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Short Communication

## LINEAR GREENERY IN URBAN AREAS AND GREEN CORRIDORS CASE STUDY: BLVD. BOSNIA AND HERZEGOVINA AND BLVD. HRISTIJAN TODOROVSKI KARPOSH, SKOPJE, NORTH MACEDONIA

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### SUMMARY

*Increasing population, expansion of urban areas and rapid urbanization are the main causes of losing green spaces, which results in many environmental problems and threatens the quality of urban life. Urban green spaces are of great importance and urban planning issues nowadays gain increasing popularity. It is realized that biological methodologies need to be used in urban planning, otherwise the quality of life will be more threatened. In order to discover the meaning and importance of green corridors in urban areas, a literature review was undertaken. Boulevards, as green corridors, are very important linear parts in the structures of dense modern cities. If planned and designed properly, they mitigate the negative effects of densely built urban environment. Green corridors provide numerous environmental benefits, they are an essential factor of sustainability and have a significant impact on biodiversity. Green corridors also provide social benefits, by enhancing well-being through contact with nature. They decrease health problems and improve the quality of life. The importance of urban green corridors was observed and presented on the example of Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh, which form an important ecological network in the northern part of Skopje, North Macedonia. The emphasis is on planning, designing and improving green corridors in urban areas like Skopje. Although these two boulevards are well designed as green corridors, with preserved old line greenery, planted with many different plant species (trees, shrubs, perennials), covered by grass, with bicycle and pedestrian paths, there is still potential for improvement. Linear parks on both sides of the new part of the Blvd. Hristijan Todorovski Karposh would be a great idea.*

### Key words:

*green corridors, urban planning, Blvd. Bosnia and Herzegovina, Blvd. Hristijan Todorovski Karposh*

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## INTRODUCTION

The system of greenery in cities consists of different types of green areas. Some of them are made by man while others are the existing green areas integrated into the spatial planning of the city. Urban green corridors are among the most important urban green spaces which are made by human interventions (Eraghi et al., 2015). They are multipurpose green areas, networks of linear elements, which are planned, designed and managed to perform ecological, recreational, cultural, aesthetics or other functions (Ahern, 1995; Ndubisi et al., 1995). In addition, green corridors, as local open spaces which are easily accessible to citizens, can play a strategic role as traffic-free recreational routeways (Groome, 1990). Some authors place the strongest emphasis on the importance of green corridors in terms of nature and environment protection (Al Masri et al., 2019), while some others consider that the most important role of green corridors is allowing exchange between natural living elements, by connecting different areas or different habitats (Ćurčić & Đurđić, 2013).

The term green corridors and the idea of green corridor design emerged in the 1980s. In the beginning, in the late 19<sup>th</sup> and early 20<sup>th</sup> century, green corridors planning was introduced in order to maintain or provide continuity of urban open spaces, i.e. to connect urban parks (Toccolini et al., 2006; Hellmund & Smith, 2013). Toccolini et al. (2006) state that the origins of the green corridors planning approach are based on Olmsted's 'Parkways' concept in America and the Garden City concept of Ebenezer Howard during the 20<sup>th</sup> century in England. According to Hellmund & Smith (2013), the early prototypes for greenways (green corridors) are created to connect urban parks.

There are many definitions of green corridors. Authors have described green corridors differently, emphasizing what they consider to be the most significant. However, the most significant benefits come from the fact that green corridors are spaces that allow movement of all types of living organisms (Walker & Craighead, 1997; Hilty et al., 2006). Walker & Craighead (1997), for example, emphasise the possibility of movement in response to environmental changes and natural disasters.

Green areas in the urban environment, including urban green corridors, are created to be used for different activities of all age groups. Therefore, management planning of green areas is very important. Proper management planning of green corridors contributes to creating urban green areas that will fulfil the needs of all residents (Pena et al., 2010). Green corridors, as urban green areas connecting other green spaces in the urban environment, are rich in different types of vegetation and should provide comfortable, aesthetic and safe communication through urban open spaces (Groenewegen et al., 2006). That means achieving sustainable urban planning by improving the quality of life for citizens (Teimouri & Yigitcanlar, 2018). Green connectivity is improving the level of sustainability for the residents because linking green areas with green corridors provides numerous environmental benefits in open areas from the aspect of protection, improvement of natural resources and support of environmental requirements (Eraghi et al., 2015; Al Masri et al., 2019).

