THE CHALLENGES OF IMPLEMENTING THE GREEN-BLUE INFRASTRUCTURE IN THE METROPOLITAN AREAS OF THE BIG CITIES IN ROMANIA

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Abstract

This paper aims to demonstrate the necessity of infrastructure planning in the big cities of Romania starting from a theoretical approach to the subject. Green space and green infrastructure have a close connection with topics like urban sprawl, climate change, or nature-based solutions. The present results are based on the research on Google Scholar of the publications that have appeared in recent years. Thus, most scientific papers mostly refer to urban green infrastructure in relation to the field of planning, public health, nature-based solutions and climate change and, in a lower extent, to GIS systems, pandemic and social equity. The conclusions show that an interdisciplinary approach is needed, and that a strategic and priority urban planning must evaluate ecosystem services offered by green infrastructure in order to sustain a healthy city.

Key words: green areas, urban green infrastructure, ecosystem services, NBS, strategic planning.

INTRODUCTION

Urban sprawl increases land fragmentation and decreases connectivity, affecting green space functions and biodiversity, inducing urban growth (Bhatta, 2010; Popescu et al., 2020). Although urban growth can have positive consequences (a greater economic output, new job opportunities), uncontrolled urban sprawl has negative effects, such as a higher cost of infrastructure and services, energy inefficiency, a negative impact on ecosystems, loss of agricultural land, rising temperatures, deterioration of air, water and soil quality.

The most common context of *green space* is the urban context. In cities, although the number of protected green spaces has increased – such as Natura 2000 sites – other green spaces are shrinking, at the expense of the land on which it is being built (European Commission, 2020). The increased interest in green space research is explained by the understanding that nature has a positive impact on human well-being (Frumkin, 2013; Taylor & Hochuli, 2017). Green space is usually considered to be composed of vegetation associated with natural elements (Taylor &

Hochuli, 2017). *Green infrastructure*, a related term, refers to a network of green space, on a city or landscape scale, whose function is in relation to urban inhabitants (Tzoulas et al., 2007; Pienaru & Rădulescu, 2022). Today, the concept of green infrastructure represents a new understanding of the relationship between man and nature and gives a new meaning to the green space planning (Hu et al., 2020). *Urban green (or blue-green) infrastructure* can be defined as a network of natural or nature-based elements located in urban built-up areas. Its elements are increasingly being used for their benefits to humans and wildlife and as a method of adapting to climate change.

Climate change has become a challenge for all of humanity, with negative effects on both natural and socio-economic ecosystems. Coping with climate change requires proactive adaptation actions (Wang & Wang, 2023) for a green, resilient and inclusive development. Planting trees and installing green infrastructure will help to cool urban areas and mitigate the impact of natural disasters. According to the European Commission, *nature-based solutions* (NBS) are essential for reducing emissions and adapting to climate

change. The NBS concept, considered to be an umbrella concept, contains a strong spatial planning dimension and is related to many other concepts and approaches, such as green/blue/urban infrastructure, ecosystem services, urban forestry, etc. (European Commission, 2022).

The benefits of NBS and the promotion of green infrastructure have been focused in European and international frameworks: The EU Green Deal (European Commission, 2019), EU Biodiversity Strategy for 2030 (European Commission, 2020a), The European Union's action plan to reduce air, water and soil pollution to zero (European Commission, 2021), stating that they should be systematically integrated into urban planning – in public spaces, in infrastructure, in buildings and their surroundings.

A recent World Bank study on Romania's development (World Bank, 2023) shows that in Romanian urban areas air pollution often exceeds the limits set by the EU, especially in winter. Rural areas are struggling to manage their forests and increasingly nutrient pollution and chemicals is observed in water bodies. Romania is prone to certain natural disasters induced by climate change, and also the agricultural sector is vulnerable due to the fragmentation of agricultural holdings.

