The development of green infrastructure concept within Slovenian spatial planning practice

The term "green infrastructure" was established at the end of the 20th century in the United States and Western Europe. The concept itself has evolved over time in response to environmental problems. It addresses planning issues by combining landscape and ecological planning methods with knowledge of natural and social systems. Drawing on Slovenian case studies, this paper aims to understand the ability of the Green Infrastructure concept to operate across scales, disciplines and administrative boundaries.

The aim of this article is to present the background and the development of green infrastructure concept as a contemporary landscape planning approach, and, to highlight a few Slovenian case studies, which are considered as relevant examples of green infrastructure planning concept. Since connectivity is one of the main principles of green infrastructure, a special emphasis will be put on the importance of ecological connectivity as one of the core functions of green infrastructure.

Green infrastructure is a concept that emerged some 20 years ago and has been a part of contemporary landscape planning practice ever since. Despite the novelty of the term, the concept itself evolved from several (historical) planning concepts. The majority of these concepts developed as a response to two environmental crises, the first one following the first industrial revolution on the transition from 18th to 19th century and the second the economic growth in the years after the 2nd World War. Industrial revolution, followed by expansion of cities and pollution caused the degradation of living environment and evoked the first attempts towards improving the quality of human environment. The culmination of environmental problems, combined with the knowledge that some environmental damages are irreversible (e.g. species' extinction) in the late 1960's resulted in strong environmental movement, oriented towards improving the quality of not only human, but natural environment as well and establishing nature conservation and environmental protection as the core issues of contemporary society.

Nowadays, green infrastructure is well renowned concept among spatial and landscape planning practitioners, academics, policy makers, as well as in public arena. The expansion of the concept results also in various interpretations, each of them focusing on different aspects – e.g. the importance of GI for nature and habitat protection, the anthropocentric interpretation of GI as ecosystem services, or, as an alternative to grey infrastructure in forms of nature-based solutions. The purpose of this paper is also to highlight the complexity of the concept and the importance of understanding its ability to function across scales, across disciplines, as well as across administrative borders.

Theoretical background

GI definition

The term "green infrastructure" was established at the end of the 20th century in USA and Western Europe. In 20 years' time it has spread all over the world. Mell (2017) explains its development through three eras: (1) the exploration era (1998 – 2007), when the concept was

❶ Similarities and differences between GI and ecological connectivity concepts.

	Green infrastructure	Ecological connectivity
The context of concept's emergence/diffusion	Environmental crisis, pollution, degradation of human and natural environment	Habitat (and species) loss and isolation, disturbed connectivity and migrations
Theoretical foundation	Origin in (1) Landscape planning and (2) Landscape ecology: (1) GI as a planning concept where green areas are not considered as a development leftover but planned parallel to other land uses as: (2) a system of interconnected and interdependent elements	Origin in Landscape ecology: landscape connectivity principle, connecting habitats and enabling flows of energy, as well as species' migration and recolonization of patches
Spatial organization	Hierarchical system: local – regional – national – transnational level; urban GI as a special component within that system	Hierarchical system: ecosystems – landscapes – regions Landscape mosaics Matrix – patch - corridor
Objectives	Connectivity, multifunctionality and heterogeneity of the system. Anthropocentric (ecosystem services) aspect, as well as eco/biocentric aspect	Habitat size and distribution that enables their functioning. Structural and functional landscape organization that ensures connectivity

established, (2) the expansion era (2005 – 2010), with an emphasis on implementation and discussion among academics as well as among decision makers, and (3) the consolidation era (2010 onwards), when firm theoretical background is accompanied by clearly defined vision and implementation of the concept.

The early definitions are based on the physical aspect of GI, whereas the development of the concept puts emphasis on defining GI as an approach to planning. Benedict and McMahon (2002: 12) defined GI as "*an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations.*" When the GI concept evolved, the understanding of GI broadened and led towards defining GI not just as a system of interconnected elements, but mainly as an approach to planning, or, as Dige *et al.* (2014: 8) emphasize: "*... a tool for providing ecological, economic and social benefits through natural solutions, helping us to understand the advantages nature offers human society and to mobilize investments that sustain and enhance these benefits.*"

GI basic principles

The term "infrastructure" itself defines the first principle of GI – in order for the whole system to work, its elements and processes must be (1) structurally and/or functionally connected. Since GI is planned to provide benefits for society, environment, and economy, (2) the multi-functionality of the system is required. Individual parts of the system differ in size, function and character and therefore contribute to (3) system's heterogeneity. Finally, yet importantly, GI provides benefits across scales, therefore (4) one of its main characteristics is hierarchical structure.

