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Authors	Hiel, Ksenija;Mladenovic, Emina;Cukanovic, Jelena;Ljubojevic, Mirjana
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## **Potential for green corridors along the Danube River in Novi Sad, Serbia**

Ksenija Hiel, Emina Mladenovic, Jelena Cukanovic, Mirjana Ljubojevic  
*University of Novi Sad, Faculty of Agriculture, Department of Fruit Science,  
Viticulture, Horticulture and Landscape Architecture*

### **Introduction**

Green corridors are areas or bands that play the role of separating two functionally different areas with natural elements usually different types of vegetation (trees, shrubs, flowers, and grass). Another important feature of green corridors is linking the leafy area into a unique whole. In this case, prevent fragmentation habitat corridors and represented areas in which it can develop biodiversity. If the green corridors are along the banks (lakes, rivers, seas, channels) their importance is increasing. Green corridors that follow the coastline, depending on the types of trees and shrubs may have a significant impact on water levels and groundwater levels. In social terms microclimate conditions of green belts along the water allows the development of a number of functional programs. If these corridors are within the urban structure benefits that these areas provide their citizens are manifold. The variety of content along the coast can have a positive impact on mental and physical health of users. The banks and their contents must be designed and made available to all residents because it will be the only way to enable their everyday use that leads to positive results for the health of the individual. In this sense, the selection of functions, their positioning along a green corridor and the water's surface, and the distance between certain functional content must be carefully thought out. All functions within the Green corridors along the banks of the Danube and the canal Danube-Tisa-Danube (DTD) in Novi Sad must be connected with continuous pedestrian and bicycle communication - paths. Bearing in mind that the bike trail corridor Eurovelo 6 in its one part passes through the territory of Novi Sad this association is even more significant. In order to fulfil the requirement of accessibility of these paths along the coast, they must be associated with the entire system of walking and biking paths throughout the city. The city network of these paths must also be associated with a network of interurban and suburban areas in the immediate environment of Novi Sad. The theme of this paper is to explore the potential that provides the left bank of the Danube and both banks of the canal DTD in Novi Sad. Part of the research paper is to identified the existing facilities and it's important for recreation and socialization for all residents particularly ones living along the Danube and canal DTD waterfront.

## **Background/Literature Review**

Cities on the shores have natural preconditions for a better and more humane life of their citizens. In a number of studies the impact of the river of life in urban areas are investigating (Stojanović et. al. 2013). In addition to climate and landscapes that affect urban areas with water, economic, social, and sociological and health aspects are important factors for the development of the settlement. Rivers can be used for different purposes like source for drinking water, irrigation and / or flood control, transportation, sports and recreation such as boating, swimming, fishing, water skiing etc. All together these waterfronts areas are making direct influence to aesthetic effects of urban river banks (Cengiz, 2013). Regeneration of water banks can be observed from many aspects. Marta Moretti points out the strengths and weaknesses of each regeneration by defining "waterfront" as urban area in direct contact with water, explaining that in cities on water, this area usually corresponds on the area occupied by port infrastructure and port activities (Moretti, 2008) however, this statement does not apply in the case of Novi Sad. The passenger ships dock in Novi Sad occupies a negligible length guided coast in the stretch of about 100 meters of a total 10,620 m. Novi Sad cargo port where the vessel fit for the transport of goods is in the canal DTD and occupies only 525 meters from the shores of the total length of the canal 5,283 meters. As part of this coast, there is a lock which occupies 355 meters of the canal DTD coast. Apart from port and dock on the banks of the Danube River and the canal DTD in Novi Sad there are many other facilities such as swimming, rowing and yachting clubs, rafts, promenade etc.

The gravitational power of the shores on the water depends on the number and variety of functional elements as well as their availability and accessibility for all users. The Danube is the second largest river in Europe. Length of its course of 2,850 km is connecting ten countries and four capital cities. Since the greater length of the current river Danube is navigable waterway it is Trans European (pan-European corridor VII). The canal linking the Danube to the Black Sea built in 1984 and the Danube-Rhine-Main from 1992 with the length of the waterway of 3,500 km is connecting the North to the Black Sea. Length of the Danube linking the two sides of Europe represents a huge potential of the tourism development (Milanković et. al. 2014, Marković and Petrović, 2011). In its many parts Danube present also a natural border between the countries. Geopolitical and economic positions of the cities along the Danube represent the potential for all countries through which the Danube flows (Baltălungă and Dumitrescu, 2008). Along the greater part of the Danube cycling route Eurovelo 6 is stretching trough Serbia, which starts in the north at Bački Breg and almost its entire course follows the bed of the

Danube and its meanders up to the Iron Gate and the border with Romania. On the part of the territory of Novi Sad this corridor follows the banks of the Danube on the west from Kamenjar until the bridge over the Danube, near the canal DTD in the east border of the town. Environmental Impact Studies of the river flowing through settlements are numerous, but specifically to explore the left bank of the Danube in Novi Sad has not yet been implemented. Micro location Šodroš and Kamenička ade in the east of the study segment represents a rare area of biodiversity and habitat of fauna (Dolinaj et al 2010).

