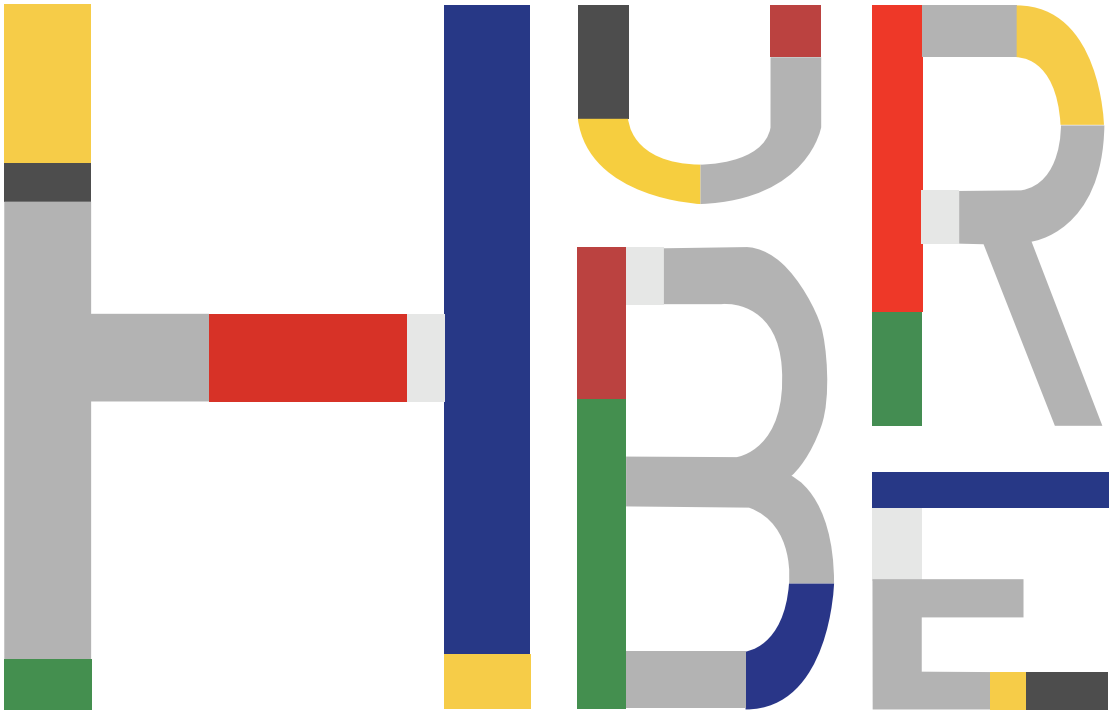

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4-5 October 2021
Faculty of Architecture, University of Sarajevo
Sarajevo, Bosnia and Herzegovina

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TABLE OF CONTENTS

HEALTHY URBAN AND ARCHITECTURAL DESIGN

Rising the Significance of Green Infrastructure in Belgrade, Serbia: Pedestrian and Bicycle Mobility Changes during the COVID-19

Vladimir Mihajlov, Ivan Simic, Aleksandra Stupar
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ABSTRACT

The response to the COVID-19 pandemic brought about significant changes in urban mobility and the city usage patterns. This paper elaborates the effect of lockdown measures on the pedestrian and bicycle use of urban green spaces in Belgrade, Serbia (May 6 - September 29, 2020). Mobile Limitless Application and bicycle counters data from thousands of pedestrian and bicycle users were used to detect spatial and temporal changes in activities. It is estimated that outdoor pedestrian activity increased by 23% from the beginning of COVID-19 safety measures implementation, compared to an average detected during the last 2 years in the same time frame. Both pedestrians and cyclists intensified activities on lanes within green areas or along them. Finally, pedestrian and bicycle mobility have increased in urban parks, peri-urban forests and riverbank pedestrian lanes, emphasizing the importance of access to green open spaces, especially during the COVID-19 distress.

