no
20.	Park "The 700th anniversary of Lviv"	20.21	no
21.	Park "Bodnarivka"	5.80	no
22.	Park "Levanddivske Ozero"	5.70	no
23.	Park "Mayorivka"	30.60	no
24.	Memorial site "Hill of Honor"	0.76	no
25.	Landscape reserve "Torphovische Biligoscha"	92.00	yes
26.	Botanical garden – Ivan Franko National University of Lviv	18.50	yes
27.	Botanical garden – National Forestry University of Ukraine	22.70	yes
Total		**1,068.97**	

Thus, the total area of the city's parks is 1,068.97 ha, and the largest object is the Regional Landscape Park "Znesinnya". At the same time, 24% of the city's parks belong to the objects of the nature reserve fund of Ukraine.

According to the obtained data, it is possible to calculate the provision of the urban population with public green spaces according to the formula (Kucheriavyi, 2005):

$$P_{pgs} = (S_p + S_{gs} + S_b)/N_p \quad (1)$$

where: P_{pgs} – rate of public plantings (m^2.person^{-1}); S_p – area of parks; S_{gs} – area of green sites; S_b – area of boulevards; N_p – number of population

Thus, norm for landscaping in Lviv is:

$$P_{pgs} = (1{,}068{,}970\ m^2)/721{,}301\ persons = 14.82\ m^2.person^{-1} \quad (2)$$

4 Conclusions

The green infrastructure of the city of Lviv is based mainly on objects – cores, there are city parks and squares – i.e. public facilities. They are mostly owned by the city.

However, for the proper park management, the establishment of dialogue with the local population, the Department of Ecology and Natural Resources has assigned a position of gardeners; each gardener is responsible for a specific administrative district of the city. Having such position give an option to contribute to the more widespread use of nature-oriented practices in city parks.

The volume of parks included in the nature reserve fund is 24%. The calculation of the provision of the urban population with public green spaces is 14.82 m^2.person^{-1}. This figure can be increased, as the city has a reserve for landscaping.

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References

Benedict, M. A., & McMahon, E. (2006). *Green Infrastructure: Linking Landscapes and Communities.* Island Press: Washington, DC, USA, 299 p. https://www.researchgate.net/publication/40777458_Green_Infrastructure_Linking_Landscapes_and_Communities

European Commission (2013). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Green Infrastructure (GI) – Enhancing Europe's Natural Capital. European Commission: Brussels, Belgium, p. 11. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0249

Klieshch, A. & Maksymenko, N. (2020). Positional-dynamic territorial structure of the urban landscape. *Journal of Geology, Geography and Geoecology*, 29(3), 539–549. https://doi.org/10.15421/112049

Kucheriavyi, V. (2005). *Landscaping of urban areas.* Lviv: Svit. 450 p. http://www.e-catalog.name/x/x/x?LNG=&P21DBN=NBUV&I21DBN=NBUV_PRINT&S21FMT=fullw_print&C21COM=F&Z21MFN=341736

Lviv City Council (2006). *Master Plan for Lviv.* Informative Portal of Openness and Availability to Town-Planning Documentation. http://loda.zuap.org/city_district/%d0%bb%d1%8c%d0%b2%d1%96%d0%b2?post_type=genplans & https://drive.google.com/drive/u/0/folders/14z0dQ6_ZSvKpFcwPEUWZ8ES7Cwez1nV9

Lviv City Council (2021). *Lviv Municipal Company "Green Lviv".* https://city-adm.lviv.ua/lmr/utilities/lkp-zelenyi-lviv

Maksymenko, N. V., & Burchenko, S. V. (2019). Basis of the green infrastructure strategy: international experience. *Man and Environment. Issues of Neoecology*, 31, 16–25. https://doi.org/10.26565/1992-4224-2019-31-02

Maksymenko, N., Burchenko, S., Miller, K., Cohen, L., & Krivtsov, V. (2021a). Inventory of green roofs in Kharkiv (Ukraine) and Edinburgh (Scotland): current occurrence, future potential and implications for biodiversity and ecosystem services. *Current issues of formal and non-formal education in environmental monitoring and conservation: coll. of abstracts of the I International Internet Conference,* 127–128. http://ecomonitoring.karazin.ua/wp-content/uploads/2021/03/zbirka10034.pdf

Maksymenko. N. V., Gololobova, O. O., Shcherban, V. I., & Pohorila, M. V. (2021b). Introduction of sustainable plant components in green infrastructure in the context of nature-oriented solutions. *Man and Environment. Issues of Neoecology*, 35, 58–71. https://doi.org/10.26565/1992-4224-2021-35-06

Maksymenko, N., Shkaruba, A., Titenko, H., & Utkina, K. (2021c). Research of green-blue infrastructure of Ukrainian cities in a new project of the International Visegrad Fund. *"Ecology, Environmental Protection and Sustainable Environmental Management: Education – Science – Production – 2021": Materials of XXIII international scientific-practical conference,* 153–154.

Maksymenko, N., Sonko, S., Skryhan, H., Burchenko, S., & Gladkiy, A. (2021d). Green infrastructure of post-USSR cities for prevention of noise pollution (2021). *IV International Scientific Congress «Society of Ambient Intelligence – 2021» (ISCSAI 2021).* 100. https://doi.org/10.1051/shsconf/202110005004

Ministry of Regional Development, Construction and Housing of Ukraine (2019). *DBN B.2.2-12 "Planning and Development of Territories".* Official webportal of the Ukraine's Parliament. https://zakon.rada.gov.ua/rada/show/v0104858-19#Text

Ministry of Regional Development, Construction and Housing and Communal Economy of Ukraine (2011). *DSTU-N B B.1-1-12 "Guidelines on the structure and content of the zoning plan.* Official webportal of the Ukraine's Parliament. https://zakon.rada.gov.ua/rada/show/v0345858-11#Text

Nazaruk, M., & Zhuk, Y. (2013). Green zone of small and medium cities of Lviv region: current status and performance issues. *Physical geography and geomorphology*, 69(1), 54–62.

Resolution of the Lviv City Council (2018, January). *On approval of the Program for the maintenance of parks in Lviv* for 2018–2021, № 2909. https://www8.city-adm.lviv.ua/inTEAM/Uhvaly.nsf/(SearchForWeb)/805420EB34E-8E346C225822400533484?OpenDocument

Shpakivska, I. M. (2001). *The estimation of microbial stability in the plantation of Lviv city.* Proceedings of the Shevchenko Scientific Society. Ecological collection. Ecological problems of nature management and biodiversity of Lviv region, 7, 282–286. http://dspace.nbuv.gov.ua/bitstream/handle/123456789/73491/30-Shpakivska.pdf?sequence=1

State Committee of Construction, Architecture and Housing Policy of Ukraine (2001). *Instructions on technical inventory of green areas in cities and towns of Ukraine.* Official webportal of the Ukraine's Parliament. https://zakon.rada.gov.ua/laws/show/z0182-02#Text

State Committee of Ukraine for Urban Planning and Architecture (1992). *DBN 360-92 "Urban planning. Planning and construction of urban and rural settlements".* Official webportal of the Ukraine's Parliament. https://zakon.rada.gov.ua/rada/show/v0044481-92#Text

Stolberh, F. (2000). Urban ecology. Kyiv, Libra. 465 p. http://zoology.univer.kharkov.ua/lit/atemconserfaunalit/Stolberg-ecologia-goroda-2000.pdf

Tsaryk, L, &.Poznijak, I. (2016). On the problem of gardening and the role of the functioning park complex in Ternopil urboehkosistem. *Scientific Notes Ternopil V. Hnatyuk National Pedagogical University. Series: Geography,* 40(1), 263–270. http://surl.li/bdaee

Verkhovna Rada of Ukraine (2005). *On Settlement Improvement.* Official webportal of the Ukraine's Parliament. https://zakon.rada.gov.ua/laws/show/2807-15#Text

Verkhovna Rada of Ukraine (2014). *Association Agreement between the European Union and the European Atomic Energy Community and their member states, of the one part, and Ukraine, of the other part.* Official webportal of the Ukraine's Parliament https://zakon.rada.gov.ua/laws/show/984_011#Text

Zhuk, I. (2012). *Lychakivskyi park.* https://lia.lvivcenter.org/uk/objects/park-lychakivskyi/

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Research Article

Analysis of green infrastructure and nature-based solutions in Warsaw – selected aspects for planning urban space

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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. Green infrastructure, as a planned network of natural and semi-natural elements in cities, delivers a wide range of ecosystem services and improves urban environmental conditions. Planning the network of green infrastructure becomes a standard part of urban and spatial planning. Implementation strategies of green infrastructure in urban environment include applications of new specific elements and nature-based solutions. Green infrastructure research covers a wide range of topics. Our research focuses on the selected aspects of spatial analysis of green infrastructure in the city of Warsaw: distribution of main public green areas at the urban scale – forests and parks in the urban fabric, the forms of their protection, the use of linear elements of green infrastructure along communication routes, and the implementation of new elements of nature-based solutions in the urban environment – green roofs, green facades, and rain gardens. Based on the analysis of the studied selected aspects, recommendations were formulated for strengthening the interconnectivity of the green infrastructure system at an urban scale and implementation of new green infrastructure elements and in the intensively built-up districts where the number and size of green areas are insufficient.

Keywords: green infrastructure, urban planning, spatial analysis, nature-based solutions

1 Introduction

Strategies of the European Commission for planned network of natural and semi-natural elements and green infrastructure in cities aim to improve the environmental conditions in cities and thus the health and quality of life of citizens (European Commission, 2022). At the same time, it seems that not only the percentages of natural elements and their availability to the population are relevant, but also their interconnectedness to the landscape and rich species biodiversity.

A strategically planned network of green infrastructure can deliver a wide range of ecosystem services such as water purification, air quality, space for recreation, and climate mitigation and adaptation. Elements of green infrastructure have physical, psychological, emotional, and socio-economic benefits for individuals and society (Hudeková, Mederly & Tóth, 2018) and represent a holistic approach to connecting natural and green areas in the city.

So as for the human species, there was simply not enough time to adapt to an artificial urban environment and nature still represents a vital environment that can eliminate increased stress and mental health problems (Beatley, 2011; Kellert, 2018). The results of research at the interface of neurology, cognitive sciences, and environmental design have shown (Klichowski & Patricio, 2017) that the natural external environment significantly positively affects the cognitive functions of the human brain, in contrast to the artificial urban external environment. The quality of natural elements and green infrastructure thus represents a necessary factor for the satisfaction of the inhabitants and for the overall quality of the city (Joklová et.al, 2019; Noszczyk et al., 2022). Of particular importance is vegetation, which

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in addition to absorbing CO_2 also has other functions – microclimatic, environmental, recreational, social, and aesthetic. Greenery is understood as an effective measure to mitigate the effects of climate change, has a positive impact on public health. It is emphasized that green infrastructure elements in large cities, such as: green roofs, parks, and alleys, provide benefits for the health of the population, such as: clean air and better water quality, contribute to the protection of human health, save energy, and facilitate rainwater management. It is necessary to ensure that green infrastructure becomes a standard part of urban and spatial planning (Zachariasz, 2019; Pochodyła, Glińska-Lewczuk & Jaszczak, 2021).

Implementation of green infrastructure solutions is important especially in large urban agglomerations to alleviate accumulated environmental problems and mitigate heat island effects (Supuka, 2018; Tóth, Halajová & Halaj, 2015). As noted by Depietri (2022), urban green infrastructure is desirable to complement grey infrastructure in urban areas and synergistic outcomes result from the design and implementation of elements of urban green infrastructure. The implementation of urban green infrastructure represents a win-win solution for urban sustainability (Depietri, 2022; Derickson, Klein & Keeler, 2021).

For the planning of sustainable cities Ahern (2007) emphasizes that green infrastructure supports ecological and physical processes in the built environment including hydrology, bio-diversity, and also cultural-human activities. Green infrastructure is a concept that is closely tied to blue infrastructure and applies principles of landscape ecology to urban environments (Ahern, 2007).

According to Kováč (2018), the concept of greenery in cities should be an integral concept of the city's vision in strategic or master plan documents. The concepts of the green infrastructure are based on the morphological and climatic conditions of the city, the character of its urban structure and public spaces. Thus, each city has its own system of green infrastructure with different degrees of connectivity. The development of the system should be clearly defined in urban concepts at the level of the whole city as well as its individual parts (Kováč, 2018).

Our research focuses on the selected aspects of spatial analysis of green infrastructure in the city of Warsaw: distribution of main public green areas at the urban scale – forests and parks in the urban fabric, forms of their protection, the use of linear elements along routes, and the use of new nature-based solutions.

2 Material and methods

The main sources of data for the research of the spatial distribution of green infrastructure in the urban fabric of Warsaw were map materials, land-use planning documents, and field research. Based on data from satellite maps, selected elements of the green infrastructure in Warsaw were identified, and the data were supplemented and confronted by field research. During the field research, photographic material was also collected, documenting the individual typological groups of elements of green infrastructure. Specific attention was paid to the survey of forms of protection of green infrastructure, the survey of the spatial distribution of green areas in the urban structure and their connectivity. Attention was given also to the analysis of linear elements – plantings along communication routes. This analysis covered first and second-category routes. We also examined the implementation of current technical solutions of green infrastructure elements and nature-based solutions into the urban structure of the city – applications of green roofs or facades and rain gardens.

Maps showing the typology and spatial distribution of green infrastructure, forms of nature protection, forest areas and natural greenery, public parks, squares, greenery along communication routes as well as green roofs, walls, and rain gardens within the administrative boundaries of the city, were created and became the basis for analysis. Software technologies of computer-aided design systems (CAD software) and geographic information systems (GIS software) were used in the creation of maps. QGIS, a free open-source platform, supporting viewing, editing, and analysis of geospatial data, and 2D and 3D CAD programs (AutoCAD) were used to explore design ideas, visualize concepts and schemes simulating the green infrastructure spatial performance in the urban fabric.

3 Results and discussion

3.1 Analysis of distribution of green areas in urban fabric and their connectivity

Based on data collected during field research and analysis of satellite maps, the location of selected elements of the green infrastructure in Warsaw – the main green areas of forests and parks are depicted in Fig. 1.

The greater density of forests and natural areas occurs in the southern districts of Warsaw, less in the northern part of the city's administrative boundaries. These areas have the potential to form the so-called green belt around Warsaw. The discontinuity of the green belt occurs mainly in the vicinity of the main access roads to the city. An important corridor of green-blue infrastructure is

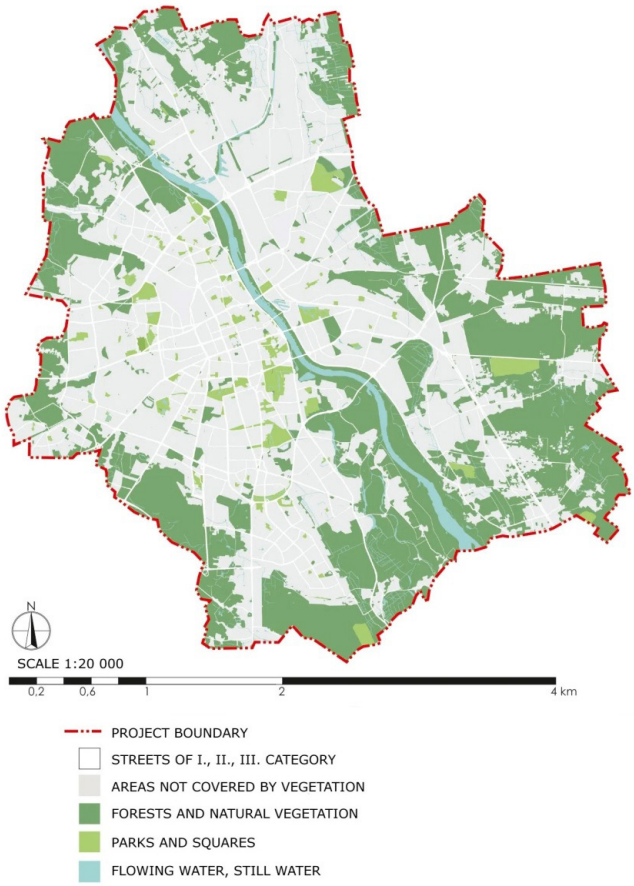

Figure 1 Distribution of green areas within the administrative boundaries of Warsaw
Source: Pochodyła, 2018

formed by the Vistula River and it connects the northern and southern parts of the city's green belt (Fig. 1).

The intensity of green areas also decreases significantly towards the city center, which is influenced by the densifying forms of built-up areas and urban development in the center.

In the central parts of the city, parks or green squares represent the main typological forms of green areas. The largest parks in Warsaw is Pole Mokotowskie (approx. 73 ha), Park Marszałka Edwarda Rydz-Śmiały (approx. 53 ha) and Park Skaryszewski (approx. 50 ha). Field observations have confirmed that the parks are considered attractive places for residents and tourists. They are often visited by users of all ages and are well maintained. In addition to the high vegetation and additional plantings, which improve the aesthetics of the places, water reservoirs can be seen in many parks, supporting the concept of connecting green and blue infrastructure (Pochodyła, 2018). The distribution and typology of the park areas vary considerably depending on the location in the city. The largest number of green squares as specific types of green spaces are in Śródmieście, in the center of Warsaw.

3.2 Forms of protection of green areas in Warsaw

The significant green areas in Warsaw are protected by various forms of protection, protected areas are located mainly on the northern and southern outskirts of the city (Fig. 2). Some forms of protection overlap, e.g. the Vistula Valley in Warsaw is established as a specially protected Natura 2000 site (Central Vistula Valley), the Warsaw Protected Landscape Area, and, additionally, it acts as an ecological corridor. In the north-western edge of the city there is a part of the protected zone of the Kampinos National Park, and in the south-eastern edge, the part of the Mazovia Landscape Park with a buffer zone. In addition to the central Vistula Valley, there are several special areas of Natura 2000 protection: Bielanski Forest, Natoliński Forest, Forest of Jan III. Sobieski and Rembertów test site. In addition, the following areas have been designated as nature reserves: Bielański Forest, Kabacki Forest, Natoliński Forest, Skarpa Ursynowska, Morysin, Czerniakowskie Lake, Zawadowskie Islands, Forest of Jan III. Sobieski, Olszynka Grochowska and Kawęczyn.

The protected green areas in Warszaw are shown in Fig. 2.

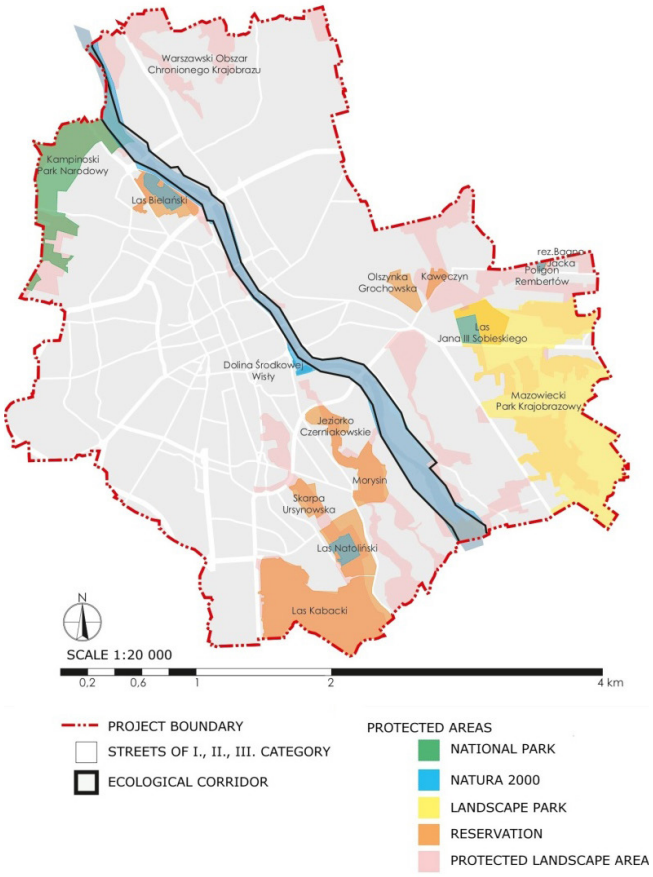

Figure 2 Forms of protection of green areas in Warsaw
Source: Pochodyła, 2018

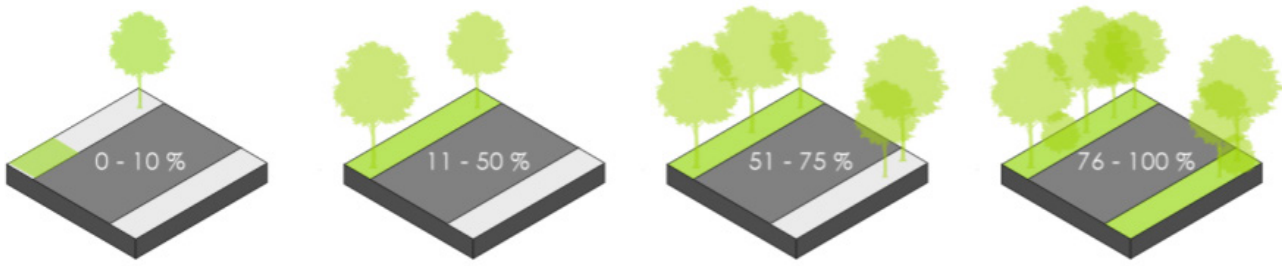

Figure 3 Planting intensity categories along communication routes
Source: Pochodyła, 2018

3.3 Linear elements of green infrastructure – plantings along communication routes

Other analyzed elements of green infrastructure were plantings along communication routes. The analysis covered first and second-class roads. According to the proportion of plantings in the relation to the length of roads, 4 categories were created for the purposes of analysis (Fig. 3).

These categories of planting intensity of the accompanying vegetation along road routes are shown in Fig. 4. Sequences of the communication routes where, in the relation to the total length of the road, plantings occupy 10–50% are marked in orange, sequences where plantings occupy 51–75% are marked in yellow, and sequences where plantings represent more than 75% are marked green. Fragments with a slight proportion of the vegetation (less than 10%) do not have a color-coding (Fig. 4). Roads with the smallest representation of accompanying vegetation are located mainly in the city center (for example Ulica Marszałkowska – Fig. 6), in the southeastern part of the city, and also along access roads from the southwest. More intensive plantings along the roads are found mainly in the southern districts of Warsaw (Fig. 4).

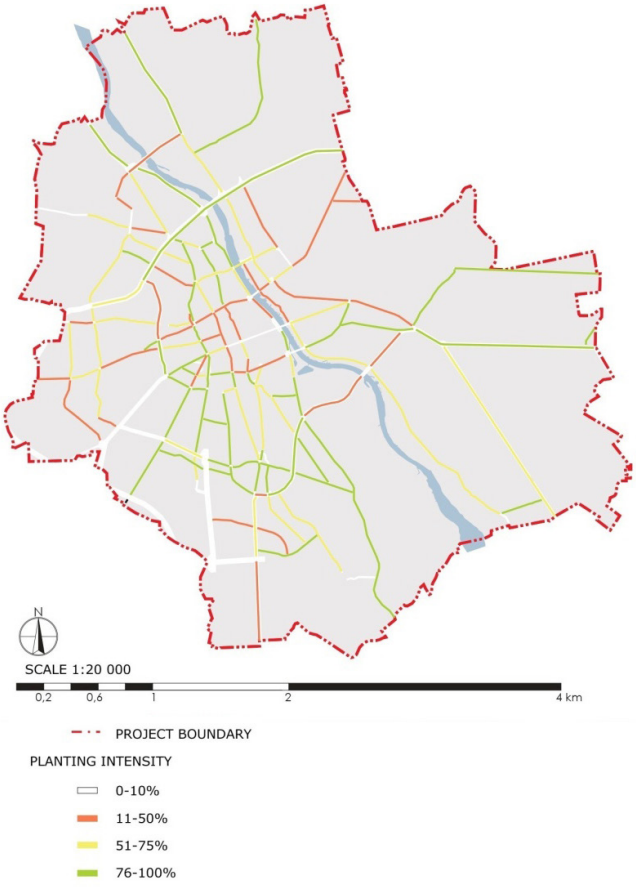

Figure 4 Categories of planting intensity of the accompanying vegetation along road routes
Source: Pochodyła, 2018

The most common forms of vegetation along Warsaw roads are strips of lawns or trees. Common species include *Tilia cordata*, *Acer platanoides*, *Acer negundo*, *Populus canescens*. Climbing plants, such as *Parthenocissus quinquefolia*, are sometimes used on noise barriers. Compositions of a low, medium, and high vegetation are less common. An interesting approach that fits into the idea of green infrastructure is the greening of tram lines, which can be seen in Warsaw, for example, on Anders Street (Fig. 6) or O. J. Popiełuszko Street (Fig. 5).

Figure 5 Green tram line along the Popiełuszko street
Source: Pochodyła, 2018

Figure 6 Examples of analyzed streets: Marszałkowska street without vegetation (left) and Anders street (right)
Source: Pochodyła, 2018

3.4 Current technological solutions, green roofs, facades and rain gardens

The use of current technological solutions was also analyzed, in applications of green roofs or facades and rain gardens. Based on the field research, 17 green roofs and 10 rain gardens were identified in Warsaw. These elements are located mainly in the central part of Warsaw. Roof gardens are located mainly on public buildings, such as the Copernicus Science Center and the University of Warsaw Library (Fig. 7). Among residential buildings, such solutions can be found, for example, in the Żoliborz Artystyczny housing estate. Green roofs are also popular in commercial buildings, e.g. C.H. Arkadia or Złote Tarasy.

The most popular green exterior wall is located on the street of I. Krasicki, or Koszykowa street. The rain gardens, which were implemented under the "Warsaw Catches Water" program, implemented by the Sendzimir Foundation 108, are located mainly at educational institutions.

The analysis of the existing elements of green infrastructure in Warsaw shows that the green infrastructure network is fragmented and dispersed. The number and size of green areas are insufficient, especially in the densely built-up urban fabric of the city center, in the adjacent neighboring districts, and in the northern part (Białołęka district). Urban development and urban densification lead to an increase in buildings and paved areas. Similar results are provided by Kuchcik et al. (2016) or Szulczewska, Giedych & Maksymiuk (2017). Kuchcik et al. (2016) report, that the ratio of biologically vital areas in older housing estates is 54.3% and in newer housing estates 40.7%. According to Szulczewska, Giedych & Maksymiuk (2017) forests cover 17% of the total city surface, and they are located mainly in urban peripheries, green spaces represented by parks, smaller pocket parks, allotment gardens, cemeteries, estate, and street greenery cover 8.8% of the city area and the distribution of green spaces in the urban fabric is uneven. Nevertheless, it should be noted that existing forest and park areas are extensive at the urban edge and the vegetation in these peri-urban areas is in good condition, having the potential to form a green belt around Warsaw. Along the communication routes, new plantings become introduced, specifically along tram lines.

Based on the analysis of the distribution of green areas in the urban fabric and their connectivity, linear elements of green infrastructure – plantings along communication routes and the use of current technological solutions, green roofs, facades, and rain gardens, the guidelines were formulated, which indicate recommendations for

Figure 7 Nature based solutions: green roof and rain garden at the Library of Warsaw University
Source: Pochodyła, 2018

implementation of new elements of green infrastructure and for management of existing resources:

- Uninterrupted continuity and interconnectivity of the green infrastructure system should be maintained or created.
- Efforts should be made to introduce new interconnecting elements of green infrastructure and to minimize the loss of greenery on the outskirts of the city (for example eco-ducts in the points of discontinuity of the green belt by the main access roads to the city).
- In areas with high natural and landscape value, recreational functions should be minimized and adapted to the capacity of the areas.
- Vegetation lanes should be introduced on bypasses, expressways, and along main roads within the Warsaw borders.
- Plantings along the communication routes should be intensified.
- Implementation of green infrastructure elements (planting and rain-water management solutions) at existing car parking areas.
- Implementation of specific green infrastructure elements in intensively built-up areas and new development areas (green walls, green roofs, and rain-water management solutions).

4 Conclusions

The research on green infrastructure and its relationship to patterns of the urban fabric is important for identifying its planning concepts at the multi-scale levels, from the whole city as well as to its individual parts. The analysis of selected aspects of the green infrastructure in the city of Warsaw showed 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 it is not possible to create other types of green spaces.

