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GREEN INFRASTRUCTURE EVALUATION MODEL: CASE STUDY OF BELGRADE

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Abstract. *In this article, we consider possibilities to apply green infrastructure as an urban planning approach that provides polyvalent space for ecosystem services and human well-being and evaluates their impact on the city (re)generative space of biophilia. Two residential areas in Belgrade (block 45 in New Belgrade and Savamala neighborhood in the old city center) will be used as the focus of the research presented in this article. Even though they are characterized by different ecological, urban, morphological and social characteristics, they share direct contact with Sava River. Therefore, the adaptive potential of these spatial segments will be the subject of the analysis presented in this article, and the emphasis will be on applying and evaluating design within the integrated network of green infrastructure, and the study will determine what impact it has to planning and implementation of elements of green infrastructure.*

Key words: *Evaluation model, green infrastructure, environmental planning and design, the ecosystem approach, biophilia, Blocks 45, Savamala.*

1. INTRODUCTION

Unlike natural ecosystems, urban systems create large ecological footprint that reflects in degradation of natural habitats, as well as in the loss of biodiversity and ecosystem services (Alberti, 1999). The urban heat island effect and disturbance of the natural runoff of water impair the quality of life and desirable positive effects of open public and private spaces (Gill et al., 2007). The value base of planning paradigm was altered by the new discourses of ecology. The ecosystem approach to planning in the framework of integrated socio-ecological system implies attaining human well-being, in which integrated social elements can be viewed as distinct types of physical and biological components (Pickett and Cadenasso, 2004). This approach is based on the principles of multi-scalability, hierarchical structure of ecosystems, the relation elements-processes, connectivity and spatial continuity (Pickett and Cadenasso,

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2004; Ahern, 2007). Studies show that the ecosystem services are essential to the survival of wildlife on Earth, according to that they are also essential for people and their well-being (Ahern, 2007; Irvine et al., 2010). As part of discourse, the term green infrastructure (hereinafter GI) appears as a new-planning and design concept that supports a set of ecological and cultural functions, contributes to better health and well-being of people (Ahern, 2007; Irvine et al., 2010; Lafortezza et al., 2013; Zaręba 2014).

The main subject of this paper are the possibilities of applying the concept of GI in the area of urban structures of Belgrade and evaluating their impact on cities green infrastructure. The study will address the possibilities of implementation of its spatial elements at neighbourhood/district level and linking them with Belgrade's green core as its main component at a higher city level. Two urban areas of Belgrade were taken for case studies: Block 45 in New Belgrade and Savamala in the old town, as representatives of two different models of urban structure, both located right next to the Sava River, the main green-blue corridor of the city. The study will determine what consequences it has for planning and implementation of elements of GI. The paper will also explore the potential of the informal greening of urban areas as a result of spontaneous activities of citizens and associations at the local level. These links also acquire a different format depending on the model of urban structure. The article will explore the capacity and compatibility of informal greening so that it could be integrated with the planned network of GI and thus successfully completed, as well as explore the potential of the informal greening of urban areas as a result of spontaneous activities of citizens and associations at the local level.

Informal green areas can be the result of different individual or collective actions, both located on the private, as well as the common or public area. Also, they are diverse in terms of their spatial configuration and relation to the built and natural elements of surrounding, and thus to the components that constitute the green infrastructure. However, the physical level, which is linked to the neighbourhood-district or individual land/ building is common to all forms of informal greening. The basic assumption is that the forms of development of the urban areas establish mutually different relationships with the corresponding elements of GI, which primarily refers to those elements of GI at lower spatial levels of a neighborhood/ district. The impact of community greening on the quality of local GI will be identified by comparing the green areas exposed to two different types of cultivation and maintenance—non-institutional (community greening) and institutional (provided by the public company). The analysis should provide data which will show the different impact of both approaches. These spontaneously formed processes will be analyzed in order to examine the possibilities for inclusion in the strategy and action.