Keywords: *Urban mobility change, Urban green infrastructure, COVID-19.*

INTRODUCTION

In the context of COVID-19 situation and measures of its prevention, green infrastructure could be considered as a provider of human well-being and health. In addition to the ecological function of preserving biodiversity, providing ecosystem services, and reducing pollution, human interactions with urban green spaces have to be taken into account. Many urban biodiversity patterns arise in response to, and are maintained specifically by, repeated human activity. Irvine et al. (2010) refer to a social-psychological perspective of urban nature as an important component of the quality of life and the research focused on benefits gained from "nearby nature" also consider a proximity to or the amount of green space (even a window view). Scientific literature mentioned above reveals many benefits which green infrastructure can have for human health and well-being. Impacts on the local community are also significant because the availability of nearby nature is shown to promote social interaction and a sense of community (Kim and Kaplan, 2004; Simic et al., 2017).

Also, the term green infrastructure appears in recent studies as an important element of planning and design strategies targeting sustainable development and resilience (Voghera and Giudice, 2019; Pinto, 2014; Barton and Pretty, 2012), as well as climate change adaptation (Heidt and Neef, 2008). Supporting a set of ecological and cultural functions (Shashua-Bar and Hoffman, 2000), it also represents a contribution to the urban health and general well-being of people (Biotope Area Factor, 1990; Benedict et al., 2002; Kruuse, 2011). Such network of greenery consisting of urban parks, peri-urban forests and other types of open spaces (eg "urban green infrastructure") provide many environmental and health benefits for citizens, e.g. cooler temperatures for microclimate adaptation (Irvine et al., 2010; Simic et al., 2017) and cleaner air and water (Zareba, 2014).

However, the opportunities for city users to receive mental and physical health benefits from urban green spaces may become even more important during the times of distress, such as the COVID-19 pandemic. Occasionally, residents face health and economic crisis, isolation, and limited mobility during the implementation of social distancing policies (Brooks et al., 2020; Venter et al., 2020). Some of the recent studies (Goldstein and Kilgannon, 2020; Samuelsson et al., 2020; Coker et al., 2020) link increased mortality from COVID-19 to the increased levels of PM 2.5 particles, shading a new light on the role of green infrastructure in urban air purification.

The response to the COVID-19 pandemic brought about significant changes in urban mobility and the city usage patterns. The interdependance between lockdown measures and outdoor pedestrian and bicycle activity increase in urban green spaces has become noticeable. The issue of distancing measures also considers the role of urban green spaces (including publicly accessible trees, parks, natural vegetation and peri-urban forests) in the process of adaptation of city users to pandemic containment measures. This emerging topic already provides the data confirming the increased number of visits to green urban spaces, as well as a shift of their perceived importance during COVID-19 (Fisher and Grima, 2020; Venter et al., 2020; Goldstein et al., 2020). Regarding this, the increased demand for recreational activities in nature has been detected, as well as the positive effects on both mental and physical health. The potential of urban green infrastructure in enhancing the resilience of urban population during the pandemic has also been noticed (Samuelsson et al., 2020). However, access to urban green spaces is not distributed equally in cities, and is often considered as an issue of social inequality (Rigolon, 2016). Consequently, reconsidering the use of public space is important during the COVID-19 pandemic, influencing

important changes to the future urban design and the perception of public space (Honey-Roses et al., 2020).

Green infrastructure should be currently seen as a multi-functional outdoor space which provides two main groups of benefits: 1) the provision of clean air and comfortable outdoor spaces contributing to both individual and general health and well-being and 2) upgrading of urban mobility and daily activities, used frequently during COVID-19 distress. It also represents an important mitigation factor for the overall COVID-19 effects on urban population.

In order to collect the information on the effects of the COVID-19 containment measures on the patterns of use of Belgrade green infrastructure several sources were used: the mobile tracking data and the Google mobility data from the Limitless Android Application (Stupar et al., 2019), as well as the data collected by the bicycle counters positioned on the Sava river dock. The survey was conducted within the Municipality Stari Grad (Belgrade, Serbia) and it revealed the increase of outdoor pedestrian and bicycle activities in green infrastructure during the implementation of the COVID-19 safety measures. The importance of the access to green open spaces in cities was confirmed during the time of distress, especially its influence to an overall resilience of both the built environment and local communities.