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References

Ahern, J. (2007). Green infrastructure for cities: the spatial dimension. In Novotny, V. & Brown, P. (Eds.). *Cities of the future: towards integrated sustainable water and landscape management.* IWA Publishing. https://people.umass.edu/jfa/pdf/Chapter17_Ahern2%20copy.pdf

Beatley, T. (2011). *Biophilic Cities: Integrating Nature into Urban Design and Planning.* Washington, D.C: Island Press.

Depietri, Y. (2022). Planning for urban green infrastructure: addressing tradeoffs and synergies. *Current Opinion in Environmental Sustainability,* 54, 101148. https://doi.org/10.1016/j.cosust.2021.12.001

Derickson, K., Klein, M., & Keeler, B. L. (2021). Reflections on crafting a policy

toolkit for equitable green infrastructure. *npj Urban Sustainability,* 1, 1–4. https://doi.org/10.1038/s42949-021-00014-0

European Commission (2022). Directorate-General for Environment. (n.d.). *The EU Strategy on Green Infrastructure.* https://ec.europa.eu/environment/nature/ecosystems/strategy/index_en.htm

Hudeková, Z., Mederly, P., & Tóth, A. (2018). *Green infrastructure. A guide not only for Municipalities.* City District Bratislava – Karlova Ves, 2018, 12. https://www.karlovaves.sk/wp-content/uploads/Zelena-infrastruktura-prirucka-nielen-pre-samospravy.pdf

Joklová, V., Djukic, A., Harmanescu, M., & Jančová, N. (2019). Conceptual approaches to environmental quality and livability in smaller cities. In Benko, M. Gregor, P., & Vitkova, L. (Eds.). *Book on the unexplored cultural heritage in communities by the Danube, DANUrB 2017–2019.* Praha, Czech Republic: Gasset, 104–111.

Kellert, S. R. (2018). *Nature by Design. The Practice of Biophilic Design*. Yale University Press, New Heaven, 3–224.

Klichowski, M., & Patricio, C. (2017). Does the human brain really like ICT tools and being outdoors? A brief overview of the cognitive neuroscience perspective of the CyberParks concept. *Enhancing Places through Technology – Proceedings from the ICiTy conference,* 223–239.

Kováč, B. (2018). Landscape in spatial planning in Slovakia. *Landscape in spatial planning in 21th Century: proceedings from the conference.* AUÚP Czech Republic, Mikulov 12.–13. 4. 2018. Brno: Institute of Territorial Development, 16–24.

Kuchcik, M., Dudek, W., Blazejczyk, K., Milewski, P., & Blazejczyk, A. (2016). Two Faces to the Greenery on Housing Estates – Mitigating Climate but Aggravating Allergy. A Warsaw Case Study. *Urban Forestry and Urban Greening*, 16, 170–181. http://dx.doi.org/10.1016/j.ufug.2016.02.012

Noszczyk, T., Gorzelany, J., Kukulska-Kozieł, A., & Hernik, J. (2022). The impact of the COVID-19 pandemic on the importance of urban green spaces to the public. *Land Use Policy*, 113, 105925. https://doi.org/10.1016/j.landusepol.2021.105925

Pochodyła, E. (2018). *Zielona infrastruktura – idee, programy, projekty. Współczesne rozwiązania w Warszawie.* Master thesis under Jaszczak A. supervision. Department of Landscape Architecture, University of Warmia and Mazury in Olsztyn.

Pochodyła, E., Glińska-Lewczuk, K., & Jaszczak, A. (2021). Blue-Green Infrastructure as a New Trend and an Effective Tool for Water Management in Urban Areas. *Landscape Online*, 92, 1–20. https://doi.org/10.3097/LO.202192

Supuka, J. (2018). Current Issues of Urban Settlements and Potential of their Solutions through Green Infrastructure. *Životné prostredie*, 52(1), 11–18. https://publikacie.uke.sav.sk/sites/default/files/2018_1_011_018_Supuka.pdf

Szulczewska, B., Giedych, R., & Maksymiuk, G. (2017). Can We Face the Challenge: How to Implement a Theoretical Concept of Green Infrastructure into Planning Practice? Warszaw Case Study. *Landscape Research,* 42(2), 176–194. https://doi.org/10.1080/01426397.2016.1240764

Tóth, A., Halajová, D., & Halaj, P. (2015). Green Infrastructure: A Strategic Tool for Climate Change Mitigation in Urban Environments. *Ecology and Safety*, 9, 132–138. https://www.scientific-publications.net/en/article/1000705/

Zachariasz, A. (2019). Development of the System of the Green Areas of Kraków from The Nineteenth Century to The Present, *IOP Conference Series: Materials Science and Engineering,* 471, 11, 2097. https://doi.org/10.1088/1757-899X/471/11/112097

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Research Article

Evidence of paucity of residential green spaces from the normalized difference vegetation index (NDVI) in Metropolitan Lagos, Nigeria

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A Biophillic city reconnects man with nature through green spaces which foster mental and physical productivity. The industrial revolution ushered in a wave of technological deterministic choices at the expense of environmental deterministic processes in the fashioning of cities. The background of this research is set in the urban residential fabric of the metropolitan city of Lagos. This study is relevant because in Lagos metropolis, residential areas have a land use zoning of 52% as opposed to 2.8% for urban open spaces. The research study aims to investigate the greenness index or NDVI of three selected residential estates each representative of the residential densities (low, medium, high) in metropolitan Lagos and its indications for the abundance or dearth of residential greenspaces. The sampling frame was gotten by multi-stage random sampling and the data collection tool used was high-resolution object-oriented imagery. The data analysis made use of geo-referencing ARCGIS and ERDAS IMAGINE software. The results show the Normalized Difference Vegetation index (NDVI) values of the residential estates are low (<0.2) thus revealing residential areas with negligible vegetation. In conclusion, the dearth of green spaces which are physical observed within the residential fabric of Lagos city on a ground truth basis have been substantiated by the results of this research. Therefore, it is important to consider actions to improve the greenness index of the city as well as ensure that peri-urban settlements which are rapidly developing in Lagos city do so in a sustainable manner based on green principles.

Keywords: biophilic city, residential estates, green spaces, city sustainability

1 Introduction

Buildings throughout history and in all regions of the world employ the healing effect of biophilia. Orr (1993) shows examples of how every building up until the Twentieth Century evinces biophilia's healing effect, although that may not be the only explanation for their success. From the onset of 20th Century, architecture abandons biophilia or uses it selectively, and even in those cases, not always successfully. Nevertheless, some buildings from the early 20th Century onward employ organic forms in a biophilic manner, and explicitly biophilic elements have been used in recent decades (Heerwagen, 2000). Evidence both from scientific sources and from traditional wisdom is giving rise to the need for a healthier environment. This principle in the built environment works through the reconnection of man with his surroundings through the application of the special geometry of nature to improve mental and physical enhancement. The resultant effect is the reduction of stress on the human mind and body, building his immunity to fight illness and to promote healing. This is seen in the greenness index of the living spaces where residents' dwell. For most of history, medicine took the environment seriously as a factor in health and healing. However, the industrial revolution brought increasing embracing of technological processes at the expense of environmental inclusion. Health care followed suite and focused largely on direct intervention via drugs, surgery, etc. This approach is now seen to have its set-backs. This is because salutogenicity a phenomenon that emphasizes healing environments has arisen in medical research. It proposes that a healing environment arises when human beings draw from the complexity of nature and conceive of themselves as in touch with their feelings and emotions. In plain terms, salutogenic environments are health inducing and improving environments. People are increasingly demanding such salutogenic environments that lower stress: living and working spaces that act to keep us

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healthy. Therefore, the introduction of green spaces into living environments as well as the preservation of green infrastructure in cityscape is necessary to achieve this order. It is hence sad to note that visibly there is a paucity of green spaces in developing cities in west Africa. Lagos is the largest city in West Africa and it is a trail blazer where several innovations are concerned. This research aims to reveal that there is a dearth of green spaces in residential metropolitan Lagos and proffers recommendations to abate this malaise.

1.1 The use of High-Resolution Satellite Imagery in Urban Open Space Research.

The classification of greyspace and greenspace units of residential private open spaces through visual interpretation and manual digitization has been done through large scale aerial photographs (Pauleit et al., 2003). The efficiency of this technique for detailed mapping, is hampered by its time-consuming and impractical nature in extracting data on private gardens (private open spaces) in medium or large size cities. Until recently, the spatial resolution of satellite sensors has been too coarse and largely low (e.g. 30 or 20 m for Landsat TM or SPOT) to be appropriate for application, given the small size of the average private garden (private open space). Image Interpretation can be defined as the art of analyzing photographs or images to extract useful information about image features and categorizing such features into meaningful classes (Image Classification). The last generation of high-resolution Earth Observation satellites, e.g. Ikonos or Quickbird, World view, provides images with a level of detail compatible with urban mapping i.e. from 4 to 2.5 m to even <1 m spatial resolution and can thus provide data at a level appropriate to garden analysis. In addition, multispectral sensors have the advantage, over color aerial photographs, of recording near infrared light which is the most sensitive spectral domain used to map vegetation canopy properties (Guyot,1990). Object-oriented techniques recognize that important meaningful information is not represented in single pixels but in image objects and their mutual relations, that is with reference to their context (Benz et al., 2004; Blaschke & Strobl, 2001). These techniques have demonstrated great potential to improve the automatic extraction of information from very high-resolution imagery (Benz et al., 2004; Laliberte et al., 2007). Software applications such as ERDAS imagine, ARCGIS, QGIS have been designed to analyze and interpret imagery data, generating classification groups such as bare land, vegetation and building structures and even process the Normalized Differentiated Vegetation Index (NDVI) of each of the selected residential estate. The NDVI, which is a combination of red and NIR reflectance measurements, is one of the most widely used vegetation indices in the world (Ramsey, Wright & McGinty, 2004, 2004) and it has been used extensively as an indicator of the state of vegetation over many spatial and temporal resolutions Abdollahi et al. (2008). It is based on the difference between the maximum absorption of radiation in the red spectral band and the maximum reflection of radiation in the near-infrared spectral bands. Values of the NDVI range between -1.0 and +1.0, but are usually positive for soil and vegetation. For bare soils alone, depending on composition and wetness, NDVI varies between 0.1 and 0.2, Glenn et al. (2008) They also reported that in remote sensing studies bare soil value scaled at 0, and 100% vegetation scaled at +1 to get fractional cover for a given pixel or area of interest in the scene. Denser and/or healthier vegetation will have higher values. NDVI values for vegetation usually offer a means of efficient and objective evaluation of phenological characteristics (Saino et al., 2004).

The index ranges from -1 to 1, with more positive values indicating greener, and thus more vegetation, in the pixel. It ranges from values -1 to +1. Very low values of NDVI (-0.1 and below) correspond to barren areas of rock, sand, or urban/built-up. Zero indicates no vegetation or water cover. Moderate values represent low density of vegetation (0.1 to 0.3), while high values indicate vegetation (0.6 to 0.8) (Takeuchi & Yasuoka, 2004).

The NDVI of each of the selected residential estate was calculated and processed to reveal the greenness index of the residential estates.

2 Materials and methods

2.1 Methods

The research employed mixed methods. Quantitative and Qualitative modes of inquiry adopted. The primary data was collected through reconnaissance surveys done in the four selected residential estates while the qualitative method which utilized the high-resolution, object-oriented satellite imagery and provided complementary data which was analyzed. The qualitative data collection was done with aid of recent satellite imagery of the selected estates after a reconnaissance survey was conducted to ascertain the coordinates of the selected residential estates. The data types and their respective sources are given in the Table below (Table 1). A noteworthy mention is given to the digital globe foundation (@digitalglobeFDN) who gave an educational imagery grant of different areas within metropolitan Lagos that covers the selected residential estates. This foundation partnered with hexagospatial.com to also provide the Erdas Imagine software for analyzing and

Table 1 Project Datasets

S/N	Segment	Data type	Source	Date of production
1	secondary data	digitized administrative map of Lagos State	LASG website	2017
2	primary data	worldview satellite imagery of 2016 with <1 m resolution	worldview	2017
3	secondary data	estates data	different LCDAS in Lagos state	2017
4	primary data	GPS coordinates of points within the study area	author's handheld GPS enabled device	2017
5	secondary data	questionnaire data	questionnaire survey	2017

Sources: LASG,2017; Digital globe foundation, 2017

Table 2 Imagery Data Information

6 images fit your filter criteria			Catalogue									Digital globe
Select	Browse image	Catalog id	Imaging bands	Space craft	Acquisition date	Total max off nadir angle (o)	Area max off nadir angle (o)	Area min sun elevation	Area max GSD (m)	Total cloud cover pct (%)	Area cloud cover pct (%)	MS Aggr
	view	10400100170D2A00	Pan-MS1-MS2	WW03	2016/01/25	22.0	22.0	57.64	0.35	0	0	N/A
	view	104001001A504500	Pan-MS1-MS2	WW03	2016/04/10	20.8	20.8	73.50	0.35	4	4	N/A
	view	103001004E6E5500	Pan-MS1-MS2	WW02	2015/12/08	26.7	26.7	55.18	0.57	0	0	N/A
	view	104001001CD61C00	Pan-MS1-MS2	WW03	2016/04/29	16.3	16.3	72.54	0.33	0	0	N/A
	view	1040010029D6CD00	Pan-MS1-MS2	WW03	2017/02/14	24.6	24.6	60.20	0.36	35	35	N/A
	view	10500100047B4C00	Pan-MS1	GE01	2016/05/21	18.4	18.4	63.90	0.45	3	3	N/A

Source: Digital globe foundation

classifying the imagery data as well as other tools such as the Greenness Index, Area analyzer and Incidence network as part of the educational grant.

The Software instrumentation used to analyze the imagery data include the following:

- ERDAS Imagine 2016: This was used in the pre-processing, processing, post-processing of the Worldview satellite imagery covering the study area.
- ArcGIS 10.2: This was used to extract the shapefile of the study area from the digitized administrative map of Lagos state and to perform various spatial analyses.
- Microsoft Office Suite (Excel, PowerPoint, Visio and Word): These were used to prepare reports, slides, and flowcharts and also to perform analysis of acquired data.
- FileZilla: This was used to download the High-resolution satellite imageries from the Digital Globe website.
- WinRAR 3.8: This was used to extract the Worldview imageries from the compressed downloaded file. The imagery datasets acquired were detailed in the Table 2.

2.2 Satellite Imageries

The image IDS were acquired through the application process for the education grant.

They are as follows:

- Imagery Datasets Details (Image IDs)
- 103001004E6E5500,104001001CD61C00
- 104001001A504500,10400100170D2A00
- 1040010029D6CD00,10500100047B4C00

Each area of interest (AOI) was mandated to exceed 5 km^2 per shape file, but must not exceed a total of 25 km^2 altogether. The imagery was provided courtesy Digital globe foundation as an educational grant which is the non-profit arm of the profit-making Digital Globe company. As an objective measure of overall greenness, we calculated the NDVI of the walkable neighborhood for each parcel. The NDVI is a remotely sensed spectral vegetation index derived from satellite mounted sensors and calculated in the equation below. The NDVI measures the amount of photosynthetically active light that is absorbed in each survey pixel, or its greenness, which varies with the absorption spectra of the objects in that pixel and the percentage of the pixel covered by each type of object. The index ranges from -1 to 1, with more positive values indicating greener, and thus more vegetation, in the pixel. The NDVI has a predictable linear relationship with net primary productivity – the energy accumulated by plants during photosynthesis – and has been related to bird reproductive success and morphology, and plant and animal diversity (Coops et al. 2014; Saino et al. 2004). Calculation of NDVI for giving pixel always results in a number that ranges from minus one (-1) to plus one (+1) however, no green leaves give a value close to zero. A zero means no vegetation and close to +1 (0.8 to 0.9) indicates the highest possible density of green leaves. The NDVI is the most common measurement used for measuring vegetation cover. It ranges from values -1 to +1. Very low values of NDVI (-0.1 and below) correspond to barren areas of rock, sand, or urban/built-up. Zero indicates the water cover. Moderate values represent low density of vegetation (0.1 to 0.3), while high values indicate vegetation (0.6 to 0.8) (Takeuchi & Yasuoka, 2004). The author used a dataset acquired from Worldview 2 and Worldview 3 (acquisition date between 2016-2017. The NDVI of each of the selected residential estate was calculated and processed to reveal the greenness index of each residential estate.

$$NDVI = [NIR - R]/[NIR + R] \quad (1)$$

where: NDVI – normalized difference vegetation index; NIR – near infra-red; *R* – red

When the vegetation has optimal health, it reflects more near infrared (NIR) – greenlight compared to other wavelengths but it absorbs more red and blue light. In other words, it is the process of quantifying vegetation by computing the difference between the near-infrared which vegetation strongly reflects and red light which vegetation absorbs.

3 Results and discussion

The High-resolution satellite imagery were classified using the supervised classification on the ERDAS IMAGINE 2016 software as elaborated in the research methodology. The results from the classified images show the areas where there is vegetation (greenspace) as denoted by the green areas, the red areas or yellow/gold in some cases show where there is bare land (greyspace) while the orange areas show where there are buildings. The green areas include patches of greenspaces in the residential private open spaces within the selected

Table 3 Results: normalized difference vegetation index (NDVI) (low density estates)

S/N	Name of residential estate (low density)	Normal difference vegetation index (NDVI) (mean value)
1	Parkview Estate (private)	0.068
2	Dolphin Estate (public)	0.031
3	Goshen Beach Estate (public)	0.013
4	Femi Okunnu Estate (public)	0.073

Table 4 NDVI result for Parkview Estate (private)

Minimum NDVI value	Maximum NDVI value	Median NDVI value	Mode NDVI value	Mean NDVI value	Standard deviation NDVI value
-0.1688	0.3424	0.0488	0.0349	0.0680	0.0610

Table 5 NDVI result for Dolphin Estate (public)

Minimum NDVI value	Maximum NDVI value	Median NDVI value	Mode NDVI value	Mean NDVI value	Standard deviation NDVI value
-0.0992	0.0325	0.0213	0.0213	0.0031	0.0400

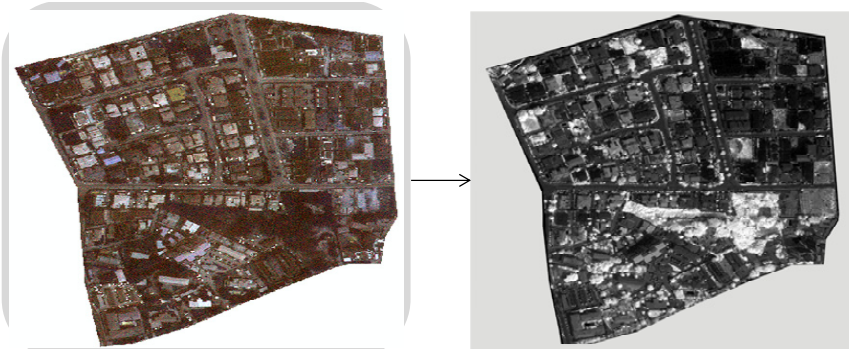

Figure 1 Imagery Classification image: Parkview Estate (private)

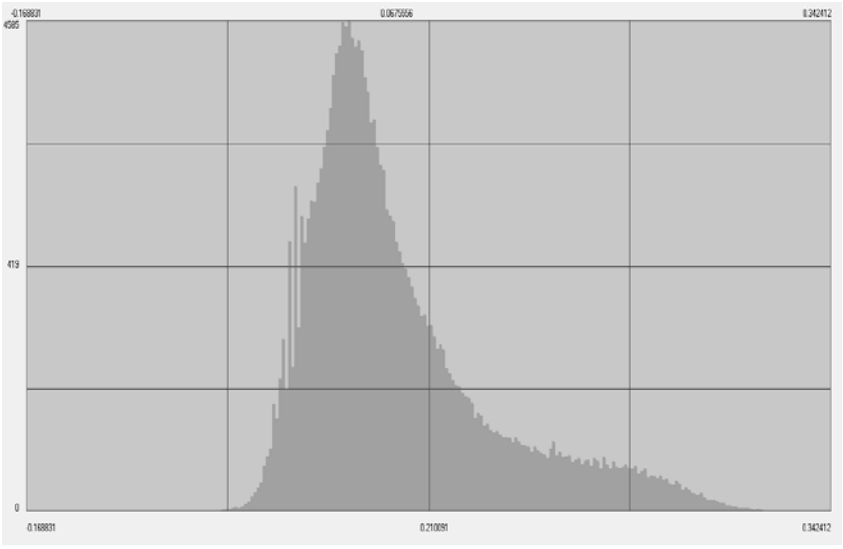

Figure 2 Histogram – (NDVI result: Parkview Estate (private)

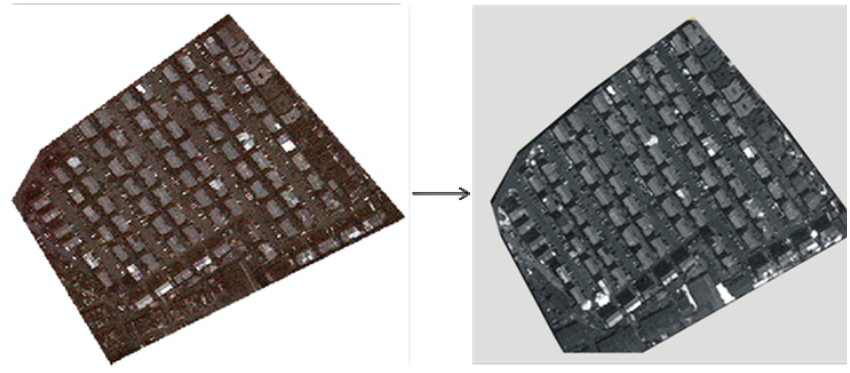

Figure 3 Imagery Classification image: Dolphin Estate (public)

residential estate as well as open land which is yet to be built upon. These are expressed in numerical signatures that show proportions of green, buildings and bare ground in the statistical table generated by the ERDAS IMAGINE software. The study reveals the Normalized Difference Vegetation Index (NDVI) in the selected residential estates. The NDVI is the most common measurement used for measuring vegetation cover. It ranges from values -1 to +1. Very low values of NDVI (-0.1 and below) correspond to barren areas of rock, sand, or urban/built-up. Zero indicates the water cover. Moderate values represent low density of vegetation (0.1 to 0.3), while high values indicate vegetation (0.6 to 0.8) (Takeuchi & Yasuoka, 2004). The NDVI was derived from the high-resolution object-oriented satellite imagery and was analyzed using the latest version of geospatial software ERDAS IMAGINE. The summary of the results and breakdown of the results are shown in the Tables 3, 4, 5, 6 and 7 below and a summary of all values in Table 8 below. Also, in Figs. 1–8, the images of the classified imageries are depicted below.

The summary of the normalized difference vegetation index (NDVI) is shown in the table 8.

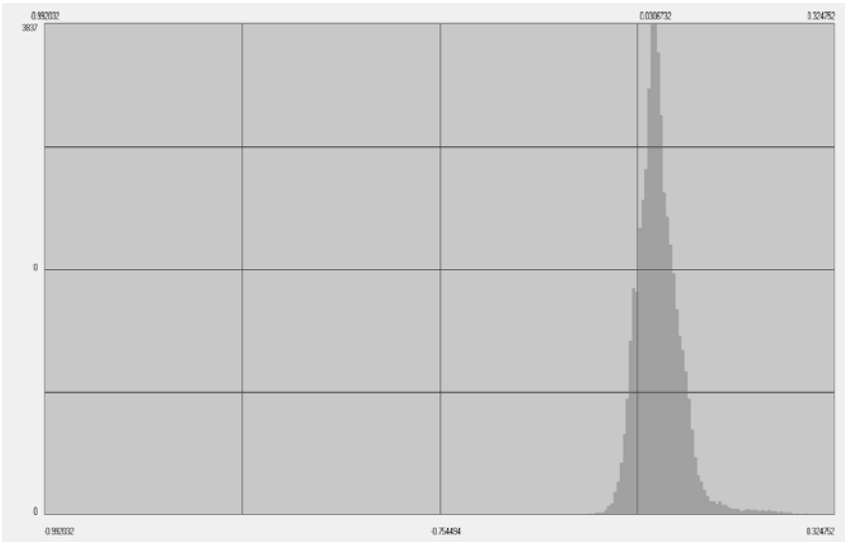

Figure 4 Histogram – (NDVI result: Dolphin Estate (public)

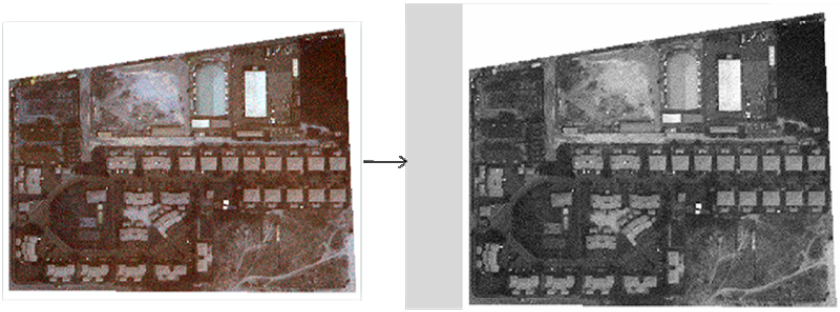

Figure 5 Imagery Classification image: Goshen Beach Estate (private)

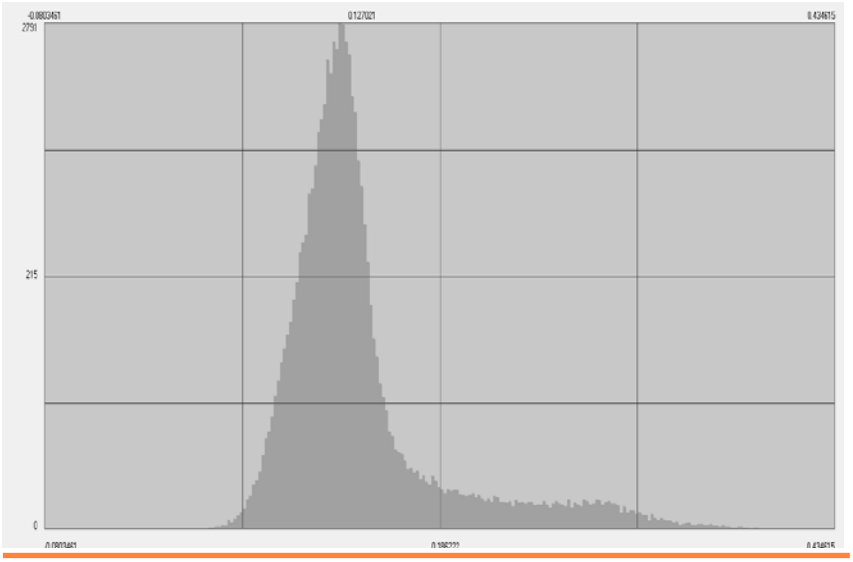

Figure 6 Histogram – (NDVI result: Goshen Beach Estate (private)

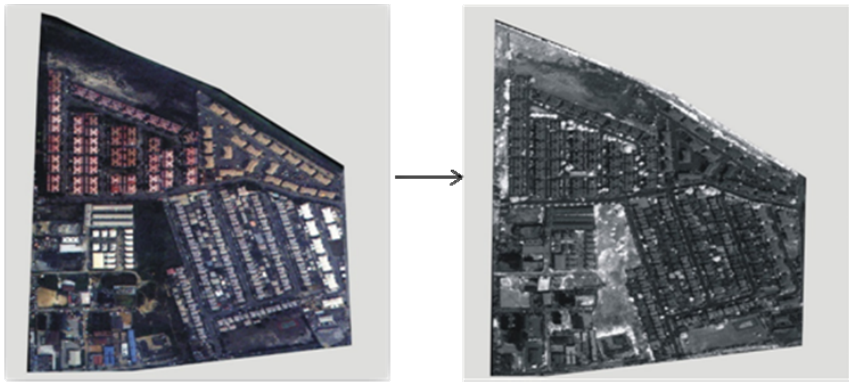

Figure 7 Imagery Classification image: Femi Okunnu Estate (public)

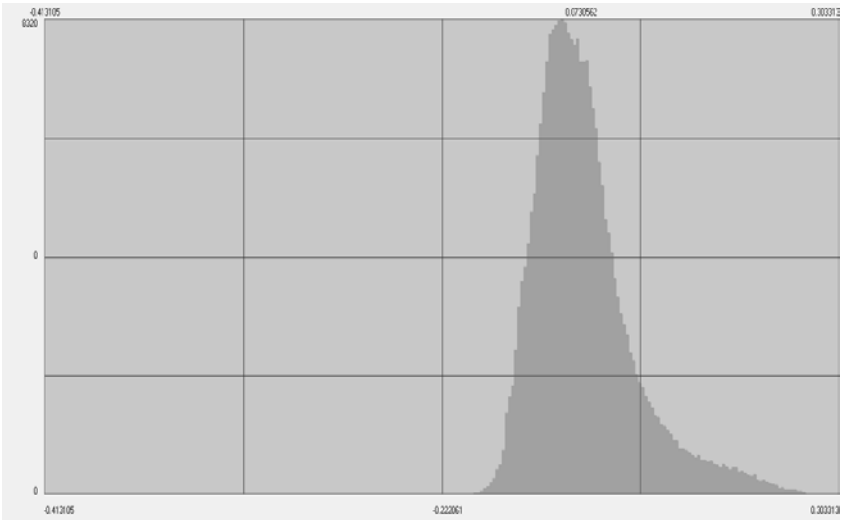

Figure 8 Histogram – (NDVI result: Femi Okunnu Estate (public)

Table 6 NDVI result for Goshen Beach Estate (private)

Minimum NDVI value	Maximum NDVI value	Median NDVI value	Mode NDVI value	Mean NDVI value	Standard deviation NDVI value
-0.0803	0.4346	0.1108	0.1107	0.0127	0.0560

Table 7 NDVI result for Femi Okunnu Estate (public)

Minimum NDVI value	Maximum NDVI value	Median NDVI value	Mode NDVI value	Mean NDVI value	Standard deviation NDVI value
-0.4131	0.3033	0.0626	0.0514	0.0730	0.0460

Table 8 Summary of the normalized difference vegetation index (NDVI) from each residential estate

NDVI result for Parkview Estate (private)

Minimum NDVI value	Maximum NDVI value	Median NDVI value	Mode NDVI value	Mean NDVI value	Standard deviation NDVI value
-0.1688	0.3424	0.0488	0.0349	0.0680	0.0610

Mean NDVI in parkview state (Private) was 0.07, Standard Deviation [SD] was 0.01 and the range was -0.16 to 0.34

NDVI result for Dolphin Estate (public)

Minimum NDVI value	Maximum NDVI value	Median NDVI value	Mode NDVI value	Mean NDVI value	Standard deviation NDVI value
-0.0992	0.0325	0.0213	0.0213	0.0031	0.0400

Mean NDVI in Dolphin Estate (Public) was 0.03, Standard Deviation [SD] was 0.04 and the range was -0.09 to 0.33

NDVI result for Goshen Beach Estate (private)

Minimum NDVI value	Maximum NDVI value	Median NDVI value	Mode NDVI value	Mean NDVI value	Standard deviation NDVI value
-0.0803	0.4346	0.1108	0.1107	0.0127	0.0560

Mean NDVI in Goshen Beach Estate (Private) was 0.01, Standard Deviation [SD] was 0.06 and the range was -0.08 to 0.43

NDVI result for Femi Okunnu Estate (public)

Minimum NDVI value	Maximum NDVI value	Median NDVI value	Mode NDVI value	Mean NDVI value	Standard deviation NDVI value
-0.4131	0.3033	0.0626	0.0514	0.0730	0.0460

Mean NDVI in Femi Okunnu Estate (Public) was 0.07, Standard Deviation [SD] was 0.04 and the range was -0.4 to 0.30

4 Conclusion

Built environment professionals; architects, landscape architects, urban designers, engineers and many others are instrumental in the creation of such environments on a local, regional and city scale. They can derive design ideas to help achieve this goal only by looking beyond mainstream conventional built environment practices, which buys into the same overly technological worldview and include the presence of living flora which is therapeutic and a key element of biophilic architecture. This would help to improve the greenscape of the residential areas. As a rapidly growing city, the mistakes that have been made in the metropolitan areas of the state can be corrected in the peri-urban areas which are also fast developing. This would forestall the rapid spiral of mass housing productions that have a dearth of green spaces and improve the greenness index of the city.

