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A study of Behela river as a blue green corridor in Timișoara

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Abstract

The study presents the arguments for the creation of urban green corridors in Timișoara, in the context of a rapidly expanding metropolitan area. The history, natural conditions (geographical, hydrological and biological), urban development of the city as well as the European and global context are taken into account. Green corridors, through their ecological, economic, social and cultural functions, integrate the concepts of green infrastructure, ecosystem services and adaptation to climate change. The Behela river represents a valuable green-blue area, due to its unique position, which unites the two major defining green areas of Timisoara: Pădurea Verde ("Green Forest") and the Bega Canal. The study discusses transforming Behela's riparian area into a sustainable urban mobility corridor with bike lanes and promenade paths, zonal center for outdoor activities, and ecological corridor with multiple ecosystem services.

KEYWORDS: green corridors, Behela, landscape, river

The territorial expansion of large cities is a global trend, with complex implications at the level of territorial planning and development. The city of Timișoara is in such a continuous process of expansion, accelerated in the last 15 years by massive real estate developments on the outskirts of the city and in the neighboring villages (Dumbrăvița, Giroc, Ghiroda). The residents' need for green space has led to an increased demand for individual and collective housing and thus residential areas have expanded at an accelerated pace throughout the periphery and peri-urban areas, on land previously used for agriculture or by dismantling larger private gardens into small plots. The built areas, both residential and the access roads network, have increased significantly, thus creating a continuous built structure to the detriment of green spaces and an imbalance between the natural and anthropogenic factors. [14] [15] This phenomenon of urban expansion is known as "urban sprawl". With the densification of built spaces in the city, urban plots with potential for becoming landscaped green spaces are fewer and fewer, and economic and administrative pressure is increasingly high to capitalize on them.

The size of green spaces in relation to the number of inhabitants of Timișoara has experienced a less favorable evolution throughout history. In 1944, each inhabitant benefitted from 13.1 m^2 of green space, and by 1992 these figures stood at just 5.2 m^2. [3] The trends of the last decade to prioritize ecology, both at European Union level [13] and globally, have meant legislative and administrative efforts to increase urban green areas in Romania as well. Thus, Timișoara registered around 16m^2 of green spaces in 2019 [18], an upward trend compared to 1992, but still below the minimum mandated by law of 26 m^2. [17] In 2020, by transferring Pădurea Verde ("The Green Forest") into the local administration's ownership, the size of green spaces per capita in Timișoara increased, to around 38m^2, but due to the lack of an updated Green Cadastre, exact data is not available at present.

The urban climate is fundamentally different from the neighboring countryside through dissimilarities in temperature, solar radiation, humidity, precipitation patterns and wind speed. The "heat island" effect is a common phenomenon in urban agglomerations, where the average temperature is 1-4 °C higher than in neighbouring rural areas. [4] Large built-up areas, population density, emissions from transport and industry contribute to pollution (which is 5 to 25 times higher in cities), higher temperatures, heavier rainfall, higher cloudiness, lower solar radiation and a higher rate of radiation capture.

There is a global consensus about the importance of urban green spaces, both in existing cities and in ecological city planning. Urban areas with predominant vegetation diminish the negative consequences of the "heat island" effect, contribute to lowering the average temperature in urban agglomerations, combat the effects of air and noise pollution, reduce the risk of flooding, protect biodiversity and contribute significantly to the health and quality of life of urban inhabitants. [11]

At the level of the European Union countries (including Romania), the concept of green infrastructure is an important pillar of sectoral policies, both at local level (through urban planning policies) and at regional, national and cross-border level (through territorial planning policies). [9] Green infrastructure refers to an interconnected and multifunctional

network of green and blue spaces [12] that contributes to ecosystem connectivity, protecting the natural environment, enhancing ecosystem services and mitigating climate change-related risks. An infrastructure of interconnected green spaces offers far more public benefits than a series of distinct green spaces. [9] Public parks, private gardens, forests, rivers, street vegetation, green roofs, agricultural land are included in the urban green infrastructure.