THE RESEARCH POLYGON

Municipality Stari Grad was chosen as a study areas due to the high intensity of both pedestrian and bicycle mobility. Centrally located, it covers 698 ha and is populated by approximately 70,000 people representing the urban downtown and the epicenter of urban happenings. Five city parks, riverbank promenade (along the rivers Sava and Danube) and one peri-urban forest (Veliko ratno ostrvo) link this area with the municipalities of New Belgrade and Savski Venac. Cycling in this area is especially intensive between May and October. There are around 20km of bicycle paths, mainly along the riverbank (Cycling routes and bike maps in and around Belgrade, 2020).

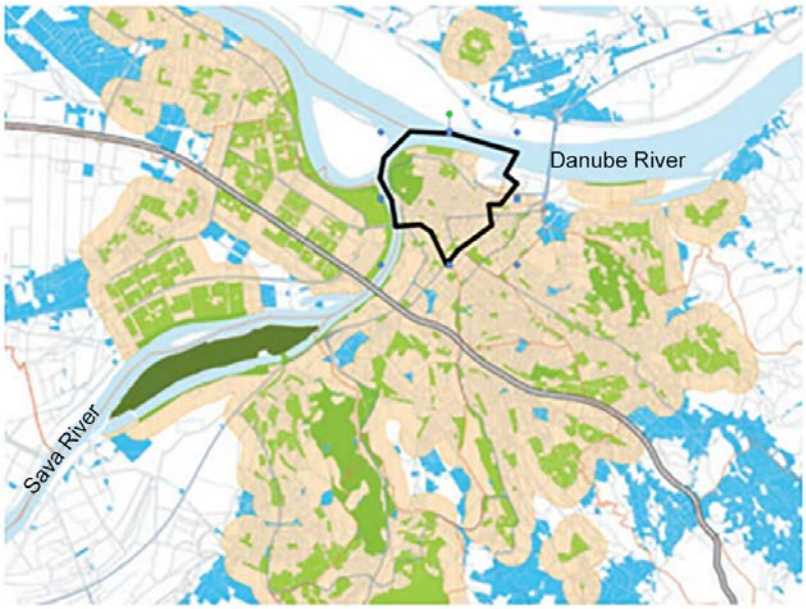

Figure 1: Municipality Stari Grad: boundaries and urban green infrastructure (Teofilovic et al., 2016).

The green spaces of the municipality Stari Grad represent a part of the wider city green network, including the Danube riverbanks and the anticipated linear park in an ex-railway area. The Green regulation of Belgrade defines this green core as a continuous green area whose backbones are river banks, as green-blue corridors with a system of parks and multifunctional facilities in their immediate vicinity (Cvejić et al., 2010). The planned linear park (4.5 kilometers), should represent a pedestrian link between the central zone and the lower part of the municipality, providing a riverbank promenade, bicycle lanes, children's playgrounds, exhibition spaces, sports facilities. It is supposed to affect the reduction of air pollution, also mitigating summer heat waves.

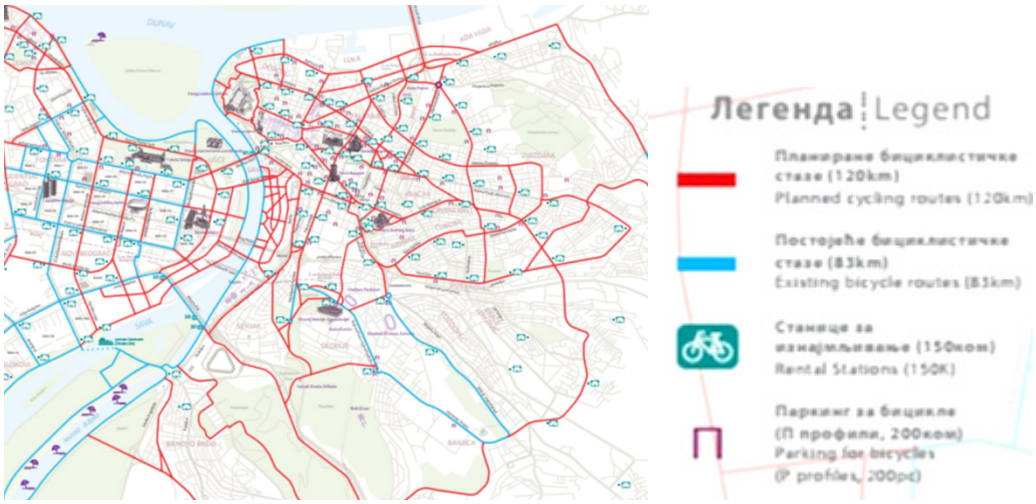

Figure 2: Area of Stari Grad municipality with the existing bicycle routes and urban green infrastructure (Belgrade SUMP - Smart Urban Mobility Plan, 2019).