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References

Abdollahi, J., Bghestani. N., Savaghebi, M. H., & Rahimian, M. H. (2008). Determining vegetation cover percentage of arid regions using IRS and GIS (Case Study: Nadooshan Watershed). *Journal of Science and Technology of Agriculture and Natural Resources*, (44), 301–313.

Benz, U. C., Hofmann, P., Willhauck, G., Lingenfelder, I., & Heynen, M. (2004). Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information. *ISPRS Journal of photogrammetry and remote sensing*, 58(3–4), 239–258. https://doi.org/10.1016/j.isprsjprs.2003.10.002

Blaschke, T., & Strobl, J. (2001). What's wrong with pixels? Some recent developments interfacing remote sensing and GIS. *Zeitschrift für Geoinformationssysteme,* 12–17. www.courses.washington.edu/cfr530/GIS200106012.pdf

Coops, N. C., Fontana, F. M., Harvey, G. K., Nelson, T. A., & Wulder, M. A. (2014). Monitoring of a national-scale indirect indicator of biodiversity using a long time-series of remotely sensed imagery. *Canadian Journal of Remote Sensing,* 40(3), 179–191. https://doi.org/10.1080/07038992.2014.945826

Digital Globe Foundation (2017). Imagery Dataset information received as an education grant.

Glenn, E. P., Huete, A. R., Nagler, P. L., & Nelson, S. G. (2008). Relationship between remotely-sensed vegetation indices, canopy attributes and plant physiological processes: What vegetation indices can and cannot tell us about the landscape. *Sensors*, 8(4), 2136–2160. https://doi.org/10.3390/s8042136

Guyot, G. (1990). *Optical Properties of Vegetation Canopies.* In Applications of Remote Sensing in Agriculture, edited by M.D. Steven and J.A. Clark, pp.19–43. Butterworth, London.

Heerwagen, J. (2000). Green buildings, organizational success and occupant productivity. *Building Research & Information*, 28(5–6), 353–367. https://www.wbdg.org/files/pdfs/grn_bldgs_org_success.pdf

Laliberte, A. S., Rango, A., Herrick, J. E., Fredrickson, E. L., & Burkett, L. (2007). An object-based image analysis approach for determining fractional cover of senescent and green vegetation with digital plot photography. *Journal of Arid Environments,* 69(1), 1–14. https://doi:10.1016/j.jaridenv.2006.08.016

Orr, D. W. (1993). Love it or lose it: The coming biophilia revolution. St. R. Kellert and EO Wilson (Eds.). *The Biophilia Hypothesis*. Washington (Island Press) 1993, pp. 414–440.

Pauleit, S., Slinn, P., Handley, J., & Lindley, S. (2003). Promoting the natural green structure in towns and cities: the accessible natural greenspace standards model (ANGSt). *Journal of Built Environment*, 29(2), 157–171. https://doi.org/10.2148/benv.29.2.157.54469

Ramsey, R. D., Wright Jr, D. L., & McGinty, C. (2004). Evaluating the use of Landsat 30m Enhanced Thematic Mapper to monitor vegetation cover in shrub-steppe environments. *Geocarto international,* 19(2), 39–47. https://doi:10.1080/10106040408542305

Saino, N., Szép, T., Ambrosini, R., Romano, M., & Møller, A. P. (2004). Ecological conditions during winter affect sexual selection and breeding in a migratory bird. Proceedings of the Royal Society of London. *Series B: Biological Sciences,* 271(1540), 681–686. https://doi:10.1098/rspb.2003.2656

Takeuchi, W., & Yasuoka, Y. (2004). Development of normalized vegetation, soil and water indices derived from satellite remote sensing data. *Journal of the Japan society of photogrammetry and remote sensing,* 43(6), 7–19. https://doi.org/10.4287/jsprs.43.6_7

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Research Article

Non-adherence to the residential private open space to building footprint coverage regulations in Lagos state: a research-evidenced need for introspection

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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 cities in Nigeria. In metropolitan Lagos, a study of three selected medium density residential estates reveals a non-adherence to the building regulation for the private open space to building footprint coverage ratios in the residential estates. The research method used in this study is methodological triangulation employing both quantitative and qualitative methods. The sampling is based on multistage cluster sampling, and the data collection tools were high resolution satellite imagery, survey (through the administration of questionnaires). The results of the study reveal that in the medium density residential estates, a typical spatial pattern of the residential private open spaces from imagery classification data and ground truth data have ratios that indicate 70% of the Residential lot is for building footprint coverage while 30% is reserved for private open space as opposed to the specification by the Lagos state building regulation which specifies that 60% should be reserved for building footprint coverage and 40% for private open space. In conclusion, it is imperative that there be an introspection and a possible review of the Lagos state building regulation in the face of 21st century realities of the Lagos metropolitan population demands.

Keywords: residential private open spaces, non-adherence, building footprint coverage, building regulations

1 Introduction

The growth of cities in developing countries into healthy and safe cities is predicated upon their development guidelines and regulations and adherence or compliance to it. These include urban planning regulations at a city scale and building regulations at a landscape scale. These laws and regulations are purposely designed to regulate various development aspects that includes, zoning practices, private open space (POS) to building footprint coverage (BFC) ratios, greenspace to greyspace ratios, occupancy type building height and so on based on the peculiar needs of each city. The problem of rapid and unplanned rate of urban growth in Lagos state is a threat to its sustainable development. This unplanned or inadequately managed urban expansion leads to rapid sprawl, pollution, and environmental degradation and loss of Urban open spaces. It also encourages the non-adherence to the building regulations which were designed to provide ecosystem services, psychosocial services and health services to the residents of the city. Although residential areas have been researched upon, research from a landscape architecture perspective that enquires into the availability and role of private open spaces in residential areas is sparse in sub-Saharan Africa. In consequence, the results of this research will reveal information as well as inspire new thinking about residential private open spaces and the non- adherence to specified blueprints of the Lagos state building regulation. A summary of the aspects of the Lagos state building regulations that concern residential private open spaces are described in the Table 1.

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Table 1 Lagos state building regulation (spatial patterns summarized)

Use zone (residential density type)	Plot size (m^2)	Maximum building footprint coverage per plot (%)	Dwelling units per hectare (no)	Greenspace landscaping percentage per plot (%)
Low	1,000	50	30	20
Medium	864	60	90	10
High	648	70	270	10

Source: Lagos State Building Regulation. 2010. https://epp.lagosstate.gov.ng/regulations/REVISED_LASPPPA_REGULATION_2019_1.pdf

Table 2 Summary of LASG building regulation for spatial structure

Residential density	Private open space to building fooprint coverage (POS : BFC) Lagos State Government building regulation
Low density	50POS:50BFC
Medium density	40POS:60BFC
High density	30POS:70BFC

Greenspace: Greyspace (GRN: GRY) Ratio calculation in the Private Open Space.

Greenspace Permitted for Low Density: 20% Of the Residential Lot.

Private Open Space Permitted for Low Density: 50% Of the Residential Lot.(50POS:50BFC)

So Greenspace Takes 20/50 = 40 GRN: 60 GRY

Private Open Space Permitted for Medium Density: 40% Of the Residential Lot.(40POS:60BFC)

Green Space for Medium Density = 10/40 = 30 GRN: 70 GRY.

Private Open Space Permitted for Medium Density: 30% Of the Residential Lot.(30POS:70BFC)

Greenspace for High Density = 10/30 = 30GRN: 70 GRY.

A summary of the Lagos state building regulation spatial structure is hence described below in Table 2.

1.1 Adherence to building regulations in different cities of the world

Contemporary Building regulations address several issues from building layout to the building material standards and even the height of the building. Paris is one of the Cities where building regulations for Private open space to Building footprint coverage have been adhered to and the consequent positive impact has earned the city its status as one of the world's greatest capital worthies of emulation to many. This was achieved through the provision and strict adherence of land use regulations dated back to 1867 during the second empire. It is worthy of note that prior to this period, the city of Paris was famous for being the European capital of dirtiness and filth because of its sporadic growth and its characteristic network of narrow roads and streets, inadequate or absence of open spaces (Pasold, 2012). The George-Eugene Haussmann's sustainable planning philosophy brought an immense impact on the provision of building regulations that includes appropriate private open space to building footprint coverage ratios, meant to ensure safety, better lighting, and a healthy built environment and this led to the shift of Paris in the 19th century from dirtiest city to beautiful and healthy city. The city of Stockholm which is the capital city of Sweden is another example of planned city par excellence in Europe. Despite suffering eight fire outbreaks within a century, the primitive impetus to have a planned city ensured that the rebuilding of the city was planned in an orderly manner under the City Planner known as the" Conductor." As early as 1640, the Master Plan of the area, was adopted and land use regulations that made provision for adequate private open space to building footprint ratios that allow for firefighting machines as well as outdoor recreation, lighting and ventilation has improved the quality of the built environment and thereby making the city to what it is today (Pasold, 2012).

As a general guide in Australia according to (Australian Capital Territory (ACT), 2013), private open space should have a minimum area equal to half (50%) the total residential lot to which it relates (It is sometimes 60%). In other words, the acceptable Private open space to Building footprint coverage ratio for residential areas with single dwelling unit is 50 POS:50BFC (or 60POS:40BFC in some cases.) In other words, the acceptable Private open space to Building coverage footprint ratio for residential areas with single dwelling unit is 50POS:50BFC (or 60POS:40BFC in some cases.)

In the U.S.A. Building regulation began in the late 1800s when major cities began to adopt and enforce building

codes in response to large fires in densely populated urban areas. The scope of early building codes has broadened from the primary intent of reducing fire risk and have become sets of regulations that address structural integrity, fire resistance, safe exits, lighting, ventilation, and construction materials, private open space to building footprint coverage ratio and so on. They specify the minimum requirements to safeguard the health, safety, and general welfare of building occupants. The adherence level is high and several states have strict penalties to non-adherence. The International Code Council (ICC) publishes 15 models codes which are updated every three years through an open, consensus based process (ICC, 2021). The development and widespread adoption of building codes has created a uniform regulatory environment in which design professionals and contractors are held to a set of standards adopted by and applicable to the jurisdiction in which they work (ICC, 2015). Different states in the United States of America have differing residential open green space standards. However, the average percentage to be devoted to landscaping amounts to a minimum 15% of total lot area in residential developments, and 10% of the total lot area in non-residential developments, although they can be as much as 25% in some states. Also, the ratio of organic landscape materials (Greenspace) to inorganic landscape materials (grey space) is specified at an average of 70% to 30%. In the Hollywood Vehicular Use Area and Landscaping Regulation, Vehicular use areas of more than 15.24 m are to set aside 25% of the entire area for green space, while lots of less than 15.24 m are to set aside 15% of the entire lot for green space (Hollywood Community Redevelopment Agency (Hollywood CRA, 2007)).

In Japan, where earthquakes are far more common than they are in the United States, the building regulations are even more strict. After the Kobe earthquake in 1995, which killed about 6,000 people and injured 26,000, Japan has made a great endeavour to put enormous resources into new research on protecting structures, as well as retrofitting the country's older and more vulnerable structures. In Japan, depending on the Land Use Zone category the Building Coverage Ratio is regulated within 30% to 80%, and a building has to be constructed within the specified maximum Building Footprint Coverage Ratio in the zone (Ministry of Land, Infrastructure and Transport (MITT) Japan, 2013)

1.2 Adherence to building regulations in Nigerian cities

The history of Land use regulation in Nigeria is traced to the pre-colonial era when land was allocated and controlled by the traditional rulers. Oduwaye (2006a) stated that land-use administration in Nigeria was vested in natural rulers or community heads in different part of the community, prior to colonial administration or before 1854 (Oduwaye, 2006b). The traditional rulers are called Obas in the West, Emirs in the North and Obis in the Eastern part of Nigeria. They had the power to allocate, re-allocate and supervise land use. In 1946 the promulgation of Nigeria Town and Country Planning Ordinance made Provision for the planning improvement and development of different parts of the country. The post Nigerian independence period was a time when regional governments in Nigeria retained the 1946 Town and Country Planning Ordinance, however several states developed their own planning regulations, a good example of which is Lagos state that had its bye law in 1981 named "Lagos State Town and Country Planning Law", this bye law was adopted by other states of the federation. This Lagos state building regulation has guided development of building in several sections of Lagos such as Victoria Island, Apapa, and several planned part of Lagos, and has been revised periodically to reflect the needs of the rapidly growing metropolitan city and to improve the health and imageability of Lagos city (Oko, 2010). However, there is the problem of non-adherence to building regulation standards especially in cities in Nigeria which has also been observed in literature. Raji and Attah (2017) explored the level of non-adherence of building setbacks, and its resultant effects in Suleja, Niger State, Nigeria. Their research results identified several problems arising from non-compliance to building setbacks regulations, which includes, lack of outdoor spaces for parking vehicles and unsafe environment which they submitted all leads to a poor city growth. Onwuanyi and Ndinwa (2017) elucidated that in their research on residential areas in Benin city, Edo State, Nigeria, several landlords were seen to disregard the green (private open space) to built-up (building footprint coverage) area of their plot of land as specified by law and they built up almost every inch of their plot of land. This has also greatly impacted on the residential outdoor space (private open space) left for the residences (Onwuanyi & Ndinwa, 2017). Aluko (2011) highlighted the problems associated with development control as well as the level of compliance to building regulation space standards in Lagos metropolis, Nigeria based on the (Lagos State Urban and Regional Planning Development Law, 2010). He stated that the problem of development control in Lagos state is reflected in the non-compliance with the stipulated regulations for building development in the state and that these problems arise from a gradual deviation from master plan of Lagos and deregulatory authorities on development through distortion, alteration, and deviation from planning standards.

The main violators include both the public and private sectors aided by the inefficiency and indiscipline of regulatory officials as well as the compromises made by government agents in charge of development control. He enumerated that among the common contraventions are the encroachment on public rights of way and open spaces, the spring-up of buildings under high-tension lines with their roofs a few metres below the lines, the take-over of building set-backs by front shops. Also, the construction of buildings in violation of building approvals, General violation of Urban and Regional Planning Laws in Lagos State, corruption by enforcement officers and Construction of properties on public utility setback (Aluko, 2011).

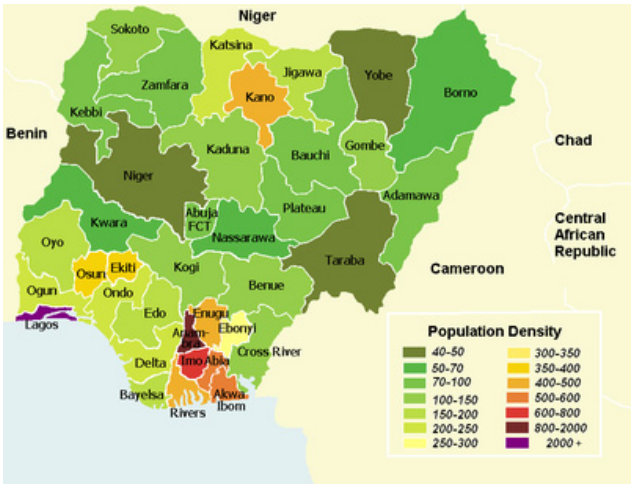

Figure 1 Map of Nigeria
Source: www.lagoslink.com

2 Materials and methods

2.1 Study area

Lagos was created in 1967 and served as the capital of Nigeria till 1991. It is located in the South-Western part of Nigeria. It has a coverage area of 3,350 sqkm. In terms of spatial development or growth, Lagos originated as a traditional settlement of close to 3.85 sqkm in about 1881 and has grown to over 1,183 sqkm in recent times. Expansion of Lagos was due to the growth of the colonial economy (Agbola & Agunbiade, 2009). Lagos State served as the seat of government between 1914 and 1992. In 1992, the Federal capital was moved to Abuja but that did not change the fact that Lagos has a more vibrant economy than Abuja due to its possession of the largest seaport and the most useful railway terminus. It is also a prominent seat of export and import out of and into the country. In the very heart of the state, lies the Lagos metropolis and it has the Atlantic seaboard as the southern boundary. It stretches 30 km long with its broad southern base along the Bight of Benin and it tapers northward and terminates at Agege at about 26 km. It is framed by longitudes 2° 42′ E and 3° 22′ E of the Greenwich Meridian and latitudes 6° 22′ N and 6° 42′ N of the equator. The metropolitan area comprises of sixteen out of the twenty Local Government Councils which make up the State. They include: Lagos Island, Eti-Osa, Lagos Mainland, Surulere, Ikeja, Ajeromilfelodun, Amuwo-Odofin, Alimosho, Apapa, Ojo, Somolu, Kosofe, Mushin, Oshodi-Isolo, Kosofe, Agege. Lagos metropolitan area is a low lying littoral body, with about 175 sqkm of built-up area of which residential areas occupy the single

Figure 2 Map of Lagos State
Source: www.lagoslink.com

largest proportion of 89.39 km² (51.9%), commercial 8.21 km² (4.8%), industrial, 14.44 km² (8.4%) institutional and special use 23.66 km² (13.7%), open spaces 4.53 km² (2.6%) and transportation 32.05 km² (18.6%) (Oduwaye, 2005). The metropolitan Lagos according to literature constitutes about 34% of the state. This accounted for close to 455 km² of the metropolis (Oduwaye, 2005). As a result of the fact that Lagos is the commercial nerve centre of the nation, there is an observable trend of migration into the city of Lagos. However, apart from being the smallest city in regard to landmass, and according to Lagos state statistics, the state accommodates or has the highest population (over 17.5 million) in the country and is regarded as the second fastest growing city in Africa. The residential areas are classified according to residential densities. The residential estates selected in this research fall under the medium density residential areas. The map of Nigeria, and map of Lagos state are shown in the Figs 1–2.

2.2 Research methods

The research methodology for this study is a methodological triangulation (also known as mixed methodology). Guba (1981) suggests that it is proper to select that paradigm whose assumptions are best met by phenomenon being investigated. Methodological Triangulation arose from an ethical need to confirm the validity of the processes and it can be achieved by using multiple sources of data (Yin, 2003). It is also used to compare data to decide if it corroborates (Creswell, 2003; Patton, 2002), and thus, to validate research results. The research philosophically leans towards postpositivistism and its focus on experimental and quantitative methods have been complemented to some extent by an interest in using qualitative methods to gather broader information outside of readily measured variables (Gephart,1999). The research design framework usually stems from the nature of the research problem and the mode of inquiry seeks to answer the research questions. This therefore influenced the choice of methodological triangulation this research and hence the Quantitative and Qualitative modes of inquiry adopted in tackling the research questions. The quantitative methods to reveal the existing private open space to building footprint coverage utilized survey data collection methods through the administration of questionnaires, however, qualitative methods utilized the high-resolution, object-oriented satellite imagery and provided complementary data which was analyzed, and this validated and complemented the data acquired through the quantitative methods.

Table 3 Summary of LGAS, LCDAS and their residential densities

Administrative division (admin-div)	No of L.G.As (admin-div) under Metropolitan Lagos	No of L.G.AS randomly selected in admin-div	L.G.As selected	L.C.D.AS subdivisions in Selected Lgas	No of L.C.D.As purposively selected	No of residential estates purposively selected	Residential densities
IKEJA	8	1	KOSOFE	3 1. Ikosi-Isheri 2. Kosofe 3. Agboyi-Ketu	1 Kosofe	1 Atunrase Estate	medium density
BADAGRY	3	1	AMUWO-ODOFIN	2 1. Oriade 2. Amuwo-odofin	1 Amuwo-odofin	2 Apple Estate Raji Rasaki Estate	medium density

Source: Fadera

Table 4 Name of residential estates and number of building units

Type of estate	Name of estate	Total number of building units. (sampling frame)	Sample size (questionnaire) confidence level 95% confidence interval 5	Number of questionnaires, administered	Number of questionnaires, returned
Public	Raji Rasaki, Amuwo	142	104	100	70
Private	Atunrase, Gbagada	105	83	85	64
Private	Apple Estate, Amuwo	95	76	80	64

Source: Fadera

Table 5 Residential estates and number of questionnaires administered

Estate name	Number of questionnaires returned	Percentage of return (%)
Private estate (Apple Estate)	64	80
Public estate (Raji Rasaki Estate)	70	70
Private estate (Atunrase Estate)	64	75
Total	198	Avg: 75

Source: Fadera

Table 6 Imagery data information

6 images fit your filter criteria					Catalogue							Digital globe
Select	Browse image	Catalog id	Imaging bands	Space craft	Acquisition date	Total max off nadir angle (o)	Area max off nadir angle (o)	Area min sun elevation	Area max GSD (m)	Total cloud cover pct (%)	Area cloud cover pct (%)	MS Aggr
	view	10400100170D2A00	Pan-MS1-MS2	WW03	2016/01/25	22.0	22.0	57.64	0.35	0	0	N/A
	view	104001001A504500	Pan-MS1-MS2	WW03	2016/04/10	20.8	20.8	73.50	0.35	4	4	N/A
	view	103001004E6E5500	Pan-MS1-MS2	WW02	2015/12/08	26.7	26.7	55.18	0.57	0	0	N/A
	view	104001001CD61C00	Pan-MS1-MS2	WW03	2016/04/29	16.3	16.3	72.54	0.33	0	0	N/A
	view	1040010029D6CD00	Pan-MS1-MS2	WW03	2017/02/14	24.6	24.6	60.20	0.36	35	35	N/A
	view	10500100047B4C00	Pan-MS1	GE01	2016/05/21	18.4	18.4	63.90	0.45	3	3	N/A

Source: Digital globe foundation, 2017

Three residential estates were selected from medium density residential areas and their private open space to building footprint coverage ratios were studied to reveal the level of adherence to the Lagos State Urban and Regional Planning and Development Law (2010). The Summary of Local Government Areas (LGAS), Local Council Development Areas (LCDAS) and their residential densities; the name of the residential estates and number of building units present in each estate; the number of building units sampled as well as the number of questionnaires distributed and returned are shown in the Table 3, 4 and 5.

The satellite imagery of the three residential estates was analyzed and the satellite imagery was retrieved courtesy of an educational grant by Digital globe foundation and is as revealed in the Table 6.