With its autonomous informal adaptation the green area generated by tenants, local community or association can be considered a significant component of GI as a part of future greening urban plan concept at local level. Informal greening spaces, like GI, have ecological and psychological significance and they are an important factor of human well-being because, like GI, they have ecological, physiological and psychological importance. Considering functionalist and traditional city models of urban structures, these informal activities of greening acquire distinct features that can be categorized by type, size, purpose and ownership of the site, type of greening, initiating actors, and the opportunity for integration into the GI system, accordingly giving the assessment model. Elements of informal greenery contribute to ecological, economic and role in human well-being (Irvine et al., 2010), and as such they are eligible to become a part of the formal, strategically planned

network of GI. The importance of informal greening activities is reflected in their potential to induce changes at higher spatial and management levels, which will be transferred to, and influence the formal strategies and plans concerning the GI. As stated in Kinzig et al. (2005) as people modifying and responding to biodiversity at local scales in public green spaces and private domestic gardens, decisions by local authorities can dictate city-wide patterns of built form and conversely green space coverage. Informal activities such as public participation in the greening of urban space is vital for the creation of public green spaces that address multiple issues of quality. Working at local scales and providing meaningful opportunities for involvement may not only facilitate acceptance of what necessarily may be radically different types of spaces but could generate solutions that are more extensive and economical than otherwise might be possible (Irvine and Kaplan, 2001). After the introductory part we will first establish a theoretical framework which defines the basic principles of the GI planning, its objectives, features spacious levels, as well as links to relevant elements of the urban fabric/structure. Then follows a description of the context of the GI planning in Belgrade, the existing researches and planning documents.

We will use three consecutive techniques for the purpose of the case research: Identification of the GI components based on patterns processed using patch-corridor-matrix model (Ahern, 2007); assessment of the problems and potentials of urban areas for application components of GI using Forman's model (Forman, 1995); identification of informal activities of greening and assessment of the potential of such space consisting of analysis, planning, site visits and documentation of the current situation. In the final part, we will compare and evaluate the findings from the case studies and draw conclusions regarding the differences arising from the specific urban areas. They will be formulated so that they can be useful as a guideline for the planning and implementation of GI at urban and local level.

2. Theoretical Framework for Planning and Design Green Infrastructure

The GI planning is based on scientific landscape planning principles including a multi-scaled perspective, recognition of pattern-process interactions, the fundamental importance of connectivity and specific guidelines for planning the spatial configuration of landscapes. It is therefore essential that the structural elements of GI are identified on the basis of patterns landscape. Benedict & McMahon (2002) define GI as an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations. Benedict and McMahon also contend that GI is the ecological framework needed for environmental, social and economic sustainability and that it differs from conventional approaches to open space planning because it looks at conservation values and actions in concert with land development, growth management and built infrastructure planning. Green infrastructure provides environmental services in urban areas, which is a prerequisite for ensuring biodiversity, social and territorial cohesion and sustainable development, and overall human well-being (Lafortezza et al., 2013; Zaręba, 2014). It is possible to establish a high level of accessibility, connectivity and attractiveness of its elements with the residential, work and recreation areas by implementing GI in the selected areas, thus offering the ecological framework necessary for environmental, social and economic sustainability. The multi-scaled includes evaluating and planning of spatial configuration of landscape patterns and ecological processes at multiple scales, and interaction of these patterns and processes (Zaręba, 2014). This analysis typically indicates

key points for physical linkages, where important connections exist, or where connections should be made. In urban environments the appropriate scales are: the metropolitan region or city, the districts or neighbourhoods, and individual sites (Ahern, 2007).

Considering the subject of this work that explores and evaluates the connection of GI and certain models of urban structure, we consider GI in terms of its structure and the elementary units it consists of. For this purpose, we rely on the definition provided by Ortega-Álvarez & MacGregor-Fors (2009) presenting GI in structural terms as components that work together to preserve a network of ecologically and socially supportive locations. Depending on the type of function or service supplied, these sites are elements of GI range in size and shape. In general, two main components of GI are the hubs and links (Benedict and Makmahon, 2002). Hubs can contain sub-elements such as nature reserves, parks and open spaces, forests and agricultural land. Links are connections that include green corridors and green belts that connect ecosystems, enabling the flow of ecological processes (Williamson, 2003). Although these elements are precisely defined spatial entities, in nature there are no sharp boundaries.

The method that we applied to two case studies consists of three phases: (A) identification of the components GI based on patterns of landscapes; (B) an assessment of resources of the studied urban areas (case studies) for application components of GI; (C) identification and assessment of potential informal green space.

Table 1 Urban landscape elements classified in the Patch-Corridor-Matrix Model sorted by levels; according to Ahern (2007) and Green Infrastructure Guidance (2009).

