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Fig. 1 Study and strategy of development of Sisak green infrastructure, 3E projekti

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Historical Development of Urban Green Infrastructure and Possibilities of its Implementation in the Republic of Croatia

HISTORICAL OVERVIEW
IMPLEMENTATION
SUSTAINABLE SPATIAL PLANNING
URBAN GREEN INFRASTRUCTURE
URBAN LANDSCAPE

Research has been motivated by a wide range of concepts of the term urban green infrastructure. As the aim was to indicate a clear basis for the term, an investigation of its development was a necessity, not only in the European, but also in a broader context.
Although green infrastructure is included in the 21st century policies of protection and development of EU landscapes, its foundations can be traced back to the models of ideal Renaissance towns and urbanist concepts mainly from the 19th and 20th century. In these historical periods used concepts meant urban landscapes as systems, a part of the environment, as seen in green corridors, green belts, green wedges, green networks and through the perception of urban green systems. As a modern concept the urban green infrastructure has been upgraded with developed roles, extending functions, scopes and scales from previous historical models. In that sense it maintains its social role of improving the quality of life in towns, while at the same time defining town texture with its urban morphological significance. At the same time it also develops ecological values and extends its scale to nonurban local, regional and international contexts.
Despite its benefits, spatial planning documents in the Republic of Croatia still lack measures and actions which would recognise the true benefit of green infrastructure in spatial development.

INTRODUCTION

The concept of green infrastructure, which has been in use in Europe since 2013 (European Commission, 2013) is a new way of looking at urban open spaces as a subsystem of the city. It is characterized by a meaningful layout of open public spaces with certain social, urban morphological and environmental roles which influence the economy of the city. The social and structural role of open spaces has been a subject of reflection in earlier historical periods while its ecological function has become a subject of recent research developed because of increasingly endangered ecological systems and the disappearance of ecological links between different habitats. Given this, urban landscapes are seen as potential holders of ecological roles and green urban infrastructures are increasingly becoming a subject of research within the concept of green infrastructures of the entire region, but also of wider spatial units. Taking into account its prominent ecological, but also other roles in the wider landscape context, there is a need for planned connection of open urban areas (especially green) in a sustainable system that is connected to the suburban landscape. At the same time, this aspect is closely related to human uses of space, which, due to climate change, often face new negative phenomena: "greenhouse effect", urban "heat islands", floods, soil erosion, landslides, fires, etc. Open urban areas remain the most important spaces for social contacts of city dwellers despite the time of technological progress and its impact on the social life of the individual (social networks, virtual reality, etc.) so their importance for cities is unquestionable (Ward Thompson, 2002). In this sense, in addition to the urban green infrastructure there are also "non-green" open areas, contributing to the preservation of the inherited tradition of historic cities whose main public spaces in the past were squares and city streets. Therefore, all open areas (those that do not occupy buildings) represent "nature" in a city that does not have to be only or exclusively "green" (Kienast D. cieted in Weilacher, 2006).

The research stems from the thesis that urban green infrastructure is a concept that finds its origin in history, when cities had a much simpler structure and similar basic roles as well as a relationship with open, public areas that defined urban structures and urban life. As a new concept, however, it has expanded the understanding and role of open public spaces in the city, as well as that of the wider landscape. Furthermore, the hypothesis is that green infrastructure is not sufficiently supported in Croatian legislation and planning processes, which consequently limits its implementation in the urban planning system.

METHODOLOGICAL FRAMEWORK

The extent to which historical urban concepts are comparable to the contemporary concept of green infrastructure is re-examined through comparative analysis and interpretation of urban plans and concepts of historic cities. The analysis includes theoretical, hypothetical and practical concepts (realizations), which basically represent open and green areas with a certain degree of systematization, networking or respect for open areas as a city-defining element.

The analysis was based on the interpretation of cartographic representations and / or textual descriptions of a set of criteria that examine compliance of historical concepts with today's definition and role of green infrastructure. The criteria include determining the basic role and purpose of the historical concept (social, ecological, economic or some other role), the category of open areas it covers (typology of open areas) and spatial features of the concept – systemicity of the concept (network, corridor, dispersion), degree and scale of area networking (the entire urban area, part of the city, suburban area), as well as the composition of the concept (representation of elements of green and blue infrastructure). The synthesis of data from the analysis identifies elements and items of green infrastructure that appear in earlier periods, as connected to the undeveloped tissue of the city, the open area of the city.

The paper analyzes and interprets today's planning and legal regulations of the Republic of Croatia[1] related to the implementation of the "Strategy on Green Infrastructure". Iti s what has determined the possibilities and the state of implementation of the concept of green infrastructure at the national and local level.

Defining the term green infrastructure

The European Commission (2013) defines green infrastructure as a strategically planned network of natural and semi-natural areas that includes all its ecological features and is designed and managed in a way that provides a wide range of benefits to the ecosystem. It includes "green" and "blue" areas (green areas and water corridors) and other physical features in inland, coastal and marine areas, be it rural or urban.

The network of "green" and "blue" urban and suburban areas brings natural, economic and social benefits, contributes to the health of citizens by expanding recreational opportunities and the general quality of life, supports "green" economy and increases biodiversity and the general state of the environment. Within the same document The European Commission advocates the protection, restoration, creation and improvement of green infrastructure. It is considered an integral part of spatial planning and territorial development in cases where green infrastructure is a better alternative to standard "gray" infrastructure systems and the importance of green infrastructure in protecting Europe's natural capital and its integration into EU sectoral policies and financial instruments is emphasized.

The British Landscape Institute defines green infrastructure as a network of natural, semi-natural spatial elements, green zones, rivers and lakes that stretch between villages and cities connecting green zones from local to interstate areas (Landscape Institute, 2013). This is one of the greatest contributions of green infrastructure to spatial planning today – the systematic perception of the landscape at all levels ('cross scale'), interconnecting different scales and presenting green infrastructure as part of a larger "picture" of the city, region, state and ultimately, the continent.

Table I Overview of different levels of green infrastructure application*

Level of application	Elements of green infrastructure
International level	Large natural elements that pass through several countries – international river basins, mountain ranges, forest areas, protected areas, Natura 2000 areas.
State level	Identification of important green areas at the state level – national parks, nature parks, important river basins, larger lakes, important forest habitats, mountain ranges, coastal areas, wetlands, flood zones and other locally specific areas.
Regional level	Regional protected natural areas and those of great importance for the region – lakes, river basins, mountain ranges, forests of high natural value, vast pastures, rural and agricultural areas, coastal areas, wetlands, floodplains.
Local level	Areas of meadows and forests, rivers, streams, ponds, lakes, local nature reserves or other forms of protected areas, urban parks, gardens, courtyards, green roofs, vertical gardens, but also bio purifiers, rain gardens, hedges, tree lines, pedestrian and bicycle trails, restored or abandoned industrial areas, sports fields, golf courses, children's playgrounds, squares, open spaces of schools and kindergartens, as well as public, business and industrial facilities/areas, cemeteries, nurseries, agricultural land, wildlife crossings.