3 Results and discussion

The results from the ground truth data reveal that 97% of the residential lots in Apple Estate have a POS: BFC ratio of 30 POS:70 BFC while 3% of the residential lots have a POS: BFC ratio of 20 POS:80 BFC. This indicates that according to the ground truth data, the typical residential lot in Apple Estate has a POS: BFC ratio of 30 POS:70. The RESULTS of the imagery classification data reveal that 59% of the residential lots have a POS: BFC ratio of 30 POS:70 BFC while 20% of the residential lots have a POS: BFC ratio of 20 POS:80 BFC and 14% have a POS: BFC ratio of 50 POS:50 BFC. This indicates also according to the imagery classification data that the typical residential lot in Apple Estate has a POS: BFC ratio of 30 POS:70. In Atunrase Estate, the RESULTS of the ground truth data reveal that 73% of the residential lots have a POS: BFC ratio of 30 POS:70 BFC while 27% of the residential lots have a POS: BFC ratio of 20 POS:80 BFC. This indicates according to the ground truth data, that the typical residential lot in Atunrase Estate has a POS: BFC ratio of 30 POS:70. The RESULTS of the imagery classification data for Atunrase Estates reveals that 64% of the residential lots have a POS: BFC ratio of 20 POS:80 BFC while 36% of the residential lots have a POS: BFC ratio of 30 POS:70 BFC. This indicates also according to the imagery classification data that the typical residential

Table 7 Results from ground truth data (POS:BFC ratio) medium density estates

Name of residential estate	Ratio of private open space to building coverage (POS : BFC)							Total
Medium density estates	10 POS : 90 BFC	20 POS : 80 BFC	30 POS : 70 BFC	40 POS : 60 BFC	50 POS : 50 BFC	60 POS : 40 BFC	70 POS : 30 BFC	
Private estate (Apple Estate) frequency	0	2	62	0	0	0	0	64
Frequency (%)	0	3.1	96.9	0	0	0	0	100
Public estate (Raji Rasaki Estate) frequency	0	17	53	0	0	0	0	70
Frequency (%)	0	24.3	75.7	0	0	0	0	100
Private estate (Atunrase Estate) frequency	0	17	47	0	0	0	0	64
Frequency (%)	0	26.6	73.4	0	0	0	0	100
Average frequency (%)	0	18	82	0	0	0	0	100

Table 8 Results from imagery data (POS : BFC ratio) in medium density estates

Name of residential estate (medium density)	Ratio of private open space to building coverage foot print (POS : BFC) from imagery						Total
	10 POS : 90 BFC	20 POS : 80 BFC	30 POS : 70 BFC	40 POS : 60 BFC	50 POS : 50 BFC	60 POS : 40 BFC	
Private estate (Apple Estate) frequency	0	13	38	4	9	0	64
Frequency (%)	0	20.3	59.4	6.2	14.1	0	100
Public estate (Raji Rasaki Estate) frequency	0	11	59	0	0	0	70
Frequency (%)	0	15.7	84.3	0	0	0	100
Private estate (Atunrase Estate) frequency	0	41	23	0	0	0	64
Frequency (%)	0	64.1	35.9	0	0	0	100
Average frequency (%)	0	33.4	60S	2	4.6	0	100

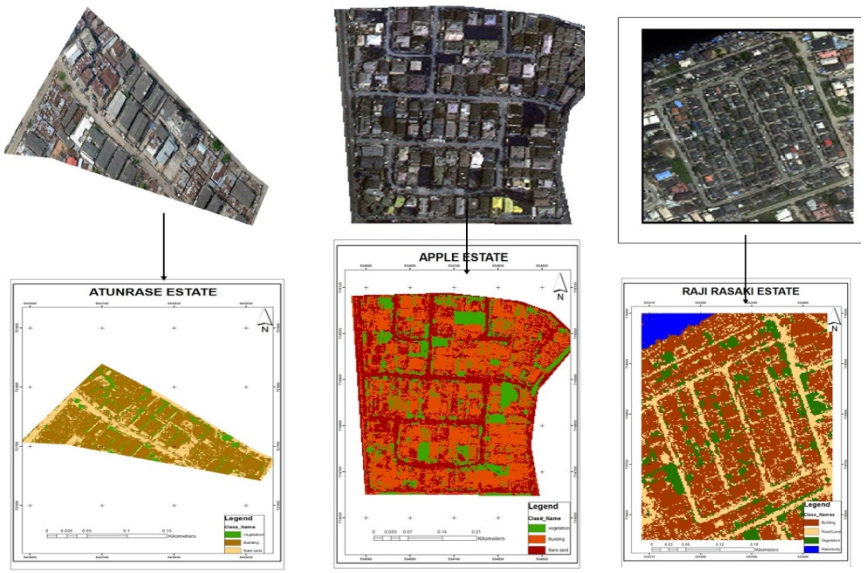

Figure 3 Aerial images of residential estates

lot in Atunrase Estate has a POS: BFC ratio of 20 POS:80. In Raji Rasaki Estate, the RESULTS of the ground truth data reveal that 76% of the residential lots have a POS: BFC ratio of 30 POS:70 BFC while 24% of the residential lots have a POS: BFC ratio of 20 POS:80 BFC. This indicates that the according to the ground truth data, a typical residential lot in Raji Rasaki Estate has a POS: BFC ratio of 30 POS:70. In Comparison, the RESULTS of the imagery classification data reveal that 16% of the residential lots have a POS: BFC ratio of 20 POS:80 BFC while 84% of the residential lots have a POS: BFC ratio of 30 POS:70 BFC. This indicates also according to the imagery classification data that

the typical residential lot in Raji Rasaki Estate has a POS: BFC ratio of 30 POS:70. This information is summarized in the Table 7. Also, the classified images of the selected residential estates are revealed in the figure following the table below.

The images from the results of the imagery classification shows green patches indicative of the greenness observed from viewing, the brown and orange coloured areas depict the built up areas of the residential estate concerned and this clearly shows that there is a dearth of green spaces in the build-up of these communities.

References

Agbola, T., & Agunbiade, E. M. (2009). Urbanization, Slum Development And Security Of Tenure: The Challenges Of Meeting Millennium Development Goal 7. In Metropolitan Lagos, Nigeria. In: De Sherbiniin, A., A. Rahman, A. Barbieri, J.C. Fotso, and Y. Zhu (eds.). *Urban Population-Environment Dynamics in the Developing World: Case Studies and Lessons Learned*, Committee for International Cooperation in National Research in Demography (CICRED), Paris. http://www.ciesin.org/repository/pern/papers/urban_pde_agbola_agunbiade.pdf

Aluko, O. (2011). Development Control in Lagos State: An Assessment of Public Compliance to Space Standards for Urban Development. *African Research Review*, 5(5), 169–184. https://DOI: 10.4314/afrrev.v5i5.14

Australian Capital Territory (ACT) (2013). *ACT Government Environment and sustainable development*. February 2013. Retrieved from www.environment.act.gov.au, https://www.planning.act.gov.au/__data/assets/pdf_file/0018/582201/ESDD_2012-13_Annual_Report.pdf

Creswell, J. W. (2003). *Research design: qualitative, quantitative, and mixed methods approaches.* Thousand Oaks, California, Sage Publications, 2003.

Digital Globe Foundation (2017). Imagery Data Information.

Gephart, R. (1999). Paradigms and research methods. [Online] Research Methods Forum, 4 (Summer), Retrieved October 3, 2009 from the Academy of Management website. http://division.aomonline.org/rm/1999_RMD_Forum_Paradigms_and_Research_Method s.ht

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal*, 29(2), 75–91. https://doi.org/10.1007/BF02766777

Hollywood CRA (2007). Hollywood Community Redevelopment Agency retrieved from http://www.hollywoodcra.org/DocumentCenter/Home/View/31

ICC (2015). International Code Council https://www.iccsafe.org/wpcontent/uploads/fact-sheet.pdf

ICC (2021). International Code Council https://global.iccsafe.org/international-codes-and standards

Lagos State Building Regulation (2010). https://epp.lagosstate.gov.ng/regulations/REVISED_LASPPPA_REGULATION_2019_1.pdf

Lagos State Urban and Regional Planning and Development Law (2010). www.estateintel.com/wp-content/uploads/2016/05/Lagos-Physical-Planning-Law-2010.compressed.pdf

Ministry of Land, Infrastructure and Transport (MITT) Japan (2013). Okasaki Atsuo Ministry of Land, Infrastructure, Tourism and Transport retrieved from https://www.mlit.go.jp/common/000162473.pdf

Oduwaye, L. (2005). Residential land values and their determinants in high density neighbourhoods of Metropolitan Lagos. *Institute of African Studies Research Review,* 21(2), 37–53. https://hdl.handle.net/10520/EJC45962

Oduwaye, L. (2006a). Citizenship Participation in Environmental Planning and Management in Nigeria: Suggestions. *Journal of Human Ecology*, 20(1), 43–48. https://doi.org/10.1080/09709274.2006.11905900

Oduwaye, L. (2006b). Effects of Globalization on Lagos Cityscape. *Research Review,* 22 (2), 37–54. https://hdl.handle.net/10520/EJC45984

Oko, J. O. (2010). Sustainable design, planning and policy considerations for the prevention of slum in emerging cities and megacities. *Paper presented at the Archibuilt Forum 2010, Abuja, Nigeria.*

Onwuanyi, N., & Ndinwa C. E. (2017). Remaking Nigeria's Urbanism: Assessing and Redressing the Dearth of Open Spaces in Benin City, Faculty of Built Environment, Universiti Teknologi Malaysia Website: http://www.ijbes.utm.my *IJBES,* 4(2), 121–130.

Pasold, L. (2012). February 6. Paris Buildings: A Brief History. Retrieved from https://parispropertygroup.com/blog/2012/paris-buildings-a-brief-history

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.) Thousand Oaks, CA: Sage Publications

Raji, A. U., & Attah, U. A. (2017). Enforcing Building Set Backs as a Viable Strategy for an Emerging City. *Traektoriâ Nauki = Path of Science*, 3(6), 2–1. http://dx.doi.org/10.22178/pos.23-2

Summary of LASG building regulation for spatial structure from Lagos State Urban and Regional Planning and Development Law, 2010. www.estateintel.com/wp-content/uploads/2016/05/Lagos-Physical-Planning-Law-2010.compressed.pdf

www.lagoslink.com

Yin, R. K. (2003). *Case study research: Design and methods* (3rd edition). Thousand Oaks: Sage Publications.

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Research Article

Revitalization and landscape design of the park in Stari Mikanovci, Croatia; role of existing vegetation in generating new landscape solutions

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In this paper, the procedures and indicators of systematic inventorisation and analysis of the existing vegetation of urban landscapes are presented and applied. The analysis of the vitality of existing trees was performed using the Visual Tree Assessment (VTA) method on the location of Park in Stari Mikanovci, Croatia. The results of these analyses were used as a basis for the protection and care of existing vegetation, but also their implementation in the design. For this purpose, four different conceptual solutions for the park design were formed. The process of generating different concepts tried to answer the questions: whether the maximum preservation of vegetation elements is a limiting factor in the creative phase of the design process, and whether consistent preservation of vegetation elements will generate similarities of design solutions. Four conceptual solutions were developed by four different authors who were given the same project task: (a) maximum possible preservation on the basis of analysis of the determined values of existing vegetation, and (b) uniform basic residential and recreational content of the park. All other components and features of the landscape are left as variable, arbitrary and author-determined parameters. Multi-criteria descriptive analysis of the proposed design solutions showed that the existing vegetation is not a limiting factor for the typology, diversity, disposition and degree of intervention in the creative phase of the design process.

Keywords: vegetation, analysis, valorisation, landscape solution, park

1 Introduction

Designing open urban areas, especially typical urban landscapes such as parks, is a common design task. Although it follows the established principles and procedures that make up the design methodology, certain segments of this process are insufficiently connected, emphasised, and presented within the final design. Although each project task declaratively includes inventorisation, analysis, and protection of existing features and elements of the landscape but especially natural elements, new design solutions often present in insufficiently clear ways to what extent existing plant valorisation is included in the design solutions. The focus is often on the description, presentation and visualisation of design, and less on systematic and clear indicators of the manner and degree of preservation of existing natural qualities. Also, simplified and unsystematic analysis of existing natural elements can lead to deterioration of natural qualities, unreasonable or premature removal of vegetation, as well as reckless design decisions that perceive existing vegetation and other natural elements as "obstacles" to new design or technical execution. In these cases, the justification for the removal of existing vegetation and other natural elements lies precisely in the insufficiently analysed or argued values of these components of the landscape. The focus of this paper is to connect inventory and landscape analysis with the generation of new design solutions. Emphasis is placed on the existing vegetation of the landscape.

The first part of the paper presents the procedures and indicators of systematic inventorisation and analysis of existing vegetation that precede the design of open

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space. Derived procedures and indicators were applied in the valorisation and analysis of a specific example – Stari Mikanovci Park, as a basis for protection and treatment of existing vegetation and generating guidelines for new landscape design of the park. In the second part of the paper, the possibilities of maximum implementation of previously derived data within the design process, i.e. designing a new park solution, are examined. In this sense, it was examined whether different design solutions can consistently preserve and implement all the values of existing vegetation without compromising the quality and diversity of newly designed solutions. It was also examined whether different types of landscapes, such as a park, beach or square, require different treatment of existing vegetation.

1.1 The role and value of vegetation in shaped landscapes

Vegetation elements, along with other elements in the landscape, are used to organise space, solve spatial problems, and achieve design goals (Colvin, 1990). The use of plants as formative elements is conditioned by natural laws, as well as visual and spatial phenomena of the urban environment (Dunnett & Hitchmough, 2004; Beck, 2013; Hirschfeld, 2001; DOE, 1996). At the same time, the use of vegetation elements varies greatly depending on man's intentions, needs or simply the attitude towards nature at a certain point in time (Doick et al., 2018). The many roles of vegetation in the city landscape can be divided in different ways. According to Pereković and Kamenečki (2016), they can be: (a) spatial-structural and functional roles, (b) perceptual and visual-aesthetic roles, (c) ecological and technical roles, and (d) "recovery" roles via impact on human health. Vegetation as a spatial – structural and functional element defines the basic spatial relationships and proportions in the landscape ("plants as a spatial phenomenon", "vegetation architecture"), as well as its purpose by encouraging or discouraging certain behaviours and uses of the landscape. Perceptual and visual – aesthetic roles of vegetation elements refer to the use of plants to achieve certain effects that we perceive with all our senses. The ecological role of vegetation elements is inherent in its vegetation (e.g. oxygen production, increase in air humidity, pollution absorption, etc.) but also in the needs of remediation or mitigation of certain spatial problems (e.g. slope stabilisation, wind protection, noise protection). Nowadays, the ecological roles of vegetation in dealing with climate change are especially relevant. Usually, all the mentioned roles of vegetation are taken simultaneously, in the earliest stages of the design process, since each local landscape has certain existing vegetation characteristics, and due to the fact that possible roles of vegetation elements are numerous and often interconnected. Acceptance and systematic analysis, as well as consistent implementation of the value of existing vegetation are one of the important tools for improving the landscape and the environment as a whole. Within inventory urban trees are usually categorised through their vitality and their ecological aspects, but their role in the shape of urban character is often left out. The results of the research on the role of individual trees in urban image (Nádasy, Sándor & Illyés, 2019) show that the trees with the highest ecological value are not the ones that do not influence the local community and their memory of space.

1.2 Characteristics and condition of the park Stari Mikanovci, Croatia

The park is located in the central part of the settlement, and it is an important point of gravity with its historical centre (Nesek Ltd., 2005) along with an archaeological site close by (Ministry of Culture and Media). The research area was chosen because it is the only public park in the settlement around which all municipal institutions and a church are positioned and it also represents the centre of all social events of the community. The central open area of the settlement does not have the characteristics of a recognizable and representative open urban space. Existing space content does not provide diverse and meaningful use for the local community and it does not promote environmental value. The park has the characteristics of a transit space that allows movement and easy access to public facilities, but not additional features that allow or encourage hold and stay. The total area of the park is 2,920 m^2, of which 1,539 m^2 are green areas and 1,318 m^2 are paved areas (Fig. 1). The park is bordered on three sides by roads, so there is a direct visual and physical connection which prevents quality use of space. The northern edge of the park is defined by the municipal building, which requires a dense network of communications in the northern part of the park. Currently, the park has only elementary uses – movement and use of benches. The composition of the park seems random and unrelated, which is due to the diverse materials, shapes and colours of the structural elements of the park upgraded through the decades of use. The basic spatial features of the park include a large proportion of tall trees with broad canopies that exceed almost the entire area of the park. The temporal trees of the park also make a kind of memory of the place. For these reasons, a detailed analysis of existing vegetation is envisaged as a prerequisite for future spatial intervention. The result of such an analysis is the vitality of the tree, conservation guidelines, determination of maintenance measures and guidelines, and the production of unambiguous data on

Figure 1 Park Stari Mikanovci, Croatia (2019)

the potential and limitations of the existing vegetation of the park.

2 Material and methods

2.1 Analysis of the roles, characteristics and vitality of vegetation

The assessment of the health status of existing trees in the park was performed using the Visual Tree Assessment (VTA) method, according to Mattheck and Breloer (1994). Use of the VTA method is not innovative but in Croatia it is used as a main approach in systematic inventorisation and its results are the main input in deciding which trees can be included in new design. This method is based on: (a) assessment of the vitality of the tree with regard to the condition of the canopy (dry branches, leaf dryness, discoloration, etc.), tissue injuries (trunk, roots, bark) and the presence of secondary pests (fungal diseases and insects) and (b) on the basis of symptoms of diseases and errors of wood determines the possibility of breaking or falling of the tree (mechanical aspect). In the analysis of existing vegetation, the degree of vitality of plants is divided into 3 categories (Table 1).

The results of the analysis of plant vitality are made with the aim of assessment and giving recommendations for further undertaking of appropriate interventions such

Table 1 Categorization of the degree of vitality of plants

Degree of vitality	Description
(1) healthy plants	– no damage is noticeable or minor damage is visible, which does not pose a danger to the survival of the individual without the application of appropriate care procedures
(2) damaged plants	– medium to severe damage is noticeable, which needs to be paid attention to and appropriate care procedures applied
(3) very damaged plants	– severe damage that requires urgent remediation or removal is noticeable, as it poses a danger to visitors, other plants in the park or property

Table 2 Categories of plant care for pruning

Pruning measures	Description
(1) cleaning and thinning the canopy	– removal of dry, diseased, dying or broken branches, removal of branches to increase light and air permeability and reduce the weight of branches, removal of climbers, etc.
(2) raising the canopy	– removal of lower branches that obstruct the passage of pedestrians or vehicles, branches that are too close to buildings
(3) canopy reduction	– removing part of the canopy or large branches if they exceed the desired size, too much interfere with the canopy of neighbouring trees, interfering with their photosynthesis or disturbing the surrounding facilities and infrastructure

as: 1) gradual removal of old trees 2) plant protection and 3) a maintenance plan for the park. The range of recommended interventions, which is made after the vitality analysis, is divided into two basic forms of interventions: (a) removal of plants or (b) maintenance measures/pruning. Pruning as a form of recommended care is categorised into three groups (Table 2). Following the implementation of these measures, further regular inspection of the tree is recommended at least once a year.

Assessment of plant health (vitality) and plant conservation guidelines in Stari Mikanovci Park were conducted on two occasions, in September and October 2019. During the field visit and assessment of the condition, each individual plant was numerically marked, cartographically documented (GIS) and photo-documented. Valorisation of each individual plant was carried out through a tabular presentation for each individual plant, which included: plant numbering, species determination; crown diameter (cm); canopy height (m); canopy tilt (>20%); root damage; canopy damage; bark damage; cavities in the trunk; fungi; infrastructure damage; vitality assessment; required procedure; other notes.

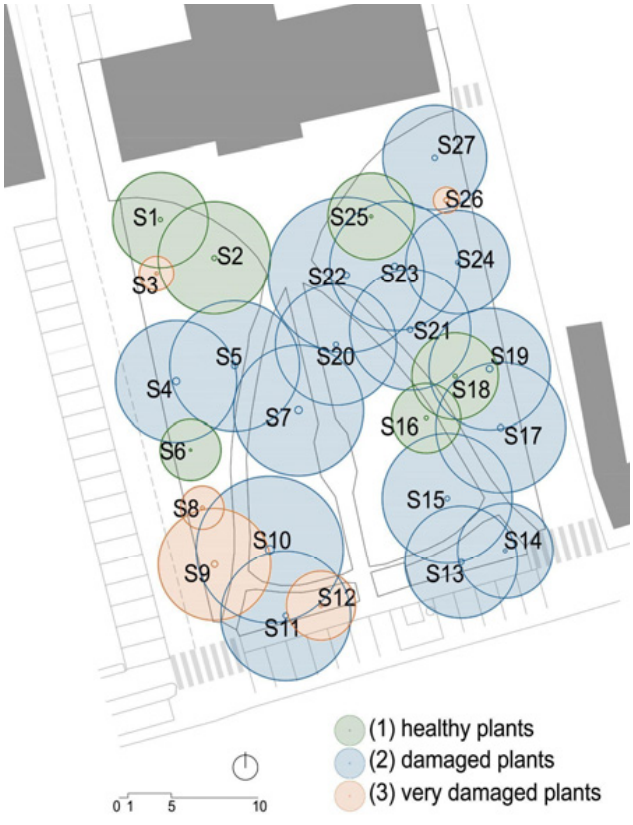

Figure 2 Inventarisation and analysis of existing vegetation, the degree of vitality of plants is shown in 3 categories

Plant health indicators (vitality) are described with detailed visual, spatial, structural, functional, and ecological characteristics of existing plants in the park: functional (e.g. shade, separation, protection from dust and/or noise, honey properties, edible species for humans and animals, etc.), visual and structural (e.g. accent role, visual protection, flowering properties, directional gaze, etc.), toxicity, allergenicity, and maintenance requirements (Franjić & Škvorc, 2010). The assessment of the condition of each individual plant is the result of an overall assessment based on all the above indicators, whereby existing plants are classified into several basic categories: 1) plants that has to be removed immediately; 2) plants that will be removed or replaced over period of time (plants that carry positive qualities but due to health conditions or other unfavourable conditions should be monitored and replaced or removed at a certain time); and 3) plants that require care and maintenance measures.

2.2 Development of conceptual solutions for the park

The project guidelines of the Park were derived from spatial and social inventories and analyses of space and inputs given by the municipality and local community. Based on the project guidelines, a conceptualization of variant solutions for the new design of the park was made. The usual landscape design of the park is made as a product of the process of designing urban landscapes (inventorisation and analysis of landscapes, defining the project program, making diagrams and conceptual sketches). However, the conceptualization of the solution is conditioned by the principle of preservation of all existing vegetation whose vitality is assessed, respecting the principles of protection and improvement of urban habitats, preservation of features and existing or potential functions of vegetation. The project guidelines included uniform elements (resting area, contemplation and relaxation space for municipal, cultural and educational events and other). Four conceptual designs were generated by four different authors (Kamenečki et al., 2020). Variable and distinctive features of the concepts were analysed by descriptive multi-criteria analysis and comparison of solutions according to given criteria: typology of open space (park – plaza – green square), the ratio of paved and green areas ("soft landscape" – "hard landscape"), defining the edge of the park immediate environment (open – closed), compositional basis (formal – informal), philosophy of solution (reinterpretation of historical symbols of the place – modern reinterpretation), the relationship of the open area and to the municipal buildings (separate units – integrated units) and disposition of basic contents (zoning). The given parameters were applied and tested

on four variant solutions that were developed and presented at the level of the conceptual landscape design.

3 Results and discussion

3.1 Results of analysis of plant characteristics and vitality

In the park Stari Mikanovci, three groups of vegetation have been singled out – trees, shrubs and perennials. General visual-spatial features indicate the dominance of trees that with vertical habitus, massive and horizontal dimensions of the canopy exceed almost the entire surface of the park (Fig. 2). Their lifespan also indicates the value of trees as bearers of the memory of a place. Detailed insight and analysis show the need to carry out the necessary arboricultural interventions, which were not carried out adequately and regularly in the past. Landscaping work on existing vegetation must be taken as protective measures in order to ensure safe and undisturbed communication and use of visitors, as well as the safety of the vehicles in traffic and those parked. Maintenance is necessary to establish a smooth development and balance of canopies between individual trees, most of which have reached their biological maturity and shape. If maintenance measures are not applied continuously, trees will begin to lose their vitality, and will become more susceptible to the harmful effects of biotic and abiotic factors. Trees of impaired vitality are more susceptible to attack by secondary pests; rot and insect fungi, which seriously impair mechanical stability and lead to drying of individual branches and the entire tree. Extreme and sudden climate changes such as those recorded in recent years can cause additional stress, death or major mechanical damage for the trees.

The results of the analysis point to the fact that most of the trees in the park are of good vitality, while impaired biological and mechanical condition occurred mainly as a result of poor planning of planting plan and irregular or

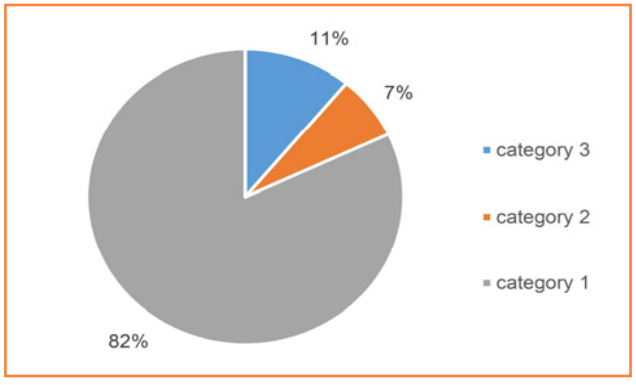

Figure 3 Distribution of trees by vitality category

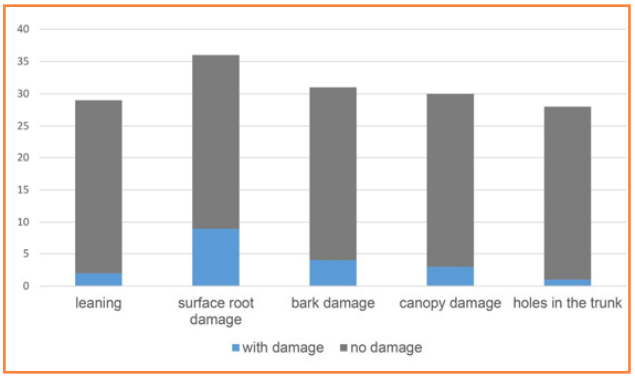

Figure 4 The amount of damaged trees according to the type of damage

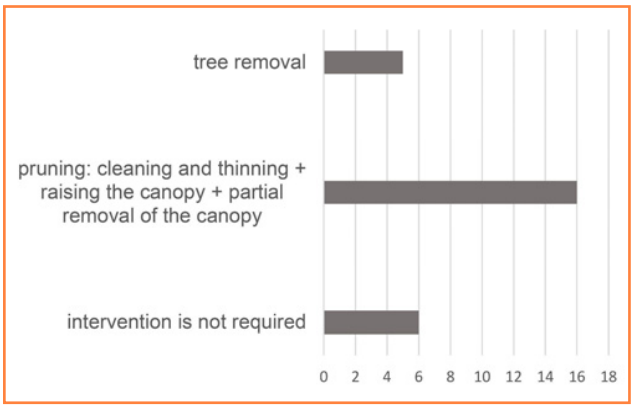

Figure 5 Number of trees on which certain arboricultural interventions need to be carried out

inadequate maintenance. Only five trees, out of 27, have weaker or significantly impaired vitality (Fig. 3).

Tree canopies are very large in diameter, which is often characteristic of trees in parks and urban areas. Average values of crown diameter range from 4 to 15 m. The widest crown is 18 m which is also the tallest tree in the park with a height of 24 m. Although average heights range from 9 to 21 m, more than a half of the trees reach heights above 20 m. Since the canopies are large in diameter, the competition for light conditions in the upper story is much more pronounced, which is manifested in the numerous interference of branches in adjacent canopies so the maintenance cost is increased by frequent cycles of trimming. The largest trunk diameter measured was 1.02 m.

The most common type of tree damage in the park is superficial root damage (Fig. 4). Most of these damages, as well as those on the bark, are quite common for trees that have lived in urban conditions for years and most often do not pose a great danger to plant life. Such damage usually calluses properly, so the rot of fungi is prevented from entering the interior of the trunk, which confirms the result that most of the trees in the park are still of good vitality. Trunk holes and trunk rot were

significantly observed in only one individual (S9). On two trees (S8 and S24) higher slope of the trunk is pronounced and could impair the static safety of the tree.

Some of the arboricultural interventions need to be carried out on 78% of the trees in the park, most often in the form of pruning, but in some cases also removal. Pruning in the form of canopy reduction is the most common form of intervention; removing part of the canopy or large branches if they exceed the desired size, or if they encroach too much on the canopy of neighbouring trees; interfering with photosynthesis or disturbing surrounding facilities and infrastructure (Fig. 5). When pruning in the form of reduction, raising or thinning of the canopy should be carried out in order to establish as symmetrical and as natural habitat as possible (Balder, Reuter & Semmler, 2010; Shigo 1991). Due to weakened physiological conditions, combined with impaired mechanical properties and due to the competition shortened survival prospects, it is recommended to remove a total of 5 individuals, one of them urgently, due to the risk of fracture.

3.2 Results of landscape design and analysis of conceptual solutions

The conceptualization of the park defined four designs that were based on the same project guidelines (Figs. 6 to 9). All design proposals have included the existing valuable vegetation (trees) defined by VTA method, valorisation, and analyses of the park area. The variability of the solution was achieved and analysed according to parameters: typology of open space, ratio of paved and green areas, definition of park edges, environmental aspects, composition/design basis, philosophy of solution, disposition of content, and relationship of open area and the building within the scope (municipal building).

Figure 6 Concept 1 – design basis

Figure 7 Concept 2 – design basis

Concept 1 "Geometric archaeology of place" (Fig. 6). The solution finds inspiration in the locality itself, connecting the existing morphology of space and trying to reinterpret it into a new set of values. The design proposal establishes a connection between the existing building and the rhythm of its porch with the natural rhythm of the existing vegetation. The concept introduces a regular grid that alternates paved zones with areas of ground cover and perennials. The concept opens and integrates the northern and southern surroundings of the park while closing the eastern and western edges.

Concept 2 "Superposition of grids" (Fig. 7). The proposed design generates its geometry from the need to organize and by evading the given existing geometry of the surrounding urban elements. The squares are formed by overlapping two regular square surfaces. The northern square is proposed for festivities and events, and the southern square provides a living area for everyday stay in the park. The entrance is placed in the same direction of the new geometry. The connection to the south-western

Figure 8 Concept 3 – design basis

Figure 9 Concept 4 – design basis

and south-eastern border of the park and immediate surroundings is established by the seemingly irregular geometry of higher and lower vegetation, and elongated rectangular surfaces of ground cover and shallow volumes of evergreen and aromatic plants.