The potential of Novi Sad for the development of river tourism is a big and still insufficiently used. Port Novi Sad is located on the 1254-kilometer on the left bank of the Danube River, which is the river corridor VII. The Danube flows through Serbia in the length of 588 km, from settlements Bezdan to Prahovo. Urban part of the city of Novi Sad has direct contact with the left bank of the Danube in the length of about 10.620,0 meters. Along the coast of the canal DTD city territory of Novi Sad is directly connected on a length of 5.283,0 m. The railway Corridor X and Danube river corridor intersects as an international transport hub. Geographic location of Novi Sad permits a river and river-maritime transport Danube river in two directions: the East and the West. Direction Danube - East connects Novi Sad with Bulgaria, Romania, Moldova, Ukraine and the Black Sea. Direction of the Danube - West provides connectivity Novi Sad with Croatian, Hungary, Slovakia, Austria, Germany, and over the Rhine - Main - Danube, Novi Sad is connected with Switzerland, France and the Netherlands, respectively Atlantic Ocean and the North Sea. Along the left bank of the Danube, which is territorially part of this research, there are several harbours for small boats and craft. On the 1263.5 km there is the Kamenjar harbour, under the Fishing Island from 1258.7 to 1257.8 km there is a total of five berth, the other three are located in the section from 1,257.7 km to 1257 km. In the area of quay with a length of 800 m is a passenger Port Novi Sad which also receives 5 vessels. Cargo port is located in the fairway canal DTD and occupies approximately 44,000 m<sup>2</sup> indoor and 100,000 m<sup>2</sup> open storage space. Under the Port of Novi Sad is the aquatory of size of 6 ha and depth of 4-6 m. The right bank of the Danube in this area is not the subject of this research since settlements Petrovaradin and Sremska Kamenica is only the administrative parts of the City of Novi Sad.

### **Goals and objectives**

The theme and main goal of this paper is to explore the potential of green corridor along the left bank of the Danube and both banks of the canal DTD Novi Sad. Having in mind the importance of greenery along waterfronts, as well as the diversity of content that attract the residents of the riverbank

intended is to display and analyze the current state of the left bank of the Danube in order to determine the potential for its development in several segments. First of all, to improve the microclimate and biodiversity by raising new green belts in areas where it does not exist and in locations where it is not adequate. The second potential to be explored lies in the gravitational power of this area in the city in terms of sport, recreation and tourism along the Danube and the canal DTD. Special potential exist in development of walking and cycling network of the city and its connection with the route Eurovelo 6. Looking at the green areas in Novi Sad as an essential part of the city core, it can be conclude that they are not established in all zones. Standard for green spaces in urban areas in EU countries are different, but statistically represents a particular area of green space per capita. Looking at Novi Sad it can be seen that different parts of the coast have a variety of functional facilities such as a weekend settlement, (Kamenjar and Ribarsko ostrvo), housing (Telep, Limani and quay), work and industry (shipyard, University Campus, harbour, industrial zone) as well as sport and recreation (Ribarsko ostrvo, beach Strand and Bećarac, rowing clubs, diver club, fishing of the association, etc.). All these facilities are potential areas for socialization for tourists and citizens.

### **Method(s)**

Analysis of the current state of the left bank of the Danube and its contents as well as the number of inhabitants are made on the basis of statistic data of Republic Geodetic Authority of the Republic Institute for Statistics, Republic Hydro meteorological Institute and JKP Informatika, the Master Plan of Novi Sad until 2021, the Environmental Atlas of Novi Sad, Strategy development of green spaces of Novi Sad 2015-2030, city of Novi Sad Accessibility Strategy for 2012-2018 and observation in the field.

Maps, plans, graphic drawings and images of the existing situation and condition of the researched area investigated. As a results potential sites and locations for the development of a new and improvement of the already formed functional content, connectivity existing green corridor with newly envisaged, as well as a network of walking and biking trails are identified.

### **Results**

A natural boundary of Novi Sad (the second largest town in Serbia) on the south and south east side is formed by Danube. Northeast city limits is artificially created by canal DTD. The city is just on the northwest and west sides open to the predominantly arable agricultural land. Parts of the city which are directly connected with the left bank of the Danube (and also the areas of this research) are cottage village Kamenjar 1-5, Adice, Telep, Limani

1-4, Mali liman, Centar-Stari grad and Podbara. Parts of the city Podbara Industrial Zone, Salajka, Vidovdansko naselje and Klisa settlement have access to the banks of the canal DTD.