* adapted and supplemented according to Landscape institute (2013)

In this sense, the level of implementation of green infrastructure can be international, national, regional and local (Table I).

Green infrastructure, as an urban practice and a possible approach to dealing with the problems of the contemporary city, can be understood as a "top down" method. According to the basic theoretical framework, it belongs to the concept of *Green Urbanism*, which takes the relationship between the city and nature as the main starting point.[2] According to its theoretical assumptions, it complies with *Ecological Urbanism*, based on the concept of ecological system, which consists of the inseparable connection of technological (infrastructural), natural (ecological in the narrower sense) and social (economic-political) system (Kostrenčić and Jukić, 2020); and *Landscape urbanism,* in which landscape is the defining element of contemporary urbanism, i.e. an important city-building medium (Bojanić Obad Šćitaroci and Matuhina, 2012; Steiner, 2011).

Origin of the term green infrastructure

The size of cities and the complexity of the processes and relations that take place in them impose the need for a holistic view of open urban areas due to a clearer perception of the causal relationship between individual elements. It is what calls for the study of

1 Nature Protection Act of the Republic of Croatia, OG 80/13; Law on Amendments to the Law on Nature Protection, OG 15/18; Act on Amendments to the Spatial Planning Act, OG 98/19; Spatial Development Strategy of the Republic of Croatia, 106/2017; Green Infrastructure Development Program in Urban Areas for the Period 2021 to 2030, Ministry of Physical Planning, Construction and State Property; Regional Development Strategy of the Republic of Croatia for the period until the end of 2020, Government of the Republic of Croatia, 2017; Low carbon development strategy of the Republic of Croatia until 2030 with a view to 2050, Ministry of Environmental and Nature Protection, 2020; Climate change adaptation strategy in the Republic of Croatia for the period until 2040. with a view to 2070, OG 46/20, Strategy and Action Plan for Nature Protection of the Republic of Croatia for the period from 2017 to 2025, OG 72/2017.

2 Kostrenčić and Jukić (2020) divide contemporary approaches to urbanism into six basic categories (according to J. Barnnett): system urbanisms, green urbanisms, traditional urbanisms, community urbanisms, socio-political urbanisms, front page urbanisms.

urban landscapes[3] as a system that operates and develops as one of urban subsystems. Until recently, the term "green system", which was predominantly used in national literature, sometimes functioned as a synonym with the term "green infrastructure". However, in recent times, the term green infrastructure has become more common, because its meaning is certainly more layered. It refers to several different systems and at the same time represents a "living" space that is sometimes difficult to systematize within a single-layer due to the causal relationship of many factors. The term urban green infrastructure represents all open urban areas that are not necessarily green[4], so this term can sometimes have a contradictory meaning if it excludes other, "non-green" open areas of the city (e.g. squares, streets and pedestrian zones). Furthermore, until recently the term infrastructure itself has been most often associated with technical systems and structures within the city (sewers, roads, etc.), so a literal understanding of the term can be counterproductive (not referring to technical determinants of the system but to its "systematicity"; interdependence to all parts of a particular system).

Urban green infrastructure, as a city system, has been researched by numerous authors using a variety of terminology that is not entirely synonymous but in some aspects coincides. For example, in addition to the terms green infrastructure, the terms *green system*, *greenway network*, and *ecological network* are used. The individual elements of these systems are *green corridors*, *green wedges*, *green belts*, *green fingers*, and *greenways*. The *greenways model* is one of the most frequent terms in the last decade of the 20th century (Maruani and Amit Cohen, 2007; Toccolini, 2004; Conine, 2004; Cawood and Somers Smith, 2006; Teng et al., 2011) while the terms *green network* (Teng et al., 2011; Mahmoud, El-sayed, 2011) and *green infrastructure* (Tzoulas et al., 2007; Sandström, 2002; Vandermeulen, 2011; Mell, 2010, Hostetler, 2011) are often mentioned at the beginning of the 21st century. It is considered that the original idea of green ways was developed into a network of green ways, which in many European countries is also called an ecological network (Hellmund and Somers Smith, 2006). In North America, the name green infrastructure is more common, while the introduction of this term to the European continent is related to the adoption of the European Strategy on Green Infrastructure in 2013. (European Commission, 2013). From that year onwards the term green infrastructure has become dominant in research of systems within urban and non-urban landscapes (Mat Nazir et al., 2015; Matthews et al., 2015; Connop et al., 2016; Mecrow and Newell, 2017; Serra-Llobet and Hermida, 2017; Navarrete-Hernandez et al., 2019; Pauleit et al., 2019; Buijs, 2019; Harrington, 2018; Shackeleton et al., 2019).

Green infrastructure is considered to be a term that enhances the definition of a green system. While the former green system of the city viewed urban space in the context of its open spaces and surrounding narrow zones, green infrastructure includes all natural, semi-natural and artificial networks of multifunctional ecological and other systems within, around and between urban spaces (Tzoulas et al., 2007). Thus, in addition to urban space, it also means the non urban area, so the city is seen in a broader spatial context. This approach was urgent due to the need to combine different aspects of understanding and inestigating. For instance, the emphasized ecological roles of green space often did not take into account other "non green" open urban and rural areas with important ecological but also significant social role for the urban population.

Given this, research in the first decade of the 21th century can be divided into two approaches: that dealing with environmental quality, which is often addressed by ecologists; and that dealing with human needs, most often addressed by urban planners and sociologists (Maruani and Cohen, 2007). Besides ecological and social roles, the morphological role of the green system is also important for the urban context. It is an extremely important aspect in forming the visual experience of the urban environment (Tyrväinen et al., 2007; Palmer, 2003; Steen Møller et al., 2019). Thus, in the first decade of the 21st century, there is a growing appreciation of the green system for the morphology of the city, which can become a dominant element of urban space and thus form a special model of the city (Moughtin and Shirely, 2005).

It is obvious that the concept of green infrastructure, i.e. its definition, was preceded by numerous pieces of research and theoretical discussions that dealt with the narrower and wider context of the city viewed from various perspectives.