Scale and Element	Region/ City	District/ Neighborhood	Individual sites/ Buildings
Urban Patches/ Hubs spots	▪ Wetlands ▪ Regional parks ▪ River islands ▪ Park forests ▪ Forests	▪ Parks ▪ Community gardens ▪ Botanic gardens ▪ Cemeteries ▪ Sport fields ▪ Squares	▪ Vacant lots ▪ Individual gardens ▪ Green roofs ▪ Terraces
Urban Corridors/ Lines	▪ Rivers ▪ Canals ▪ Riverways	▪ Drainageways ▪ Roads ▪ Powerlines ▪ inner block lanes ▪ tree alleys	▪ Green roofs ▪ Individual trees ▪ Vertical gardens
Urban Matrix		▪ Residential Neighborhoods ▪ Industrial Districts ▪ Waste disposal Areas ▪ Commercial Areas ▪ Mixed use Districts	

(A) The two case studies in this work will refer to the patch-corridor-matrix model developed by Richard Forman (1995) for the purposes of describing and understanding the spatial configuration of landscapes and identifying its fundamental elements. This is a convenient and widely recognized model for structural categorization and mapping of landscape mosaics from and universally accepted in the field of applied landscape ecology (Forman, 1995; Ahern, 2007). According to this model, there are three fundamental landscape elements - spatial components that define landscape structure: patches, corridors, and the matrix. Patches provide multiple functions including wildlife habitat, aquifer recharge areas, or sources and sinks for species or nutrients (Ahern, 2007). Corridors are

linear landscape elements that can be defined on the basis of structure or function. Forman and Godron (1986) define corridors from the structural basis as "narrow strips of land which differ from the matrix on either side. Corridors are linear landscape elements that can be defined on the basis of structure or function and they serve many functions within the landscape including habitat for wildlife, pathways or conduits for the movement of plants, animals, nutrients, and wind, or as barriers to such movement (Ahern, 2007). The matrix is the dominant land cover type in terms of area, a degree of connectivity and continuity, and control that is exerted over the dynamics of the landscape (Forman, 1995; Forman and Godron, 1986). Table 1 provides urban landscape elements classified in the Patch-Corridor-Matrix Model sorted by levels (Ahern, 2007; GI Guidance, 2009). As spatial information base for identification of landscape elements, we use the map of the current situation of biotopes of Belgrade, which is a part of the "Green regulation of Belgrade" and belongs to the official planning documents at the level of a city.

(B) To evaluate the potential of urban fields (case studies), we will use Forman's landscape planning rules for the implementation of GI elements, which recognize the fundamental, so-called 'Indispensable' patterns and their interrelationships: (1) a few large patches of natural vegetation; (2) major steam or river corridor; (3) connectivity with corridors and stepping stones between large patches; (4) heterogeneous bits of nature across the urban matrix. (Figure 1). These indispensable patterns are equally relevant in urban environments as they are in landscapes that are less dominated by human development and built infrastructure. Forman argues that these patterns are fundamental, for without them specific ecological functions will not be supported (Forman, 1995).

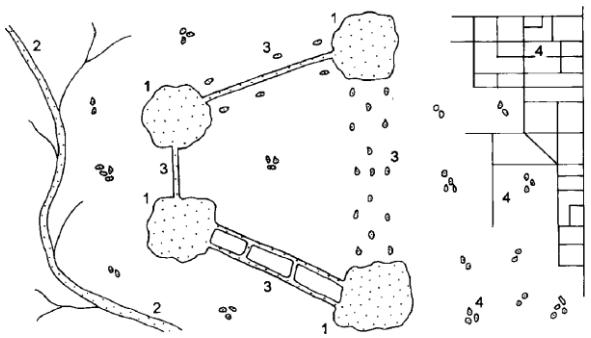

Fig. 1 Top-priority ecological 'indispensables' in planning a landscape (Forman, 1995).

(C) In the analysis, we will pay particular attention to the importance and role of informal activities that produce 'bits of nature' greening elements within the urban matrix. According to Forman's guidelines 'bits of nature' are one of four essential patterns in the planning of the urban landscape. Bits of nature within the urban matrix play a crucial role in ensuring a higher degree of connectivity of the entire urban landscape (Forman, 1995). These are a line or dot elements of GI at the local levels of neighbourhood/district and individual plots/structure (Table 1).