GI and ecological connectivity

Since the main topic of this issue is ecological connectivity, some clarifications regarding the relation between GI and ecological connectivity are necessary. The concepts are partly overlapping and interdependent, but still not complete synonyms. GI was already explained as an approach to planning, as well as the network of green areas that provide benefits for environment, society and economy. As it was already emphasized in the previous subchapter, ecological connectivity is the first among four main prerequisites that have to be fulfilled to enable the GI system to work. Ecological connectivity could be interpreted as the environmental aspect of GI, since its primary role arises from raised awareness that an "island approach" to nature conservation is insufficient and the emphasis needs to move towards ensuring connectivity of the system. Parallel to the benefits for nature (connecting habitats and increasing their resilience), other advantages of these network connections for society and economy have been recognized – most commonly known as "ecosystem services". The latter could be interpreted as anthropocentric pole of GI concept, whereas ecological connectivity in a way represents GI's ecocentric pole. The ecological connectivity describes how well an ecological network functions. Similar to GI it could be defined on various scales: as connectivity between habitat patches, at the landscape mosaic scale and at large/regional scale. The ecological connectivity concept itself arises from landscape ecology, where the term "landscape connectivity" is defined as *"the degree to which the landscape facilitates or impedes movement among resource patches"* (Taylor *et al.*, 1993). It includes structural (the spatial distribution of patches and the disturbances among them), as well as functional (the ability of species to move) connectivity. Therefore, it does not (necessarily) require the continuity of single land cover category, but a continuum of interconnected natural habitats which enables the migration of species. For better understanding, the main differences between the GI and ecological connectivity concepts are presented in Table ❶.

GI within politics and spatial planning practice?

Since the benefits of applying GI as an approach to planning have become widely renowned, its principles have been included into spatial planning legislation and practice in USA, GB, Ireland, followed by several other European countries. In 2013 the EU Strategy on Green Infrastructure emphasized international, cross-border dimension of GI and established a sound framework for applying GI into other European (The EU Strategy on Biodiversity, Common Agricultural Policy) and macro-regional (for Alpine, Danube, Adriatic & Ionian and Baltic region) policies and strategies.

GI and ecological connectivity within Slovenian spatial planning practice

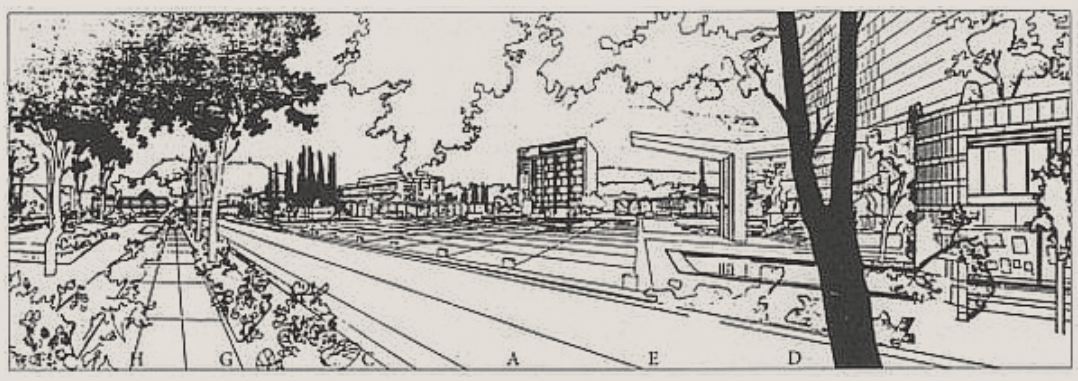
The inclusion of ecological connectivity into Slovenian spatial planning practice is well presented with J. Hudoklin's article in this issue, entitled Ecological Connectivity within the Frame of Spatial Planning in Slovenia. The main purpose of this article is to show the development of GI concept within Slovenian spatial planning practice with a few examples, starting immediately after the 2nd World War with Nova Gorica case study, and finishing with (at the time of writing this article) not yet adopted Slovenian spatial development strategy. The first two examples do not use the term "green infrastructure", but address the issues that are in the focus of GI planning. Four examples will be presented in the following subchapters, covering local, regional and national level of GI planning: GI in the towns of Nova Gorica and Ljubljana, GI of Ljubljana urban region and GI within the national spatial development strategy.

