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GREEN INFRASTRUCTURE: LEGISLATIVE AND BEHAVIORAL APPROACHES IN THE CONTEXT OF URBAN ENGINEERING

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Abstract

The authors of the article integrate legislative, cognitive-behavioural, and construction approaches to green infrastructure in the context of urban engineering involving green space as a fundamental attribute of quality of life. They briefly introduce the ideas of ideal cities of the geniuses of antiquity, Marco Vitruvius Pollio, Leonardo da Vinci, and Thomas More. The main focus is on the legislative issues of green infrastructure, particularly concerning the activities of local authorities. They perceive green infrastructure as an institute with a multi-beneficial meaning, within the framework of administrative science understood as a public interest incorporating a range of partial issues from the primary interest of environmental protection, economic development of settlements, promotion of public and mental health, social issues, and sports.

Keywords:

Green infrastructure;
Behavioral psychology;
Urban engineering;
Urban environment;
Roads.

1 Introduction

Greenery has played an important role in conceptions of ideal cities since ancient times. Green infrastructure is a system with a long history, even though it has only recently begun to receive more attention. An iconic example of urban ancient green is the Hanging Gardens of Babylon (Semiramis), which are one of the Seven Wonders of the Ancient World listed by Hellenic culture. They were described as a remarkable feat of engineering with an ascending series of tiered gardens containing a wide variety of trees, shrubs, and vines, resembling a large green mountain. According to legend, the Hanging Gardens were built alongside a grand palace known as The Marvel of Mankind, by the Neo-Babylonian King Nebuchadnezzar II (who ruled between 605 and 562 BC), for his Median wife, Queen Amytis, because she missed the green hills and valleys of her homeland.

As early as the time of Hippocrates (460-377 BC), pine groves as a tool to promote healing, roadside greenery during the Roman Empire and Maria Theresa's decrees of 1756 and 1767 on compulsory roadside greenery and the planting of trees along roads in the open countryside are already known [1], [2]. Even though Roman cities were planned in an unchanging rectangular outline, the Roman architect Vitruvius Pollio described a plan built on a centre. Marcus Vitruvius Pollio (80/70 BC - 15 AD) was an ancient Roman engineer, architect, and author of De Architectura (Obout Architecture), which preserves valuable knowledge of Roman building and technical discoveries. Vitruvius served in Caesar's army as commander of the civil engineers (praefectus fabrum) and in peacetime as a civilian architect. During the reign of Augustus, it was his extensive experience in the field of civil engineering that led him to write up his knowledge in ten books accompanied by drawings [2]. De Architectura [3], written around 20 BC, is the only surviving classical work from which we can get an idea of Roman architecture nowadays. It consists of 10 books, and Vitruvius Polio devoted the first book, Fundamentals of Urban and Town Planning, Landscape Architecture, to green infrastructure, a necessary qualification for an architect, or more precisely a civil engineer or urban engineer [4]. Recently, the authors of the article in their book publications have given emphasis on the green infrastructure of settlement formations, which can be seen in Fig.1.

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Fig. 1: Covers authors' books from 2014 to 2023 in the field of urban engineering with an emphasis on green infrastructure.

2 A cognitive-behavioural approach to the impact of the urban environment

The authors [4] defined for the first time in the conditions of Slovakia a holistic perception of urban engineering (UE) representing a multidisciplinary set of competencies, knowledge, skills, tools, and procedures used in the application practice of municipal management, aimed at the elaboration and subsequent implementation of the development strategies of settlement units (SU). UE must imply holistic planning of the SU, both physical (urban planning) and socio-economic (city planning), with significant sustainable development and adaptive integrated management corresponding to the complex potential of the SU. The strategic objective of UE is to achieve optimal indicators set by contextual planning and the processes to achieve them must be guided by the value-for-money principle. UE, through the synergy of the individual components and their compliance with national and European standards, ultimately contributes to the satisfaction of the citizens of the SU. The strategic objective of UE must be realized through the synergy of the partially planned values of the individual indicators, in particular:

- public health including psychological (mental) health,
- education and culture,
- nature and landscape protection,
- environmentally friendly, integrated transport of people and goods,
- rationalization of activities providing technical equipment for the territory,
- protection of monuments and cultural heritage,
- comprehensive security,
- social standards,
- the economic prosperity of the people living in the communities of the respective SU.