All three listed phases require identifying the issue and the potential for achieving Forman principles of landscape planning concerning the existence of all the essential elements, as well as a spatial configuration allowing the required connectivity. Previous studies (Djordjević, 2008; Popović, 2009; Radulović *et al.*, 2015) and measurements conducted on the territory of Belgrade revealed the negative effects of climate change on the ecological balance, as well as well-being of the community. Therefore, the adoption of climate adaptation and mitigation strategies became necessary (Cvejić, 2011). However, Marić *et al.* (2015) presented that there are no registered activities in the domain of investigation of the effects of green infrastructure in the context of climate change and its quantification in the Republic of Serbia. Current inaction has left numerous consequences on city biophilia - from environmental pollution, unsustainable use of natural resources, to the negative impact that further enhances the effect of climate change (Cvejić *et al.*, 2014). Serbian policies of spatial and urban planning do not consider the relation between the process of urbanization and the causes/effects of climate change correspondingly (Simić et al., 2017).

3. CASE STUDIES: BLOCK 45 AND SAVAMALA

Areas around the rivers Danube and Sava, with GI networks - islets, riverbank parks, foreland, lakes, ponds and wetlands that are located right next to them are called natural core areas of Belgrade (Belgrade green regulation 2003; City of Belgrade development strategy, 2011). The evaluation of selected units is based on several criteria defined in the Green Regulation of Belgrade: in the Green Regulation of Belgrade: the ratio of pervious surfaces, share of evapotranspirational surfaces, areas under treetops, vegetation structure of biotopes, multi-functionality, visual quality, as well as the condition of cultivation and maintenance. (Simić et al., 2017) All selected criteria provide a sufficient set for the evaluation of the condition and quality of GI before and after community greening. The banks and the riverside are recognized as important but underutilized areas of the city, and its specific location within the urban structure provides different possibilities of implementing the concept of GI. Therefore, the river Sava, as a green-blue corridor with urban areas that are directly related thereto, is taken as a testing ground for the analyses of the possibilities for the implementation of GI. Two Belgrade urban dwelling areas on the banks of Sava River-New Belgrade's Block 45 and Savamala were selected for the case study. What is common for these two urban areas is their position in relation to the green core of the city and the city's main green and blue corridors - Sava River with its coastline (Figure 2). Also, what they have in common are the identical standards that should be achieved in terms of adaptability to climate change and environmental quality. However, being related to two epochs of Belgrade's development that caused also their morphological differences, hence different problems in compatibility with functions of the city and its ecology (Sztumski, 2013). These morphological differences require problem based approaches to planning and designing of GI.

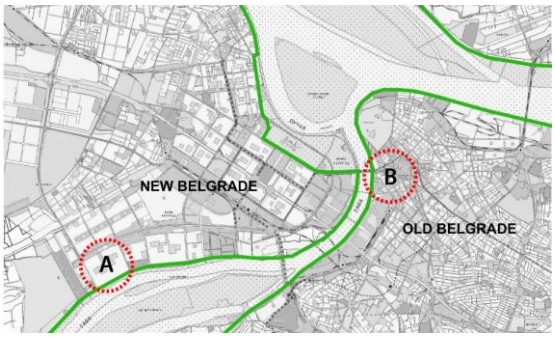

Fig. 2 Position of block 45 (A) and Savamala (B) in relation to green core of Belgrade and River Sava. (author: I. Simić)

The Belgrade Master Plan (2003) identifies this distinctive and extensive region of green and blue corridors as a "green core of Belgrade," which involves regions below the Danube and Sava river courses with GI elements corresponding to the region / city spatial level: river islands, coastal parks, forelands, lakes, ponds and marshes that are located right next to them. “Green core of Belgrade” makes the planning and conceptual basis for the planning of GI in the broader spatial levels such as region and city. For now, strategies and plans at the city and local level do not recognize sufficiently the principles of GI planning, such as multi-scalability, relations structures of the processes, connectivity and ecosystem services. The importance of GI is identified/recognized the most in terms of its role in adaptation and mitigation to climate change, in the form of action plans. The city of Belgrade in early 2015 adopted the Action Plan for Climate Change Adaptation in which as a measure of the highest priority was listed the planning and implementation of GI networks throughout the territory of the city, based on the concept defined in the Green Regulation of Belgrade (2003). In this way, spatial and urban planning at the level of town and municipality gradually turns to the preferred ecosystem approach to planning. However, in order to successfully implement GI at the local level, regulations and plans must contain information on the structural and functional properties that green spaces must have in order to integrate with components of GI at higher spatial levels, in the case of Belgrade with its “green core”.