## MATERIAL AND METHODS

This paper was prepared by searching scientific and professional papers using platforms and search engines including: Google Scholar, SCIndex and Science Direct. The following keywords and their combinations were used to perform the search: green corridors, green corridor design and elements, green corridor development, green corridors in urban areas, urban planning, linear greenery, boulevards, boulevard greenery, Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia.

The literature was selected in order to present the breadth of knowledge available on the role of green corridors and linear greenery in the urban environment. Particular emphasis was placed on literature addressing the importance of linear greenery and green corridors in urban areas, and their impact on urban living.

The importance of urban corridors was observed and presented on the example of Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh in Skopje, North Macedonia. This paper uses certain data from the archive of PE Parks and Greenery in Skopje, which is responsible for landscape designing and planting of these two boulevards. Trade names of plants from the lists of PE Parks and Greenery are matched with scientific plant names using plant databases of Royal Botanic Gardens, Kew (Kew, 2022), Royal Horticultural Society (RHS, 2022) and World Flora Online (WFO, 2022). Relevant literature and documentation are analysed from the aspect of planning, designing and improving green corridors in urban areas like Skopje.

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## RESULTS AND DISCUSSION

There are plenty of scientific studies performed by different authors analysing green corridors from different aspects. The conclusion is always that green corridors are essential for the quality of urban life.

The term sustainability has been quite relevant in recent years and it has been the topic of many studies, some of which connected directly with green corridors. Eraghi et al. (2015) wrote about sustainability and green corridors and analysed the features of green corridors in sustainability, taking into consideration that sustainability refers to a community's capacity to support the long-term health and welfare of its environment as well as all forms of life in that environment. If environmental, economic, recreational and transportation benefits are treated as sustainability factors, then the list of green corridors features is very long. Protection of the natural environment, preservation of habitats, microclimate enhancement and limited urban growth are only some of numerous important features of green corridors (Eraghi et al., 2015). Urban green corridors are green spaces that are free to use and easy to access. They provide wildlife with a corridor and migration, they provide the connection between divided communities, direct employment opportunities, opportunities for outdoor activities, alternative transportation routes for home-work journeys and non-motorized transportation, in this way decreasing the car-related family budget (Eraghi et al., 2015). Green corridors increase air quality and decrease health problems (Eraghi et al., 2015). Reducing air pollutants from motor traffic is of great significance to urban sustainable development (Eraghi et al., 2015; Yu et al., 2021). There are a lot of social benefits from urban green corridors. They improve leisure time and quality of life, induce healthier lifestyle, they attract tourism providing scenic routes for walking, cycling, access and linkage between historical and cultural heritage, they help in reducing crime and enhance well-being through contact with nature and they also offer a chance to learn about the natural environment (Eraghi et al., 2015).

The research on green corridors in Athens, Greece, lists a number of positive effects of green corridors (Tzortzi Georgi et al., 2019). Some of these effects are rarely mentioned in other studies described in this paper or are mentioned in a different context. For example, green corridors are functional and attractive areas, which are easily accessible and walkable, designed and created for aesthetic improvement of the urban environment and better socialization of people with mobility issues, allowing them to be more active (Tzortzi Georgi et al., 2019).

Another research on the importance of green corridors for sustainability was conducted by İnançoğlu et al. (2020) and presented in their paper "Green Corridors in Urban Landscapes, Case Study Nicosia Pedieos River". Analysing other studies from all over the world, they realized that a green corridor along the Pedieos River, with a total 10 m width (5 m on each side of the river), could help in improving the urban nature conservation, water management and landscape quality within the whole region (İnançoğlu et al., 2020).