The GI pioneers: GI on local/urban level: Nova Gorica and Ljubljana

The first two examples are by all means the pioneers of GI planning in Slovenia. They were chosen also because of the differences between them. Nova Gorica is a model example of deductive approach to planning, where the design of urban form and town's green network were derived from Le Corbusier's "la Ville Radieuse" theoretical model, adapted to natural conditions. Ljubljana's green system is a combination of inductive and deductive approach. Whereas the first aims to improve and connect the existing green areas, the second tests the possibilities to apply several established concepts for its better design and functioning (Ogrin *et al.*, 1994).

Nova Gorica was planned as a response to the 1947 Peace Treaty between Italy and Yugoslavia, which assigned the town of Gorica to Italy, leaving its mostly rural hinterland in Slovenia (Yugoslavia). Soon after that, the authorities started to search for a location, where a new town – a centre for Goriška and Vipavska dolina will be built. Two alternatives were proposed, one near Šempeter and the other near Solkan. At the end, the latter was chosen mostly because of the continuity and the possibilities to connect the new town with Gorica. Edvard Ravnikar was chosen to plan and design the new town and his vision was *"… to build something big, beautiful and proud, something that would radiate across the border …"*. Nova Gorica green system was planned as one of the basic elements of urban plan. The town was planned and built "from scratch" and Edvard Ravnikar was inspired by Le Corbusier's idea of the sunny city – "la Ville Radieuse", pleasant for living primarily because of many extensive green areas. The town was built on flat terrain at the point where the Soča (Isonzo) river leaves its narrow valley between the hills Sabotin (609 m) on the west and Škabrijel (646 m) on the east. With the town's altitude on merely 100 meters above sea level, the two hills' steep, rough and rocky terrain create a natural "defence" from the north, leaving the valley open towards southwest and the sea. Lower hills – forest Panovec embrace Nova Gorica on the south, providing the town a natural recreation area. Town's main street with all public institutions was designed as a wide boulevard, planted with plane trees, where buildings were placed further apart, and moving along the boulevard means moving under the tree canopies. A special emphasis was given also to the squares and parks. After 1950's the urban development of Nova Gorica (and along that also the development of its green infrastructure) moved away from its original plan. In spite of the incomplete realization of its plan, Nova Gorica preserved the character of garden city and is still renowned for its green network (see Figure ❶).

❶ **Ravnikar's vision of green boulevard. Source: RTV SLO official website,**
http://www.rtvslo.si/kultura/drugo/ideje-na-katerih-je-rasla-a-ne-dorasla-nova-gorica/155540



Contrary to Nova Gorica, Ljubljana is an "organically evolved" town, therefore its green system also evolved organically. With its medieval centre placed on a passage between two hills – Rožnik on the north west and Golovec with Castle hill on the south east, Ljubljana grew along several axes, avoiding steep hills, marshy and flooded areas and fertile soil. The passage between the two hills is merely 500 m wide, and this is the place where river Ljubljanica is leaving marshy Ljubljansko barje and entering well-drained Ljubljansko polje. The green elements (natural as well as agricultural areas) give the town as much character as its built-up areas, since they are interdependent and intertwined. A project, entitled "Zeleni sistem Ljubljane / Ljubljana's green system" (Ogrin *et al.*, 1994) recognized the qualities and potentials of preserved green elements, as well as threats, emerging from development proposals. The team not only planned town's green infrastructure with all its functions, but recognized the opportunity to develop the spatial strategy, based on the same starting points. This makes the work a pioneer among early green infrastructure plans, since green areas were not seen as a past development leftover, but a future development's backbone.

The need to connect green elements into system emerged from the need to make the system functional within the town and from the need to define the relationship between the town and its surrounding. The first places Ljubljana's green system on the urban GI examples' map, whereas the latter is "flirting" with regional GI, emphasizing the need to think, plan and act across scales in order to access all benefits of GI. Ecological connectivity is on the top of that list, since the two hills and Ljubljanica river in Ljubljana area are important parts of regional GI puzzle. As it is seen from the Figure ❷ bellow, Ljubljana's GI concept is following the 1994's concept up until today.