3.1. Block 45

Block 45 is located in the municipality of New Belgrade, first among Belgrade municipalities across the surface of the intra-block greens (396.6 hectares). The block of 32,000 inhabitants occupies a strip of land on the left bank of the Sava River, implemented as a unique urban entity at the level of the extended local community. The block is divided into a southern and a northern part. There are 21 planned buildings in the southern half, lower levels from GF + 2 to GF + 4 in the form of semi-atrium houses opened and oriented towards the river. In the northern half, it was planned to construct 45 high-storey buildings (GF+7 to GF+15). Green areas are planned as a park and recreational area, as required by the principles of Le Corbusier town planning on which New Belgrade was conceived, complementing the built facilities that are ' immersed in the greenery'. Despite the large planned areas dedicated to greenery (norm of 22m² of green space per inhabitant is required), it remains insufficiently defined and with no clear differences in relation to other areas for public use. During the last decade, climate change and adaptation strategies promoted the importance of the issue of green space. The definition of public interest, i.e.

public land and area for new development, becomes the key to New Belgrade's urban planning, as well as the reconstruction and differentiation of green spaces in the elements that make up the GI network. The draft of a detailed regulation plan for blocks 45 and 70[1] in 2009 specified new values which include, inter alia, "the preservation and improvement of the achieved high standards of living and understanding the emerging needs of the population". Only within this set of priorities in urban and regulatory plans could be talking about the implementation of strategies and action plans which include the implementation of GI. In terms of the development of GI, the Action Plan for Climate Change Adaptation (2015) provides for the development of a network of green corridors along the promenade Lazara Kardenasa that connects residents of the city with the Sava river. Their role will be linked to the cooling air by evaporation, primarily through the avenue and small groups of trees. Setting permeable paving to reduce the outflow of atmospheric water, and the construction of canals and retention ponds along the dikes and banks increases the potential drainage system in flood prevention. At the level of structures, one of the possible interventions would be the introduction of green roofs and walls, while on the level of spatial units were highlighted: the use of local plant species (including edible plants), the preservation and improvement of urban forestation, as well as promoting the concept of ecological park. At the local community level activities would be aimed at spreading environmental ideas and lifestyle, relying on the already observed trend of urban gardening among the residents of blocks. Thus, their attention would not be focused exclusively on the private gardens, but also to stimulate the past practice of self-organization and self-initiated refining of free and green surfaces in the immediate environment of buildings.

We identified the basic elements of the area in the territory based on the patch-corridor-matrix model and the biotope map of Belgrade. (Figure 3a) on the basis of which we will identify the components of GI and their inter-relations using Forman's model. In the immediate surroundings of the block, on its west and east, there are five major patches (P1, P2, P6, P7 and P8) composed of potentially valuable biotopes extensively used and with rich structure (biotope map of Belgrade, 2007). According to their purpose, these are free public spaces covered with greenery (P1, P2, P8) or intra-block green areas (P6 and P7). Within the block, there are three patches small and medium-sized (P3, P4, P5) in potential also worthy biotopes with rich structure. Concerning the purpose, these patches are intra-block greenery. Corridors in the area of the block (C1, C2, C3 and C4) can be divided according to their importance into broader city (C1, C2), local (C3, C4) and intra-block. Within the block, there are three intra-block corridors (C3, C4, C5) whose purpose is pedestrian communication and connecting the block with the main green-blue corridor (C1).

Block 45 consists of two types of urban matrix: a matrix of 45 residential skyscrapers in the northern part of the block. (GF+7 to GF+15) which are arranged in a chessboard pattern. The areas between the skyscrapers are fragmented and designed for green areas, parking lot, children's playgrounds and vehicular and pedestrian communication; matrix of the southern part of the block, which consists of semi-atrium residential buildings oriented towards the river in north-south direction). In terms of the criteria of the presence of the river corridor, block 45 is in direct contact with the Sava banks, which is the part of the main green-blue urban corridor. The northern and the southern parts of the block differ in the built form, primarily in the type of residential buildings – the northern part consists of free-standing skyscrapers, whereas the southern part consists of semi-atrium buildings with a smaller number of floors.

[1] Block 70 is built with the similar urban structure as Block 45.