Concept 3 "Symbolic expression" (Fig. 8). The design is derived from an archaeological find – a double vessel (jug) of the Vučedol culture, which is the basis of the artistic form of expression of the park itself. The memory of the existing communications has been preserved, and the central square-like space of the park has been created, which is further divided into irregular trapezoidal surfaces with planted perennials, ground cover and shrubs. Two larger residential zones and two sub-zones intended for events and residential activities have been established. The relationship to the park edge is completely uniform, a structure overgrown with climbers

Concept 4 "Abstraction of landscape elements" (Fig. 9). The design is a modern reinterpretation of the urban landscape in which a clear distinction is lost between the boundaries of individual functional elements: path, lawn, square, park. This design transfers the landscape pattern of the plain field by abstracting the wider environmental context into the park experience. The elongated surfaces with perennial plantations divide the space into fields and images of experience.

The comparison and analysis of the proposed design shows the diversity of design approaches. They are manifested through diverse typology of open space (square – park – beach – green square) as well as in a diverse spatial edge of the park (openness/closedness of the park edges according to the urban matrix of the settlement). Despite the dense distribution of high vegetation and maintaining all existing vegetation, the proposed designs achieved a very diverse open public area, as well as a ratio of green areas and paving (Table 3). All designs have successfully integrated the existing quality vegetation and are diverse in amount

Table 3 Comparison of concepts design

Conceptual proposal	Low vegetation area (km²)	Lawn area (m²)	Paved area (m²)	Type of open space
Concept 1	141	1,384	1,395	park
Concept 2	350	1,527	1,043	square
Concept 3	349	1,589	982	plaza
Concept 4	323	1,401	1,197	green square

of existing and newly planted trees but none of the solutions preserved the existing shrubs and perennials. The authors see the justification of this approach in the low vitality, poor maintenance but also due to the fact that the shrubs and groundcover have not been completely formed.

4 Conclusions

The results of this paper indicate that consistent conservation and implementation of existing vegetation should not be taken as a limiting factor to the creative phase of the design process. The density of preserved existing vegetation did not prove to be a limiting factor for the diversity of proposed design, the disposition of the content or the basic typology of space. It should be borne in mind that the value of individual trees can have a significant impact on the perception of the local community and their memory of place. For this reason, the inventorisation, valorisation and analysis of existing vegetation elements at the location should be systematic, detailed and comprehensive in the initial stages of project development. So, random and partial decisions on the removal of existing vegetation can greatly miss the meaning, goals and potentials of design. This paper showed that using a single method such as VTA can be deficient in solving the problems that are desired or can be achieved in the urban landscape, so it is advisory to use holistic approach.

References

Balder, H., Reuter, A. & Semmler, R. (2010). Handbuch zur Baumkontrolle. Patzer.

Beck, T. (2013). Principles of Ecological Landscape Design (1st ed). Island Press. https://doi.org/10.5822/978-1-61091-199-3

Colvin, B. (1990). *Landscape Design with Plants* (2nd ed). Elsevier Ltd. https://doi.org/10.1016/B978-0-434-90234-7.50006-9

DOE (Department of the Environment, Great Britain)(1996). *Greening the city – A Guide to good practice.* The Stationary Office, London.

Doick, K. J., Neilan, C., Jones,G., Allison, A., McDermott, I., Tipping, A., & Haw, R. (2018). CAVAT (Capital Asset Value for Amenity Trees): valuing amenity trees as public assets. *Arboricultural Journal*, 40(2), 67–91. https://doi.org/10.1080/03071375.2018.1454077

Dunnett, N., & Hitchmough, J. (2004). *The Dynamic Landscape: Introduction to Naturalistic Planting in Urban Landscapes* (1st ed). Taylor & Francis. https://doi.org/10.4324/9780203402870

Franjić, J., & Škvorc, Ž. (2010). *Šumsko drveće i grmlje Hrvatske* (1st ed). Sveučilište u Zagrebu – Šumarski fakultet.

Hirschfeld. C. C. L. (2001). *Theory of Garden Art*. Edt. Kinda, B. Parshall. University of Pensilvania Press. Philadelphia

Kamenečki, M., Mudronja Pletenac, A., Miholić, H., Krstonošić, D., & Pereković, P. (2020). *Detailed design of landscape architecture of the Park Stari Mikanovci.* Mapa 1; TD BP 18/2020.

Mattheck, C., & Breloer, H. (1994). *The Body Language of Trees: A Handbook for Failure Analysis,* TSO, London, p. 240.

Ministry of Culture and Media. *Register of Cultural Heritage of the Republic of Croatia*. https://min-kulture.gov.hr/izdvojeno/kulturna-bastina/registar-kulturnih-dobara-16371/16371

Nádasy, L. Z., Sándor, G., & Illyés, Z. (2019). The Role of Individual Trees in the Protection of Urban Image. *Proceedings of the Fábos Conference on Landscape and Greenway Planning*, 6(1), 1–28. https://doi.org/10.7275/0x5r-e822

Nesek Ltd. (2005). *Spatial plan of the Municipality of Stari Mikanovci.* Available online: https://www.mikanovci.hr/download/prostorni-plan-uredenja-opcine-stari-mikanovci-travanj-2005/

Pereković, P. & Kamenečki, M. (2016). Krajobrazno oblikovanje i vegetacija u urbanim sredinama. *Korak u prostor,* 1(53), 56–59.

Shigo, A. (1991). *Modern Arboriculture: A system Approach to the care of trees and their associates.* Durham

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Research Article

Green infrastructure and planning procedures – experience of creating an unofficial network of green spaces as an NGO

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Article focuses on recognizing valuable green spaces and strategic positioning of new green infrastructure elements in space from the perspecitve of a non-governmental organization. It questions the limitations, roles, and possibilities of non-governmental organizations (NGO's) in the establishment of publicly accessible and environmentally significant areas in the urban matrix. The article considers personal experiences in the implementation of such projects, their influence on the daily livelihood of citizens and how an NGO can contribute bypassing current absence of legal basis for its implementation. The methods presented in the paper are described as informative guidelines and are not scientifically backed, although they do rely on scientific knowledge of the members of NGO and previously tried methods of earlier finds. This work represents a factual outcome of actions delivered by the NGO ZIPS (Zelene i plave Sesvete) and do not have to be replicative on other showcase examples, considering their legal, cultural, and other backgrounds.

Keywords: green infrastructure, strategic planning, NGO, tree planting, public participation

1 Introduction

Creation of resilient landscapes and connecting them into a continuous and uniterrupted grid might be one of the best low-tech solutions for our adaptation to climate extremes. As individuals, people might not have the ability to act on a global scale, but they can most certainly try to improve the microclimactic conditions in the area of our living, such as preventing the creation of heat islands.

Article will primarily focus on the quad helix approach, since it has been the basis of defining relations among various stakeholders throughout many of the projects conducted by the NGO ZIPS and suits as a proper frame in the transfer of knowledge. It imposes as a starting point for presenting achievements done by the NGO in the spatial implementation of green infrastructure elements such as: recognizing key stakeholders and devising an appropriate approach in the realization of downright communication; envisioning the level of expected involvement in decision-making and co-designing; reaching decisions on the spatial location of the solutions and the reach of their influence.

To put the local level in perspective, it is important to gradually descend from a global context so this article will primarily focus on societal perspective of the issue.

1.1 Conditions and course

Society is made up from many interest groups, all acting at the same time and have rather different views on development. This is a condition in which finding a solution for anything is never easy, especially with a problem as comprehensive as climate change. European union and its member states are decisively steering the development of the continent towards a more sustainable future and, by doing so, is continuosly seeking for solutions that are applicable on various scales. At this point in time, European Union (EU) is leading in the creation of directives and programs of immeasurable importance on a global scale. Although often criticized in literature, one such comprehensive document is the European Green Deal the European Council, The Council, The European Economic and Social Committee and The Committee of The Regions the European Green Deal (2021).

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Among other, it implements green infrastructure (finding its roots in the landscape architecture) as one of the best tools for climate change mitigation (Barcelona City Council, 2013), emphasising the importance of proper rainwater managment (European Parliament and European Council, 2003).

EU has strategies and regulations regarding sustainable development, involvement of the citizens (UN, 1998) and mitigation of ecological problems (European Commission, European Environment Agency, 2021). However, what the EU sometimes lacks is the pace of action and implementation. That is most certainly result of a cautious democratic decission-making among 27 of its member states, many of its various referential organizations and desire for a wide public participation. If we are to nourish our democratic values in the future and respect all the given processes, it will certainly have implications on appropriate reactions towards our changing environment. By saying so, it is not the intention to promote non-democratic decission-making (because the past has taught us many times that totalitarian systems can bring even greater environmental disasters) but to point out that we should find other fields in which we can allow greater freedom of quicker decission-making and implementation of solutions that haven't necessarily been peer-reviewed or examined before. Such are different stakeholders in our society, among which NGO's stand out in particular (European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions Green Infrastructure (Gi), 2013).

2 Material and methods

At the end of 2021, pushed by the public, Croatian government adopted a Program for the development of green infrastructure in urban areas for the period 2021 to 2030, with the aim of establishing sustainable, resilient, safe, comfortable and orderly cities and municipalities in the Republic of Croatia (Republika Hrvatska, Ministarstvo prostornoga uređenja, graditeljstva i državne imovine, 2021). What is concerning about the given situation is the pace of the implementation of the given program, since it was first developed in 2019 and not many cities have adopted plans for green infrastructure. In parallel, multiple European cities have had green infrastructure plans on the disposal for decades (Amati, 2008; Barcelona City Council, 2013; Vienna City Administration, 2015).

Being aware that the climate change is inevitably coming, NGO commited to adaptive strategies – building green infrastructure before the valorisation and ratification through plans on the decision-making level. However, powers of the NGO are limited, so its position is to lobby, point out problems, promote, dissiminate or co-design space. Final decissions, regarding planning and decission-making, are always made by democratically elected representatives that do not have to necessarily share one's points of view.

People act by an example or by models. If something is proven to be feasible or popular, people will gladly copy it over time – be it political parties and firms in their campaigns or average citizens in their private gardens. That is the main reason why the NGO pursues projects that directly change the physical environment, wanting to create a showcase. These types of projects have far-reaching implications in the future and can accelerate shifts in planning trends. Greater freedom in decission-making (or rather not being bureaucraticly limited) and finding peculiar site-suitable solutions is one of the main advantages of NGOs, as well as the ability of a quick reaction – recognizing the moment and appropriately acting. Most of the time it is brought down to "catching curves" with a continuos agenda as a common driver, since there is no single solution for all of the problems.

Therefore, through time NGO prepared program or a strategic approach for different acting levels, as follows.

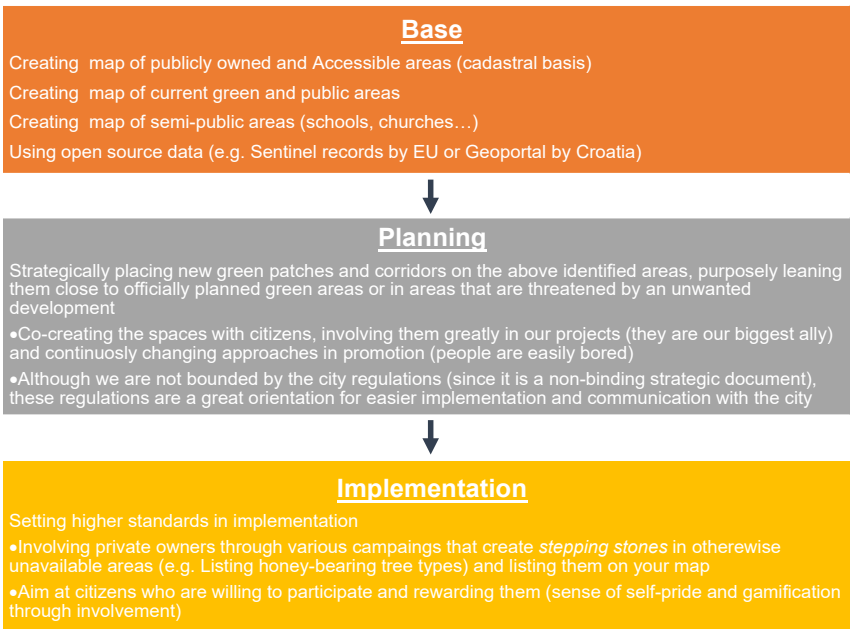

Figure 1 Graph of steps

2.1 Strategic approach to spatial development

Since the point of this article was to summarize the methods and activities of our NGO in the tendencies to accomplish a program for the implementation of a plan for green infrastructure, it is important to list some of the steps in order to carry out goals, as shown in the Fig. 1.

3 Results and discussion

As a result, in the sense of strategical planning of green infrastructure, by implementing regreening projects so far, a central triangle of publicly available spaces in the central part of Sesvete was created, overall spanning estimated 9 ha of land. Most of this space was planted with native trees and shrubs in a conventional way (no understory or solutions based on beneficial relations between the plants and its surroundings). Around 0.5 ha was realized as a therapy garden, financed through the ProGIreg project. It contributes to the welfare of the citizens and natural environment. Most of these projects were developed in otherwise marginalized areas that lack public services and are considered ghettoized (fallen industries and low social status).

3.1 Collaboration with the institutions of local, national and international significance

During last five years the NGO managed to establish partnership with the Department of Ornamental Plants, Landscape Architecture and Garden Art, and thus carried out three partner projects on the EU level: LE: Notre Landscape Forum 2019, Learning Landscapes (Fig. 2) and ReGreen Croatia – all co-funded by the Erasmus+ fund. Furthermore, ZIPS cooperates with the Faculty of Architecture on two EU projects – ProGIreg (Productive Green Infrastructure for post-industrial urban regeneration) and Centrinno. ProGIreg is an internationally recognized project regarding productive green infrastructure and it greatly enabled to position ZIPS as a referential organization. NGO is working on a project within the STEM field together with the Faculty of Electronics and Computing, lasting 18 months. These cooperations, besides for the financial stability, opened doorways to vast number of other project opportunities, learning possibilities and other partnerships.

Figure 2 Learning landscapes, NGO ZIPS, taken in 2021

3.2 Small-, medium- and large-scale projects

Collaboration with these and many other institutions has enabled realisation of large-scale projects. However, to keep the continuity of work, it is important to deliver projects of smaller scales. By doing so, NGO managed to plant around 550 trees around the central and easten-most part of Sesvete from 2019 to 2021 (Figs. 3 and 4) through various projects.

Latest project aims at the preserving two 500-year-old linden trees and their genome by cloning them and replanting a hundred of their clones Sesvete-wide (kindergartens, schools, churches, public spaces...). For this project Croatian Forestry Institute was hired which will deliver certified seedlings in the following autumn.

One of the projects in 2021 was a development of a "honey meadow" in a place that used to be a landfill. This area showed a great potential of becoming a public space for the citizens of the neighbouring Novi Jelkovec but also a great sanctuary for the bees and other pollinators.

All these combined projects contributed to the creation of a green program and a green network. NGO intends to continue with other projects in the future, finding new sources of finance. All these projects and the results can be viewed on the official NGO website (www.zeleneiplavesesvete.com)

3.3 Collaboration with the citizens and their education

The NGO owns a Facebook page, followed by more than 6,000 people (www.facebook.com/uzeleneiplavesesvete) and a Facebook group, counting almost 17,500 members (www.facebook.com/groups/117450558982945). These two Facebook pages are a great source of information and people

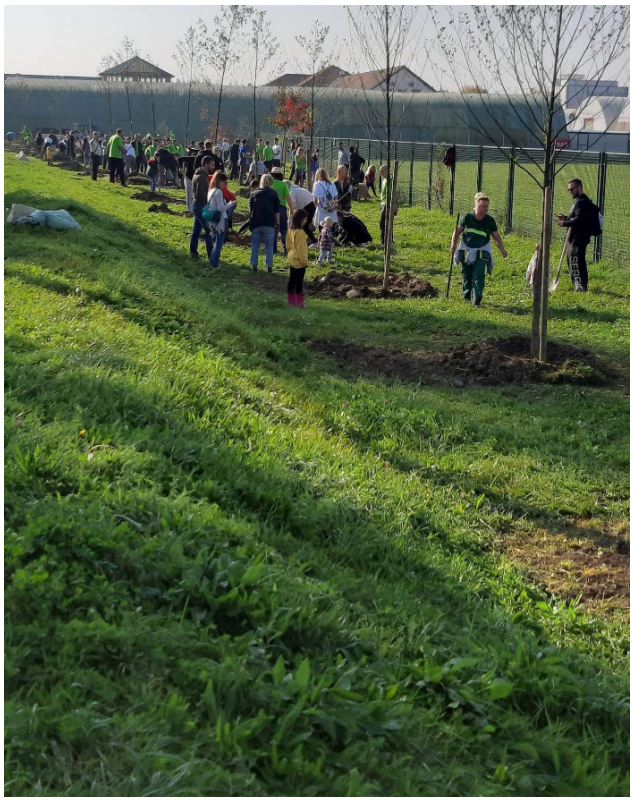

Figure 3 Tree planting, NGO ZIPS, taken in 2019

Figure 4 Tree planting – St. Francis Arboretum, NGO ZIPS, taken in 2020

use it as a form of communication and for debating. Most of the local governmentals also use this group as a form of communication with the citizens.

However, it is important to reach out to the people and involve them in the decision-making (The European Parliament and of the Council, 2003, page 1), especially to the younger generations (Table 1). That is one of the reasons why the NGO organized a whole variety of public and semi-public events connected to the topic, as seen in the Table 1.

Figure 5 Kindergarteners – Green city, NGO ZIPS, taken in 2019

4 Conclusion

In addition to create green infrastructure before the official plan is adopted, it is important to act in different fields that might not neccessarily be directly connected to the common goals. It is important to realize that work cannot be linear because everyday life is not linear either. If it is not possible to achieve projects of greater scale, it is enough to improve the livelihood of a smaller group of people (Clark & Taplin, 2012). Greater projects will come in time but should not be an obstacle in realizing smaller and simpler tasks. These will eventually develop into a complex structure that has naturally grown with people. It might not be a perfect realisation of

Table 1 Table of events

Event	Example/description
Open discussions	– various topics with presenters from the fields (traffic, demographics, environmental protection, culture...)
Workshops	– international, local, for children – presentations of work
Exhibitions	– student, professional and art works
Public events	– concerts – harp concert, singers, local music school – film festivals – documentaries about nature protection
Lectures	– school or faculty students, kindergarteners (Fig. 5), general public
Surveys	– online questionnaires and public initiatives
Public acting	– demonstrations against pollution, clean-ups, tree-planting
Media	– continuous collaboration with the media and presence through social networks

a vision but, in some situations, it might have prevented a far worse option of development. However, in doing so it is important not to settle with little, but to stride for the greatest. To quote one member of the NGO: "If you want a boat, ask for a spaceship. Also, tell them it's a temporary solution. There's nothing standing in the world longer than the temporary solutions".

Acknowledgments

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References

Amati, M. (2008). *Urban Green Belts in the Twenty-first Century.* https://www.routledge.com/Urban-Green-Belts-in-the-Twenty-first-Century/Amati/p/book/9781138275140

Barcelona City Council (2013). *Barcelona Green Infrastructure and Biodiversity Plan*, Barcelona. https://climate-adapt.eea.europa.eu/metadata/case-studies/barcelona-trees-tempering-the-mediterranean-city-climate/11302639.pdf

Clark, H., & Taplin, D. (2012). *Theory of Change Basics: A Primer on Theory of Change.* New York. https://www.theoryofchange.org/wp-content/uploads/toco_library/pdf/ToCBasics.pdf

European Commission, European Environment Agency (2021). Accounting for ecosystems and their services in the European Union, EU. https://ec.europa.eu/eurostat/documents/7870049/12943935/KS-FT-20-002-EN-N.pdf/de44610d-79e5-010a-5675-14fc4d8527d9?t=1624528835061

European Parliament and European Council (2003). Directive 2003/35/Ec, EU. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2003:156:TOC

European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions Green Infrastructure (Gi) (2013). *Technical Information on Green Infrastructure (Gi) Accompanying the Document Communication – Enhancing Europe's Natural Capital*, EU. https://ec.europa.eu/environment/nature/ecosystems/docs/green_infrastructures/1_EN_ACT_part1_v5.pdf

Republika Hrvatska, Ministarstvo prostornoga uređenja, graditeljstva i državne imovine (2021). *Program razvoja zelene infrastrukture u urbanim područjima za razdoblje od 2021 do 2030.* Godine, Croatia. https://mpgi.gov.hr/vijesti-8/donesen-program-razvoja-zelene-infrastrukture-u-urbanim-podrucjima/14152

The European Council, The Council, The European Economic and Social Committee and The Committee of The Regions the European Green Deal (2021). *Communication from The Commission to The European Parliament, EU.* https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0640&from=EN

UN (1998). *Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters Done at Aarhus.* Denmark. https://unece.org/DAM/env/pp/documents/cep43e.pdf

Vienna City Administration (2015). *Thematic Concept Green and Open Space.* Vienna. https://www.wien.gv.at/stadtentwicklung/studien/pdf/b008439.pdf

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Research Article

Mythologizing urban project: case of Barona Street in Riga

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The paper attempts to deconstruct the production of the myth associated with a street renovation project 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. Professional and civil society blamed ad hoc planning, wrong traffic organisation, inappropriate design, and poor construction quality. It is this association of solely spatial aspects with the failure to create qualitative public space that constitutes the core of the Barona Street Myth of Failed design. The article postulates that interaction of social identity and social emotions underline communicative landscapes when significant public spaces are being transformed and induce mythologizing of urban projects. 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 emphasize socio-psychological framing of urban analysis. The emotional implication of the 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 project as a tool in political power games.

Keywords: public space, myth, emotions, social identity

1 Introduction

Human dimension has been continuously approached within architecture and urban planning discourse during at least last five decennia. A number of scholars contributed to understanding of different man-environment aspects (Rapoport, 1977; Schon, 1983; Baum, 1987; Hoch, 2006, Porter et al., 2012, Gunder & Hillier, 2004, 2009; Gunder, 2016; Pérez-Gómez, 2008). However, the interest in feelings and emotions individuals and groups display during the process of spatial transformation still can be evaluated as resistant and imbalanced while embracing sociology and undermining psychology, as well as prioritizing philosophic and sociological concepts of politics and economy (Hoch, 2006; Porter et al., 2012; Baum, 2015).

Current research investigates a combination of Social Identity Theory (SIT) from sociology and Cognitive Appraisal Theory of Emotion (CATE) from social psychology for analysing the affective dimension of collective interaction within urban design process, as well as the correlation of this combination with the concept of myth, a traditional subject of folklore studies which has recently appeared as a metaphor for multiple biases in urban planning and design.

For the analytical purposes this article adopts understanding of social identity (SI) as a component of individual self-concept, which roots in self-perception of individual as a member of a social group (Tajfel & Turner, 1979). SI concerns with the value and emotional significance individuals ascribe to the membership of the group they belong to. It addresses both the ways how individuals identify themselves and interact as members of social groups and how groups are interacting as collective bodies. (Turner, 2010). The identification with a particular social group occurs through cognitive processes of self-categorization and motivation as an emotional self-strengthening, underlying the process of building social identity (Garcia-Prieto & Scherer, 2006). The evidence found that social identity largely defines the cognitive processes of the group members,

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their perception of received information and following affective and behavioural reaction (Brown, 2000; Garcia-Prieto & Scherer, 2006). How people think, feel and act within and about an event, depends on how personally relevant the event they are involved in is, as well as in which socio-cultural context it occurs.

Appraisal Theory of Emotion (CATE) suggests that there are certain communicative situations (appraisal dimensions) when the emotions are elicited and there is a correlation between situation's type, the elicited emotion and the decision to act in a certain way. During continuously and unconsciously performed appraisal of emotional events individuals update their information on a situation according to one's current needs, goals, values, and their importance not only for individual self, but also for the group they belong to.

This paper adopts the typology of appraisal dimensions, elaborated by Klaus Scherer (1984), where they are organized in four groups: relevance detection involves novelty and intrinsic pleasantness, implication assessment relates to goal, expectations, outcome, casual agency[1] and responsibility, coping potential deals with power, control and adaptability, and normative significance evaluation includes compatibility with internal and external standards (Garcia-Prieto & Sherer, 2006). During communication within urban projects, different appraisal dimensions come in focus depending on the project's type, scale, and socio-cultural context.

Due to their outspoken institutional character, urban projects can be seen as a set of collective bodies rather than a homogeneous group of individuals. It means that, within a project, individuals express their views and interests and make decisions as representatives of a particular group or formal institution, often re-appraising and disregarding their personal opinions. The frequency and intensity of re-appraisals correlate with the situations, when SI becomes silent, and depend on (but not only) the importance of the in-group[2] goals for the induvial, the sense of "ownership" of in-groups' failure or success, the person's stereotypes and existing knowledge attached to ingroup identity in a given situation, the history of intergroup relations and how groups are structured in society. The appraisal dimensions correlate with social emotions defined as "a process in which subjective appraisal and personal meaning are fundamental" (Garcia-Prieto & Scherer, 2006), allowing for an unlimited range of social responses.

Emotions like guilt and shame can be used as means to create a more stable position of the ingroup. Therefore, the members of the in-group may purposely work on eliciting these emotions in the out-group members in this way simultaneously strengthening the in-group identity. For that, rhetoric and visual communications are used, which often have the characteristics of propaganda tools. New rituals and symbolic models of emotion are created, with a certain emotion being strengthened as a symbol. This guides the collective consciousness in making decisions. According to Geertz (1973), in order to make up our minds we must know how we feel about things; and to know how we feel about things we need the public images of sentiment that only ritual, art and myth can provide.

Urban studies appropriate myth as a metaphor used to explain multiple biases, misconceptions and popular (often false) beliefs underpinning urban planning and design practice (Bristol, 1991; Clare, 2017; Butters, 2021).

Myths are "busted", "dissolved", "debunked", grouped in easy-to-remember lists of significant numbers, or juxtaposed to "realities" and "facts". However not much attention was devoted to the process of the creation of "myths", the role they play in decision making, whom they target, how and why mythologizing occurs.

Nowadays, when rapidly changing social, economic, and environmental dimensions of public spaces create a need for swift re-appraisal of existing practices in the face of new urban challenges, myth offers a cognitively comfortable resolution explaining intractable problems through more solvable and understandable.

Street scape as public space

Upgrading public spaces is a challenge that Latvian municipalities as well as the professional community of landscape architects, urban planners and architects have faced for more than 30 years, ever since the regain of Independence. For Riga the collapse of the centralized planning system contributed to deep restructuring of planning and governance institutions, transition from territorial to spatial strategic planning, focus on turbulent development of real estate and elaboration of the first Territorial Development Plan. Public space largely remained out of collective political, economic, and professional attention (Karpova, 2008; Gutmane & Schreurs, 2015). Among the four main structural elements of urban open space – parks, squares, courtyards and streets, the last two appeared to be more vulnerable in terms of planning and more socially sensitive: the "living

1 Agency is concerned with the role of others in an affective situation.

2 In-group is a social group to which a person psychologically identifies as being a member and an out-group is a social group with which an individual does not identify.

neighbourhoods" built in the Soviet time (Treija, Bratuškins & Suvorovs, 2010) and the streets of Riga historical centre (RHC) – UNESCO protected urban area. During the Soviet period the streets of both areas were redesigned according to the car-oriented urban planning approach as one of the main principles of the functional city. Significant changes in traffic organisation happened at the end of 1980s in Old Riga, when Kalku Street – the main street of Old Riga – was closed for the transit of both public and private transport. About ten years later, facilitated by the large-scale international event of Eurovision in 2003, the street profile was rebuilt according to what we know today as one-level profile without height differences between sidewalks and driveways. For two decades this innovative approach remained the only example in RHC and had no further implications. Most of more than 200 RHC streets were upgraded randomly within internal streets' reconstruction procedures led by the Riga Traffic Department (RTD).

The structure of RTD, to the street related regulations and the overall perception of a street by the public sector have been and still are of a technical character. There are no landscape architects, urban planners or gardeners employed by the Department. The local society of professionals and urban activists has widely recognised the strong prioritisation of the regulations for underground communications[3] and traffic organisation over the green infrastructure elements like street furniture, planters, and greenery, largely subordinating the aesthetic and ecological quality, as well as social inclusiveness of street public space. The few public space projects of the RHC that get implemented are generally characterised by an absence of a profound, well-organized dialogue on public space, contradicting legislation, and vague governance, as well as by growing demand for qualitative public spaces expressed by the civic society. These projects are accompanied by turbulent and often disordered communication between the involved stakeholders – municipal institutions, designers, civic society, and politicians. Such "accompaniment" causes continuous tensions, underlined by either displayed or hidden emotional fluctuation. The renovation of Barona Street between 2015 and 2018, being among the first few complex upgrades of the RHC street network, met all the technical and communicative challenges (Gutmane, 2017), becoming a social platform for wide debates on quality of public space.