Two approaches of "mature" GI planning: Green infrastructure strategy for Ljubljana urban region and Green infrastructure concept within Spatial development strategy of Slovenia (SPRS)

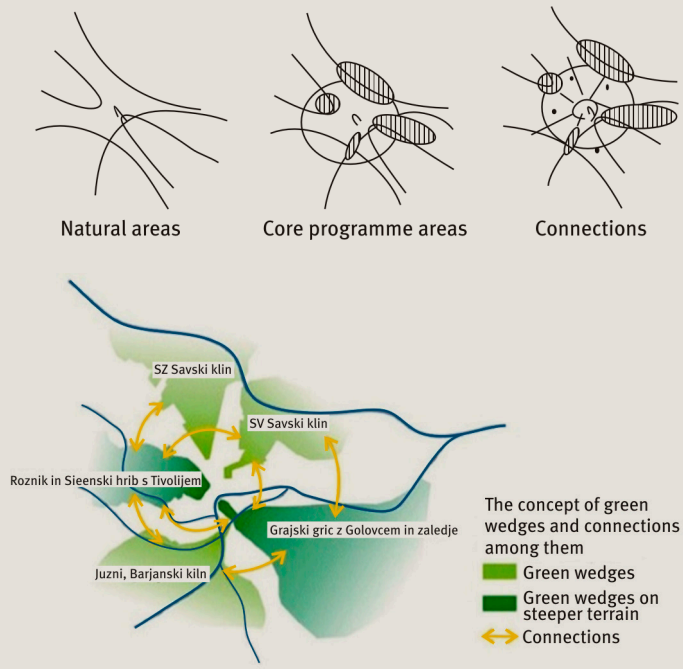
Although Ljubljana urban region (LUR) is central and the most densely populated Slovene region, it is not just country's economic and population centre and infrastructure node, but it is also the region with diverse landscape and preserved natural environment, where two important European GI core areas meet: Alps and Dinaric mountains. Preserving and/or enhancing ecological connectivity between these two areas is considered as extremely important, especially for enabling migration of big mammals. The region is currently (from 2017 to 2021) participating in an Interreg project "PERFECT" (**https://www.interregeurope.eu/perfect/**), aiming towards maximising the benefits of GI by including it its objectives into planning as well as in policy making. One of the key LUR's project objectives is identification, analysis and adoption of GI good practices into main programs of structural funds, whereas project's main result will be "Green infrastructure strategy for Ljubljana urban region", as well as the Action plan for strategy's implementation (**https://mailchi.mp/3333535745e2/perfect-novicnik-82945?e=ae3b4984d2**).

Slovenia adopted its current Spatial development strategy (SPRS) in 2004 and the document is from 2015 on in the revision process. Urban sprawl, non-rational land use especially for industrial zones and adjacent infrastructure all have negative impacts on natural environment and GI, therefore GI was recognised as one of the key topics that should be addressed within the new spatial development strategy. GI within the new SPRS is designed as a hierarchical system, which ensures connections with international GI, and provides guidelines for GI planning on lower, regional level.

Slovenia is a place, where four geographically very diverse areas meet: Pannonia plain on the north-east, Alps on the north, Dinaric mountains on the south and Adriatic Sea on the south-west. Considering natural conditions, historic and cultural influences, the country's environment is very diverse. Due to high share of mountainous, hilly and karst terrain, around 60% of the country is afforested, providing one of the few naturally preserved habitats for big mammals in Europe. High share of unsuitable terrain means that the majority of agricultural land, urban areas and infrastructure is concentrated within a few river plains, causing a strong competition for land and inevitable conflicts between development and conservation (e.g. industry and water conservation), as well between different types of development (e.g. agriculture and housing).