A *green belt* around cities or metropolitan areas can be a way of adapting to climate change. That is why Romania's urban policy foresees the strengthening of green-blue infrastructure to limit and adapt to urban hazards (climate-smart cities). The National Recovery and Resilience Plan (Ministry of European Investments and Projects, 2021) often refers to NBS as a measure to reduce air pollution in large urban agglomerations. NRRP provides the establishment of urban forests as a NBS solution, which can enrich the current green spaces insufficient in surface area and diversity. In this context, the paper presents an analysis of the main topics related to urban green infrastructure as it reflects in recent scientific articles and the necessity to implement this kind of infrastructure in metropolitan areas of the big cities in Romania. The objective of the research is to establish how large cities can create a green-blue infrastructure in a practical way, because it is a multidisciplinary topic that can be approached from several points of view.

MATERIALS AND METHODS

An exploration of the publications in Google Scholar focusing on green/urban green infrastructure highlights several related topics in close connection on this topic.

To implement the concept of green infrastructure in the big cities in Romania we need to know what the relationship with urban and spatial development is.

The period considered in this study is 2019-2023.

RESULTS AND DISCUSSIONS

The interest on green/urban green infrastructure has grown in recent years, reflected by the large number of scientific publications. A previous analysis (Popescu & Tache, 2023) showed that the number of references about green / urban green infrastructure increased 7 times between 2000 and 2020, with a maximum of interest in the years 2108 and 2019.

Between 2016 and 2023, most publications from Google Scholar having as topic "urban green infrastructure" related to fields such as "urban planning", "public health", "nature-based solutions" and "climate change", and to a lesser extent there were publications approaching "GIS systems", "COVID-19 pandemic" and "social equity". "Metropolitan areas" were also treated in relation to "urban green infrastructure", with emphasis on priority planning through certain changes in land use policies.

In the last 3 years (2021-2023) a slightly downward trend has been observed, a lower interest in the topic of green / urban green infrastructure.

Table 1 presents the main results of the research for the period 2021-2023, in Google Scholar scientific publications.

Based on this table, we can make some observations regarding the possibility of implementing green infrastructure in the metropolitan areas of the big cities in Romania, as a necessity of the present.

Table 1. Bibliographic research on urban green infrastructure planning between 2021 and 2023

	Topics addressed	Authors	Key words	Results
1.	The concept of green infrastructure - dual and ambiguous	Matsler et al., 2021	GI, ecosystem services urban ecology, urban planing, NBS, rainwater management	The duality of green infrastructure definitions: an ecological network and planning approach vs an engineering technique
2.	Evaluation indicators of urban green infrastructure	Hanna et al., 2023	Urban green infrastructure, green areas, vegetation areas	With these indicators, an overview of urban green areas can be obtained
3.	Urban green infrastructure and adaptation to climate change	Sánchez & Govindarajulu, 2023	Urbanization, climate change, coastal cities, green-blue infrastructure, changing perception	It is necessary to promote nature-based solutions for climate change adaptation
4.	Green infrastructure and efficient use of urban floodplains	Herath et al., 2023	Green-grey infrastructure, SWOT analysis, sustainable and resilient cities	The benefits of urban green infrastructure are multiple
5.	Urban green infrastructure and biodiversity	Liu et al., 2023	Urban green infrastructure, urban ecosystems, birds, biodiversity conservation, urbanization	Studying the links and patterns that exist between bird diversity and how they respond to urban green infrastructure can provide the scientific basis for green infrastructure management
6.	Urban green infrastructure and the COVID-19 pandemic	Bristowe & Heckert, 2023	Urban green space, parks, nature	It has increased the use of local green infrastructure and its appreciation by people
7.	Urban green infrastructure and ecosystem services	Du Toit et al., 2018; Bush et al., 2021	Green space, ecosystem services, biodiversity, climate change, urban planning, regulations, sustainability	Alternative food supply options (e.g. vertical gardens, green roofs, etc.) are needed for urban residents
8.	Urban green infrastructure and ecosystem services	Depietri, 2022	Urban green infrastructure, conflicts, synergistic solutions, hybrid infrastructure, stakeholders	There are positive and negative aspects of urban green infrastructure in terms of ecosystem services (services/disservices)
9.	Urban green infrastructure and urban and spatial planning	Monteiro et al., 2020; Grabowski et al., 2023	Green infrastructure, spatial planning, planning principles, urban plans, stormwater and sewage systems	If planning procedures are too complex and difficult to implement, policy makers do not consider green infrastructure as a viable planning tool.
10.	Inclusion of urban green infrastructure in city plans	Grabowski et al., 2022	Urban planning, urban green infrastructure, integrative concept, rainwater	A synthetic definition of green infrastructure is needed for the future to guide research and planning
11.	Metropolitan green infrastructures	Marull et al., 2023; Shen et al., 2023	Metropolitan green infrastructures, land use planning, landscape metabolism, landscape ecology, agricultural management, climate change	Areas of urban/metropolitan infrastructure need to be increased to avoid the ever-increasing ecological risks faced by metropolitan areas