The environment, landscape, etc., is the space to which we assign meaning, give a bond, and an emotional connection, and is the place in which we live, exist, feel, think, behave, and act. The perspective of place can integrate a space saturated with benevolence, sources of fulfilling needs, experiencing psychological well-being, and on the other hand, experiencing a state of distress. Contemporary society puts pressure on each of us with an increasing number of stressors having their source in the environment and operating in our daily lives. This influence of the urbanized environment on our psyche, perception, experience, and behaviour is a stimulating topic for the cognitive-behavioural approach, which in this context focuses on the study of how external stressors affect our internal reactions, feelings, emotions, thoughts, beliefs, and behaviours. The impact of an urbanized environment can have different effects on people, their quality of life, and their mental health, with some experiencing increased tension, anxiety, depression, or other psychological difficulties. Negative cognitive patterns may be present, such as catastrophic thinking, a focus on danger, experiencing helplessness (a cognitive aspect of stress), increased irritability, and aggressive, flight behaviour (a behavioural aspect of stress). The intention is to identify negative, dysfunctional cognitions and behavioural patterns which can be associated with this environmental impact and to gradually modify them through appropriately chosen interventions (e.g., cognitive restructuring, and behavioural

techniques). This can promote individual tolerance to stress responses, resilience, coping strategies, and adaptation to urbanized environments without negatively impacting psychological (mental) health. People's reactions to stressors vary widely, and consequently, a cognitive-behavioural perspective may better enable us to understand how different urbanization factors influence cognitive-behavioural responses to stress. It can be an effective tool for intervening and overcoming the challenges associated with modern urbanized lifestyles to make the environment a place of home.

From the above, we can clearly see the authors' perception of green infrastructure as an integral part of the quality of life. Currently, when designing integrated transport infrastructure, the priority focus is on its safety [5], [6], minimizing negative environmental impacts [7] to [9], preference for urban transport [10], and only marginal attention is paid to its influence on psychological health, in which green infrastructure can play a significant positive role.

3 European visions of ideal settlement formations integrating green infrastructure

Besides the already mentioned Vitruvius, the following geniuses of antiquity also paid considerable attention to the problem described. Leonardo di ser Piero da Vinci (1452 - 1519), an Italian Renaissance architect, inventor, sculptor, and painter, is seen as the archetype of the 'Renaissance man' and as a universal genius. In the field of urban engineering, Leonardo da Vinci's vision of the ideal city (Fig. 2) can be considered, in the authors' opinion, his most famous innovative achievements.

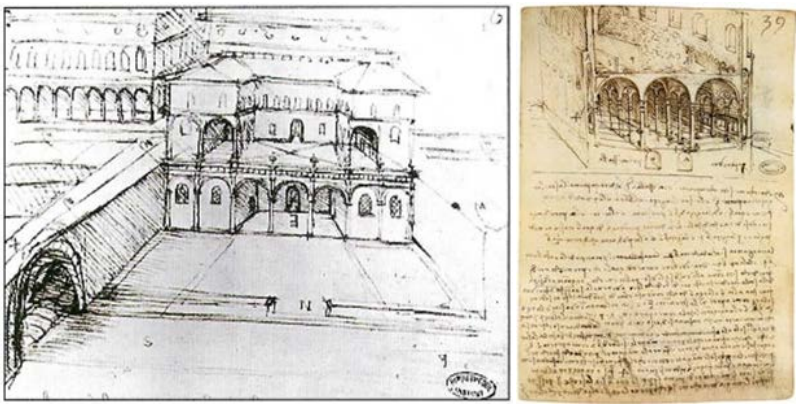


Fig. 2: Covers authors' books from 2014 to 2023 in the field of urban engineering with an emphasis on green infrastructure.