HISTORICAL DEVELOPMENT OF THE URBAN GREEN INFRASTRUCTURE CONCEPT

With the disintegration of the built nucleus city form, which took place mostly during the nineteenth century, the open green urban areas became systematically organized elements of the urban fabric. Green spaces began emerging within urban areas, most often in the form of parks, which some authors de-

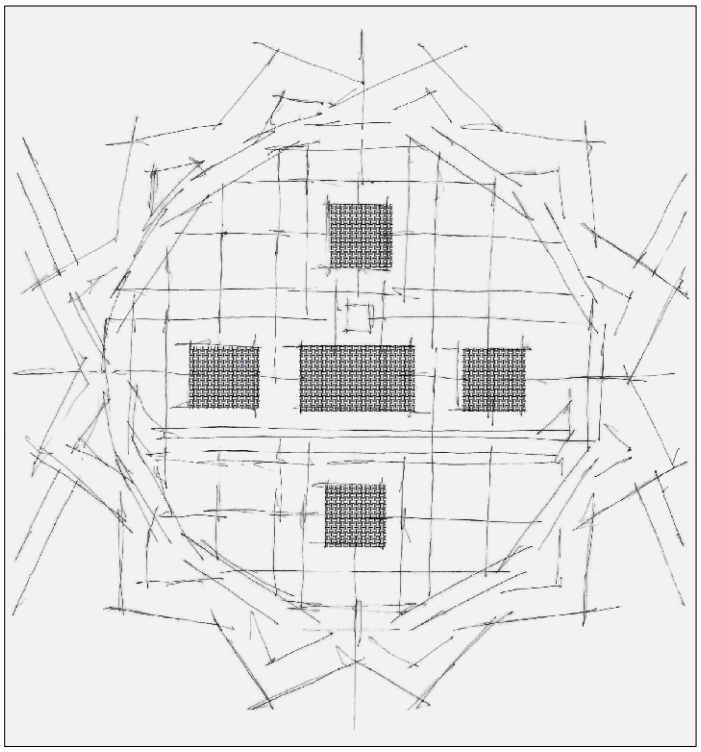


Fig. 2 Vicenzo Scamozzi, ideal city, 1615

Fig. 3 The green belt in Wagner's plan for the Ringstrasse

scribe as "bringing" landscapes into the city (Nicholson Lord, 2002). Whether created as an imitation of the lost landscapes around the city or as a developed idea of the already known forms of private or semi-private gardens (French, 1973), these landscapes can be associated with the Greek agora because in terms of their functionality they represented a social space in the form of a meeting point, a place for dwelling and companionship.

Systematic urban open areas are visible in theoretical urban models of ideal cities from the Renaissance period – P. Cataneo, 1507; Vasari di Giovane, 1598; V. Scamozzi, 1615 (French, 1973; Fig. 2). Open areas generate the urban morphology of the city and are not "leftovers" after construction, because they occupy the best quality spaces within the urban fabric. From an anthropocentric point of view, they posses their own environmental values because they consider the microclimate and ventilation of the city (Hrdalo, 2013).

These plans certainly had an impact on later considerations of systems of urban open spaces. Haussman's plan for Paris dates back to the middle of the 19th century (Fig. 4). The introduction of boulevards, connecting new or old, public, open urban areas, created a prudential system of open public spaces (Kostof, 1995; Giedion, 1977; Mumford, 1988; Choay, 1969; Hrdalo, 2013). This was the beginning of the development of a green network that included the integration of forest zones into the urban fabric of the city, but Haussman's plan defines the appearance of pointed green structures dispersed throughout the urban fabric. Derived from the existing urban morphology, this green linear element became an important link within the concept of today's green infrastructure of Paris. The transformation of forest areas on the outskirts of Paris into recreational spaces, which Haussmann intended to connect with a green belt around urban tissue, created the basis for later urban ideas.[5] The idea

3 The urban landscape is synonymous with open urban areas (Gazvoda, 1998; Ogrin, 2007). Also, Croatian terms *'krajobraz'*, *'pejzaž'* and *'krajolik'* are taken as synonyms because the terms are often used under the same definitions. For example, landscape is "the total space we can (visually) experience and is a result of the interaction of natural and anthropogenic factors" (Gašparović and Sopina, 2018); landscape is an area, perceived by the human eye, whose characteristics were created as a result of the (interaction) of nature and man (Lipovac, 2018, according to the European Landscape Convention, 2000); landscape is a specific area, seen by the human eye, the nature of which is a result of the interaction of natural and / or human factors (Act on the Ratification of the Convention on European Landscapes NN-MU 12/02)).

4 Perekovic and Miškic Domislic (2012) state that the term open urban spaces is sometimes identified with green areas or urban green areas without taking into account squares or other "non-green" open urban areas that should be viewed as part of the same system. In addition, a certain part of green areas remains illegible in the spatial planning documentation as it is classified for other priority purposes.

5 Despite the existence of these ideas, they were not implemented in Paris in later periods (Giedion, 1977).

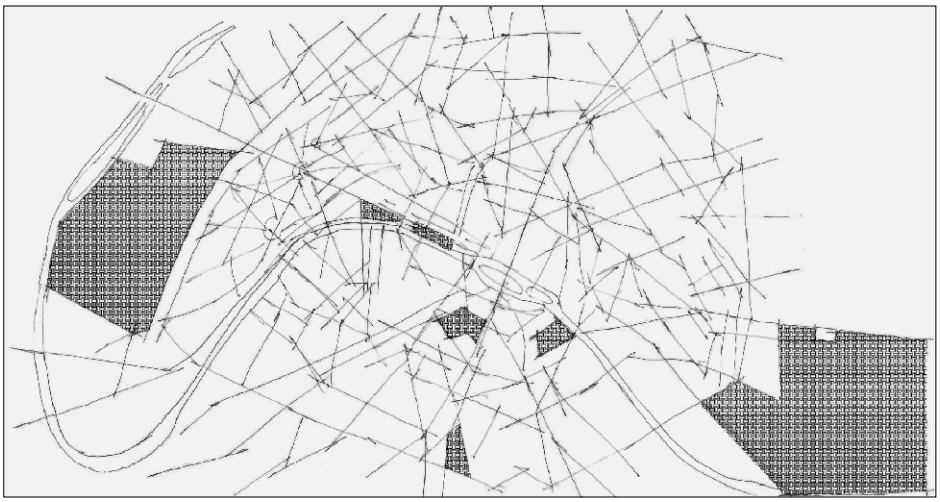


FIG. 4 GREEN ZONES IN THE HAUSSMANN'S PLAN FOR PARIS

of encircling cities with a green belt can also be linked to the mass process of demolishing city fortifications across Europe, as public parks were built in their place, creating a belt whose shape derives from the shape of the defense system. As the walls were circular, the newly created parks or other green areas created a green belt of circular character which was implemented in the form of a border between certain urban zones (Kostof, 1995; Giedion, 1977; Maksimović, 1976), as exemplified by Wagner's plan for the Vienna Ring (Fig. 3).