Two distinct urban matrixes caused the different greenery configuration: in the northern part it appears in the form of smaller park areas, with a narrow strip of greenery around the building or smaller residual areas around playgrounds and parking lots; in the southern part, green areas are less fragmented and consist of smaller park areas and greenery surrounded by a semi-atrium form of building. The apartments on the ground floor of these buildings own a narrow strip of green area, which is private property, while the remaining majority is the public green area mainly covered primarily by trees and bushes. Both urban matrixes of the block 45 have characteristic shapes bits of nature, which were created as a combination of the mentioned urban-morphological characteristics, as well as informal activities of greening initiated by dwellers. Given the importance of the bits of nature for the overall connectivity of the urban matrix, it is necessary to pay special attention to them. With informal activities, dwellers contribute to the impression that semi-atriums are a private or common space designed primarily for their needs. This informal greening transforms the semi-atrium area into very diverse and rich bits of nature (Figure 3c). Using Forman's criteria, the so called indispensable patterns of urban area, we are able to examine the potentials of the elements of the area to form a favourable spatial configuration of GI. The area in its immediate surrounding has several large patches of natural vegetation (Figure 3a, P1, P2, P7, P8) which, according to the structure of the biotope belong to 'complex, structurally rich fallow lands with mosaic arrangement of vegetation of different stages of succession' (biotope map of Belgrade, 2007). In the northern matrix of the block, informal greening is not as diverse as in the southern, primarily because of the high fragmentation of open areas due to dense and dispersed arrangement of skyscrapers and concrete areas, such as parking lots and playgrounds. The buildings and residual areas around parking lots and playgrounds reduce greenery to a narrow strip. However, dwellers' interest in individual greening is equally high, it is mainly expressed through the cultivation of flowers and low bushy vegetation such as hedges (Figure 3b).

For the planning and design of future GI, above recognized bits of nature transformed by informal activities are of great significance because it connects the levels of micro and macro, blocks with riverside areas and rivers, offering continuity of greenery. This is very significant for block inhabitants as it offers constant protection against elevated temperatures and sunlight, creating an integral space of rich biodiversity and connectivity of habitat for plant and animal species.

Fig. 3 Elements of GI (3a), bits of nature north urban matrix (3b), bits of nature south urban matrix (3c). (author: I. Simić)

3.2. Savamala

Savamala is the central urban area of Belgrade, covering an area of the two city municipalities- Savski Venac and Stari Grad. It is located on a slope along the left bank of the Sava. Savamala is bounded in the east by street Gavrilo Princip, and in the west its natural border is the river Sava. In the middle of 19th century Prince Miloš Obrenović set the direction of development of this part of town ordering traders to relocate their stores to Savamala, in future Abadžijska bazaar, as the new commercial zone and downtown area of Belgrade. People who lived and worked at that time of prosperity in Savamala were depended on the interaction with river since the goods for stores were supplied from ships to the docks of Sava river. The connection between residents of Savamala and river achieved its peak during the development of commercial zone and the construction of representative elite buildings in Karadjordjeva Street, but was interrupted by construction of the railway station and the railway in the early 20th century. During the 20th century, Savamala lost its significance and Karadjordjeva Street got traffic characteristics by becoming a transit zone. This leads to gradual degradation of its urban and environmental quality. Namely, the cutting of flux of people and greenery between the two lines - the Sava river and Karadjordjeva Street - proved to be a key issue in the development of Savamala. Although ideas on the relocation of the railway station and railway, as well as the relief of road traffic have existed since the Master Plan of Belgrade in 1972, they have not been achieved yet. However, construction of the station "Prokop" and relocation of the existing railway station would open the possibility to re-establish a vital relationship Savamala – riverbank. In recent years it became evident that there has been a resurgence of interest in this part of the city, since its degraded state is now perceived as a challenge for reactivation, especially in the civil sector, cultural and artistic circles.

Savamala is classified in plans as continuously built urban fabric, which consists of the traditional city block as the elementary unit (Master Plan of Belgrade to 2021). Along Karadjordjeva street, it is homogeneous and consists of GF+4 to GF+6 storey buildings which form a continuous street front. In the zone along the riverbanks, the urban fabric is discontinuously constructed with a combination of low-rise city block and service and storage facilities. Regarding the planning treatment of green areas of Savamala at the local level, it is only partial. While it is recognized as an urban district, it extends over the territory of two municipalities. The part in the municipality of Savski venac is covered by Local environmental action plan (LEAP, 2010) which suggests "starting plans and projects related to the oldest urban part of Belgrade-Savamala" and launching "the current relocation plan of the railway station and repurpose of Sava amphitheatre." The plan is based on the projects "Belgrade green regulation" (2003) and "Mapping and evaluating biotopes of Belgrade" (2007), which established the concept of planning of green areas, which corresponds to the concept of GI, i.e. on biotope mapping, biodiversity and ecosystem functions which a network of greenery should take. LEAP defines the basic aims, among other things, the introduction of GIS (geographical information system) of green areas and "raising the modern forms of green areas such as 'pocket parks', roof and vertical greenery and others." (LEAP, 2007). The aims also include "open cooperation with citizens, private and non-governmental organizations and their participation in decision-making about the planning of green areas" as well as "organizing forums, exhibitions, advertising material on the importance of green areas for the quality of life in the city" (ibid).