During his time with Ludovico Sforza, Leonardo devoted himself to visions of the ideal (utopian) city. In the early 1590s, Milan was devastated by the Black Death, which wiped out almost 1/3 of the population. Thanks to his scientific instincts, Leonardo intuited that the spread of the plague was fuelled by unsanitary conditions, and that health was related to the health of the city. In 1487, he proposed a concept combining artistic finesse with visions of urban engineering - creating entirely new "ideal cities" planned with a sense of health and aesthetics. He applied the classical analogy between the human body's microcosm and the earth's macrocosm. Cities are supposedly organisms that breathe, circulate fluids, and contain waste that must go. Milan had a long tradition of channelling mountain streams and melting snow, which allowed Leonardo to combine streets and canals into a unified circulation system, and the city was to be on two levels [4], [11]:

- upper - for the beauty of life and the life of pedestrians, the wide roads and arcaded avenues were to be reserved for pedestrians and lined with beautiful dwellings or hanging gardens,
- hidden (lower) - they were to contain canals and roads for supplies, storage areas, carriage paths, as well as a sewage system to carry away waste and "stinking matter".

Thomas More (1478 - 1535), an English lawyer, politician, and writer, held the office of Lord Chancellor to King Henry VIII from 1529-1532. Considered one of the foremost European scholars of his time, he presented a vision of the ideal city in his work Utopia - Two Books on the Best State and the New Island of Utopia, writing truly golden and as rewarding as it was entertaining [12].



Fig. 3: Thomas More - lawyer, politician, writer, and an illustration of his 1516 work Utopia [4].

He described the island of Utopia (a word formed from the Greek negation ú(ou) "not" and tópos "place, country", i.e., land that does not exist) in a dream of an ideal society in a book published in Antwerp in 1516. The inhabitants of Utopia obeyed strict, just laws, everyone had enough to eat and the necessary comforts, and there were neither poor nor rich. Idleness was not allowed, and each spare moment belonged to education. The primary source of livelihood was agriculture. Every two years, the inhabitants of the 54 towns, where they were engaged in crafts, repairing, and building houses, replaced the villagers. The part of the book that describes the settlement of the island is among the earliest efforts to articulate the idea of planning human settlements in relation to broader territorial connections. Towns with catchment water systems, public hospitals, and carefully landscaped gardens near houses formed an interconnected network of settlements in Utopia that were about a day's walk apart. The streets were laid out purposefully to serve traffic and protect them from the wind. The buildings were clean and neat, and facades lined the streets in unbroken rows on either side. Each district had a spacious social hall for lunches and dinners. There were no taverns, and the appearance was affected by a uniform and generally beneficial order [13].

4 Examples of green infrastructure in the context of transport construction

The period of the COVID-19 pandemic has provided ample opportunity to investigate the impact of green infrastructure on population health, particularly from a respiratory immunity or public health perspective [14], [15]. However, green infrastructure is also, in the experience of several countries, a matter of dealing with the very significant challenge of urban overcrowding and the related issue of urban poverty [16]. The impact of some elements of green infrastructure on social interactivity, community behaviour, and civic participation is another benefit frequently mentioned in the literature [17], [18]. Finally, the highly topical issue of combating climate change needs to be mentioned. [19]. Climate change represents a critical challenge for all branches of science in our time. According to several studies, the green infrastructure system is one of the most effective tools for combating climate change.

Even within the framework of the initial introduction of the concept of green infrastructure, we can say that it is an institute with a multi-beneficiary meaning. Within the Slovak administrative science, it is understood as a public interest incorporating several partial issues ranging from the primary interest of environmental protection, economic development of settlements, support of public health, social issues, and sport, which in the Slovak Republic is a public interest according to Act No. 440/2015 Coll. on Sport, as amended, § 2, to the issues of civil society and community functioning within settlements.