An essential example of thinking about green networking is visible in Howard's model of the "Garden City", whose diagram shows a scheme of systematic understanding and

FIG. 5 LONDON, GREEN BELT

planning of green spaces. The creation of ring-shaped concentric green belts that separate certain functions is a form that will later lead to the idea of a green belt as a green edge of the city (Fig. 5), not only typical for Anglo-Saxon cities, but also for the idea of connecting green areas within urban tissue (Moughtin, Shirley, 2005). Other theorists have improved Howard's idea by adding individual green elements to the urban area, in the form of parks (Maksimović, 1976; French, 1973). The idea of such "scattered" green areas within the urban fabric is also called the *'Swiss cheese system'* (French, 1973), penetrated from the periphery to the city center, connecting the suburban landscape with the urban center (Maksimović, 1976). Such a principle of green wedges is visible in the *"The Finger plan"* for Copenhagen from 1947th year (Fig. 6) and a similar principle emerged in the plans of Zagreb, Warsaw, Helsinki, Amsterdam and Freiburg (Košćak, 2000; Beatley, 2000). For example, the idea of "green fingers" or the green axis "Sljeme – Sava" appears in the Regulatory Basis of the City of Zagreb and the Directive Regulatory Basis of Zagreb from 1949/1953, as green corridors spread through the built-up fabric connecting the wooded slopes of Medvednica in the hinterland of the city and the river Sava (Fig. 7).

The concept of green urban infrastructure has certainly been influenced by the development of cities in North America. The emergence of green squares in the planned network as the basis of the cities of Savannah and Philadelphia from the 18th and 19th centuries (developed under the influence of the English Green Square) is considered to have influenced the development of the American Movement for City Parks (French, 1973). An important outcome of this movement is the development of *"corridor"* parks (Fig. 8), which were created by connecting parks, meadows, forests and waterways that are today an integral part of the green system of Boston, Philadelphia, Baltimore and Washington, as well as other cities outside the USA during the second half of the twentieth century. *"Corridor"* parks were important for the development of the concept of the green system of the city because the natural areas of linear character are implemented in the urban fabric (coastal edge, watercourses). Today, these elements are an important backbone for the implementation of urban green infrastructure as one of the most valuable, but also most sensitive parts of the urban landscape.

The development of the green system, i.e. urban green infrastructure, was also influenced by the idea of the need to create children's

playgrounds, implying their availability and even distribution within the urban fabric. This was the reason for the creation of a certain systematicity in the dispersion of elements in space, i.e. a system of dispersed ("pointed") green elements. The concept was originally applied in Chicago, where an initiative was launched to create a playground movement ('The Playground Movement'; Maksimović, 1976) and a similar idea was used by Berlage in Amsterdam to create a system of recreation and children's play zones (Giedion, 1977; Kostof, 1991).

The emergence of green belts as the edges of cities occurs after World War II in order to prevent their unsystematic expansion and growth. They can be considered a part of the urban fabric because they were often created as recreational areas and parks, and were most commonly implemented in England and other Anglo-Saxon countries (Gallion, 1993; Mandelker, 1962). At the same time, modernism created a completely new approach to the green spaces of the city. The Athens Charter brought a new understanding that supports the full integration of green and open urban areas into the urban fabric (Ogrin, 1985). Some authors associate this phenomenon with Howard's idea of a garden city as well as Sitte's thinking about the need to create a green urban space, expressed in the last chapter of his book "Green City" (Ogrin, 1985).

Awareness about the importance of green spaces in urban areas was probably influenced by Garnier's model 'Le Citte Industrielle'. However, the real quality of green spaces in functional settlements is usually limited due to insufficient functionality and design complexity of open urban areas. Nevertheless, functionalism has introduced changes in the comprehension of the relationship between open and built urban spaces, so in such circumstances, a green area is no longer an individual element within the city, but becomes a new, larger scale element which builds a network with its own system (Ogrin, 1985). Although such tendencies are visible in North American corridor parks, as well as in various theoretical models (previously mentioned), the modernist period signifies the historical moment when they were fully implemented. As modernism was the most widely accepted urban model, the system got implemented worldwide and thus probably contributed to the idea of green spaces as irreplaceable elements of the city. Since modernism did not deal with the square and the pedestrian street as a form of public urban space, postmodernism, as a reaction to the previous period, particularly emphasizes these spatial elements within the urban landscape. Therefore postmodernism, besides increased interest for tradition and history, is especially focused on the open spaces of the historic city (Velibeyoglu, 1999) and its sustainability.[6] In the postmodernist period, the city begins to be understood as part of a larger whole, and the awareness of its environmental role on Earth is growing (Hirt, 2005). Thus, the need for understanding of an urban space as a sustainable organism also grows. This implies a systematic consideration of the town, as well as the perception of the urban area as part of a wider system of non-urban spaces[7].

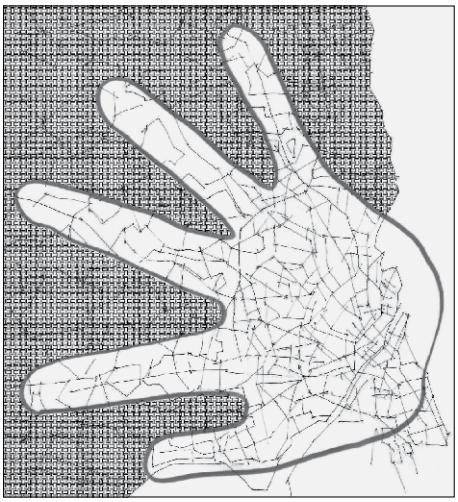
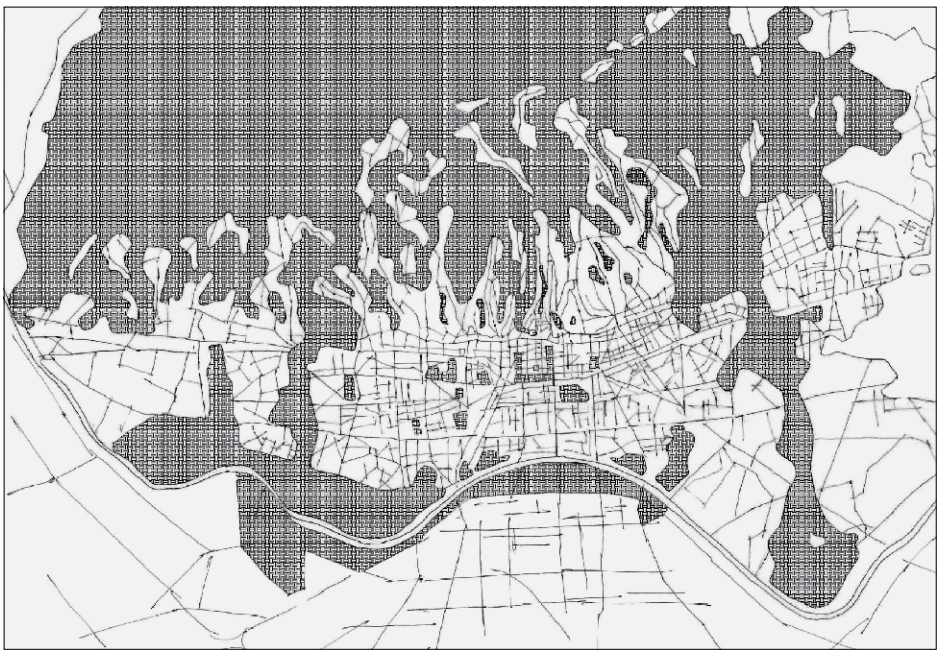