• GI concept on national level had to address several issues, but for the purpose of this article two that are considered as the most important will be emphasized: Ensuring ecological connectivity within Slovenia's national territory to connect habitats of different species, as well as providing ecological corridor on international

❷ Ljubljana's green system concept, 1994 (Kučan, 1994) – top and Ljubljana's green system as a part of municipal spatial plan, 2010 (OPN MOL, 2010) – bottom.



level, to connect Alps and Dinaric mountains and enable the migration of big mammals – especially the wolf and the bear. The largest obstacle for ensuring ecological connectivity on the international level is the fact, that the Alpine – Dinaric ecological corridor (NW – SE) must cross the main development and infrastructure corridor (NE – SW). Several conflicts might appear, especially if/when the national guidelines are not implemented on lower planning levels and/or when the national/international objectives don't meet the local ones. In order to achieve the objectives and to avoid the conflicts, a 2-year project for defining ecological corridors on the basis of existing studies, as a support for spatial planning has just started in November 2019.

- Providing a sound framework for GI planning on regional and local level. Several objectives, determined on the national level could only be implemented within regional and local spatial plans. By further elaborating national GI guidelines and adding functions that are relevant on regional and local level, a sound hierarchical GI framework could be established. Slovenia is still lacking the regional planning level (see Hudoklin's article in this issue), but hopefully regional spatial plans will be prepared within the next few years as a missing link between national and local planning acts.

Discussion and conclusion

As the presented case studies show, the concept of ecological connectivity developed and its importance increased through this period and became a basis for GI planning. All of the presented case studies give ecological connectivity some consideration, although the importance of the ecological connectivity concept within GI planning depends on the (1) temporal, (2) spatial and (3) conceptual context. (1) Early approaches to GI planning focused mostly on providing benefits for society by developing new green areas and incorporating them into wider/existing green network. Approaches that are more recent are more balanced in terms of providing benefits for society as well as for nature and biodiversity. At this point it should be noted, that the scale of these projects (regional and national) brings additional demand for considering ecological connectivity in GI planning. (2) Therefore, the higher priority of ecological connectivity on higher planning levels is evident but logical. Ecological connectivity is a concept that, although it works across scales (from ecosystem, across landscape and up to regional level), requires a draft concept on higher levels to accomplish its full potential, and can be further elaborated on lower hierarchical levels. Green infrastructure is above all a system, and a system needs to be planned and designed as a whole. (3) Different approaches towards GI planning evolved and coexist, adapting methods from (landscape and urban) planning and utilizing knowledge from landscape ecology. Landscape ecology principles provide valuable input information for planning, but planning is oriented towards introducing and managing change in the landscape, it is a discipline where many – often competing – interests need to implemented, and ecological connectivity is just one of them. ■

The author

Nadja PENKO SEIDL
University of Ljubljana, Biotechnical faculty,
Department of landscape architecture
Jamnikarjeva 101000 Ljubljana, Slovenia.
nadja.penko@bf.uni-lj.si

Learn more ...

BENEDICT, M.A., MCMAHON, E.T., 2002, Green infrastructure: Smart conservation for the 21st century. Renewable resources journal, 20, 3, pp. 12-17.

MARUŠIČ, B., 2017, Mesto, ki bo sijalo prek meje. DELO official website. [online] Available at: http://www.delo.si/sobotna/mesto-ki-bo-sijalo-prek-meje.html [Accessed 18 June 2018.

MELL, I., 2017, Green infrastructure: reflections on past, present and future praxis. Landscape Research 42(2), pp. 135-145.

OGRIN, D., MARUŠIČ, I., KUČAN, A., SIMONETI, M., KOPAČ, M., DOLEŽAL, M., 1994, Zeleni sistem Ljubljane. Zasnova. Ljubljana, UL, BF, Inštitut za krajinsko arhitekturo, 97 p.

TAYLOR P. D., FAHRIG L., HENEIN K, MERRIAM G., 1993, Connectivity is a vital element of landscape structure. Oikos, 68, 3, pp. 571-573.

References (figures)

KUČAN, A., 1994, Zeleni sistem Ljubljane. Urbani izziv 26-27, pp. 65-72.

OBČINSKI PROSTORSKI NAČRT MESTNE OBČINE LJUBLJANA, Ur. list RS 78/2010.

RTV SLO OFFICIAL WEBSITE. [online] Available at: http://www.rtvslo.si/kultura/drugo/ideje-na-katerih-je-rasla-a-ne-dorasla-nova-gorica/155540 [Accessed 5.11.2019]

Nova Gorica, Slovenia, Europe.