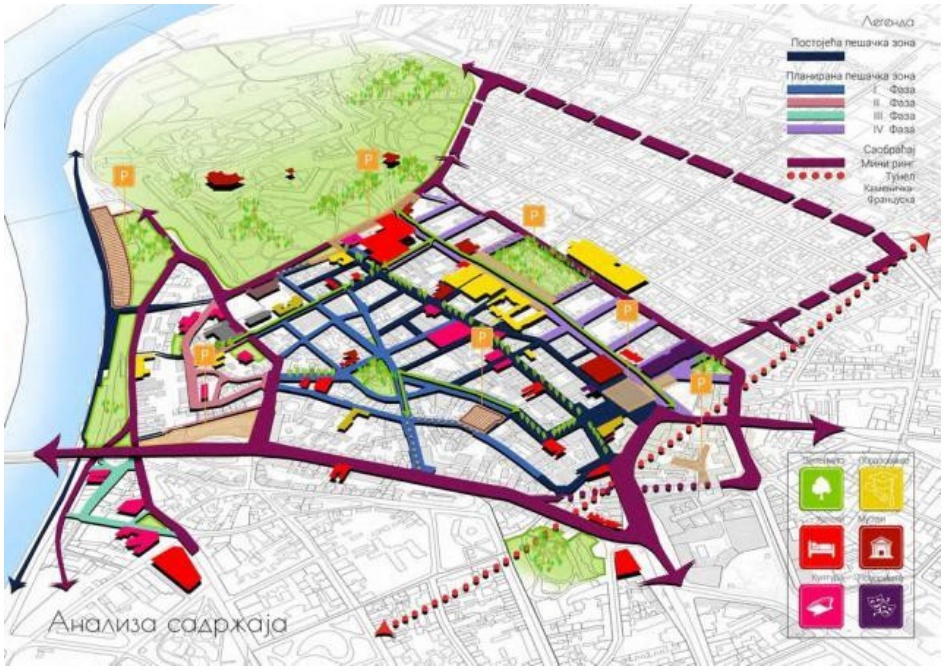

Figure 3: The pedestrian routes in the Municipality Stari Grad (Pedestrian routes plan of Stari grad, 2017).

Figure 4: The anticipated green pedestrian route along the riverbank (Belgrade Line Park plan, 2020).

MOBILITY PATTERN CHANGES

Limitless GIS Application

The data obtained by the Limitless GIS Application were used to analyze spatio-temporal changes. This mobile app, supported by the Google maps software, was developed in 2018 by the University of Belgrade-Faculty of Architecture, the Ministry of Social Affairs and the Limitless NGO, dealing with pedestrian accessibility (Stupar et al, 2019). The operationalization of ICT support primarily identifies users with urban mobility problems (including cyclists and pedestrians), enabling them to map/update the tracks and obstacles in urban space (e.g. pedestrian areas, sidewalks, parks, peri-urban forests), via the Google Maps application.

Figure 5: The Limitless GIS application. Left: the intro page. Right: Mapping the elements that define the ranking of pedestrian routes and areas in Belgrade - via the Google Maps application (Stupar et al, 2019).

Bicycle counter

The bicycle counter is situated on the Sava river dock near “Beton hala” and Kalemegdan fortress. The listed values are shown on the display. This system serves as a tool for the capacity adjustment, identifying the ratio of bicycles and people and, consequently, managing riverbank parks, planning city activities (urban mobility, etc.) or establishing track-time trends.

Figure 6: A riverbank bicycle counter, municipality Stari Grad (Bicycle counter, Flickr photo).