Based on Belgrade's patch-corridor-matrix model and biotope map, we have recognized the basic elements of the area in the territory (Figure 4) on the basis of which we will define the components of GI and their inter-relations using the Forman's model. On the territory of

Savamala we recognized six major patches (P1, P2, P3, P4, P5, P6), of which P2, P5 and P6 belong to the park greenery, P1 to intra-block greenery, P3 to square and P4 to greenery along the road. The structure of their biotopes is diverse: green areas under trees and shrubs less than 50 percent (P2, P6), a complex structurally rich fallow land (P4), green areas under trees and shrubs more than 50 percent (P5) and micro-complex mosaically arranged biotopes with the participation of built surface less than 50 percent (P1).

In this densely built urban structure, streets have the corridor function and their green potential is reflected in the tree coverage percentage, water-absorbing areas and surface water drainage system. However, the current situation indicates almost entirely untapped potential in the first place in terms of rows of trees, although there is available space for them. The main street corridor is Karadjordjeva Street (C1) with a wider urban character. The connection between Karadjordjeva street and the Sava banks is achieved by a network of smaller street corridors (C2-C7): Hercegovačka, Braće Krsmanović, Mostarska, Zvornička and Železnička streets. It should be noted that the railroad blocks direct contact of river corridors with the riverbanks.

Savamala urban matrix is defined by a densely built closed block structure, a high percentage of asphalt and other waterproof surfaces, which implies fragmentation and low biotope diversity. Bits of nature are primarily limited to the block areas. However, there has been a recent trend of informal greening in the form of collective actions initiated by local organizations. Within Mikser festival "Blue-green dream" project is organized, which brings together the local community and professionals participating in the greening of public spaces, planting rows of trees, individual trees and placing of urban furniture for horticulture (Figures 4a, 4b). Public workshop on urban gardening “Zdravamala” (Figure 4d) was held within the "Spanish house" which is currently used as an informal public space (Zdravamala, 2014). The participatory workshop "My piece of Savamala" (2015), which addressed the new solution for free public space in Karadjordjeva Street, was held in the organization of "Mixer House" and "Urban Guerrilla". This action has implemented a method of participatory design by involving various actors - the local people, experts in the field of urban planning, architecture, ecology and engineering, as well as city and local authorities (Figure 4e).

Fig. 4 Elements of GI (4a), “Blue-green dream” (4b, 4c), “Zdravamala” (4d), “My piece of Savamala” (4e). (author: I. Simić)

4. CONCLUDING REMARKS

In the cases of two urban areas of Belgrade - Belgrade's Block 45 and the territory of Savamala, two urban areas of Belgrade located right next to the river bank and the Sava River and creating the main blue-green corridor at regional/city level - the possibility for green infrastructure has been explored, as a modern concept that combines ecological and social benefits in areas of high ecological diversity, and plans and projects in accordance with the principles of biophilic design. Although in a similar position in relation to the river, these areas represent entirely different models of urban structure - Block 45 is representative of the "functionalist" model of the city, it is characterized by a spacious, open and green space, but not sufficiently differentiated and maintained, while Savamala is a typical traditional urban structure of the old city centre, as the central city area of turbulent urban development. These implied different conditions for the development of green spaces: Green regulation of Belgrade treated area of the block 45 as an integral part of the internal ring of greenery and green core, while Savamala is treated as a part of a continuously built urban area with the lowest percentage of green space. Because of these contrasting conditions in terms of green spaces, planning of GI at the local level requires different approaches. Therefore, the research put emphasis on the study of spatial context, the specific problems of urban structure that challenges actions of GI implementation.