Fig. 4: Examples from 28.4.2023 of the green infrastructure of local roads in Zilina.

The search for an effective way of building green infrastructure by focusing on transport solutions within settlements calls for the introduction of methods of municipal action that could be used in this issue. The reason why we examine the issue of green infrastructure from the legislative perspective and the plane of optimal functioning of local government is quite simple. Even though, according to various sources, this infrastructure system has a supra-regional and even supranational character, it offers the most benefits with a synergistic effect within the settlements, which in the conditions of the Slovak Republic represent municipalities as the basic units of self-government.



Fig. 5: Views from 28.8.2022 of noise barriers with green infrastructure elements as part of the Lausanne - Geneva motorway.

From an administrative science perspective, the recommended problem in public administration, including local government, is to take as systematic a holistic approach as possible, including minimizing the negative impacts of global warming in SU. Therefore, we need to critically examine the basic definition of green infrastructure as well as its regulation in different legislations [20]. Not only legal science but also urban engineering as a scientific discipline prefers a holistic approach to solving the problems of settlements.

5 Critical issues in green infrastructure legislation

The legislative problem of green infrastructure is multifaceted. The law should always mirror the knowledge of natural and social sciences and look for systemic and most effective solutions, which would be in the form envisaged by law in legislation [21]. Of course, these solutions must be consistent with the requirement of the rule of law and democracy as the fundamental pillars of modern society. In particular, at the application level, the law is extraordinarily vulnerable to the precision of expressions and definitions. Several authors and sources of legal scholarship concur in the conclusion that only terminological and conceptual precision can create a legal process, decision, and its realization and thus be a pillar of the rule of law [22]. In the conditions of the Slovak Republic, green infrastructure is specified in the framework of Act No. 543/2002 Coll., § 2(2) (zh) in the context of the letter zi. According to this Act, green infrastructure is "a network of natural and semi-natural elements, in particular green areas and aquatic ecosystems, which is created and managed to provide a wide range of ecosystem services, with particular regard to ensuring biodiversity, ecological stability, a favourable environment and the connection of the urbanized environment with the surrounding landscape". The definition of green parks and roofs follows this: A green park is an area with continuous areas of trees and other vegetation providing a setting for biodiversity in the urbanized environment, specified for this purpose in the spatial plan. A green roof is the upper part of a building or other structure covered with vegetation providing an environment for biodiversity in an urbanised area.



Fig. 6: Views from 22.8.2023 on the green infrastructure of the city of Bratislava with appropriately selected roadways of traffic areas.

The first critical issue is that the green infrastructure literature understands the green park and the green roof as elements of green infrastructure [23], [24]. Such a conclusion, however, does not follow from the legal definition, which is an undesirable situation for the interpretation of the law and its application. At a minimum, the requirements of legal scholarship for the definition of the term are integrity and systematicity. Therefore, it is necessary to take a comprehensive look at the issue of green infrastructure. According to the literature, several essential features of green infrastructure can be brought to the attention of legal scholars. Firstly, we speak of a systematic and holistic approach by the state, local government, civil society, and the business sector. Such a holistic approach is favoured, for example, by Green Infrastructure: Linking Landscape and Communities [25]. The second feature set is provided by the verbs protect and build. The role of a green infrastructure system is to protect the existing natural elements of the system and to develop new ones, through the methods of modern democratic self-management. These include parks, vertical and horizontal greenery, roadside greenery, in-beds, green roof gardens, allotments, and urban agriculture, if they are interconnected and linked to the urban environment and their surroundings.

Obviously, we do not find different forms of understanding of the issue we are studying in the literature. The traditional one is based on the 19th century and understands the issue as a multi-scalar network of ecological elements providing benefits and functions to society [26]. The narrow definition of green infrastructure only within the framework of land-use planning, as assumed by this approach, limits other effective possibilities for local government in this area. Edward T. McMahon and Mark Benedict speak of green infrastructure as a process (in general) that promotes a systematic and strategic approach to the protection and development of land suitable for nature and landscape.