RESULTS

To identify the effects of COVID-19 lockdown measures on pedestrian and bicycle activities, we measured the trend change in year 2020 (May 6-September 29) and compared it to an average detected in the same period of 2018 and 2019.

Pedestrian activity

According to the Limitless GIS app and Google Maps, the municipality Stari Grad contains over 7000 km of streets and trails utilized for recreational purposes. The first step of the analysis was focused on pedestrian activities, counting counts users` pins and the change of their intensity along most frequent directions: Dubrovacka and Tadeusa Koscuska street, the Danube promenade and the Sava dock area. The positive trend was detected, along with the growing user-base of the app. There was also a growing trend for the pedestrian movement - 4950 pedestrians per day (starting from March 15, 2020 until the end of September) vs. cca. 3900 pedestrians per day in the same period of 2018 and 2019. Additionally, the mobility trends for places like national parks, public beaches, marinas, pet-parks, plazas, and public gardens increased 23% compared to the baseline of the Belgrade Metropolitan Area (Google COVID-19 Community Mobility Report, 2020).

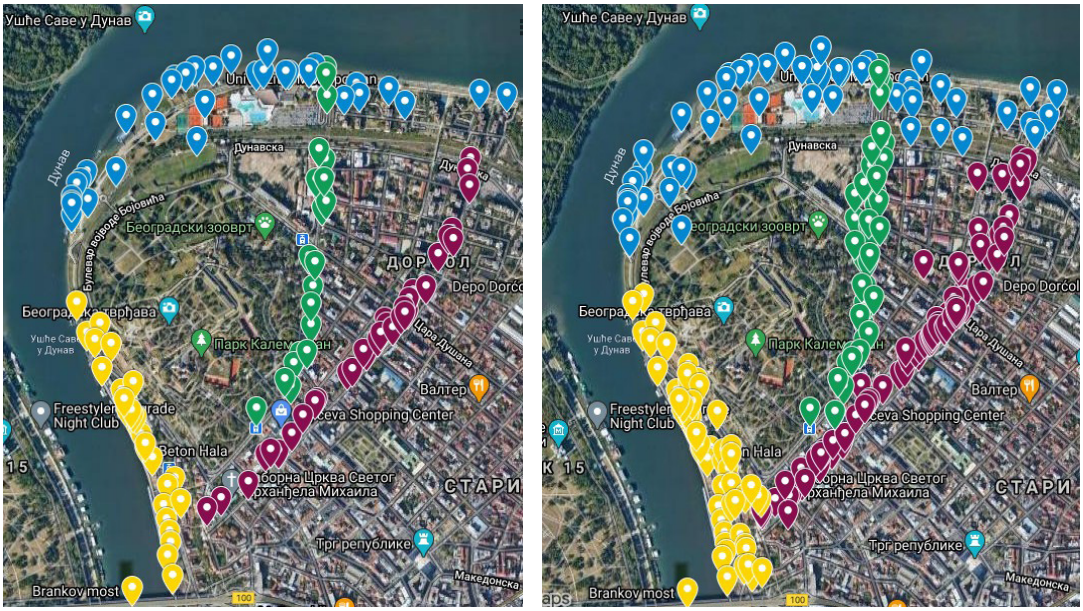

Figure 7: Mapped locations before and after the initiation of the COVID-19 measures (Limitless application, 7a-2019, 7b-2020).

Table 1: The frequency of the pedestrian movement in four zones in Stari Grad, Belgrade.

	May-September		
	2018	2019	2020
Zone 1 - Route of Kralja Petra and Dubrovačka street (maroon pins)	1189	1254	1486
Zone 2 - Route of Tadeuša Košćuška Street (green pins)	713	699	898
Zone 3 - Route of the riverbank promenade “25.maj” (blue pins)	1071	1157	1334
Zone 4 - The route of the “Sava” riverbank promenade (yellow pins)	993	901	1235
Total	3966	4011	4953

*Average frequency of movement per day for a period of five months (May-September)

Cycling activity

Approximately 18600 bicycles are counted per month between May 6th and the end of September 2020, comparing to the same time period in 2018 and 2019 (cca. 16000 bicycles per month - Danube bicycle route counter in 2018/19).