Fig. 6 Copenhagen, finger plan

Legal basis for the implementation of green infrastructure in the Republic of Croatia

In Croatia, as in other parts of the world, it is possible to single out examples of historical concepts and plans that posses an affiliation and compliance with today's concept of green infrastructure.[8] At the same time, through the example of the extinction of historical concepts[9], but also on examples of

Fig. 7 Green fingers of Zagreb which are connecting Medvednica and river Sava



6 In works of Jane Jacobs, Gordon Cullen, and Kevin Lynch.

7 This is a clear connection to the understanding of town in antiurban model of F.L. Wright in thirties in the 20th century.

8 For example, "Green Horseshoe", Regulatory Basis of the City of Zagreb, Directive Regulatory Basis of Zagreb 1949/1953 (so-called "Green Axis" Sljeme – Sava "or Antolovic's plan") and Green Dilatation (so-called "Blue Horseshoe" in Novi Zagreb).

9 For example, recent urban policies and plans have dismantled and fragmented much of the previously planned green links between Medvednica and the Sava River in Zagreb (Gašparovic and Sopina, 2018; Perekovic, Perčic, Tomic Reljic, 2018).

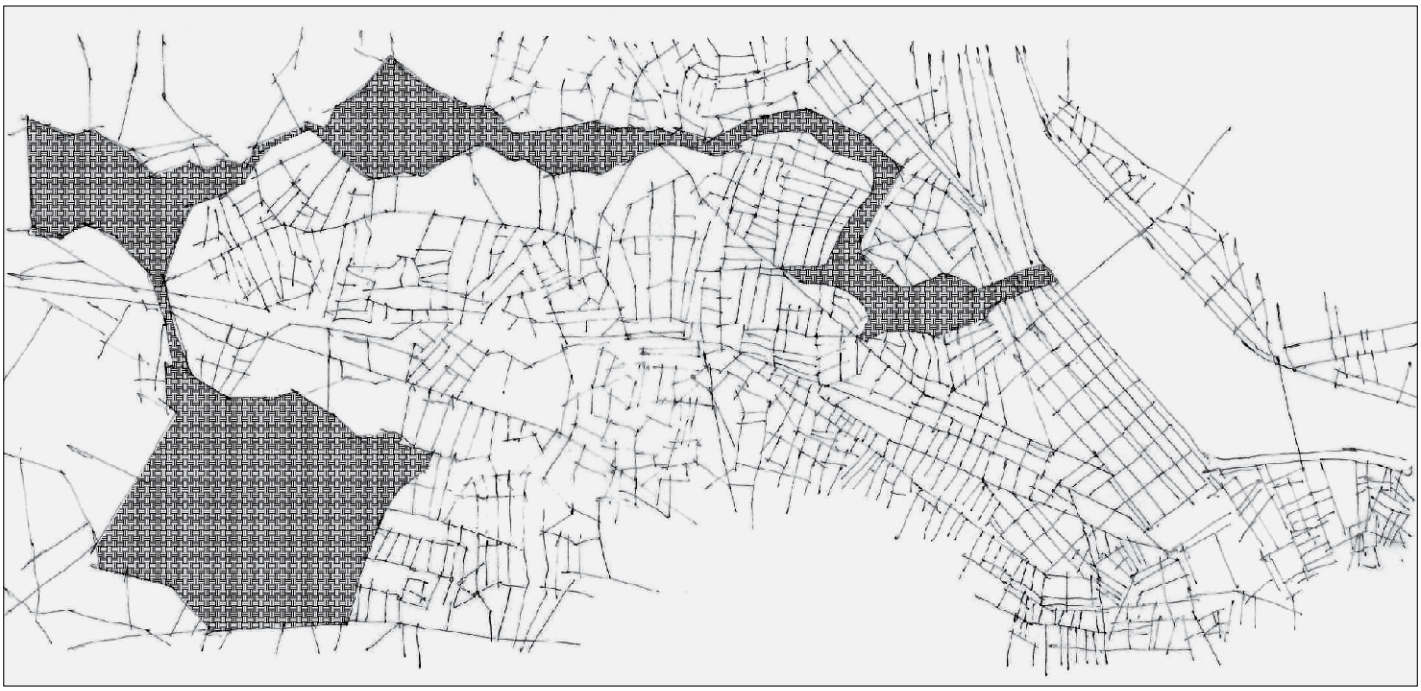


FIG. 8 BOSTON CORRIDOR PARKS – "THE EMERALD NECKLACE"

spatial planning decisions related to cultural, maritime and coastal landscapes of the Republic of Croatia, it is possible to point out the shortcomings of constructive thinking about green infrastructure as an important part of spatial planning and management.