There are different rules formulated by different authors about designing green corridors. There is a proposal in which green corridors should be designed according to the topography and contour lines (Fakhouri & Haddad, 2017) while in another proposal the accent is on the elevation gradient and the conclusion is that green corridors should be passing different elevation gradients (200 m – 1200 m) to provide comfortable sustainable places for visitors (Eraghi et al., 2015).

In the research on Hanoi City (Van Tuyen, 2021) there is an interesting solution for structural planning of the urban green corridor. It includes six principles and every action is based on the development master plan for the city. The accent is on the protection of the natural ecosystems, protection of the existing green spaces and provision of extra green space for tree planting.

The importance of green corridors for sustainability has been extensively researched, but no less emphasis has been placed on the importance of green corridors for biodiversity. The connection between green corridors and biodiversity in sustainable environment is rather prominent and many authors have studied it (Wang et al., 2021; Vergnes et al., 2012; Shahani, 2012). Biodiversity conservation is of great importance and, in order to reach the aim of sustainable development together with biodiversity conservation, it is necessary to include innovative techniques to incorporate biodiversity in the initial stage, i.e. in urban planning and infrastructure design (Wang et al., 2021). Wang et al. (2021) especially emphasise the possibility of introducing green corridors on highway overpasses to increase the connectivity of habitats for flying pollinator insects. This however would not be the only benefit. Flowering plants are often used to provide ideal living conditions for flying pollinator insects, in this way increasing the aesthetic value of the environment and enriching the space with floral scents (Wang et al., 2021). This conclusion can be useful not only for highways but also for other roads on city territories.

Some researchers put accent on the fact that green corridors are supporting wildlife (Aziz & Rasidi, 2014; Alexandre et al., 2010; Al Masri et al., 2019; Briffett et al., 2004). In their research on a study area of the Zahara River, Aziz & Rasidi (2014) argued that the green corridor should be close to a wetland area to support the wildlife. It is logical that green corridors with more forest cover, i.e. wider corridors and natural or semi-natural habitat like a river, would

have greater numbers of species and that these kinds of green corridors naturally have the potential to be routes and a dispersing mechanism for the urban wildlife (Aziz & Rasidi, 2014). On the other hand, the authors stress that every area has its own characteristics, so it is important to identify the challenges and opportunities to maximize its potential.

Safety is another aspect that should always be emphasised. Green corridors should be separated from highways with buffer zones to protect the wildlife and to provide safe places for visitors (Alexandre et al., 2010).

Another role of green corridors is that they can help in the processes of wild animals reproduction, which is made possible by mixing of wildlife individuals from different habitats (Al Masri et al., 2019).

A study which also explores human relationships with nature was performed in Singapore (Briffett et al., 2004). This study focuses on green corridors in Singapore. In particular, it analyses how people use the corridors, what kinds of wildlife and habitats there are in these areas, and the relationship between the human uses and the wildlife needs. Planning, design and management of green corridors are very important for the following: how people use the corridors, what wildlife are attracted to them and what measures of maintenance are applied (Briffett et al., 2004). The strategies of planning and designing corridors should be based on the inhabitants' values and perceptions, not only on the biotic, abiotic and cultural factors in the local landscape (Ahern, 1995).

There is an interesting research about a transit road in Gdansk (Sas-Bojarska & Rembeza, 2016). It is stressed that green infrastructure (green corridors) should be used to strengthen the road system and thus eliminate or minimize environmental and landscape damages, as well as social problems.

### Case Study: Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh

Skopje is the capital of North Macedonia. As the largest city and the political, cultural, economic and academic centre, it is characterized by densely built environment. Skopje is located in the northern part of the country and it is on a major north-south Balkan route between Belgrade and Athens.

Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh are relatively new boulevards located in the northern part of the city. Blvd. Bosnia and Herzegovina was officially launched on 19 May 2021, the first section of Blvd. Hristijan Todorovski Karposh on 9 September 2018, and the second, final section on 7 May 2021. These new boulevards offer a faster exit to the Skopje ring road (A2) for the residents of this part of the city. Developing the traffic infrastructure improve the mobility of the population and the work of local businesses.