Table 2. Average frequency of bicycle mobility per day in selected zones, according to the data obtained by bicycle counters (May 6- September 29, 2018/2019/2020).

	2018	2019	2020
Zone - Route of the coastal promenade “25.maj”	540	533	610

The observed growing trend of pedestrians and cyclists may also reflect the avoidance of public transportation due to the pandemics. In Municipality Stari Grad, pedestrians preferred the directions of Dubrovačka and Tadeuša Košćuška Streets, the Danube and Sava riverbank promenades. According to the Google urban mobility data the pedestrian activity increased by 23%, especially regarding the visits to parks and other green areas. This condition might also be the result of temporary closure of indoor training and exercise facilities. Additionally, the lack of privacy in dwelling units was apparent, especially in small apartments without balconies and families with three or more members (Maričić, 2020). The analysis also revealed the higher intensity of activities during the daylight hours, instead of the morning-evening peaks typical for the pre-COVID period. This change is more evident for cycling, especially in urban areas with high density.

CONCLUSION

The presented results indicate the increased pedestrian activity in urban parks, inner spaces of residential blocks, peri-urban forests, as well as along green pedestrian lanes, emphasizing the importance of an easy access. The availability of urban green infrastructure has a significant influence on emotional and physical well-being, especially during the periods of distress and pandemic conditions (Holmes et al., 2020). Assessing the available data, this paper could be used as a trigger for further studies and policies which would support the preservation of existing urban green infrastructure and the allocation of open green areas promoting pedestrian and bicycle activities and mobility. For example, redesigning streets and public spaces would allow additional space for these activities and provide a direct and indirect impact on different public health goals (Jennings et al., 2012). Assessing bicycle network sustainability comparing the state detected during the period of May 6th - September 29th 2020 and the data from the same periods of 2018 and 2019, this paper may provide policymakers and planners with strong additional evidence to support the preservation of existing urban green infrastructure and the allocation of open green spaces that promote bicycle activity and mobility. For example, recommendations in the case of Public space redesign in Toulouse (Civitas Initiative, 2020) included redesigning of public spaces in green infrastructure, by maintaining existing and installing new bicycle paths by:

- Creating and enlarging access-controlled and “clean zone” areas. direct cycle routes between housing areas and major destinations make cycling the most pleasant and easy way to travel around.
- Improving the access restriction policies for sensitive areas. convenient cycle in-frastructure means avoiding stop-start travel caused by obstructions, lack of priority, and narrow pavements shared with pedestrians. Good cycle parking completes the journey.
- Reducing the physical ascendancy devoted to cars: speed of travel on a bicycle can be quicker than by car through an urban area if cycling infrastructure is made integral to newly-designed streets.

The implementation and development of the Belgrade green infrastructure has its own limitations which are the result of the strict planning hierarchy. For example, the Master Plan of Belgrade 2021 (2016) subordinates all other plans and regulations at lower spatial levels. Along with this legally binding document, the urban development is guided by the Strategic Development Plan of the City of Belgrade (2010) and local environmental development plans (LEAP, Belgrade), which recognize the importance of local community initiatives, but

do not have a legally binding character (Cvejić, 2010). Therefore, the possibility of implementation is significantly reduced due to the lack of adequate official mechanisms for the inclusion of local communities. However, a certain progress in this field has been made in a recent procedure for developing a regulation plan for the linear park in Dorcol, involving diverse stakeholders (local communities, institutions, investors, non-government organizations) through several participatory urban design workshops (New linear park in Belgrade, 2020).

The analysis presented in this paper also indicates that the easily accessible open green spaces, combined with social inclusion, can mitigate the anticipated negative health effects of moderate mobility restrictions, while reducing the risk of disease transmission. It is obvious that urban green areas increase long-term resilience to similar shocks in the future. Importantly, the COVID-19 pandemic shed light on some aspects of everyday life and their questionable sustainability, raising numerous new issues regarding the higher housing density and reduced long-distance travel, the need for local recreational opportunities but also the problem of increased pressure on urban green spaces (Russo and Cirella, 2018). Therefore, the urban resilience has to be reevaluated in accordance to our new reality, hopefully generating some applicable solutions for the crises to come.

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