In this sense, at the state level, Croatia does not have a well-designed and comprehensive policy that deals with the topic of green infrastructure, but this topic is approached mainly in fragments and indirectly through individual legal documents and strategies. Among them, perhaps the most important is the Spatial Development Strategy of the Republic of Croatia (OG 106/2017), which lays the foundation for the implementation of green infrastructure. In the priorities and strategic directions of spatial development of cities, it points to the need to establish new and preserve existing systems of urban green infrastructure because it contributes to "preservation, improvement and restoration of nature, natural functions and processes in cities" (OG 106/2017, p. 124). Furthermore, it states that in the process of making plans at all levels it is necessary to "promote the development of green infrastructure – a network of green areas, in which and with which natural functions and processes take place, with multiple benefits: improved efficiency of natural resources, climate change mitigation and adaptation to them, disaster prevention, water management, efficient land and soil management, conservation of habitat and species diversity and genetic diversity for future generations, multifunctional and resilient agriculture and forestry, low carbon transport and energy, health and well-being benefits, tourism development and recreation and, in general, ecosystem resilience".[10] Other Strategies (Table II) undoubtedly point to the importance of green infrastructure, but apart from emphasizing the benefits of green infrastructure and recommendations for its incorporation into spatial development processes and documents, there is no obligation to develop and implement them. In addition, Croatia is in the process developing a "Program for the Development of Green Infrastructure in Urban Areas for the period 2021 to 2030" (Ministry of Physical Planning, Construction and State Property, 2020) in accordance with the draft National Development Strategy of the Republic of Croatia until 2030, which is expected to be an umbrella strategic document if adopted, if it adopts clear guidelines applicable at all levels. In addition to the local level, guidelines should be adopted for regional and national levels.

Amendments to the Physical Planning Act (OG 98/19, Article 3) introduce the concept of green infrastructure, which the legislator defines as "planned green and water areas and other spatial solutions based on nature, which are applied within cities and municipalities, and which contribute to the conservation, improvement and restoration of nature, natural functions and processes in order to achieve the environmental, economic and social benefits of sustainable development". However, the law does not provide for the method of implementation, except

Table II Measures and recommendations related to green infrastructure in the strategic documents in the Republic of Croatia

Strategic documents	Measures and recommendations regarding green infrastructure
Spatial Development Strategy of the Republic of Croatia (OG 106/2017)	– priorities and strategic directions of spatial development indicate the need to establish new and preserve existing systems of urban green infrastructure – networks of green areas (preservation, improvement and restoration of nature, natural functions and processes in cities) – in the planning of green infrastructure, the solutions of urban and suburban green infrastructure, green infrastructure within the integrated planning of the sea and coastal area and green infrastructure as a procedure in the rehabilitation of degraded parts of space (during urban transformation, rehabilitation and temporary use) – responses to climate change in urban areas are linked to "green infrastructure construction"; planning the ratio of built structures and natural and green areas; landslide landscaping, etc.
Regional Development Strategy of the Republic of Croatia for the period until the end of 2020 (OG 75/2017)	– local and regional development based on the "green city" – "improvement of the urban environment and development towards healthy and sustainable living areas" – the strategic goal of increasing the quality of life encourages the revitalization of existing buildings and the planning of new social and sports buildings "as part of the green infrastructure of the city" – measures to improve the quality of life and development of urban areas encourage the development of urban green infrastructure – "through the establishment of green infrastructure of cities they enable landscaping, construction of roof gardens on large buildings and the establishment of green walls and roof gardens in parts of the city where green space is lacking"
Low Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/2020)[11]	– "The program for the development of green infrastructure in urban areas elaborates goals and measures for the development of green infrastructure which, among other things, increase the energy efficiency of buildings, reduce CO_2 emissions and reduce temperatures in the areas of thermal islands in urban areas."
Climate change adaptation strategy in the Republic of Croatia for the period up to 2040 with a view to 2070 (OG 46/20)	– proposed "implementation of the concept of green infrastructure in order to strengthen resilience to climate change in urban and rural areas" (measure of hih importance) – includes "certain technical interventions, such as the construction of protective dams and walls, construction of hydraulic structures, but also afforestation, construction of green infrastructure, strengthening the absorption capacity of land to receive excess water, etc." – it is proposed "to make an analysis of the existing network of green and water areas in urban and rural areas and the possibility of improving the links between individual elements of green and blue infrastructure of local and regional importance" – improve natural and anthropogenic ecosystems in order to increase biodiversity in order to better adapt to climate change (encouraging green architecture and green and blue infrastructure)
Strategy and action plan for nature protection of the Republic of Croatia for the period from 2017 to 2025 (OG 72/2017)[12]	– the inclusion of green infrastructure in spatial planning can significantly contribute to reducing habitat fragmentation – emphasizes measures for the preservation and restoration of green infrastructure

that the development of green infrastructure is set as one of the objectives of spatial planning (OG 153/13, 98/19, Article 6, paragraph 1). Given that there is an accepted definition at EU level (European Commission, 2013), it is unclear why it is not included in the Act in translated form. The "planned green and water areas and other solutions based on nature" can in no way be considered synonymous with "strategically planned network of natural and semi-natural areas". The first refers to human-shaped spaces based on nature, while the European Commission emphasizes natural and semi-natural areas. Given that Croatia is extremely rich in natural areas (European Environment Agency /EEA/, Copernicus Land Monitoring Service, 2018), even in highly urban areas, they represent the bearers of a multifunctional network of green infrastructure. This is especially important if these natural areas are also part of the Natura 2000 network, which is the backbone of the EU green infrastructure (European Commission, 2013). Therefore, we argue that neglecting natural areas and focusing on green infrastructure exclusively, as on planned green and water areas is not in line with the European practice.

In Croatian laws, in addition to the Physical Planning Act, the green infrastructure is mentioned in the Croatian Nature Protection Act (OG 80/13, Article 9), where it is defined as: "... a multifunctional network of protected and other natural and man-made areas and landscapes of high ecological and environmental value that enhance ecosystem services". The same paragraph was changed in the amendments to the Nature Protection Act (OG 15/18) in such a way that the point defining green infrastructure was completely removed. What is retained, however, is Article 7, paragraph (3), which states that landscape protection is "based" on the classification of landscapes according to their natural and/or created features into landscape types and the structuring of interconnected and multifunctional green / landscape infrastructure networks at the local, regional and national level". The problem in this definition is that at the same time they connect (1) landscape protection, which should refer to significant and characteristic features of the landscape that need to be preserved from changes and degradations regardless of their function in the green infrastructure system, and (2) landscape typology ("classification of landscapes according to their natural and/or created features into landscape types"), as a landscape management tool in the process of assessing the character of the landscape, whether urban or extra urban and (3) green infrastructure ("structuring interconnected and multifunctional green

10 Priority goal of the Strategy, 4.5.2 .; Strengthening natural capital by planning the development of green infrastructure, OG 106/2017, p. 162.

11 Guidelines for the implementation of measures to reduce emissions and increase outflows, Measure 'Improving the Sustainability of Urban Areas' (Ministry of Environmental Protection and Energy, 2020, p. 116).

12 Strategic goal 2: 'Reduce direct pressures on nature and encourage sustainable use of natural resources' (OG 72/2017); activity 2.5.2.