We have recognized informal greening activities, their spatial patterns, actors and objectives and potential role in the network of GI. We have recognized this type of greening as "bits of nature" referring to the model of Forman's "indispensable ecological patterns". We pointed out the importance of these elements for increasing the overall connectivity of the urban matrix in which they are located, and thus the overall connectivity of GI at the local level. Research showed that informal greening could take a very diverse spatial pattern, and it is different by the character of a private/public and individual/collective. As expected, two case studies have shown very different forms of informal greening, but it can be concluded that both play an equally significant role as bits of nature across the urban matrix, increasing the overall connectivity of urban matrix in relation to other elements of GI at the local level.

Block 45 is an urban structure with a high percentage of green and open spaces within the block, as well as the nature of similar patches in its immediate surroundings, giving the needed elements of GI a great potential for the development. Planned by the principles of Le Corbusier's modernist city, these areas are well connected with each other and achieve continuous connection with the Sava pier, as the main recreational area of New Belgrade and significant potential for development of green infrastructure network. The inhabitants of blocks are involved in gardening; they cultivate their private gardens, and they also organize themselves on their own initiative and try to enrich their free and green areas in the immediate environment of their facilities. Thereby, this biophilic need for stronger bonding with the immediate natural environment is spontaneously expressed. Building typology determines the type of urban matrix, as well as the type and level of informal greening. It features two types of urban matrix, south and north. The north matrix, with free-standing skyscraper type of housing, has less diverse biotopes and more fragmented structure of green spaces around and between buildings. Informal green spaces are the result of individual or joint activities of tenants in the green areas related to housing. Tenants are self-organized and they modify these areas by planting shrubs and flowers. The south matrix, with greenery in semi-atrium type of housing, brings intense

informal greening of spaces that includes individual gardening on private plots, as well as planting high vegetation in public green space. There is also an interesting phenomenon of "extension" of individual gardening to adjacent public space.

Savamala is a dense and intensively built urban area where parks are main patches, and streets are potential corridors of GI. During the last decade there is a re-affirmation of the region, based on local initiatives in the cultural and creative sectors. Savamala has become a center of cultural events which gradually runs the local population to accept trends of greener lifestyle, biophilia and active participation in the process of developing their living environment. The revival of actions and initiatives related to environmental revitalization and the introduction of a network of green spaces, which are in line with the urban structure of Savamala and its morphology. The questions of reconnecting with the Sava along the river banks is the key to establishing a continuous network of green infrastructure in the traditional core of Belgrade. Informal actions of greening spaces are substantially different in character than the one in block 45. The public spaces such as squares, urban pockets and surfaces along the roads have become the main available space for bits of nature. Unlike the block 45, the main initiators of informal activities in Savamala are locally based organizations. They are organizing inclusive projects and public participatory workshops involving experts, local residents and other stakeholders aiming to improve the public space environmental quality. In the urban matrix of Savamala, these public bits of nature are a key link in connecting all of the components of GI at the local level.

These processes, which started spontaneously and are primarily linked to the informal intervention level, should be engaged in designing and arranging planning strategies, which would raise recorded patterns to a higher spatial and organisational level. Given the need for immediate action to mitigate the impact of carbon-intensive life and enhance overall human well-being it can be concluded that the correct initiatives aimed at the local context show higher flexibility and productivity, and hence their potential, especially in the field of strengthening green infrastructure, must be exploited intensively and facilitated with corresponding actions at the city level.

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MODEL ZA EVALUACIJU ZELENE INFRASTRUKTURE NA PRIMERU BEOGRADA

U ovom radu razmatraju se mogućnosti primene zelene infrastrukture kao pristup urbanističkom planiranju koji obezbeđuje polivalentan prostor za ekosistem kao I za blagostanje ljudi. Takođe se ocenjuje njihov uticaj na gradski (re) generativni prostor biofilije. Kao fokus istraživanja su prikazana dva stambena naselja u Beogradu (Blok 45 na Novom Beogradu I Savamala u starom gradskom jezgru). Iako se odlikuju različitim ekološkim, urbanim, morfološkim I socijalnim karakteristikama, oni imaju direktan kontakt sa rekom Savom. Usled toga će adaptivni potencijal ovih prostornih segmenata biti predmet analize predstavljene u ovom radu, a naglasak je na primeni i oceni dizajna u okviru integrisane mreže zelene infrastrukture. Ovo istraživanje ima za cilj da odredi kakav je uticaj na planiranje I implementaciju elemenata zelene infrastrukture.

Ključne reči: *Model za evaluaciju, zelena infrastruktura, dizajn i planiranje životne sredine, ekosistemski pristup, biofilija, blok 45, Savamala*.