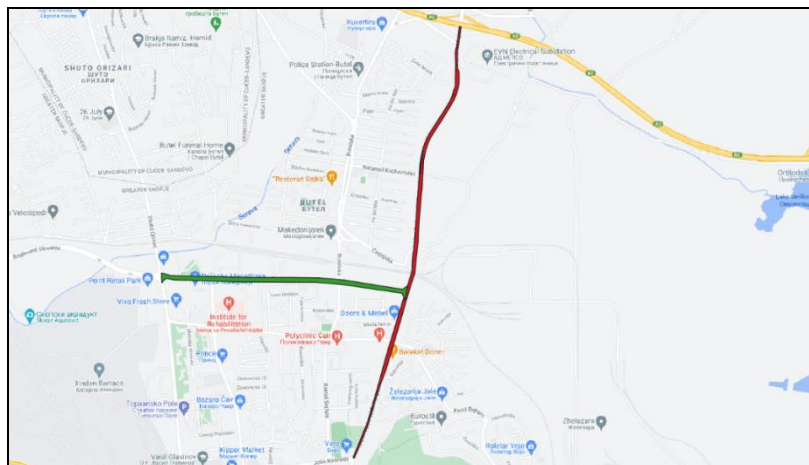


Figure 1. Location of Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia: QGIS Software, Google Road, 2021 (Source: Brndevska Stipanović V.)

There are no studies related to these two boulevards. In “Study on Greening and Afforestation of the City of Skopje” (Hadji Pecova et al., 2015), green corridors are mentioned as an ecological network along the roads and boulevards in the valley of Skopje. The task of outlining the basis of the ecological network in Skopje is a new task for the experts engaged in the study and for the management and local governments (Hadji Pecova et al., 2015). There has been just one published study on green corridors in North Macedonia: the study on green corridors along the Serava River, from its spring to the confluence with the Vardar River, and along the Lepenec River, from the village of Orman to the confluence with the Vardar River (Hadji Pecova et al., 2017).

Some of the information about planting new greenery on Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh, presented in this paper, are from the archives of PE Parks and Greenery, Skopje. Planting was done in November and December 2020, starting from 14 November, by PE Parks and Greenery, Skopje.

Blvd. Bosnia and Herzegovina is a new boulevard with a total length of about 1700 meters (from Blvd. Slovenia to Blvd. Hristijan Todorovski Karposh), (Fig. 1 – marked with green colour), 40 meters wide, with six lanes, pedestrian and bicycle paths, central and side greenery on both sides and new street lighting.

Blvd. Hristijan Todorovski Karposh is 2 kilometres long (from the crossroad with Blvd. Bosnia and Herzegovina to the ring road A2) (Fig. 1 – marked with red colour), with six lanes, 3.5 meters each, bicycle and pedestrian paths, new street lighting and central and side greenery on both sides. This part of the boulevard joins the old section (from the crossroad with street John Kennedy to Blvd. Bosnia and Herzegovina).

Although the boulevards are new, they have already been planted with greenery. There is central greenery (Fig. 2, 3) and side greenery (Fig. 4, 5) on both sides of Blvd. Bosnia and Herzegovina. In certain places along the boulevard, there are two lines of new greenery (one of them covered by grass (Fig. 4) and the other one planted with trees (Fig. 5)). It is excellent that the old greenery (line greenery of deciduous trees by the pedestrian path (Fig. 4) and some trees from the central greenery (Fig. 3) has been preserved. Most common species in the old greenery are *Aesculus hippocastanum* L. and *Platanus orientalis* L.



Figure 2. Central greenery, Blvd. Bosnia and Herzegovina, Skopje, North Macedonia, 2021  
(Source: Brndevska Stipanović V.)



Figure 3. Central greenery with old trees, Blvd. Bosnia and Herzegovina, Skopje, North Macedonia, 2021  
(Source: Brndevska Stipanović V.)