TABLE III OVERVIEW OF URBAN CONCEPTS AND MODELS WHICH HAVE CONTRIBUTED TO THE DEVELOPMENT OF THE URBAN GREEN INFRASTRUCTURE

Urban concept/ models through history	Criteria of the analysis			Impact on today's green infrastructure
	Categories of open surfaces	Basic role and purpose of the elements	Level and scale of networking, composition characteristics	
Models of ideal cities – Renaissance	central **square**	– center of the urban system – an open area that generates the urban morphology of the city (not the "residue" created after construction; occupies the qualities and target areas of the city) – open space is not typologically diverse, but numerous social functions take place on it because it is the central point of urban, public life (residence, children's play, sports activities, events ...) – ecological importance (microclimate)	high systematicity in the organization of squares, pedestrian streets and the perimeter wall	1. systematicity 2. the social role of the square 3. thinking about ecological values
	streets	– walk – environmntal importance of ventilation and microclimate		
	city walls	– space of walls and the immediate zone next to them (green) – walk		
Haussman's plan for Paris from the middle of the 19th century	the idea of a **green belt** 250 m wide around the city ("green belt")	– restricting the uncontrolled growth of the city – residential-recreational role	medium-high degree of systematization through the establishment and networking of open areas, including the background of the city	1. emergence of a green belt and a point system 2. green connections (alleys and boulevards) 3. emergence of planned recreational spaces within green areas 4. ecological value of forest integration in urban area
	pointed park structures distributed on the city fabric	– space of urban morphology – residential, recreational role		
	urban woodlands (Bois de Boulogne, Bois de Vincennes)	– recreational and dwelling		
	aleys/boulevars	– green connections through the city – communications		
Wagner's plan for Vienna – "*Ringstrasse*", from the middle of the 19th century	implementation of **a green belt or** ring ("green belt") created by the demolition of former fortification walls and other military fortifications around the old town, intended as a circular boulevard around the old part of the city	– morphological loosening of the urban structure because it separates the old from the new part of the city (inner green ring) – connecting open public urban spaces into a circular system – belt – a mixture of built and unbuilt (public buildings are important in it) – promenades are becoming an important part of citizens' lives	a medium-high degree of systematicity through the establishment of a green belt separating typologically different parts of the city	1. appearance of a green inner band 2. development of promenades
Garden city – E. Howard, end of the 19th century	implementation of a **green belt** on the edge of the city;	– limiting the uncontrolled growth of the city – productive role – recreational role	a medium-high degree of systematicity where open areas define the urban morphology of the city	1. green belt 2. radial green connections (connection between the center and the hinterland of the city) 3. ecological values – adapting the concept to local topographic conditions 4. bringing rural values to the city 5. development of the concept into a hierarchical system of garden cities separated by green areas
	central **park**	– defining the urban core – social center		
	radial connections of the central park with the green belt	– communication / connection – defining urban morphology		
Eberstadt, Mohring – Peterson, Berlin city scheme – competition work from 1910 (2nd prize)	idea of **green wedges**	– development of radial green connections in the form of a wedge by creating a connection between the city hinterland and the central part of the city – social functions are enriched due to the interconnection of green areas that ensure better connection of city residents with green zones – is a forerunner of the "*Finger Plan*" for Copenhagen	a medium-high degree of systematicity where the radial system of green areas defines urban morphology	1. appearance of green wedges (connections of the city center with the city hinterland)

/ landscape infrastructure networks"). In doing so, as already indicated, the term "landscape infrastructure" can not be considered synonymous with green infrastructure. Furthermore, in the strategic documents adopted in Croatia, green infrastructure is nominally mentioned and in certain segments its implementation is proposed, but the social and structural role of green areas in the city, which is the impetus for the development of green infrastructure, is not noticeable in all strategies, or are completely marginalized.

A positive step forward is that in Croatia several cities have decided to develop studies, strategies or action plans for green infrastructure and similar documents directly related to it. They are either in the development phase or have just been completed, so their implementation cannot be analyzed in this paper (example Sesvete, 2013; Zagreb, 2016 and 2018; Sisak, 2018; Križevci, 2020; Varaždin 2020; Rijeka, 2020; Petrinja, 2020; Lipik, 2020; Đakovo, 2020; Osijek, 2020; Obrovac, 2020). These studies, strategies and plans should serve as a basis for the development of spatial development plans of cities, general urban plans or detailed development plans. Despite the fact that there are no guidelines nor is the social aspect mentioned in national documents, in most of the studies made they are mostly included. The importance of social function is emphasized by Grădinara and Hersperger (2018) who are engaged in the research of green infrastructure in the strategic

Urban concept/ models through history	Criteria of the analysis			Impact on today's green infrastructure
	Categories of open surfaces	**Basic role and purpose of the elements**	**Level and scale of networking, composition characteristics**	
Corridor parks in North America – second half of the 19th century	**green corridors** ("linear parks")	– inclusion of watercourses as an important part of urban open space *(blue infrastructure)* – creation of a system of connected parks in the form of a corridor (e.g. 1878 "Emerald Necklace" in Boston, F.L. Olmstead, consisting of a series of connected open areas, mainly parks and water areas) – sequential appearance of programmatically different green areas – appearance of remedial green spaces along street corridors	a medium-high degree of systematicity established with the help of organic linear penetrations	1. emergence of green corridors 2. development of blue infrastructure (blue infrastructure) 3. emergence of the remedial role of the landscape
"The playground movement" – end of 19th century	**system of pointed** elements	– emergence of children's playgrounds – represents accessibility and even distribution within the city tissue in such a way that the maximum distance to them does not exceed half a mile (approx. 805 m) from the place of residence	a medium-high degree of systematicity created by means of evenly distributed point elements	1. emergence of a system of point elements 2. emergence of children's playgrounds
Copenhagen *"Finger plan"* – 1947	implementation of **green fingers** ("finger plan")	– plan for the expansion of urban traffic from the city center to the periphery and, accordingly, the establishment of a system of green areas ("wedges") separating residential areas – differentiation of the urban landscape by different functions – immediate availability of green recreational areas from residential areas – variety of functions (recreational, sports, agricultural) – becomes the basis for the development of a "green space system" of many cities	a high degree of systematicity implemented as a form of city expansion	
„London's Green Belt" – middle of the 20th century	implementation of a **green belt** on the edge of the city ("green belt")	– integration of the hinterland of the city as a space that is organically connected with the urban landscape with the purpose of urban expansion regulation, preservation of open areas between built-up areas – integration of production functions into the urban landscape – multifunctionality of the green belt (areas for different purposes – sports, recreation, agriculture, protective green areas)	a high degree of systematicity that defines the edge of the urban area	1. creation of a multifunctional landscape (integration of economic, recreational, residential role)
Green axis *„Sljeme – Sava"*; the Antolic plan (regulatory basis for Zagreb 1949/1953)	planning of the so-called **green axis** system "Sljeme – Sava"	– creation of a green network and corridor with the deepest possible penetrations of green areas from Sljeme towards the river Sava – understanding the corridor of open areas as an integral part of urban functions – recreation and protective role – zoning of open areas for various purposes (zones of green areas, sports and recreation) – influence on the microclimate of the city *"sunshine and ventilation of the city"*	a high degre of systematicity of organic structural natural features	1. creating a network emphasizing green fingers 2. protection of natural values of space (Medvednica, river Sava) 3. introduction of ecological values (mostly based on an anthropocentric view)
Functionalism (CIAM, Athens charter), 20th century	creation of a **green network** (made of areas and lines) through the city	– multifunctional green city network – diverse purpose of open spaces (typology of urban green areas and planning norms) – designed parks and green areas become the basic space between buildings with functions for all types of dwelling and recreation (green residential areas)	a high degree of systematicity that turn large areas into urban green spaces that spontaneously create a green urban network	1. Green spaces become an indispensable (necessary) elements of the city
Postmodernism	re-descovery of the **square** and the **street**	– reintegration of non-green parts of the system with its former values (square, street)	very high degree of systematization where spatial elements are viewed through various discourses (urban, social, ecological, economic)	1. developing environmental awareness 2. developing the systemic nature of the overall urban landscape 3. discovering the value of local characteristics and cultural heritage 4. high differentiation of open space functions, but also the development of their multifunctionality
	reinterpretation of **parks and other urban green areas**	– development of importance of adjustment to the local specific conditions – integration of cultural heritage as an landscape element – development of green spaces as sustainable system		