As indicated above, civil society participation and community activities are part of the infrastructure. Some sources speak of a form of philosophy or policy of local government. This is the concept of environmental justice. Environmental justice emerged as a normative concept and social movement in the US in the 1970s and is often referred to as the spatial distribution of environmental goods and ills among people, including "equity in the distribution of environmental goods" [27]. The legislative narrowing of the space for understanding green infrastructure, as presented to us by the Wildlife and Countryside Act, may not be critical. Indeed, most policies in this area are implemented by:

a) local government,
b) civil society and communities,
c) the business sector.

Legal definitions are particularly relevant when it is necessary to enforce a particular action or, conversely, to refrain from an action. However, in its constitutional and moral nature, self-government is a matter of an extensive range of activities, limited only by an explicit prohibition of activity or by the fact that the law already entrusts these tasks to other entities. Thus, from this legal point of view, there is nothing to prevent the local government from adopting even bold concepts of understanding green infrastructure, as presented in the expert foreign literature.

6 Critical issues in green infrastructure legislation

From the point of view of administrative methods, however, it is necessary to draw our attention to the tendencies of the development of general self-government against established and formerly outdated practices. As a standard, we distinguish between methods of public administration that rely on the authority of the subject of self-government (the phrase 'authoritarian' is sometimes used) and methods of persuasion, which include various forms of economic and organizational action by public authorities. Typical examples of the former are authoritative decisions, fines, and other sanctions. On

the other hand, within the second group, we see fiscal instruments to motivate the implementation of an activity (in our case, for the private sector, green infrastructure elements beyond the needs of classical construction projects as forced investments) and partnerships between civil and community society, business, and municipal/city government. We prefer a partnership model of action by public authorities, especially because of the requirement for the long-term sustainability of solutions.

In the Slovak Republic, neither the concept of green infrastructure nor local government is defined in this way, and the "top-down model" of governance still takes precedence over partnership. Under the current legal situation, this is manifested, for example, by the mandatory percentages of green areas in municipal and zonal land-use plans. In terms of form, the land-use plan is now considered the most effective instrument for enforcing the construction of green infrastructure elements in the territory. Not even the major reform of building law has led to a radical change in the definitional and, therefore, legal-applicational understanding. The reform of the construction law has created a pair of new acts as of 1 April 2024, namely Act No. 200/2022 Coll. on spatial planning, which already explicitly includes the term green infrastructure, and Act No. 201/2022 Coll. on construction, which imposes an obligation on the designer to incorporate elements of green infrastructure into projects. From the point of view of the issue we are examining, the Act on Spatial Planning is more interesting. The latter sees green infrastructure as a public interest and a mandatory part of all stages of spatial planning documentation. This leads us to the second critical issue, which we have already outlined in the introduction. That is a preservationist or conservationist understanding of green infrastructure or a different view of the issue from a development perspective, emphasizing sustainable development § 5(v) of the Town and Country Planning Act states: the public interest is the interest expressed by the spatial planning documentation which mainly benefits the public with regard to sustainable spatial development which ensures territorial cohesion, social cohesion and non-discrimination, the interest of children and socially excluded or vulnerable communities, the territorial system of ecological stability, ecological connectivity, green infrastructure, the preservation of landscape and cultural heritage values, the protection and efficient use of natural resources and other territorial features, nature conservation, water protection and biodiversity conservation, environmental protection, public health protection, national defence, national security, civil protection, fire protection, and taking into account the conditions of a changing climate and adaptive capacity. This definition does not imply a preferential approach and risks limiting itself to a 'conservationist' approach, i.e., preserving the status quo. This corresponds to the explication of the concept of public interest itself. In the Slovak Republic, the public interest is perceived as a priority task of public administration. The municipality is therefore also obliged to implement primarily the public interest, and secondly, it is a legal reason (Article 20(4) of the Constitution of the Slovak Republic) for expropriation or restriction of the right of ownership.