Figure 4. Side greenery, Blvd. Bosnia and Herzegovina, Skopje, North Macedonia, 2021  
(Source: Brndevska Stipanović V.)



Figure 5. Side greenery (line with trees), Blvd. Bosnia and Herzegovina, Skopje, North Macedonia, 2021  
(Source: Brndevska Stipanović V.)

New plants used for landscape designing of Blvd. Bosnia and Herzegovina in Skopje, North Macedonia, are shown in Table 1.

Table 1. Inventory of new urban dendroflora of Blvd. Bosnia and Herzegovina, Skopje, North Macedonia  
Source: The archives of PE Parks and Greenery, Skopje. Customised-trade names of plants matched with scientific plant names via websites: Kew (2022), RHS (2022) and WFO (2022)

Scientific name	Number of individuals
<i>Carpinus betulus</i> 'Fastigiata'	19
<i>Catalpa bignonioides</i> 'Nana'	74
<i>Chamaecyparis lawsoniana</i> 'Ellwoodii'	43
<i>Chamaecyparis lawsoniana</i> 'Ellwood's Gold'	8
<i>Fagus sylvatica</i> 'Purpurea'	67
<i>Juniperus</i> × <i>pfitzeriana</i> 'Old Gold'	174
<i>Thuja occidentalis</i> 'Smaragd'	17

The old section of Blvd. Hristijan Todorovski Karposh (from the crossroad with street John Kennedy to Blvd. Bosnia and Herzegovina) is excellently designed with linear greenery of deciduous trees (Fig. 6, 7).



Figure 6. Linear greenery (old trees), Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia, 2021  
(Source: Brndevska Stipanović V.)



Figure 7. Linear greenery, Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia, 2021  
(Source: Brndevska Stipanović V.)

Most common species in the old greenery of Blvd. Hristijan Todorovski Karposh are *Fraxinus* sp., *Platanus orientalis* L. and *Tilia tomentosa* Moench. Some of them are not so old, planted in the last five years (Fig. 7).

At the beginning of the old section of this boulevard there is Park Chair (Fig. 8). Park Chair enriches this green corridor and gives a positive effect on the whole image of corridor.

There is central greenery (Fig. 9, 10) and side greenery (Fig. 10, 11) on both sides of the new part of Blvd. Hristijan Todorovski Karposh.

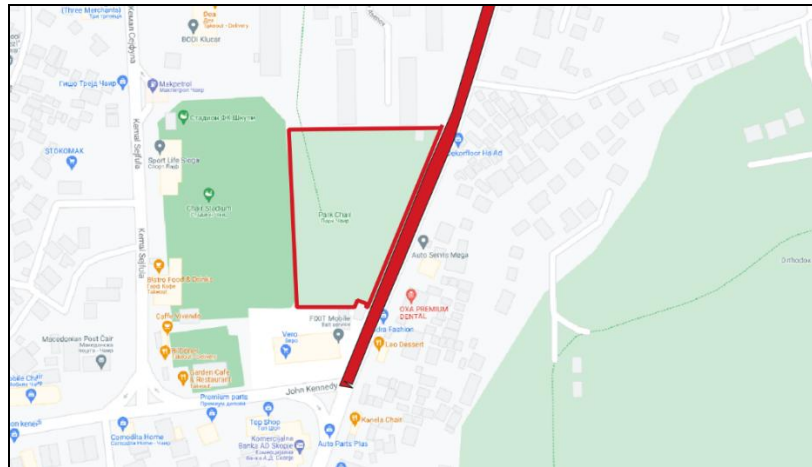


Figure 8. Location of Park Chair on Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia: QGIS Software, Google Road, 2021 (Source: Brndevska Stipanović V.)