The renovation of the Krisjana Barona Street was executed similarly to other streets projects in this period according to the internal plans of the Riga City Council Traffic Department (RTD) under the pavement reconstruction status as one of the first projects elaborated in compliance with a simplified acceptance procedure. The latter presupposed a reduced set of technical drawings, which included traffic organisation and schematic depiction of pavement layout, as well as an additional explanatory note. There were no requirements included for adjustment of green and technical street infrastructure, including streetlights, road signs, greenery, urban furniture and lighting. The strategy of simplified procedures was initially a success, enabling private persons, as well as municipality itself to reach the desired outcome with a smaller time and financial investment in project preparation. However, preliminary analysis of the renovations, implemented between 2014 and 2021 according to the Riga City council Traffic Department (Riga City Council, n.d.), indicates that the municipality was not able to stabilize the tendency and the number of renovated pavements dropped twice between 2014 and 2020, in 2014 reconstructing 68 streets, 2016 – 48 and 2020 – 34, but slightly increasing to 45 in 2021[4]. These fluctuations can be attributed to several factors: an increased number of complete reconstructions which demanded greater financial investments; first exercises to upgrade streets on the level of renovation, when along with pavement reconstruction the designers (mostly road engineers as the main contractors) had to elaborate landscape design; high activity of urban activists who looked forward to participating in the elaboration of the projects as external experts; and the accompanying political "games of power", which intensified gradually from 2016 to 2019, resulting in the change of political profile, when the coalition of parties of social orientation led by the "Russian" Mayor of Riga lost its 10 years' position to the liberal and conservative coalition in the 2019 municipal elections. These processes largely shaped the atmosphere and the context in which the elaboration and implementation of Barona Street project occurred. Being branded as an initiative of the mayor, it was both affected by and had an impact on the processes to varying degrees.

Until 2015 no complex renovation of the streets as public spaces including green infrastructure (GI) was carried out.

3 Planting trees and bushes within red lines, e.g. along the driveways is prohibited by regulations of underground facilities (Latvijas republikas tiesību akti, 2014), which require 2 m protection zone for greenery and amenities. It makes legally impossible to upgrade GI within RHC streets because of high density of underground facilities and relatively narrow sidewalks.

4 Riga City Council. (n.d.). Pakalpojumi. Segumu atjaunošana pēc darbu veikšanas no 2017. gada 15. marta. Traffic department. Retrieved April 2, 2022, from https://www.rdsd.lv/uploads/media/61d2b4b5eaaf6.pdf

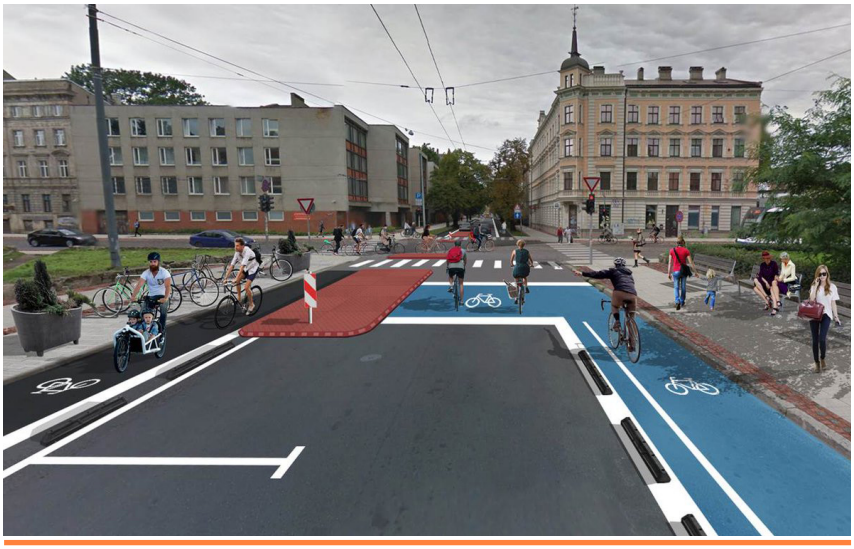

Figure 1 Bike box and narrowed crossing at Bruņinieku street. Note. Visualisation Vertex projekti. From lsm.lv [Photograph], by Riga city council traffic department, 2020, LSM.LV
Source: https://www.lsm.lv/raksts/zinas/latvija/uzsak-remontdarbus-riga-bruninieku-iela.a368492/

Among 325 street reconstruction works which occurred during this period, only 36 included complete pavement reconstruction (driveways & sidewalks). In most streets, pavement was renewed either on driveways or sidewalks, partly or interchangeably. Half of complete pavement renovations happened in RHC, where 8 main streets underwent significant changes, contributing largely to increasing quality of RHC public spaces. Reconstruction of two streets – Sporta (2020) and Bruninieku (2021) – can be classified as renovation, since some innovative solutions, such as speed calming elements (elevated and narrowed crossings), velo boxes[5] (Fig. 1), as well as street furniture were implemented. Despite the significant contributions of these projects, they cannot be perceived as a complex approach to quality of public space, because the projects did not include the very much needed renewal of GI. Therefore it can be argued that Barona Street renovation remains the first and until now the only project where the attempt to approach the street as a public space not a technical construction was undertaken, designing sidewalks according to the universal design principles, paying attention to the pavement design aesthetics, introducing qualitative street furniture and complex GI renewing with 3-level system (cover plants, bushes, trees) and species design.

Appraisal dimensions and mythologizing process

Analysing the communication within Barona Street renovation from the 4 appraisal dimensions, it is possible to range them according to the role they played in eliciting emotional events, mythologizing process, impact on quality of design and building, as well as on institutional and political "well-being". Three appraisal dimensions to a greater or lesser extent elicit social emotions of guilt, shame, scorn, and pride, which were explicitly present during the Barona Street reconstruction. The fourth – normative significance evaluation – appeared to be less relevant due to low impact on emotional situations.

The relevance detection dimension, which correlates with novelty, familiarity, and intrinsic pleasantness aspects, can be evaluated as a source for further emotional events and the emotional atmosphere around the Barona Street communicative landscape. Since pleasantness is a more individual attribute, it was difficult to instrumentally access the needed information, which otherwise could have been done by carrying out an intrapersonal or intragroup analysis. However, the novelty and familiarity aspects were most detectable and exposed during the analysis of the project. There were several innovations introduced for Barona Street renovation, which concerned (a) the set of stakeholders, (b) procedural settings (rituals), and (c) spatial components of design.

a) Considering the significance of the street, RTD invited landscape architects to participate in the project, even though the legal procedures did not require it. The ALPS ainavu darbnīca team, having experience in urban activism, designed a strategy for civic participation, estimating the duration of the project as three years contrary to the officially foreseen one year. The participation plan included involvement of wider civic society of the street (mainly owners of houses, retail tenants and institutions), urban activists of Riga and the professional society. The participative events were planned according to the target audience and level of involvement, including informative events for the wider society, public discussions of design solutions, street festivals and media events. For each event the responsible body and the specific time were assigned. The plan was discussed and accepted internally

5 Bike box is a marking in a form of a square on junctions with traffic light, which creates a space for the bikers in front of the cars in order to give them priority to turn left.

Figures 2 Participative event on Barona Street, organized by landscape architects and journalists
Source: from iflaeurope (Photograph), by Igors Vatolins, 2015, IFLA EUROPE. https://iflaeurope.eu/index.php/site/project/upgrading-streetscape-in-riga-city-historical-centre

within RTD. However, there were no supervisors or curators chosen from the side of municipality. No financial resources were allocated either. After its success in the 2009 elections, the socially oriented Riga political leadership of Harmony (Saskaņa) party & allies[6] took the course, among other social aspects, on renovations of public spaces. Thus, Barona Street was politically branded as "one of the biggest street infrastructures renewal projects" (LA.LV, 2015). Despite the absence of officially accepted participative rituals, when the project design was completed, but not yet approved by the Construction Board, the presentation of the design solutions took place in Riga City Hall in June 2015 (LA.LV, 2015). The meeting was a part of the participation plan proposed by the landscape architects and was organized by Riga municipality, gathering more than 100 participants – real estate owners, retail tenants, interested professionals, and urban activists. In the words of one participant, real estate estate owner, it was the first time when the inhabitants were informed before the building work started. This successful participative event was the only one from the proposed participation plan which was organized by municipality. The others – discussions with professional society, with the street inhabitants and institutions, were organized by the team of landscape architects and by them invited journalists on a voluntary basis (Fig. 2).

The activities around Barona Street municipality appeared in a reduced form of "tamed" press releases in official and social media. This choice of the municipal branding strategy left space for more intensive discussions in the emerging social media, which largely contributed to the institutionalizations of urban activists[7] and played a crucial role in mythologizing the process. The landscape architects' team organized several participatory involvement events. However, without municipal support, it failed to fulfil the three year activity plan and to form an equally strong professional answer to often in a populistic manner occurring "battles of opinions" in social and official media. Public attention of such scale and media diversity to the RTD-executed projects was an unfamiliar situation for both the RTD, which had no appropriate knowledge or suitably experienced in communications professionals, and for the team of designers, which, similarly to the Department staff, had no experience in social media debates. It is important to note that, except for the absence of means and experience, both the designers and the Department staff did not place a high importance on the need to "battle" on design solutions, since they had a shared view on the proposed design, recommended bike lane, universal design, multilevel greenery, and street furniture. Several internal debates did take place on technical solutions. Being strongly motivated to deliver the best possible result and appreciating the fact that the RTD staff was equally motivated notwithstanding the largely absent appropriate legislative and institutional order, the designers however were not able to remain impartial in front of the sudden and aggressive communication and were forced to choose the social identity

6 The Social Democratic Party "Harmony" is a social-democratic political party in Latvia. It is the largest political party in the parliament of the republic of Latvia that represents the Russian minority of Latvia ("The Social Democratic Party "Harmony," 2022).

7 Several urban activists, who actively criticised Barona Street project, shortly after the start of the project, in January 2016, founded NGO "Pilsēta cilvēkiem" (City for people), using Barona Street project as facilitator of their recognition. Today it can be evaluated as the most influential NGO, which is not associated with Riga neighbourhood. More information (https://en.pilsetacilvekiem.lv/)

of the RTD from which "to speak out". This choice was determined by the common professional values and shared social emotions of scorn (towards the "fights" in social media) and frustration, shaping unattractive emotional atmosphere underlying challenging, but inspirational and highly creative cooperation.

Sudden and intense stimulation, if related to novel and unfamiliar situations, influences coping potential dimension, increasing or decreasing available energy on sensory-motor level (Scherer, 2009). The elicited social emotions participate in disruption or sustaining of social groups and institutions by investing or denying an investment of emotional energy (Voronov and Vince, 2012). The six key persons of the RTD responsible for Barona Street project left the Department during the 4 years since the start of the project: 2 were dismissed, and four left because of low motivation to share the social identity of the Department. Joining the RTD social identity for the time of the project, the designers' team of road engineers and landscape architects was less impacted by the situation due to having a stronger "own" social identity. However, the different values between road engineers and landscape architects also contributed to the disruption of further collaboration.

b) Besides the participation and communication plan, other situations that induced partly or fully unconventional rituals, concerned procedural settings – simplified approval procedures for pavement reconstruction, landscape design project and cultural historical assessment. The latter came as an additional requirement from the National heritage institution after the project preparation was started. However, not being directly related to the construction works and being a familiar procedure to the landscape architects, it did not create sudden or abrupt events and therefore had no significant impact on the fluctuation of the project's emotional atmosphere. The same partly applied to the design project, except the difficulties landscape architects experienced convincing the RTD persons in charge to elaborate the landscape design project simultaneously with the pavement reconstruction confirmation card. The landscape project was, however, elaborated on time: first as an initiative of the landscape architects, and then approved officially. Even though the simplified procedure was not entirely new for the RTD, it included the technical requirement to dismantle only 0.3 m of the pavement surface which was crucial for the construction. A year later this rule was dismissed. However, the first stage of the reconstruction works was realized according to this rule, which significantly influenced the building quality for the 50-year-old pavement of the street, which had to be deconstructed deeper due to poor technical condition.

Other innovations at that time introduced universal design, advisory bike lanes, a complex approach to green infrastructure and appropriate street furniture. All become a subject of public discussions, having, however, a different degree of emanation into media space, uneven impact on the future procedures and street design and, more crucially, on the creation of the public image of the project. Although the street was a first furnished according to the public space guidelines widely shared in modern cities, taking into account such social-spatial aspects as intensity of use, interests of street retail, social interaction inviting composition of benches, insulation, integrated greenery etc., little collective attention was attracted, which correlates with the nearly complete absence of publications. The renewed green

Figure 3 Renewed green infrastructure and historical pavement on Barona Street
Source: Adapted from ALPS.ARCHI (Photograph), by Luize Elizabete Ruksane, 2018, ALPS ainavu darbnīca. http://www.alps.archi/portfolio/kr-barona-ielas-labiekartojuma-atjaunosana-posma-no-aspazijas-bulv-lidz-brivibas-ielai/

infrastructure included approaches like 3-level greenery, replacement of the lawns along the street by ground cover plants, bushes, historically used pavement (round granite cobblestones) for tree roots protection and construction for permeable and walkable loan, specially designed by landscape architects, planting trees in the ground within red lines, restoring historical lanes and creating the new places for the trees according to spatial dimensions of the street and the species design (Fig. 3).

All these approaches were unprecedented in Riga and required a great joint effort of RTD staff, diverse "family" of underground facilities institutions and road engineers & landscape architects' team, while Riga had not and still does not have proper guidelines for the public spaces and green infrastructure (GI), consequently and systematically executed green infrastructure plans, allocated funding and appropriate legal procedures. Despite all the "have-nots", the GI plan for Barona Street was implemented for 80 percent, "losing" 17 of 115 planned trees to the underground facilities and the 2nd level greenery within the border of RHC to the Heritage institution. The appreciation and replication of the joint institutional – professional effort provided the first steppingstone for creating the systematic approach to the green infrastructure very much needed in Riga, however neither the furnishing nor the upgrade of the GI got attention in the public discussions and debates. At contrary, universal design, which included only street profile (continuous level of sidewalks) and pavement design (tactile pavement), which was already realised in Riga before on the crossing, as well as advisory bike lane (the first example in Riga) become, together with quality of construction works, the focal points of turbulent discussions in the media and the "building blocks" of the following mystification of the process.

The dimension of implication assessment, related to goal, expectations, outcome, casual agency[8] and responsibility, although being active in eliciting numerous emotional events, defined the communicative landscape of the project proportionally to activation of group's social identities. The project occurred under conditions of multiple unfamiliar and novel situations, amplified by initial absence of shared views, structural and governance inadequacy, shortage of technical means, human and financial resourses, and legislative contradictions. This inevitably led to the difference of goals and expectations stakeholders identified for themselves in a written or informal way, which they were not able to properly mediate among themselves for various reasons. However, there was a certain pattern in the messy and largely disordered project communication.

The goals and expectations can be grouped into two groups: "result-oriented" and "process-oriented". Under the result-oriented falls the very particular and tangible goal to build an exemplarily designed and qualitatively constructed street. This goal was shared by the RTD, designers' team, politicians, part of the inhabitants of the street and to some extent constructor companies. However, all stakeholders had slightly different motivations to reach these common results. The process-oriented group included urban activists and the wider society they involved. Their goal was stated through their communicative themes and means, which was later illustratively set in the title of the newly founded NGO – "City for People", presupposing close attention to the process, the detail, and the governance. The first group of stakeholders can be seen as a formal institution with normatively assigned status and authority, the second – as an informal, mobile, and emerging entity without status and authority.

These shaped to some extent contradictory expectations the participants of the process put into the project, defining means for communication. In socio-psychological terms, all the diversity of stakeholders involved can be viewed as in-group and out-group, having different goals, expectations, and means of communication. The SI of both groups can be evaluated as weakly formed: the result-oriented in-group SI was a combination of formally and vaguely communicating numerous historically established, "old", institutional SIs, and the process-oriented outcome group's SI was young, not yet formed and therefore weak. The appeal to Authority was common for both groups– in this situation a political power, in the case of ingroup it was supportive, because of formal hierarchical relations, in the second – challenging the political authority and the established hierarchy. The appeal to Authority for those involved in formal relations is prescribed by the institutional hierarchy according to distributed responsibilities. It is to great extend internalized and defines such everyday institutional rituals of urban project as contracting, construction meetings, on-site supervision etc. Therefore, this ritualized appeal has neither need nor tendency to be publicly disseminated. Reversely, young and weak SI of urban activists, which at that moment acted as individuals, had a strong need "to be heard", to become visible and recognizable. This defined the communication strategy of both groups, the shift of goals and the choice of means, which included over-attribution by the out-group of casual agency and responsibilities for the projects' misfortunes to the publicly exposed

8 Agency is concerned with the role of others in entailing an affective situation.

Figures 4 Picket in front of Riga City council against urban policy of the coalition using emotionally persuasive tools like slogans and names calling: central of three front posters depicts the persons of RTD leading staff with the text under "Search for a work" (Meklē darbu). Casual oversimplification and repetition: four one type posters in background depict mayor of Riga Nils Ushakovs (Nīls Ušakovs) with the text "promises of Nils" (Nila solījumi). From pilsetacilvekiem.lv (Photograph), by Ieva Leiniša, 2018, Pilsēta cilvēkiem
Source: https://www.facebook.com/PilsetaCilvekiem/photos/2222992127914072

Figures 5 Appeal to authority and labelling. The urban activists perform riding bikes on the sidewalks of Barona Street. Picture underlined by M. Colville-Andersen citation "The current solution of Barona Street is shameful!". From pilsetacilvekiem.lv (Photograph] by pilsēta cilvēkiem, 2018
Mikael Kolville-Andersen, a Canadian-Danish urban influencer, was invited by NGO "Pilsēta cilvēkiem" two times in 2018 to speak on the actual for Riga urban issues
Source: https://www.facebook.com/pilsetacilvekiem/posts/2248373925375892/

figures of politicians, RTD leadership and partly designers, instead of approaching unreadiness of Riga's historically formed governmental structures to deal with qualitative renovation of public spaces. The over-attribution of external causation and the replacing responsibility for the events entailed by an affective situation (Scherer, 1997, Scherer, 2009), were feeling of powerlessness, low or lost control and flexibility in dealing with situations of high importance for an individual, also as member of the group, frequently elicit emotions like fear and anger. The disposition to give the responsibility to "others" while assessing implications, also activates the second appraisal dimension of coping potential, which deals with control, power, and adaptability.

There are three main factors, which place *appraisal dimension of coping potential* as central in the context of Barona Street project.

- The centrality (amount of time, resources, attention) of "games of power" in the sense of gaining influence on and control over the project process and outcomes.
- Extreme and negative publicity over and around the project, which mostly mystified the real process.
- Impact, which the "games of power" and mythologizing had on the outcomes of the project and the structural system, responsible for Riga public spaces and the political power in Riga.

There is an assumption that cognitive appraisals, depending on the individual's perceived goals, values or coping potential rather than on objective characteristics, can be biased and can lead to inappropriate evaluation of the events (Scherer & Brosch, 2009). For example, an individual can unrealistically ascribe extreme responsibility to those

Figures 6 The urban activists are together with political opposition, among them a person, who become a person in charge for Riga transportation after election 2020
Source: Adapted from pilsetacilvekiem.lv [Photograph], by Ieva Leiniša, 2018, Pilsēta cilvēkiem. https://www.facebook.com/PilsetaCilvekiem/photos/2222992127914072

having perceived or overestimated power, developing external appraisal bias due to own feeling of no or lost control. In the Barona Street the project involved urban activists, at that moment only forming a group, acted more as individuals in evaluating the situations and choosing communicative means according to their emotional reactions on imperfections of the project's processing. Their conviction that "it should be done better" outlined towards low level of control, authority and influence within the project, as well as the related need to strengthen the group and its social identity and gaining "voice", directed their choice of rather aggressive communication in social media during the construction process, often using textual and visual tools of propaganda, described by Dimitrov et al. (2021), like exaggerating and overexposing the building process failures, misinterpreting design solutions. Eliciting emotions of guilt and shame by using the techniques remained a common communication strategy of the group for several years, when the tools like casual oversimplification, names calling/labelling, slogans, repetition, public blaming and shaming of the persons in charge (Fig. 4), appeal to authority (Fig. 5) were used while dealing with other transformation of public spaces done by Riga municipality. What is more crucial, the urban activism often were merged with politics (Fig. 6).

One can speculate if the urban activists, which started their "carriers" on the case of Barona Street and a year later founded an NGO with allusive title[9], were politically engaged from the beginning and their tasks were to work against the coalition in position by (ab)using significant urban project, or their goals, tasks and means of communicative strategy had an emotional background and could be explained by SIT and CATE. Whether one or another assumption or the combination of both are true, the goals and the methods of communication and the attitude towards the project of both groups were juxtaposed notwithstanding the publicly proclaimed by the outgroup interest in quality, effective governance, and democracy of public spaces. Similarly, there is no evidence gathered, to which extend Barona Street project contributed to political demise of Harmony in Riga and dismission of popular Riga lord mayor. However, dismission of two key persons – RTD director and construction supervisor in the middle of the process, in the situation of shortage of qualified landscape constructors, very tight realisation time[10], novelty of the challenging tasks and related discorded communication, as well as intensive public attention, in an utmost degree disturbed the implementation process and contributed to the creation of RTD as an Symbol of Urban Evil, but Barona Street project as a Failure of urban design in minds of many intellectuals, professionals and, most important, decision makers. In 2020 "City for People" released a video after expedited elections, where seven lord mayor candidates were asked to name the worst example of urban design in Riga. Five named Barona Street, however, asked to point the mistakes and the ways to better them, they were not able to give an answer (Pilsēta cilvēkiem, 2020). The aggressive communication, using of propaganda visual and textual instruments, contributed to

9 The name of NGO "Pilsēta cilvēkiem" (City for people) creates allusion to the title of seminal book of Jahn Gehl "Cities for people" (2010).

10 Project approved July 2015, constructor chosen through public tender September 2015, works started end September, the appropriate whether conditions stopped at the end of October.

the quick rise of social capital of the urban activists[11], re-attributed responsibility and casual agency to the individuals and political party, shifted collective and political attention from the urgent needs like employing landscape architects and community workers by RDT, negotiations with communication holders about legal possibilities to plant trees within red lines and in the protection zone of the underground communications, etc. The myth of Failed Barona Street was created.

2 Conclusions

1. The Barona Street Myth places bold emphasis on Failed design, notwithstanding the evidence that imperfections of Barona Street renovation to the great extend happened due to the inadequacy of public space policy, and collective perception of the street solely as technical construction at the moment of project execution, absence of appropriate public space governance and management. In this way it conceals the responsibility of imperfect governance, guiding public discussions and actions away from systematic complex approach to public spaces.
2. Socio-psychological implication offers interpretation of myth as a tool for creating and strengthening social identity, which correlates with feeling of low level of control, not having authority, being "without voice". Mythologizing Barona Street renovation activated appraisal dimension of coping potential, which deals with control, power, and adaptability. Two major groups of stakeholders, involved in the process – the formal one of institutions and informal of urban activists – applied different communication strategies: the first – passive and tamed, the second – active and aggressive. The latter, developing external appraisal bias, re-attributed the responsibility for low quality to political leaders of that time, involved municipal workers and designers, instead of on historically formed Riga's governance inability to engage with public spaces.
3. Using emotionally appealing and persuasive tools, which often are employed by ideological propaganda, urban activists unnecessary shifted public attention away from structural issues and created preconditions for using street reconstruction project as a tool in the political power games.
4. The mythologizing of Barona project, form one hand, facilitated public discussion on quality of public spaces and contributed to the institutionalisation of urban activism, from another accelerated unnecessary politicizing of urban design and building process. The case can be placed in broader discussion on abuse of participation, devaluation of urban activism and the role of public space as a level for social revival.
5. Urban projects as situations of complex interaction of diverse socio-spatial, economic, environmental, political, and cultural aspects with high degree of novelty can be placed between highly appropriate cases (together with politics) in studying social emotions.
6. The linkage between social emotions and social identity allows to methodologically approach psychological aspects of urban practice by postulating that salient social emotions largely shape communicative landscapes of urban projects when significant public spaces are being transformed.

11 The first video on the Facebook site was of Barona Street reconstruction process with 56 views, 8 from 18 during the year placed video were about Barona Street, the most popular reached more than 13 000 views. For information is used Facebook web page https://www.facebook.com/PilsetaCilvekiem

References

Baum, H. S. (1987). *The invisible bureaucracy: The unconscious in organizational problem solving.* Oxford University Press.

Baum, H. (2015). Planning with half a mind: Why planners resist emotion. *Planning Theory & Practice,* 16(4), 498–516. https://doi.org/10.1080/14649357.2015.1071870

Bristol, K. G. (1991). The Pruitt-Igoe myth. *Journal of Architectural Education,* 44(3), 163–171. https://doi.org/10.1080/10464883.1991.11102687

Brown, R. (2000). Social identity theory: Past achievements, current problems and future challenges. *European journal of social psychology,* 30(6), 745–778. https://doi.org/10.1002/1099-0992(200011/12)30:6<745::AID-EJSP24>3.0.CO;2-O

Butters, C. (2021). Myths and Issues about Sustainable Living. *Sustainability*, 13(14), 7521. https://doi.org/10.3390/su13147521

Clare, A. (2017, January 11). Busting Urban Planning Myths. *Things are good.* https://www.thingsaregood.com/2017/01/11/busting-urban-planning-myths/

Dimitrov, D., Ali, B. B., Shaar, S., Alam, F., Silvestri, F., Firooz, H., Nakov, P. & Martino, G. D. S. (2021). Detecting propaganda techniques in memes. *arXiv preprint arXiv:2109.08013*. https://doi.org/10.48550/arXiv.2109.08013

Garcia-Prieto, P., & Scherer, K. R. (2006). Connecting social identity theory and cognitive appraisal theory of emotions. *Social identities: Motivational, emotional, cultural influences,* 189–207. https://doi.org/10.4324/9780203002971

Geertz, C. (1973). Thick Description: Toward an Interpretive Theory of Culture 1973.

Gehl, J. (2013). *Cities for people.* Island press.

Gunder, M., & Hillier, J. (2004). Conforming to the expectations of the profession: A Lacanian perspective on planning practice, norms and values. *Planning Theory & Practice,* 5(2), 217–235. https://doi.org/10.1080/1464935041000169176 3

Gunder, M., & Hillier, J. (2009). *Planning in ten words or less: A Lacanian entanglement with spatial planning.* Routledge. https://doi.org/10.4324/9781315246697

Gunder, M. (2016), ‚Planning's "failure" to ensure efficient market delivery: A Lacanian deconstruction of this neoliberal scapegoating fantasy'. *European Planning Studies,* 24(1), 21–38. https://doi.org/10.1080/09654313.2015.1067291

Gutmane, H., & Schreurs, J. (2015). Recycling the past: the case of the intensive training programme in urbanism. *Landscape Architecture and Art,* 7(7), 29–38.

Gūtmane, H. (2017). *Barona ielas atgūšana: meklējot "celiņu vājredzīgajiem", Latvijas Architektūra.* LILITA, Rīga, 2(130), 35–39.