Fig. 7: Examples of green parking from 16.07.2023 in Lausanne, Switzerland.

If green infrastructure is limited to preserving the status quo with no aspiration for development, especially in the context of sustainable development, the wording in the Planning Act would only create an opportunity for coercion of individuals and legal entities and restrictions. However, this theoretical level has an important practical dimension. For example, in the systematics of green infrastructure in terms of funds and regional development, the space within the restrictive framework of this concept has essentially narrowed, and thus, the whole logically cannot be understood under this concept of issues such as green parking.

At the same time, parking is one of the cardinal problems in Slovak cities and settlements. Since the legislation, as we have already mentioned above, is currently modest in this issue, for example, even partial laws such as the Municipal Act No. 369/1990 Coll. restrict this issue to public green space, which is a significantly narrower understanding.

7 Conclusion

Contemporary society puts pressure on all of us. More and more stressors have their source in the environment and operate in our daily lives [28]. The authors consider the positive impact of green infrastructure of settlements as one of the possible minimization measures. With a short presentation of possible approaches to the topic of green infrastructure and the grasp of this concept, we wanted to present that it is a big challenge for the scientific community to look for different shades of this phenomenon in the conditions of the Slovak Republic and to involve such scientific disciplines as behavioural psychology, sociology and, of course, economics and the science of public administration alongside the already traditional environmental science, ecology, urban planning or urban engineering in this investigation. The authors point to transport infrastructure as one of the pilot pillars of a green infrastructure system. It encompasses all the benefits and partial public interests and is a good argument for why a much more comprehensive approach is needed, also on a legislative level, to changes in the definition of regulation of green infrastructure.

The authors implicitly implemented green infrastructure in the draft STN 73 6100 [29] into the concept of urban engineering - a multidisciplinary set of competencies, knowledge, skills, tools, and procedures used in the application practice of municipal management, directed toward the development and subsequent implementation of the intentions of the development strategies of settlement units. This definition is compatible with international development in the SCR (Smart City and Region) field. According to MIRRI SR, smart cities and regions are those that use data, ICT, and participation, i.e., the involvement of a wide range of stakeholders in decision-making, as tools for achieving goals that are beneficial for saving financial and material resources, providing better quality, more convenient and efficient public services, and meeting measurable indicators (at the city or regional level). They apply the principles of integration, inclusion, innovation, and strategy in decision-making and project design, with the activities implemented having a demonstrable positive impact on the long-term improvement of the quality of life in the city and region and sustainable development.

In this article, the authors have attempted to integrate legislative, cognitive-behavioural, and construction approaches green infrastructure, thus anticipating the opening of a closer collaboration between psychologists, lawyers, and, finally, traffic planner [30] construction engineers systematically promoting green infrastructure in the context of urban engineering.

Green infrastructure can be understood in a static or dynamic sense. In the static sense, it represents a multifunctional system of public and private green spaces, organically interconnected with aquatic ecosystems of natural origin or created by human activity. It links the urbanized environment with the surrounding landscape, which provides a range of ecosystem services. These include water and air purification, climate regulation, nutrient and soil cycling, natural waste decomposition, habitat provision, services, and benefits to human society in the field:

- socio-economic - such as conditions for sport, quality of housing, healthy lifestyles,
- community - such as social interactivity, sense of community behavior, community development, and culture,
- health – especially concerning respiratory health, cardiovascular health, stress reduction, and the generation of positive emotions.

In a dynamic sense, it is an approach of action by the public authority (in the case of Slovakia, mainly the local government) directed towards the protection of existing elements of green infrastructure. It means naturally occurring green and water areas and building new features by the method of support, but also authoritative decision-making, mainly in the form of spatial regulation. Building new features involves, in particular, systematic and comprehensive measures for the construction of green inner blocks, roadside greenery, green roofs and vertical greenery, parks and gardens, community gardens, and urban agriculture in urbanized environments. Prefer partnership with the private sector as a sustainable development method rather than over-bureaucratization and authoritarian decision-making by public authorities.

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