Figure 9. Central greenery, Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia, 2020 (Source: The archives of PE Parks and Greenery, Skopje, North Macedonia)

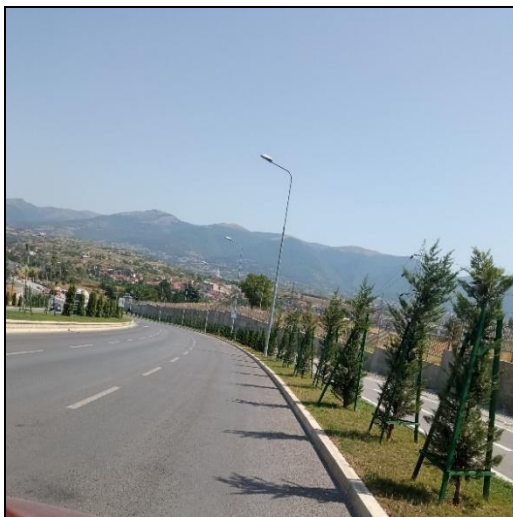


Figure 10. Side and central greenery, Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia, 2021 (Source: Brndevska Stipanović V.)

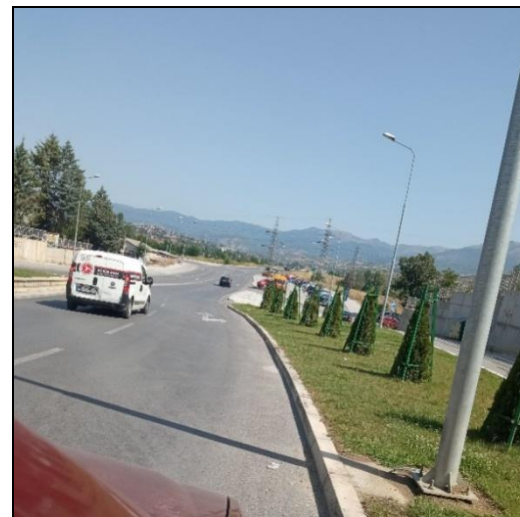


Figure 11. Side greenery, Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia, 2021 (Source: Brndevska Stipanović V.)



Plants used for landscape designing of Blvd. Hristijan Todorovski Karposh in Skopje, North Macedonia are shown in Table 2.

Table 2. Inventory of new urban dendroflora of Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia  
Source: The archives of PE Parks and Greenery, Skopje. Customised-trade names of plants matched with scientific plant names via websites: Kew (2022), RHS (2022) and WFO (2022)

Scientific name	Number of individuals
<i>Acer pseudoplatanus</i> L.	137
<i>Acer rubrum</i> L.	17
<i>Buxus microphylla</i> Siebold & Zucc.	5
<i>Buxus microphylla</i> Golden Dream ('Peergold' <sup>PBR</sup> )	20
<i>Buxus sempervirens</i> L. (clipped ball)	62
<i>Catalpa bignonioides</i> 'Nana'	2
<i>Cedrus deodara</i> 'Aurea'	6
<i>Cotoneaster horizontalis</i> Decne.	100
× <i>Cupressocyparis leylandii</i> (A.B.Jacks. & Dallim.) Dallim.	207
x <i>Cupressocyparis leylandii</i> 'Castelwellan Gold'	1
<i>Erica coronata</i> Andrews	26
<i>Fraxinus excelsior</i> 'Globosa'	20
<i>Fraxinus ornus</i> 'Mecsek'	1
<i>Imperata cylindrical</i> 'Red Baron'	20
<i>Juniperus conferta</i> 'Blue Pacific'	50
<i>Juniperus horizontalis</i> 'Blue Chip'	50
<i>Lavandula angustifolia</i> Mill.	138
<i>Ligustrum japonicum</i> 'Texanum' (ball on stem)	9
<i>Magnolia grandiflora</i> L.	12
<i>Mahonia eurybracteata</i> Fedde	36
<i>Malus x floribunda</i> Siebold ex Van Houtte	20
<i>Pachysandra terminalis</i> Siebold & Zucc.	400
<i>Picea abies</i> (L.) H.Karst.	10
<i>Picea pungens</i> Engelm.	25
<i>Photinia x fraseri</i> 'Red Robin' (ball on stem)	45
<i>Pieris japonica</i> subsp. <i>Formosa</i> (Wall.) Kitam.	80
<i>Quercus ilex</i> Lour. (ball on stem)	16
<i>Quercus rubra</i> L.	9
<i>Sorbus scandica</i> H.J.Coste	17
<i>Syringa meyeri</i> C.K.Schneid. (ball on stem)	8
<i>Syringa microphylla</i> 'Superba' (ball on stem)	8
<i>Thuja occidentalis</i> 'Fastigiata'	55
<i>Thuja occidentalis</i> 'Smaragd'	198
<i>Thuja occidentalis</i> var. <i>woodwardii</i> Späth	50