spatial plans of individual urban regions of the EU. Comparing planning approaches using hierarchical cluster analysis, the authors found that there are two different approaches to integrating green infrastructure into strategic documents; the integrated approach[13] and socio-cultural approach.[14] The authors did not notice a clear pattern of green infrastructure planning given the tradition of planning in a particular country, but they attribute this to the unique institutional context within which the plans are adopted. Many principles and related concepts of urban green infrastructure are present in part in the strategic planning of EU green areas, but Davies and Lafortezza (2017) indicate that there are differences in terms of content and level of consideration.

A positive example of the implementation of green infrastructure is the United Kingdom, which in the National Planning Policy Framework (Ministry of Housing, Communities and Local Government, 2019) indicates that plans at all levels must be strategically approached to conserve and improve the habitat network

13 This approach is considered comprehensive by Grădinar and Hersperger (2018) because the mutual influence of social and ecological systems

14 According to Grădinar and Hersperger (2018), urban regions have this approach for which green areas play an important role in urban aesthetics, preservation of the cultural landscape and preservation of historical heritage. However, as the authors point out, such regions have other instruments related to the planning of natural components, such as landscape plans in Germany or a regional land use plan in the Helsinki region.

and green infrastructure (paragraph 171). The Natural Environment Planning Practice Guidance (2019, in: Gregory, 2019) states that green infrastructure requirements must be considered at the earliest stages of planning and must be included in the making of development proposals. In addition to the national level, England and Scotland have adopted guidelines for green infrastructure; Natural England's Green Infrastructure Guidance (Natural England, 2011) and Green infrastructure: design and placemaking (The Scottish Government, 2011) which provide recommendations for all levels, from strategic and local plans, through residential, to individual housing. This has resulted in many examples not only of the development of strategies and plans for green infrastructure but also of the implementation of projects that contribute to environmental stability and social benefits for residents as well as to the sustainability of cities and adaptation to climate change.

Many positive examples can also be found in Germany; Leipzig, Mecklenburg-Vorpommern, Lenzener Elbtalaue, Emscher (European Commission, 2014). Namely, Germany has adopted the Federal Green Infrastructure Concept (Federal Agency for Nature Conservation /BfN/, 2017), which is envisaged as a basis for decision-making in plans adopted by the German Federation. As a backbone, the document sets out protected areas of nature, natural heritage, species and habitats, and ecosystem networks.

The Republic of Slovenia defines the green system in the Spatial Planning Act (Official Gazette of the RS, No. 61/17), which is expanded in the new draft Act, still under public discussion (Ministry of Environment and Spatial Planning, 2020), with definitions of green system settlements and the green system of the region, which also shows the initiative of implementation on all levels of planning. At the same time, for the purposes of drafting the Spatial Development Strategy of Slovenia 2050, they have been working on a professional background (Penko Seidl et al., 2017) related to green infrastructure, which provides detailed guidelines for its implementation, including the criteria for determining elements of green infrastructure at the national level.

Therefore, we believe that Croatia has an obligation to adapt the approach to the implementation of green infrastructure to its planning system, so that it is in accordance with the recommendations of the European Commission. It is proposed to adopt at the national level a document with detailed guidelines that counties, cities and municipalities can consider when planning development and later directly implement through targeted projects.

CONCLUSION

By reviewing the development of cities and urban concepts of historical periods, it can be concluded that the ideas of a systematic view of space existed before the twentieth century. Thus, the hypothesis that green infrastructure has its origin in historic cities is correct. The most obvious examples are models of ideal renaissance cities where the systematicity of open areas of the city in combination with anthropocentric ecological values is visible. Later it further developd through concepts such as "green corridors", "green belts", "green wedges", "green fingers", "green dotted elements", "urban green system and green networks".

However, through the concept of green infrastructure innovations, due to the perception of open areas, have been introduced on several levels. Thus, a certain open urban area is part of the urban green infrastructure, but also an element of regional and national green infrastructure. In this aspect, we find an important contribution of today's model of green infrastructure, which due to numerous environmental issues of today stands for "new" ecological values.

Although nowadays the contribution of green infrastructure is unquestionable, spatial planning documents of the Republic of Croatia are essentially of a theoretical nature without expressed real measures and activities that would achieve sustainable development of cities, including contributions to the concept of green infrastructure. Without a solid legal basis, as well as national guidelines, the implementation of green infrastructure remains at the level of the initiative of individual cities that understand green infrastructure as one of the imperatives of spatial development and sustainability. And therein lie today's best practices whose base should be regulated at the national level in the form of guidelines and instructions for the development of strategies, studies and plans for green infrastructure at all planning levels; from national to local, so that their development and application is comprehensive and mutually synchronised.

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Illustration sources

Fig. 1 Zavod za ukrasno bilje, krajobraznu arhitekturu i vrtnu umjetnost, Agronomski fakultet u Zagrebu, 2018

Fig. 2-8 (redrawed original plans), Perekovic, 2021

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