From a theoretical point of view, regarding metropolitan green infrastructures, it is observed that although there is still some ambiguity in the **definition and terminology of the green infrastructure**, there is still an advantage because it allows interdisciplinary approaches, thereby boosting research. No single concept is recommended, but rather recognition of alternative terms and specification of meaning as necessary.

Green infrastructure implementation solutions are needed in the metropolitan areas of Romania because the benefits of urban green infrastructure are multiple. In metropolitan areas, **nature-based solutions** must be promoted for adaptation to climate change, and the local community has an essential role. There is much recent research focusing on green infrastructure in metropolitan areas, especially in countries that want to make the transition to climate-resilient cities.

In the context of the metropolitan areas of the big cities in Romania, the **ecosystem services** offered by the urban green infrastructure must be evaluated. According to the analyzed articles the most representative ecosystem services are those of supply and regulation, and the least attention is paid to those of support. Urban green infrastructure is not evenly distributed in metropolitan areas, so residents do not benefit equally from certain ecosystem services (e.g. recreation service provided by a park), especially in poor areas, slums, where they are sometimes absent and their lack is a health risk. In a metropolitan area, many residents rely on urban green infrastructure for their livelihood, so alternative food supply options are needed (such as vertical gardens, green roofs, etc.).

The latest research shows that there are positive and negative aspects of metropolitan green infrastructure in terms of ecosystem services (services/disservices). Approaching this balance for the implementation of metropolitan green infrastructure requires multidisciplinary teams. The development of a hybrid infrastructure (green-gray) can be a solution to overcome the compromises that may appear.

The literature shows that metropolitan **green infrastructure planning** is based on principles such as connectivity, multifunctionality, multiple scale, integration, diversity, applicability, governance and continuity. Of course, in the case of the big cities in Romania, there may be different approaches regarding the identification, selection and evaluation of the evaluation principles of the metropolitan green infrastructure due to the different priorities existing in the political agendas, which in turn are also influenced by factors such as geographical location or cultural dynamics.

The implementation of green infrastructure in the metropolitan areas of large cities in Romania is necessary because cities must be **friendly to biodiversity**, they need nature. **Strategic urban planning** must take into account that the requirement of green spaces depends on the socio-economic and temporal gradient (services ecosystems are not a measurable whole, but intertwined with social and political processes). Although urban planning fails to explicitly define what green infrastructure is in metropolitan areas, concepts related to stormwater and less landscape related seem to predominate (most of the ecosystem benefits of urban green infrastructure are related to stormwater).

CONCLUSIONS

After 2020 the interest on urban green infrastructure focused on its benefits – its role to counter the effects on climate change or to increase biodiversity.

In cities and metropolitan areas, planning a green infrastructure is a complex activity, difficult to implement but is still a viable planning tool.

Metropolitan areas face increasingly frequent ecological risks, which cause a decrease in the supply of ecosystem services. In order to avoid risks, the areas of metropolitan green infrastructure must be increased by a priority planning. Future research is needed for the definition of urban green infrastructure to focus on the relationship between ecological, technological and societal infrastructure, and to facilitate the production of the greatest number of social benefits.

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