Many different plant species (trees, shrubs and perennials) used in the greening of the boulevards have different sizes, colours, shapes and textures. This diversity increases the aesthetic effect and also enriches the functions of concrete boulevards as green corridors.

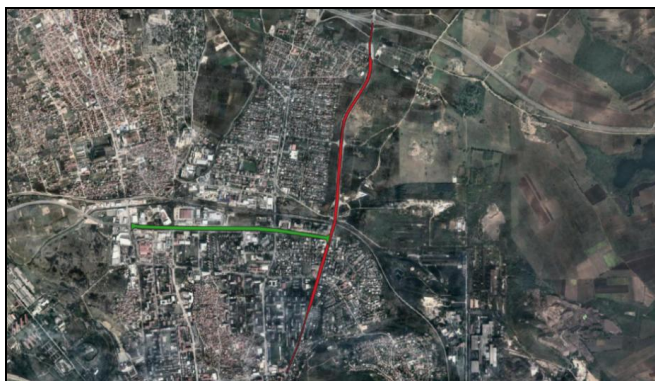


Figure 12. Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh, Skopje, North Macedonia: QGIS Software, Google Road, 2021 (Source: Brndevska Stipanović V.)

Although Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh are well planned and designed as green corridors, by analysing the surroundings (Fig. 12) we can conclude that there is a possibility for linear parks on both sides of the new part of Blvd. Hristijan Todorovski Karposh. Linear parks would be a great idea that would improve the city life. A linear park on the left side of the boulevard would reduce motor traffic and air pollution. A linear park on the right side would make this territory more attractive. It is also a good chance to increase biodiversity by planting native vegetation and promote social interaction by transforming the existing vacant land into usable space which would improve pedestrian circulation and safety (Aziz & Rasidi, 2014; Tzortzi Georgi et al., 2019).

## CONCLUSION

The quality of life in the urban environment largely depends on urban green spaces. Therefore, it is very important how they are designed, managed and protected (Abizadeh & Zali, 2013). Every different type of urban green space has a specific role and importance in the urban environment. The importance of green corridors in urban areas is enormous. As a network of linear elements they connect different urban green spaces. In this way, green corridors offer a lot of opportunities for citizens. They provide a number of environmental benefits and they are an essential factor of sustainability. Green corridors are relevant for biodiversity conservation providing a habitat and migration for different kinds of living organisms. They provide social benefits, decrease health problems and increase air quality. Green corridors also have a positive effect on the micro-climate. The topic of green corridors has been analysed from different aspects in literature. Considering their importance, green corridors need to be an essential part of urban planning for every city, especially for cities which are densely built and are characterised by rapid urbanization, like Skopje in North Macedonia.

Blvd. Bosnia and Herzegovina and Blvd. Hristijan Todorovski Karposh form an important ecological network in the northern part of Skopje. They are well designed as green corridors, planted with many different plant species (trees, shrubs, perennials), covered by grass, with bicycle and pedestrian paths. One important fact is that the old line greenery is preserved. On the other hand, there is a possibility for linear parks on both sides of the new part of the Blvd. Hristijan Todorovski Karposh. Linear parks would be a great idea that would improve the city life. A linear park on the left side of the boulevard would reduce motor traffic and air pollution, while a linear park on the right side would make this territory more attractive.

However, in order to establish the new parts of the existing corridor and to make this proposal a real project, it is necessary to have support from regional and local authorities and also have active involvement of the relevant stakeholders.

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**Conflict of interest:** The authors declare that they have no conflict of interest.

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