Hoch, C. (2006). Emotions and Planning. *Planning Theory & Practice,* 7(4), 367–382. http://dx.doi.org/10.1080/14649350600984436

Karpova, Z. (2008). Quality of living Environment in Latvia. situation today. *Architecture & Urban Planning,* (2), 180–193. https://web.p.ebscohost.com/abstract?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=16914333&asa=Y&AN=37587047&h=ShBr0GSI8Z8po1i5OEFbbMngiSIQBnjCIgjtd%2fR%2bZMZfPOUTdLwryzqUDUufoHKSABdvJkGbFrO1D2K%2fFfEuZg%3d%3d&crl=c&resultNs=AdminWebAuth&resultLocal=ErrCrlNotAuth&crlhashurl=login.aspx%3fdirect%3dtrue%26profile%3dehost%26scope%3dsite%26authtype%3dcrawler%26jrnl%3d16914333%26asa%3dY%26AN%3d37587047

Krišjāna Barona iela. (2018). ALPS.ARCHI [Photograph], by Luize Elizabete Ruksane, ALPS ainavu darbnīca. http://www.alps.archi/portfolio/kr-barona-ielas-labiekartojuma-atjaunosana-posma-no-aspazijas-bulv-lidz-brivibas-ielai/)

LA.LV. (2015, September 1). *Sākas Krišjāņa Barona ielas rekonstrukcija*. Šogad izmaksas – 2,6 miljoni eiro. https://www.la.lv/sakas-krisjana-barona-ielas-rekonstrukcija-sogad-izmaksas-26-miljoni-eiro

Latvijas republikas tiesību akti. (2014, 30. septembris). *Ministru kabineta noteikumi Nr.574, par Latvijas būvnormatīvu LBN 008-14 "Inženiertīklu izvietojums".* https://likumi.lv/ta/id/269200-noteikumi-par-latvijas-buvnormativu-lbn-008-14-inzeniertiklu-izvietojums

LTV Dienas ziņas. (2020, July 27). *Uzsāk remontdarbus Rīgā, Bruņinieku ielā.* https://www.lsm.lv/raksts/zinas/latvija/uzsak-remontdarbus-riga-bruninieku-iela.a368492/

Pérez-Gómez, A. (2008). *Built upon love: architectural longing after ethics and aesthetics.* MIT Press.

Pilsēta cilvēkiem. (2018, October 17). Foto: Ieva Leiniša, LETA, Jauns.lv. [http://jauns.lv/.../33622-piketa-pie-rigas-domes-pieprasa...] This [photo]. Facebook. https://www.facebook.com/PilsetaCilvekiem/photos/2222992127914072

Pilsēta cilvēkiem. (2018, October 17). Foto: Ieva Leiniša, LETA, Jauns.lv. [http://jauns.lv/.../33622-piketa-pie-rigas-domes-pieprasa...] This [photo collage]. Facebook. https://www.facebook.com/PilsetaCilvekiem/photos

Pilsēta cilvēkiem. (2018, December 1). Dāņu pilsētplānotājs: Kr. Barona ielas rekomendējošās velojoslas ir apkaunojums. Šonedēļ Rīgu apciemojušais pasaulslavenais dāņu pilsētplānotājs Mikaels Kolville-Andersens intervijā. This [photo]. Facebook. https://www.facebook.com/pilsetacilvekiem/posts/2248373925375892/

Pilsēta cilvēkiem. (2020, August 27). Kura ir briesmīgākā vieta velosipēdistiem? Mēra amata kandidāti gandrīz vienprātīgi kā bīstamāko vietu Rīgā velosipēdistiem nosauca Krišjāņa Barona ielu. This [video]. Facebook. https://www.facebook.com/PilsetaCilvekiem/videos/668108020467651

Porter, L., Sandercock, L., Umemoto, K., Bates, L. K., Zapata, M. A., Kondo, M. C., Zitcer, A., Lake, R. W., Fonza, A. Sletto, B., Erfan, A.& Sandercock, L. (2012). What's Love Got To Do With It? Illuminations on Loving Attachment in Planning. *Planning Theory & Practice,* 13(4), 593–627. https://doi.org/10.1080/14649357.2012.731210

Rapoport, A. (1977). *Human aspects of urban form: towards a man – environment approach to urban form and design*. Pergamon Press.

Riga City Council. (n.d.). *Pakalpojumi. Segumu atjaunošana pēc darbu veikšanas no. 2017. gada 15. marta.* Traffic department. Retrieved April 2, 2022, from https://www.rdsd.lv/uploads/media/61d2b4b5eaaf6.pdf

Scherer, K. R. (1984). Emotion as a multicomponent process: a model and some cross-cultural data. *Review of personality & social psychology,* 5, 37–63. https://psycnet.apa.org/record/1986-17269-001

Scherer, K. (1997). Profiles of emotion-antecedent appraisal: Testing theoretical predictions across cultures. *Cognition & Emotion,* 11(2), 113–150. https://doi.org/10.1080/026999397379962

Scherer, K. (2009). The dynamic architecture of emotion: Evidence for the component process model. *Cognition & Emotion,* 23(7), 1307–1351. http://dx.doi.org/10.1080/02699930902928969

Scherer, K., & Brosch, T. (2009). Culture-specific appraisal biases contribute to emotion dispositions. *European Journal of Personality*, 23(3), 265–288. https://doi.org/10.1002/per.714

Schon, D. A. (1983). *The reflective practitioner: How professionals think in action*. vol. 5126, Basic books.

Tajfel, H. & Turner, J. C. (1979). An integrative theory of intergroup conflict. *The social psychology of intergroup relations,* 33(47), 74.

The Social Democratic Party "Harmony". (2022, April 2). In Wikipedia. https://en.wikipedia.org/wiki/Social_Democratic_Party_%22Harmony%22

Treija, S., Bratuškins, U., & Suvorovs, E. (2010). The Use of Public Open Spaces in Large-scale Housing Estates in Riga. *Architecture & Urban Planning*, 10(4), 44–50.

Turner, J. C. (2010). Towards a cognitive redefinition of the social group. In T. Postmes & N. R. Branscombe (Eds.), *Rediscovering social identity* (pp. 210–234). Psychology Press.

Voronov, M. & Vince, R. (2012). Integrating emotions into the analysis of institutional work. *Academy of Management Review,* 37(1), 58–81. https://doi.org/10.5465/amr.2010.0247

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Research Article

Unconventional interventions on redeveloping unused urban landscapes based on social interactions

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In urban landscape, we are increasingly encountering the phenomenon of forgotten places, open areas without function, which were created by sanitation of unpromising objects or influence of various other external factors. We mostly talk about so-called mid-blocks and inner pavilion places which are open free spaces between two elements of a building, or empty areas between two or more separate objects without mutual connection. Thus, undeveloped places in the already standing continuous development which are intended to be reconstructed. This would be the most suitable solution from the point of view of a certain urban concept of the city because the original development would be supplemented and a meaningful urban structure would be created again. However, over time, it is not always easy and possible to redevelop all these places. In this case, it is necessary to think of a new function that would partially replace the original one. As part of green infrastructure and urban planning, municipalities often integrate various green solutions into these places which encourage their residents and users to spend their free time meaningfully in them. In the long run, these solutions are probably the best possible alternative to the above-mentioned supplementation of urban structures. However, it does not always have to be an expensive and sophisticated design but sometimes only a small short-term intervention based on a deeper developed idea called "bring back function" will suffice. The paper describes unconventional interventions to the places without function and seeks their connection with users in the context of social interaction.

Keywords: research by design, urban landscape, social interactions, open space, small-scale architecture

1 Introduction

The quality of the space we create in the landscape is conditioned by a combination of strong opinions and decisive actions. We think of public space as a set of several entities that are sometimes vague, unspoken, and difficult to grasp. They can be full or empty. We are also sensitive to what is happening to the space at the city level and, consequently, to the impact of the outcome of nonconceptual decisions on the landscape, as the cultural cradle (Tóth et al., 2019) of our nation. A space that enriches our everyday life at various levels, whether conscious or unconscious for some, is rarer today than ever before. It grows in value and passes quickly. Although it persists in places, it also disappears and arises. It is becoming a scarce commodity and we are ahead of time which will grab and take a piece of it. Our task is first and foremost to perceive spaces and discover those that have been foreign to us so far. Here, the question arises as to whether we can still consider "emptiness" as one of the characteristic features of today's space. It is not primarily the main axis of interpretation of the term, but from the point of view of architecture, landscape architecture and urbanism, it regularly appears in places without the "empty" function. In landscape architecture, space is usually open (OpenSpace) and harmoniously integrates a certain work – an idea with the phenomenon of origin. So, the idea connects with the place. When we talk about spatial composition, that composition has several dimensions: technical, psychological, aesthetic, functional, social, and cultural. If we talk about the functional dimension, it is especially in connection with the function of space, which means for what function the space should serve. The term multifunctionality is normally used in contemporary landscape architecture as a positive feature – meaning a space is created to provide several functions at once. In addition to

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the functional dimension, quality space must also be aesthetically strong, well-engineered, social, where the focus is on the user and his/her social interaction and social inclusion (Čibik & Štěpánková, 2021), and cultural, where the space must achieve a certain local identity and enhance, underline the local character. Within urbanism and urban planning as creative and scientific disciplines, concepts such as: human scale, cities for people, cities for all, etc. are appearing more and more nowadays (Lukas-Sithole, 2020). There is even much, perhaps too much, talk about gender-sensitive planning (Sidorová et al., 2016), user-friendliness of urban design and planning, a fair and shared city, or an inclusive city. In all areas of urban planning, the final design depends on the needs of the people. Therefore, we should let them decide what activities they are interested in.

1.1 Theoretical background

Some questionings are very common in nowadays landscape architecture design: what role can open spaces play in reviving public life? How can public spaces effectively contribute to making social interaction possible? And even more decisive: what kind of tools can be used to achieve these goals? It seems that temporality and dynamics are prevailing over permanence, creativity is overcoming regulations. Interventions that can articulate public interactions through low cost and temporary strategies are seen as having the ability to create a positive impact on urban habitat. Highlighting the importance of promoting a vibrant public space capable of activating public life while serving as a symbol of urban quality (Hernandez & Casanova, 2014). In this sense, mutating strategies based on citizens as decision makers appear as solutions very well accepted once they commute the most evident needs with different resources available in different places and time. Seeing the city as an event place can result in some interesting situations that enrich social interaction. We humans are unique and each of us is a unity of sensations and backgrounds. The presence of Nature in cities is able to bring us back to a common base of principles where we feel somehow connected and where we are back in the mood of letting ourselves enjoy our characteristics of social beings. This idea is brought about by the Fourth Nature concept which envisions the evolution of our relation to the natural world through consciousness and the recovery of uniqueness in multiplicity. We perceive the design process through a wide range of output forms. These are in-depth analyses, text accompanying and technical reports, various strategies, graphs, diagrams, graphic outputs, and visualizations. The application of scientific methods within the artistic-creative environment is a great challenge for anyone who tries to do so. The process of research in architecture is often similar to the process experienced by an architect in practice. Every good design is preceded by a set of detailed analyses without which it is difficult for the designer to work towards a quality result. The interpretation of the final design is primarily graphical but the process that preceded the design is already research based on the processing of certain data. According to Mitchell and Jolley (2012), a conflict arises between design and research, which he considers as a problem. This claim cannot be accepted. There is a strong bond between design and research, and this interconnection is not seen as a conflict, but as a natural relationship on which it is necessary to build. It is a constantly evolving process in which texts, images and stories enter, so practically everything that affects us. Selective processing, exclusion and subsequent folding, generation, mixing brings different types of colouring (selection and processing of data can be random, subjective or, conversely, objective). We influence these parameters by ourselves with the input data and the decision on how we will process them (Greš, 2018). It is important for architects and landscape architects to be able to implement a range of effective research strategies. Now, we perceive an ever-increasing trend of tasks diversification of the landscape architect (Deming & Swaffield, 2011). The scale and scope of this discipline is constantly expanding. The logical and innovative approach, which prioritizes the legitimacy of knowledge based on collective and proven practices over strict adherence to various protocols obtained solely based on scientific models, creates a strong argument for generating a new legitimacy paradigm for new types of research processes, such as the research methods (van den Brink et al., 2017). When working with non-functional spaces, we often find ourselves in an environment where conceptual solutions and more universal working procedures – architectural and landscape-architectural design, are not entirely easy, due to the complexity of the issue, to apply reliably. Likewise, the methods mentioned below may not lead to satisfactory conclusions. Their results are often misleading and the architectural concept would have to be developed in more detail to confirm the established hypotheses. Confirmation or refutation of the design of fragments of conceptual solutions that appear in this contribution, represents the landscape-architectural design and later the realization and real space. However, this goes beyond the scope of the submitted paper (Dlesk, 2016).

2 Material and methods

The research presents the basic contours of the strategic process that can be observed in the field of the well-known concept "bring back function" at the level

of the surrounding European countries and deals with a specific example. Through case study methods of qualitative research, various case studies were studied and compared, which were included in the working database in the preparatory phase. For the needs of this research, a locality (Partizánske, Western Slovakia) with an urban character was selected, where an object – a spatial-forming element called "Rampolynå", was created in a place without a function. The space was chosen regarding to its focus, functioning, visual identity, area, location, position, and geographical location in relation to the landscape and the city, to ensure sufficient diversity while maintaining the relevance of the example to the Central European context. The wooden object was created as part of an international student workshop called (1 : 1) Workshop in the summer of 2019. The main goal of the workshop is to analyse a selected area of the city, in which the creators have never been, in ten intensive days and to build a wooden structure and thus expand practical skills and experience. The created object remains in place after the workshop and becomes an important part of it. The workshop is a moving event and unique of its kind because it brings life to forgotten places with potential or faded past (Cséfalvay et al., 2020).

The location in which the small-scale object is located is the Milan Rastislav Štefánik Park (Fig. 1), which until recently had only a transitional function and the function of a barrier between the industrial zone and the housing areas. Since the founding of the city, it has been an important part of the concept of an ideal industrial city. It formed part of the belt of regulatory greenery, which separated the production area from the rest of the city in which it lived and was supposed to regulate smog and noise from the factory (Janíčková, 2019). During the full operation of the large shoe company owned by famous Tomáš Baťa, the park played an important role with a psychosocial influence in the lives of the employees who

Figure 1 Wider relations and location of the Rampolynå. Milan Rastislav Štefánik Park, Partizánske (hatched area), where the wooden structure is located, is part of the green belt. Insulating greenery, along with a 1st class road, separates the industrial part of the city from the housing areas

passed through it on the way to/from work. In recent years, however, it did not fulfil its function and the place became forgotten. Therefore, it was necessary to revive the space with something new and somehow draw attention to its past. The research in this paper was mainly covered by the methods of Case study research and Research by design which are described below in this chapter. Observational methods were also used directly, where the observer in the designated area and time observes the behaviour of people in space (Jančovičová & Štěpánková, 2014). In addition to these methods, so-called in-depth interviews with residents and users also entered the data collection process. In-depth interviews, also called informal or semi-structured interviews, are one of the methods of qualitative research and thus complement data collection. This method is one of the simplest methods of collecting primary material and data (Adamková, 2018). Graphic outputs are considered to be the most effective analytical and interpretive method in architecture. Therefore, vector graphics tools were primarily used to analyse and process the results (Čibik & Štěpánková, 2021).

2.1 Case study research

A process in which we collect data in the form of textual and graphical documentation of selected existing spaces and areas through well-documented, systematic, and in-depth analysis of empirical research. On the basis of implemented projects, other research methods are used to identify and evaluate the aspect we have researched. The case studies interpret new findings in an effort to advance and develop landscape architecture. This is also declared by the Landscape Architecture Foundation (LAF). According to the foundation, the case study method is a suitable and valuable approach in landscape planning as well as in the scientific research process. The advantage of the case study method in landscape architecture, as well as other planning and design disciplines, where classical empirical scientific methods are difficult to apply, lies in the ability to gain holistic knowledge from practice. Based on already implemented projects, we can easily examine and observe whether the newly emerging concepts and ideas are correct and whether they meet the goal we have chosen (Čibik & Štěpánková, 2021). There may be some degree of subjectivity here but it is questionable whether objectivity plays a key role in this case (Sidorová & Feriancová, 2014).

2.2 Research by design

Research by design is one of the methods of scientific research in which design is considered as a tool of research in the planning process of a certain creative activity and also in the study of various materials, sketches, various mappings, etc. (Fig. 2). However, in practice, this method does not have clear boundaries (Dlesk, 2016). The positions of its interpretation, understanding and application are still open for discussion. The exact definition is difficult to find because everyone explains it in their own way and just as neither of these interpretations is correct, on the other hand, each of them has something in it and we must consider it relevant and accept it. To describe it simply "research by design" is a method of research through design (Hauberg, 2011). However, this is not done intuitively, but based on study (experimental design study), data, research and evaluation. It is an activity that is largely influenced by subjectivity, but at the same time it is a way of thinking in which the architect asks certain questions, to which he seeks complex answers, and this is nevertheless an essential essence

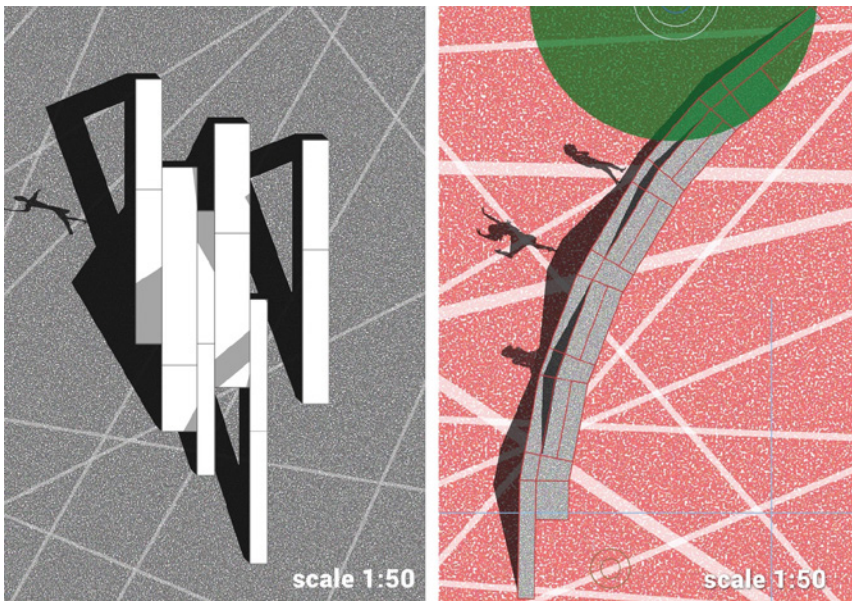

Figure 2 The workshop participants with similar individual concepts were grouped into working groups and continued like this on the three most prominent concepts which were presented during the group critics where the final form of the proposed object was determined. The principle of the final design was based on the collage method – the strong elements of the individual projects were merged and the resulting object was drawn into technical drawings and 3D models
Source: participants of the workshop, vectorised by author

of any research (Thompson, 2008). Professors Martin Tamke and Mette Ramsgaard Thomsen (Ramsgaard-Thomsen & Tamke, 2009) from the Royal Danish Academy (DKAK), Institute of Architecture and Technology, consider the design process in architecture as a reflexive activity where comparisons, assessments and evaluations are carried out through sketches, cyclical movement between design and search and continuous oscillation between the problem and its solution (Dlesk, 2016).

3 Results and discussion

Social interaction is one of the biggest shortcomings of modern society. The way most of our cities were developed until now shows us big issues to be worked on. Compactness and continuity for instance are characteristics to be enhanced. An important player in this goal is nature once its presence turns a formerly "empty" space into an occupied place and its different graduations along streets provide fluidity in the city structure. This brings quality, subserving greatly social interaction, which within the city is created by its own physical spaces. If its public spaces are of good virtue then socio-cultural activities will begin to prevail over the primary functions of the city. The social resource in the city plays an important role in its life and structure. It must therefore be subject to constant development and spatial change in order to persuade the city's inhabitants to stop and think. To observe and perceive, to feel connected to it. When this happens, a sense of belonging is created, changing positively the relation between user and ambience, between users themselves too. For this kind of result, it is also recommended to combine existing historical and cultural values in a homogeneous way with some modern spatial solutions. The societal value of a public space can be huge if it regularly contributes to building a place where several groups of people have a dialogue at the same time. A well-designed space is open to communities (Marques, McIntosh & Chanse, 2020) of people from different social classes, regardless of race, age, origin, or gender. Such places mediate social interaction, social mixing, social integration and support the development of links between communities. A typical example of a spatial element that has created a new meaningful space in a public space without a function is the Rampolynå. Rampolynå is a free-standing wooden structure – an element of small architecture that clearly defines its functions, but at the same time, opens to different interpretations of everyone who interacts with it. The public space thus receives an architecture that complements and transforms it at the same time. The postmodern style of work fits perfectly into its surroundings – the modernist town of Partizánske, Slovakia and its other architectural layers. Already during its design process, a wide range of people were involved in participatory planning in cooperation with the local NGO's and the residents and users of the space themselves. In the first stage of analysis, it was ascertained how the visitors of the park behave, what groups of the city's inhabitants move in it, what is in it and what is missing in it. The interests and activities of the respondents were monitored. Mainly what activities are involved and whether they perform them in a group or as individuals. The movement and operation of users within the space was also an important factor. One of the basic requirements in a human-friendly space is to allow comfortable movement of pedestrians. Quality walking movement should be safe and free. The dynamic as well as the static movement was monitored, and thus in which places within the solved area the users stayed. Larger groups of people in various places created social security. An equally important monitored attribute must be the attribute healthy environment and greenery in the planning process. The variations in way of living that are emerging nowadays will come together with changes in design. New challenges demand new operational modes. The recently studied NDD Nature Deficit Disorder by Richard Louv (2019) shows us in a forced way, the solutions we must aim for. Different physical and behavioural problems come out derived from a life disconnected from Nature (Back Prochnow, 2020). In this sense, the way our cities are planned and also if not most important, the way we intend to requalify our living environments must urgently prescribe the presence of Nature at its different scales. Our capacity of creation is immense, we need to adjust it to be used in tune with the natural world. New technologies in design must be positioned with the intention of reconnecting us and not departing us from our environment. Understanding the city itself as a form of Nature. Our knowledge transforms Nature. Our knowledge transforms Nature into a cultural landscape (Calaza-Martínez, Freire-González & Blanco-Pampín, 2019; Netsch & Gugerell, 2019) that can enhance or dismiss the connection we are looking for. Cities are frequently taken as the opposite of Nature, but no, this can be considered a false assumption, easy to understand when we observe one of nature's basic laws: polarity. It says that opposite things are in fact the same, just in different intensities. The beauty of this concept is that these polarities are always moving, changing, searching for balance. And this is exactly how our idea of cities and how our new mindset in planning must be. Just like our internal processes, physical and psychological states influence the consciousness we experience, the spaces within the city also have this capacity of bringing back balance for the basis scenario where our own balance can find support. This is where landscape architecture

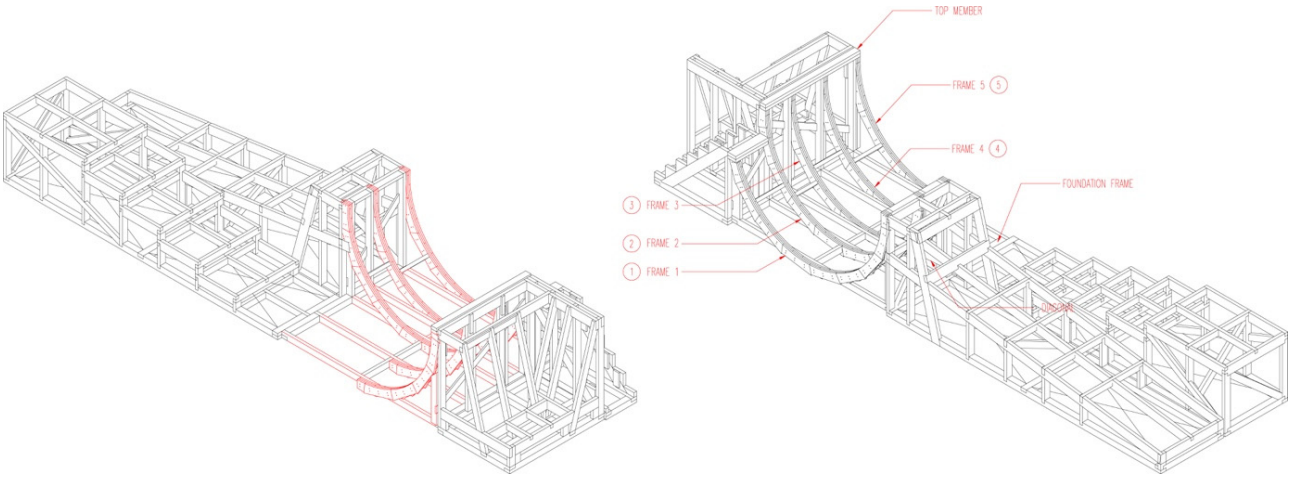

Figure 3 Construction detail of the wooden structure. The workshop (1 : 1) was also focused on expand practical skills and experience of participants, which resulted in sophisticated design process. The close connection of the design with the subsequent self-help construction of the building broadens their horizons within the unusual typologies in public space
Source: participants of the workshop, vectorised by author

comes in: the way in which external events also weigh on this human balance. We actively and humanely create our own perception and consciousness based on our experiences. So planning is supposed to bring the best experiences possible to its users, according to the evolutionary moment they are in. Milan Rastislav Štefánik Park together with the Rampolynå wooden structure offer users a set of these attributes. An element of small-scale architecture was added to the place that was "only" a non-functional green open area until summer of 2019 which forces users to stop, think, relax, debate, and socialize. Rampolynå (Fig. 3) is unique and unforgettable, it is a "One for all and All for one" kind of object. Its postmodern style fits its surroundings – modernist town of Partizánske and its other architectural layers perfectly. It was designed not only for an empty and unused green belt sort of park but also for hosting events organized by local NGO "Fabrika Umenia". Its secondary function as a stage has already been tested by diverse events.

4 Conclusions

Changing and renewing means being able to understand the moving and the liveness of our settlements. The balance between open spaces and buildings, between private and public, between individuality and sociality can change from one specific period of time to another. We are entering a new era, where us, human beings, and our health together with the planet health must be the ultimate target of planning. Architecture and urban design must be able to understand its power also in our sensitivity, in our mood, in our emotions, since one of the biggest demands of our time is mental health that can be assured also by social interaction. Our designs must be able to create conditions in which our inner essence can be mirrored, in otherness. That means in everything that surrounds us, we must be able to find meanings and truth and beauty. Our cities must enhance our experience of living, instigating our senses from new perspectives. This becomes possible when in a conscious way of design, the conceptual ideas connect with the place. It is what is called a "*Genius Loci* approach" (Castello & Back Prochnow, 2021). When we talk about spatial composition, it is intrinsic that it will have several dimensions. All these arise from the fact that we are not passive recipients of world events. We actively participate in the interactions between events and ourselves – which together will determine our perception. So, being able to perceive the place's characteristics and features can lead us to the most interesting results in planning and designing. Not every dimension must or shall be present in every place – that turns the approach even more dynamic. Some places are supposed to be "empty" for example, to let the whole urban landscape breathe. Empty of concreteness but full of nature, full of people. It's a necessary part of the organic tissue that shows nowadays even greater value. We are living sick, in sick cities, because we do not allow Nature's processes and flows. We are apart. Considering cities as liveable, however there are and there will always be parts to be renewed, it is crucial not to be afraid of these changes. Some examples are clear and obvious, others show themselves only for peculiar ways of observing. To demonstrate the way our researches and works foresee and consider landscape design adequate to our future reality, it is already possible to bring some examples from different countries and experiences, as the one presented in this paper.

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References

Adamková, J. (2018). T*he possibilities of horticultural production in stalled spaces and public spaces of postindustrial city:* doctoral dissertation thesis. Brno University of Technology, Brno, 202.

Back Prochnow, S. (2020). *Quarta Natureza – Para o Quarto Distrito Tudo Está Conectado:* doctoral dissertation thesis. Federal University of the Rio Grande Do Sul, Porto Alegre, 496.

Calaza-Martínez, P., Freire-González, N., & Blanco-Pampín, C. (2019). Sacred landscapes in Galicia: Small religious architecture and symbolism. *Acta Horticulturae et Regiotecturae,* 22(1), 8–13. https://doi.org/10.2478/ahr-2019-0002

Castello, L., & Prochnow, S. B. (2021). Once upon a time a *genius loci* conceived a place. *China-USA Business Review,* 20(5). https://doi.org/10.17265/1537-1514/2021.05.001

Cséfalvay, A., Maczová, M., Michalíková, V., & Pišteková, D. (2020, August 21). Rampolyna, Partizánske. *BigSEE Architecture Award.* https://bigsee.eu/rampolyna-partizanske/

Čibik, M., & Štěpánková, R. (2021). *University Campus – Sustainable Multifunctional Component of the City Urbanized Area* : doctoral dissertation thesis. Slovak University of Agriculture in Nitra, Nitra, 303.

Deming, E. M., & Swaffield, S. (2011). *Landscape Architecture Research. Inquiry, Strategy, Design.* Willey and sons, New Jersey, 272.

Dlesk, R. (2016). *Invasive interventions as impulses for the emergence of urban spaces:* doctoral dissertation thesis. Slovak Technical University, Bratislava, 143.