The potential development of the various functions in the city is affected by significant natural forces - water levels of the Danube and the level of groundwater in the alluvial plains and terraces of Novi Sad. In addition the conditions created by the urban fabric of the city are making significant influence. The emergence of high water is the most common in the periods April-August and October-December. The lowest water level of the Danube in Novi Sad was recorded at a height of 70.83 m above sea level, the average water level is at a level of 70.40 and the highest recorded level of the Danube in 1965 was at a level 79.51. Investigated part of the territory of Novi Sad, in this paper, is the angle between 71.76 and 78.85 meters above sea level which indicates a direct risk of flooding. In this sense dendroflora which can be provided for reconstruction of the existing green corridors and planting new belts must have the characteristics of binding the land, increased hydrophilicity power i.e. the power of existence in conditions of high groundwater level medians and occasional flooding and resistance to urban stress (species from the genera *Populus* sp., and *Salix* sp.). Distance between trees should ensure proper development of the crown, which will provide its form for adequate shading of pedestrian-bike paths along which these avenues have to be. Greenery around the sports and recreational facilities should provide microclimate conditions as favourable for users. These greenery groups must meet also aesthetic criteria, so that these areas can be more attractive to their visitors. Potential areas identified as possible sites for the erection of new avenues of trees are mostly in the southern part of the city along the Kamenjar, Telep and part with the Navy and shipyard. Locations without sufficiently greenery are industrial zone along the canal DTD. Bearing in mind one of the two most dominant and frequent wind as is south-eastern new plants greenery belts in these parts have to have the wind protection function. Second roles should meet the criteria of land reclamation.

The strip from shipyards along the Limana I-IV, and the quay to the mouth of the canal DTD is the most developed coastal zone that was reconstructed in the period from 2010 to the 2012. (Figure1) For certain segments of this strip some functions are along waterfront such as swimming, rowing, sailing clubs, harbour and dock-berths for boats and rafts, Theatre boat and monument Žrtava racije on the quay. Elsewhere facilities, mainly sports recreational characters are developed between the built structure of the city (housing and education) and the dike. Possibility of potential development of existing content along this strip is minimal. Sports facilities are mutually spaced at

appropriate intervals as compared to the existing urban structure ie. population that gravitates to them. First potential in this zone is reflected in the arrangement of the current "wild" beach "Bećarac" in the area of the University campus and the second lies in revitalization of the existing relatively old trees and shrubs.

In the whole study area Ribarsko ostrvo is an exemption representing green area. Camping and cottage village with numerous restaurants in direct contact with the Danube is the most vulnerable flood areas. For any intervention in the future at this location, a thorough analysis and evaluation of the current situation of greenery and all objects of different functions has to be precondition. On the basis of such studies the potential of camping settlements and river tourism can be developed. The plant material must be successively renewed. The development of fishing in Šodroš which is nearby can contribute to the rapid international development of tourism. These two locations (Ribarsko ostrvo and Šodroš-Kamenička ada) represent the largest potential for development of sports tourism. (Figure 1)

The southern part of the study area Kamenjar and Adice due to disorganization has the greatest potential for the development of content that a city on the water should have. Wrist Šodroš together with Kamnička ada represent a unique reserve of flora and fauna (certain types of Danube fish spawn here, there are storks and frogs, and swans). In this sense, the potential development of functional content should be limited to controlled visits and functions that will not endanger the existing biodiversity, but to enable its survival and development. Boats should not have a motor-driven. Such a restriction one hand would reduce water pollution and noise that adversely affect particular on fauna and on the other hand can create an oasis of peace and quietness in the "center" of the city. The level of groundwater and water levels of the Danube in this area should be reduced by planting trees and shrubs already mentioned. The diversity of content on this area should be reduced to the smallest number in order to create truly natural environment (bicycle - hiking trails along the coast and through the densely planted dendroflora in the middle of the peninsula, and children's playgrounds and sports fields - bowling, chess, badminton, volleyball, etc. on the ages.

Zones Kamenjar 1-5 although on the periphery of Novi Sad, is providing a large potential for the development of coastal waterfront of Novi Sad. Current potential is reflected in the development and refurbishment of the existing cottage settlements (in the undefended flood zone on the Danube), which has some stretches segments (Kamnjaar 4-5) of high standard and large private weekend house (Figure 1). Although not respecting applicable regulations of



Special potential of Novi Sad waterfronts represents an international bicycle route Eurovelo 6 Corridor. This path should be in the entire length of the left bank of the Danube up to the bridge where it moves to the other side of the river. Position of shipyards and navy intercepted a line along the coast and draws bikers in the urban core, which should be corrected in a future urban intervention. All places where this route is intersecting with the city network of bicycle paths should be clearly indicated. These hubs could be a potential gathering place and spaces for socialization.

### **Discussion and Conclusion**

We got the assumption that banks of the Danube and the canal DTD in Novi Sad have significant potential for phased remodelling of existing green strips as well as increasing the area of greenery forming a green corridor along the coast. This corridor associated with the existing street tree-lined should allow unobstructed and the smooth development of biodiversity. Another benefit is reflected in the improvement of microclimate conditions that would be formed out along the pedestrian-bicycle paths along the coast and with all functional content organized along waterfront. The refurbishment of the southern segment of the researched area around the mouth of the canal DTD into the Danube would significantly change the image of the city, and provide adequate spaces for socialization, recreation and improving physical and mental health. Tourists can get better conditions for the visit and stay in Novi Sad using complementary facilities that are in contact with water sports and sport fishing. The green corridor with bicycle paths along waterfront and as part of Eurovelo 6 Corridor can provide better conditions introducing historical and cultural sights to visitors from the tourist boats. The overall changes could significantly affect the city's economy and its citizens and will without doubt change the image of the Novi Sad.

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