Greš, M. (2018). *Cloud*: diploma thesis. Academy of Fine Arts and Design, Bratislava, 30.

Hauberg, J. (2011). Research by Design – A Research Strategy. *Lusofona Journal of Architecture and Education,* (5), 45–56. http://revistas.ulusofona.pt/index.php/revlae/issue/current

Hernandez, J., & Casanova, H. (2014). *Public Space Acupuncture – Strategies and Interventions for Activating City Life.* Actar Publishers, New York, 350.

Jančovičová, M., & Štěpánková, R. (2014). *Direct Observation Methods in Sustainable Public Spaces Creation of Rural Settlements:* doctoral dissertation thesis. Slovak University of Agriculture in Nitra, Nitra, 133.

Janíčková, K. (2019, September 4). *Partizánske má v parku unikát. Viete, čo je Rampolynå?...* týždeň. https://www.tyzden.sk/kultura/58209/partizanske-ma-v-parku-unikat-viete-co-je-rampolyn/

Louv, R. (2019, October 15). What is Nature-Deficit Disorder? *Richard Louv Blog*. http://richardlouv.com/blog/what-is-nature-deficit-disorder

Lukas-Sithole, M. (2020). Greening Nyanga: Developing a Community Park in a Complex Urban Environment in Cape Town, South Africa. *Acta Horticulturae et Regiotecturae,* 23(2), 96–100. https://doi.org/10.2478/ahr-2020-0019

Marques, B., McIntosh, J., & Chanse, V. (2020). Improving Community Health and Wellbeing Through Multi-Functional Green Infrastructure in Cities Undergoing Densification. *Acta Horticulturae et Regiotecturae*, 23(2), 101–107. https://doi.org/10.2478/ahr-2020-0020

Mitchell, L. M., & Jolley, M. J. (2012). *Research Design Explained.* Wadsworth Publishing, Belmont, 752.

Netsch, S., & Gugerell, K. (2019). Reuse of Churches in Urban and Rural Dutch Landscapes. *Acta Horticulturae et Regiotecturae,* 22(1), 48–55. https://doi.org/10.2478/ahr-2019-0009

Ramsgaard-Thomsen, M., & Tamke, M. (2009). Narratives of making: thinking practice led research in architecture. In *Communicating (by) Design,* 2009, 1–8.

Sidorová, M., & Feriancová, Ľ. (2014). *Catalytic impact of marketplaces on public spaces:* doctoral dissertation thesis. Slovak University of Agriculture in Nitra, Nitra, 107.

Sidorová, M., Bainakova, A., Fajmonová, V., Lammelová, Z., Mazzini, M., & Stará, K. (2016). *Jak navrhnout férově sdílené město.* Heinrich-Böll-Stiftung e.V. a WPS Prague, Prague, 36.

Thompson, I. (2008). Ecology, *Community and Delight. Sources of Values in Landscape Architecture.* Taylor and Francis, New York, London, 201.

Tóth, A., Timpe, A., Stiles, R., Damyanovic, D., Valánszki, I., Salašová, A., Cieszewska, A., & Brabec, E. (2019). Small sacral Christian architecture in the cultural landscapes of Europe. *Acta Horticulturae et Regiotecturae,* 22(1), 1–7. https://doi.org/10.2478/ahr-2019-0001

van den Brink, A., Bruns, D., Tobi, H., & Bell, S. (2017). *Research in landscape architecture – methods and methodology.* Routledge, New York, 18.

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Research Article

Toxic and allergenic plant species in primary school yards of Zagreb's Lower Town district

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The green infrastructure of Zagreb's Lower Town is made up of row-planted trees and green spaces within blocks of buildings. All schools are surrounded by green spaces that have a positive impact on the environment. Although most green spaces contribute to improving the quality of life, they also contain toxic and allergenic species which are potentially hazardous, particularly to children. This paper aims to make an inventory of plant species in the environment of primary schools in Zagreb's Lower Town district, and to determine the presence of toxic and allergenic species. The field research was conducted from March to the end of May 2021 at 7 primary school locations. 13 either annual or biennial plant families were catalogued. In total, 34 species of herbaceous perennials and geophytes, and 36 species of trees from 17 plant families were listed. A total of 38 species of shrubs and climbers were found. Also, a total of 35 poisonous and 28 allergenic plant taxa are planted in the green spaces surrounding primary schools. The most common poisonous species found are *Hedera helix* and *Taxus baccata*, and *Ilex aquifolium*, a highly poisonous species, was also found. No moderately poisonous species have been found at all. As far as allergenic species are concerned, school environments are dominated by those that produce low and moderate levels of pollen concentration in the air. Species that produce high levels of pollen concentration (e.g., *Betula pendula*, *Robinia pseudoacacia*, etc.) are the least represented ones, while species that produce a very high concentration of pollen have not been recorded in any of the localities.

Keywords: primary schools, school gardens, ornamental plants, poisonous plants, allergies

1 Introduction

Within the context of urban green spaces, special attention should be given to primary school gardens. Titman (1994) sees school grounds as: a place to work in (physical activity and new skills development), a place to think in (to study and develop new skills), a place for the senses (to enjoy colours, smells, sounds, and nature in general), and a place to be (for privacy and enjoyment of silence). In other words, school gardens are spaces that facilitate the physical, psychological, and intellectual development of children and young people.

From the second half of the 18th to the end of the 19th century, Croatia's education system was regulated by directives, orders, and decrees which sought to set up a school garden in each school (Slačanac & Munjiza, 2007). At the end of the 19th century, school gardens were declared commercial gardens as well, which expanded their use, and enabled schools to start generating profit from their gardens (Kolar-Dimitrijević, 2014). The 1923 Education Act made the institution of school garden obligatory. In 1936, the agricultural administrative authorities were assigned the task of preparing the commercial framework of school gardens, proposing school garden layouts and plans, and seedling distribution at no cost. In 1956, school cooperatives of different orientations (e.g., field crop husbandry, fruit and vegetable growing, floriculture, beekeeping, etc.) were established, whose development actually led to the silent liquidation of school gardens (Munjiza, 2003). Interest in school gardens was reignited after 1990. The then new conception of Croatian education reaffirmed school gardens (Židovec et al., 2018), and recognised their role in developing interest in the field of ecology and environmental education, and in being young people's social and psychological support with elements of psychotherapy through work (Munjiza, 2003).

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Due to a long tradition of school gardens, and their use encouraged in teaching, it is expected that children will, at some point, get exposed to direct or indirect contact with plant species. Although teaching in the natural environment of school gardens has many positive aspects, the possibility of negative outcomes due to allergic reactions or poisoning via consumption of toxic plant parts is always present. In the last few decades, an increase in the use of ornamental plants in parks and gardens, public and workplaces have become a new source of aeroallergens (D'Amato et al., 2007). Eder, Ege & von Mutius (2006) estimate that pollen allergy has risen by 40%, and exposure to allergens is a key environmental factor, much like other air pollutants, that causes asthma. The accidental poisoning of children by ingestion of plants causes over 50% of all poisoning cases in Slovakia (Plackova, Caganova & Kresánek, 2006). It is suggested that children's inadequate plant identification skills are responsible for their consumption of some poisonous plant parts. The risk of toxic plant consumption is considered to be highest amongst younger children who lack awareness about the toxicity of plants or their fruit (Fančovičová & Prokop, 2011). Familiarity that results from exposure to plants in nature influences children's ability to identify plants (Lindemann-Matthies, 2005). It is evident from the above historical overview that school gardens have a long tradition, and that continued emphasis has been placed on their importance. School gardens in urban areas are also an integral part of the latter's green infrastructure. Although most species planted in cities and school gardens contribute to improving the quality of life, they can be poisonous and allergenic, which is potentially hazardous, particularly to children.

This paper aims to make an inventory of the ornamental plant species in the gardens of primary schools in Zagreb's Lower Town district, and to determine the presence of toxic and allergenic species.

2 Material and methods

The research was conducted in the green spaces of primary schools in Zagreb's Lower Town (Donji Grad) district. The Lower Town district is Zagreb's strict city centre and is located at 45° 48′ N longitude and 15° 58′ E latitude, covering 301.64 he in area, and occupying 3.02% of the total area of the city (Grad Zagreb, 2017).

The field research was conducted from March to the end of May 2021. The research included 7 primary schools and was approved by the principals who granted the researchers entry, and permission to take photographs. Two of the primary schools do not have their own schoolyards but have other small green areas and also use public green area in front of the school in the same way they would use schoolyard (Table 1).

Table 1 Primary schools of Zagreb's Lower Town

Primary school mark	Year of opening	Schoolyard
PS-1	1961	×
PS-2	1957	×
PS-3	1895	-
PS-4	1925	-
PS-5	1901	×
PS-6	1864	×
PS-7	1875	×

To measure the size of plot around the schools, the Geoportal of the State Geodetic Administration of the Republic of Croatia (2021) was used. Using the GIS online tool, the area of the schoolyards was measured: the total area of each plot; each construction area; each front yard area; each schoolyard area; and the length of each hedgerow. Each area was measured in square metres (m^2), and each hedgerow in metres (m).

To make an inventory of plant species, the field research was conducted from March to the end of May 2021. To determine the species of plants, their taxonomy, and invasiveness, relevant botanical literature was used. Poisonous plant species were determined based on: Crvenka (1996), Forenbacher (1998), Grlić (1984), Petrić and Tomašević (2003). The toxicity class of each plant species is presented in accordance with Filmer's (2012) modified plant toxicity categorisation. The allergenicity of each plant species was determined based on D'Amato et al. (2007).

Potentially aeroallergenic plants must contain allergenic compounds in their pollen grain, be anemophilous, and produce pollen in large quantities. The allergenicity category of each plant species was determined in accordance with the modified categorisation of Peternel et al. (2004), which classifies dendrological plants according to their level of allergenicity as follows: low (I), moderate (II), high (III), and very high (IV) pollen levels. Highly sensitive individuals will develop symptoms of an allergic reaction even when the pollen count is low (1), most sensitive individuals when the count is moderate (2), and when the pollen count is high (3) and very high (4), all individuals sensitive to pollen will develop symptoms of an allergic reaction.

Table 2 Plot areas of primary schools in Zagreb's Lower Town district (m^2)

PS	Total plot area (m^2)	Construction area (m^2)	Green space area (m^2)	Sports ground area (m^2)
PS-1	3,741	761	2,980	–
PS-2	5,876	1,840	1,755	2,281
PS-3	4,190	2,415	910*	865
PS-4	3,631	3,034	597*	–
PS-5	3,766	800	996	1,970
PS-6	3,908	1,050	558	2,300
PS-7	8,139	2,604	1,316	4,219
Average	4,750	1,786	1,302	2,327

* public areas located in front of the primary school included

3 Results and discussion

With the help of the Geoportal of the State Geodetic Administration of the Republic of Croatia, the area of each school garden was measured: the total area of each plot; each construction area; the area of each green space; and the area of each school's sports grounds. The total area of each primary school plot includes the school building, the school's sports hall, the school's car park, paths, green spaces, and its sports grounds.

PS-7 has the largest total plot area (Table 2). PS-4 has the largest construction area, while PS-5 has the smallest construction area. There are green space areas adjacent to three schools: PS-3, PS-4, and PS-6. The green space areas of PS-3 and PS-4 do not belong to the cadastral parcels of the two schools, but are public green space areas that have been included in the total school plot area, given that pupils use them for their needs (placement of flowerpots, break time, etc.). PS-3 shares its cadastral parcel with other public facilities. The primary schools on the outskirts of Zagreb's Lower Town district have a significantly larger total plot area than those in the centre of the district.

As Table 3 shows, a total of 22 species of annual or biennial plant species from 13 plant families, 34 perennials and geophytes from 19 plant families, 38 species of shrubs and woody climbers from 20 plant families, and 34 species of trees from 17 plant families were catalogued. A total of 6 invasive species were found. Most perennials and geophytes are from the Asparagaceae and Lamiaceae families, most shrubs and woody climbers from the Lamiaceae and Rosaceae families, and most trees from the Aceraceae family.

35 poisonous plant species have been found, the most common of which is *Hedera helix*, which is present in all the primary schools. *Taxus baccata*, and *Prunus laurocerasus* are amongst the more common poisonous species. In terms of their toxicity class, 15 are highly toxic (2), 12 slightly toxic (4), and 8 fatally toxic (1). From amongst the highly poisonous plant species, *Ilex aquifolium* should be singled out. It is a protected plant species that was found in the immediate vicinity of PS-1's schoolyard. It has prickly leaves, which makes it unsuitable for the schoolyard. The presence of *Ligustrum vulgare* should also be noted as it is a species which is poisonous in its entirety. It forms the hedgerow in as many as four locations.

From amongst the fatally toxic species, *Prunus laurocerasus* and *Taxus baccata* stand out. Both species are poisonous in their entirety, and their toxins can affect human health adversely (causing vomiting, diarrhoea, heart palpitations, etc.). Although the (seedless) aril of *Taxus baccata* is edible, caution is advised because the fruit's bright colour creates interest in children exposing them to the risk of poisoning. *Nerium oleander* is an evergreen shrub that is taken indoors in winter. All its parts are poisonous. In pregnant women, it can cause strong contractions and a miscarriage, and its juice can cause skin irritation and allergic reactions (Maretić, 1986). Planting *Nerium oleander* in primary schools should definitely be avoided.

28 allergenic plant species were found. *Taxus baccata* is the most widely spread, while *Betula pendula*, *Ligustrum vulgare*, and *Platanus* are also common. It is important to notify that only male plants of yew produce pollen. In terms of allergenicity, the green spaces of schools are dominated by species that produce low levels of pollen concentration in the air (11). Highly allergenic (3) species are the least represented ones. This group includes *Betula pendula*, *Robinia pseudoacacia*, and *Parietaria judaica*, a perennial which blooms from May to September, and which produces a large amount of pollen during flowering causing allergies (Nikolić et al., 2008).

Table 3 List of catalogued species, their incidence (number of locations where the species had been recorded), invasiveness, toxicity class, and allergenicity category

Plant family		Plant species	Incidence	Invasiveness	Toxicity class	Allergenicity category
Annual and biennial plant species						
1	Apiaceae	*Petroselinum crispum* (Mill.) A. W. Hill	1			
2	Asteraceae	*Arctium lappa* L.	1			
3		*Argyranthemum frutescens* (L.) Sch.Bip.	1			
4		*Dahlia pinnata* Cav.	1			
5		*Euryops pectinatus* Cass.	1			
6		*Osteospermum ecklonis* (DC.) Norl.	1			
7		*Tagetes erecta* L.	2	x		
8	Balsaminaceae	*Impatiens walleriana* Hook.f.	1	x		
9	Begoniaceae	*Begonia semperflorens* Link et Otto	2			
10		*Heliotropium arborescens* L.	1		1	
11	Boraginaceae	*Myosotis sylvatica* Ehrh.	1			
12	Brassicaceae	*Lobularia maritima* (L.) Desv.	1			
13	Caryophyllaceae	*Dianthus caryophyllus* L.	2		2	
14		*Dianthus chinensis* L.	1			
15	Crassulaceae	*Crassula* sp. L.	1			
16	Lythraceae	*Cuphea hyssopifolia* Kunth	2		4	
17	Geraniaceae	*Pelargonium* sp.	1			
18	Lamiaceae	*Ocimum basilicum* L.	1			
19	Scrophulariaceae	*Veronica persica* Poiret	1	x		
20	Solanaceae	*Calibrachoa parviflora* (Juss.) D'Arcy	1			
21		*Petunia axillaris* (Lam.) B.S.P.	1			
22		*Solanum lycopersicum* L.	1			
Perennials and geophytes						
1	Acoraceae	*Acorus gramineus* Sol. Aiton	1			
2	Aizoaceae	*Delosperma cooperi* (Hook.f.) L. Bolus	1			
3	Amaryllidaceae	*Narcissus* sp.	1		2	
4	Apocynaceae	*Vinca major* L.	1			
5		*Vinca minor* L.	2			
6		*Vinca minor* L. 'Variegata'	1			
7	Asparagaceae	*Hosta* sp.	1			
8		*Hyacinthus orientalis* L.	1		2	
9		*Muscari neglectum* Guss. ex Ten.	1			
10		*Yucca gloriosa* L.	1			
11	Asteraceae	*Bellis perennis* L.	1		4	
12		*Chrysanthemum indicum* L.	2			
13	Boraginaceae	*Glandora diffusa* (Lag.) I. M. Johnst.	1			
14	Crassulaceae	*Sedum ternatum* Michx.	1			
15		*Sempervivum tectorum* L.	4			
16	Iridaceae	*Crocus vernus* (L.) Hill	1			
17		*Iris germanica* L.	1			

First continuation of table 3

Plant family		Plant species	Incidence	Invasiveness	Toxicity class	Allergenicity category
18	Lamiaceae	*Glechoma hederacea* L.	1		2	
19		*Mentha* × *piperita* L.	1			
20		*Origanum vulgare* L.	1			
21		*Plectranthus forsteri* 'Marginatus'	1			
22	Liliaceae	*Lilium* sp.	1			
23		*Tulipa* sp.	1		2	
24	Paeoniaceae	*Paeonia mascula* (L.) Mill.	1			
25	Poaceae	*Phyllostachys bissetii* (Carr.) A.et C.Riv.	1			
26	Polemoniaceae	*Phlox subulata* L.	1			
27	Rosaceae	*Duchesnea indica* (Andr.) Focke	1	x		
28		*Fragaria* × *ananassa* Duchesne ex Weston	3			
29	Saxifragaceae	*Heuchera* 'Green Spice'	1			
30		*Heuchera* sp.	1			
31		*Saxifraga* × *arendsii* Engl.	1			
32	Urticaceae	*Parietaria judaica* L.	1			(III)
33	Verbenaceae	*Verbena* × *hybrida* Groenland & Rümpler	1			
34	Violaceae	*Viola odorata* L.	1			
		Shrubs and climbers				
1	Adoxaceae	*Sambucus nigra* L.	2		1	(I)
2	Apocynaceae	*Nerium oleander* L.	1		1	
3	Aquifoliaceae	*Ilex aquifolium* L.	1		2	
4	Araliaceae	*Hedera helix* L.	7		2	
5	Asteraceae	*Santolina rosmarinifolia* L.	1			
6	Berberidaceae	*Berberis thunbergii* DC.	3		4	
7	Bignoniaceae	*Campsis radicans* (L.) Seem. ex Bureau	1		4	
8	Caprifoliaceae	*Lonicera caprifolium* L.	2			
9		*Lonicera nitida* E. H. Wilson	1			
10	Celastraceae	*Euonymus fortunei* (Turcz.) Hand.-Maz.	2		2	
11		*Euonymus japonicus* Thunb.	1		2	
12	Cupressaceae	*Juniperus* sp. L.	2			(II)
13	Ericaceae	*Rhododendron indicum* (L.) Sweet	1		1	
14	Fabaceae	*Wisteria sinensis* (Sims) Sweet	1		1	
15	Hydrangeaceae	*Deutzia scabra* Thunb.	1			
16	Lamiaceae	*Lavandula angustifolia* Mill	1			
17		*Lavandula officinalis* Chaix	3			
18		*Lavandula stoechas* L.	1			
19		*Rosmarinus officinalis* L.	1			
20		*Rosmarinus officinalis* L. 'Capri'	2			
21		*Salvia officinalis* L.	2			
22		*Thymus vulgaris* L.	1			
23		*Thymus* × *citriodorus* 'Silver Queen'	1			

Second continuation of table 3

Plant family		Plant species	Incidence	Invasiveness	Toxicity class	Allergenicity category
24	Malvaceae	*Hibiscus syriacus* L.	1			
25	Myrtaceae	*Myrtus communis* L.	1		2	
26	Oleaceae	*Forsythia suspensa* (Thunb.) Vahl	1			
27		*Ligustrum ovalifolium* Hassk.	1		2	
28		*Ligustrum vulgare* L.	4		2	(II)-(III)
29		*Syringa vulgaris* L.	3			(I)
30	Pinaceae	*Pinus mugo* Turra	1			
31	Ranunculaceae	*Clematis vitalba* L.	2		4	
32	Rosaceae	*Chaenomeles japonica* (Thunb.) Lindl. ex Spach	1			
33		*Cotoneaster horizontalis* Decne.	2		2	
34		*Photinia* × *fraseri* Dress	1			
35		*Prunus laurocerasus* L.	6		1	
36		*Rosa* sp.	4			(I)
37		*Rubus caesius* L.	1			
38		*Spiraea* × *vanhouttei* (Briot) Zabel	1			
		Trees				
1	Aceraceae	*Acer campestre* L.	1			
2		*Acer negundo* L.	3	x	4	(II)
3		*Acer palmatum* Thunb. ex E. Murray	1		4	
4		*Acer pseudoplatanus* L.	1		4	(II)
5		*Acer saccharinum* L.	2		4	(II)
6	Altingiaceae	*Liquidambar styraciflua* L.	1			(I)
7	Betulaceae	*Betula pendula* Roth.	5		4	(III)
8		*Carpinus betulus* L.	1			(II)
9		*Carpinus betulus* L. 'Fastigiata'	1			(II)
10	Cupressaceae	*Chamaecyparis lawsoniana* (A. Murray) Parl.	1			(II)
11		*Thuja occidentalis* L.	1		2	(II)
12	Fabaceae	*Gleditsia triacanthos* L.	1			
13		*Robinia pseudoacacia* L.	1	x	1	(III)
14	Hippocastanaceae	*Aesculus hippocastanum* L.	2		2	(II)
15	Magnoliaceae	*Magnolia liliiflora* Desr.	1			
16	Moraceae	*Ficus carica* L.	1			
17		*Maclura pomifera* (Raf.) C. K. Schneid.	1			
18	Oleaceae	*Fraxinus angustifolia* Vahl	1		4	(II)-(III)
19		*Fraxinus excelsior* L.	2		4	(II)-(III)
20	Pinaceae	*Abies alba* Mill.	1			(I)
21		*Cedrus atlantica* (Endl.) Manetti ex Carriere 'Glauca'	1			
22		*Picea abies* (L.) H. Karst.	1			(I)
23	Platanaceae	*Platanus* × *acerifolia*/Aiton/Willd.	4			(II)-(III)
24	Rosaceae	*Malus domestica* Borkh.	1			

Third continuation of table 3

Plant family		Plant species	Incidence	Invasiveness	Toxicity class	Allergenicity category
25	Rosaceae	*Prunus avium* (L.) L.	1			
26		*Pyrus communis* L.	2			
27	Salicaceae	*Populus nigra* L. 'Italica'	1			(I)
28	Sapindaceae	*Koelreuteria paniculata* Laxm.	1			
29	Taxaceae	*Taxus baccata* L.	6		1	(II)
30	Tiliaceae	*Tilia cordata* Mill.	3			(I)
31		*Tilia platyphyllos* Scop.	2			(I)
32		*Tilia tomentosa* Moench	2			(I)
33	Ulmaceae	*Celtis australis* L.	1			(I)
34		*Celtis occidentalis* L.	1			

4 Conclusions

Due to school spaces being restricted and green schoolyard areas being mostly small, in Zagreb's Lower Town district a relatively small number of species have been catalogued. In turn, this showed that toxic and allergenic species in the total number of species catalogued is high when it comes to woody plant species (trees, shrubs and climbers). The most frequent poisonous and allergenic species (*Taxus baccata*, *Betula pendula*, *Hedera helix* and *Ligustrum vulgare*) catalogued in the immediate vicinity of primary schools in Zagreb's Lower Town district are the same as those that have been catalogued in similar studies (Vlahović & Karlović, 2013; Perinčić, Milović & Radoš, 2014; Mrđan et al., 2017; Židovec et al., 2018) conducted in the vicinity of other education institutions elsewhere. This points to the fact that there is no growing knowledge about potential problem. Awareness should be raised among personnel responsible for planning and planting on all green areas around education institutions. Species planted should be chosen more carefully, avoiding species that are moderately and strongly allergenic or poisonous in their immediate vicinity. 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 them by children. Growing of poisonous annuals, biennials and perennials should be avoided. Children should be more informed about plant species, their value and characteristics.

References

Crvenka M. (1996). *Atlas otrovnog bilja.* Svjetlo riječi, Livno.

D'Amato, G., Cecchi, L., Bonini, S., Nunes, C., Annesi-Maesano, I., Behrendt, H., ... & Van Cauwenberge, P. (2007). Allergenic pollen and pollen allergy in Europe. *Allergy*, 62(9), 976–990. https://doi.org/10.1111/j.1398-9995.2007.01393.x

Eder, W., Ege, M. J., & von Mutius, E. (2006). The asthma epidemic. *New England Journal of Medicine,* 355(21), 2226–2235. https://doi.org/10.1056/nejmra054308

Fančovičová, J., & Prokop, P. (2011). Children's Ability to Recognise Toxic and Non-Toxic Fruits. *Eurasia Journal of Mathematics. Science & Technology Education,* 7(2), 115–120. https://doi.org/10.12973/ejmste/75186

Filmer, A. K. (2012). *Safe and Poisonous Garden Plants.* University of California, Davis.

Forenbacher, S. (1998). *Otrovne biljke i biljna otrovanja životinja.* Školska knjiga, Zagreb.

Grad Zagreb (2017). *Mjesna samouprava – Gradska četvrt Donji Grad.* Grad Zagreb službene stranice. https://www.zagreb.hr/

Grlić, Lj. (1984). *99 jestivih i otrovnih boba.* Prosvjeta, Zagreb.

Kolar-Dimitrijević, M. (2014). Značenje školskih vrtova u sjevernoj Hrvatskoj u vrijeme Austro-ugarske monarhije. *Ekonomska i Ekohistorija: časopis za gospodarsku povijest i povijest okoliša,* 10(1), 217–232.

Lindemann-Matthies, P. (2005). 'Loveable'mammals and 'lifeless' plants: how children's interest in common local organisms can be enhanced through observation of nature. *International journal of science education,* 27(6), 655–677. https://doi.org/10.1080/09500690500038116

Maretić. Z. (1986). *Naše otrovne životinje i biljke.* Stvarnost, Zagreb.

Mrđan, S., Ljubojević, M., Orlović, S., Čukanović, J., & Dulić, J. (2017). Poisonous and allergenic plant species in preschool's and primary school's yards in the cita of Novi Sad. *Urban Forestry & Urban Greening,* 25, 112–119. http://dx.doi.org/10.1016/j.ufug.2017.05.007

Munjiza, E. (2003). *Pedagogijska funkcija školskih vrtova*. Hrvatski pedagoško-književnički zbor, ogranak Slavonski Brod Teka d.o.o., Velika Kopanica.

Nikolić, T., Kovačić, S., Ruščić, M., Milović, M., Stamenković, V., Mihelj, D., Jasprica, N., Bogdanović, S., & Topić, J. (2008). *Flora jadranske obale I otoka – 250 najčešćih vrsta.* Školska knjiga Zagreb.

Perinčić, B., Milović, M., & Radoš, D. (2014). *Otrovne biljne vrste u dvorištima škola i dječjih vrtića grada Zadra.* Stručni rad, Sveučilište u Zadru, Zadar.

Petrić P., & Tomašević, M. (2003). *Biljne vrsta uzročnici peludnih alergija.* Spin Valis, Požega.

Peternel, R., Srnec, L., Čulig, J., Zaninović, K., Mitić, B., & Vukušić, I. (2004). Atmospheric pollen season in Zagreb (Croatia) and its relationship with temperature and precipitation. *International journal of biometeorology,* 48(4), 186–191. https://doi.org/10.1007/s00484-004-0202-x

Plackova, S., Caganova, B., & Kresánek, J. (2006). Epidemiology of poisonings in children. *Lékarský obzor*, 55(7/8), 296.

Slačanac, I., & Munjiza, E. (2007). Programski sadržaji razredne nastave i mogućnosti njihove realizacije u školskim vrtovima. *Život i škola,* 17(1), 88–91.

State Geodetic Administration of the Republic of Croatia (2021). *National Spatial Data Infrastructure.* https://geoportal.nipp.hr/

Titman, W. (1994). *Special places; special people: The hidden curriculum of school grounds*. WWF UK, Learning through Landscape Trust, Winchester.

Vlahović, I., & Karlović, K. (2013). Otrovne i alergene biljne vrste u školskim vrtovima grada Samobora. *Agronomski glasnik,* 75(2–3), 107–116.

Židovec, V., Pirić, T., Skendrović Babojelić, M., & Dujmović Purgar, D. (2018). Vrtovi odgojno-obrazovnih institucija na području gradske četvrti Sesvete. *Agronomski glasnik*, 5(80), 313–317.