An example of green infrastructure at the city level is green or green-blue urban corridors (in the presence of the water element). These are strips of green spaces, within the city, that connect parks, gardens, forests, riparian corridors to each other and/or to natural green areas. The benefits of urban green corridors are ecological, economic, social and cultural. From an ecological point of view, green corridors serve as habitats for local fauna, especially in riparian areas, representing natural ecosystems with unique biodiversity and contribute to maintaining an ecological balance in cities; prevent soil erosion, increase rainwater absorption and filtration through natural solutions and reduce sewage system overload; help improve air quality as well as mitigate the heat island effect. [7] At a social and cultural level, green corridors help make outdoor recreational activities accessible, promote physical and mental well-being and create urban travel routes with a reduced impact on the environment. From an economic point of view, green corridors contribute to reducing the costs associated with pollution, supporting tourism and the local economy, through the creation of connected sustainable services. [5]

Timișoara is located in western Romania, in the Banat Plain. It is the fifth largest city in the country, with 250,000 residents in the city proper, and another 106,000 in the neighboring localities included in the metropolitan area. [19] The city is crossed from East to West by the Bega Canal, with a compact network of green spaces being concentrated along its banks.

Historically, the territory around Timișoara was an area of swamps, fed by the intertwined courses of the Bega and Timiș rivers. In the eighteenth century, a complex hydroameliorative process was started in the region. It included the drainage and regulation of riverbeds, building the Bega Canal as a navigable waterway and the construction of an important network of drainage ditches. [1] The process brought about the drying up of swamps, reducing floods, obtaining constant water flows of Bega and thus the possibility of expansion and economic development of Timișoara. In recent decades, however, with uncontrolled urban development and neglect of the land improvement infrastructure, the network of drainage canals has deteriorated and considerably reduced in size. Thus, from the blue network of the Timișoara metropolitan area, only the Bega Channel and its direct tributaries (Luchin, Bistra, Behela, Vâna Roşie, Vâna Ogrinova, Crivabara and Bega Veche) remain [2] as well as, to a very small extent, the remaining drainage canals.

In this context, the green corridor Pădurea Verde – Behela River – Bega River constitutes a particularly valuable and unique green-blue area in Timișoara.

Pădurea Verde to the north is a forested area of approximately 724 hectares, which mainly serves the ecological role of climate balancing. [2] Currently undeveloped for use by the general public, the local administration aims to harness its potential as a forest-park, an urban promenade and an outdoor recreation space for the city's inhabitants, as well as an important tourist attraction. [16]

The Bega Canal to the south represents an axis of the city from East to West, along which lies a compact chain of parks and urban green spaces. The increase of the urban and landscape value of the Bega Canal is a priority the local administration level and action steps have been are are being taken in this direction. [16] The banks of the Bega River are landscaped as spaces for promenade and recreation, as well as a continuous bicycle route, which starts from Andrei Șaguna Bridge, close to the confluence of Bega with the Behela River, crosses the entire city and continues to the border with Serbia to the SW.

The Behela River therefore has a privileged and unique position in Timișoara's landscape, that of being the only natural corridor that unites the two defining green areas of the city: the Pădurea Verde and the Bega Canal.

The object of this study is the opportunity to transform the riparian area of the Behela River, from the river's exit from Pădurea Verde to its discharge into the Bega Canal, into a symbolic green-blue corridor for Timișoara. Located in a fully urbanized area, Behela and its adjacent areas constitute a significant urban green corridor, under the pressure of significant threats to the integrity of its ecosystems – aggressive urban development, large-scale urban works (traffic ring) and pollution.

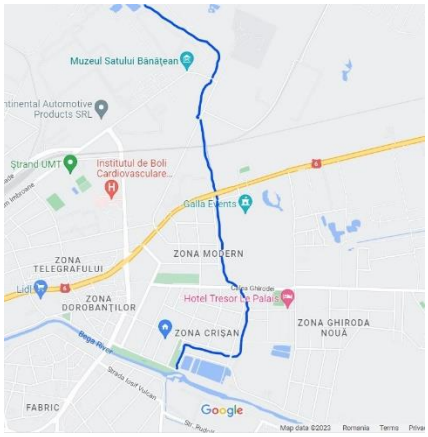

Fig. 1 – Behela River – studied area – from the Pădurea Verde to its discharge into Bega Canal [20]

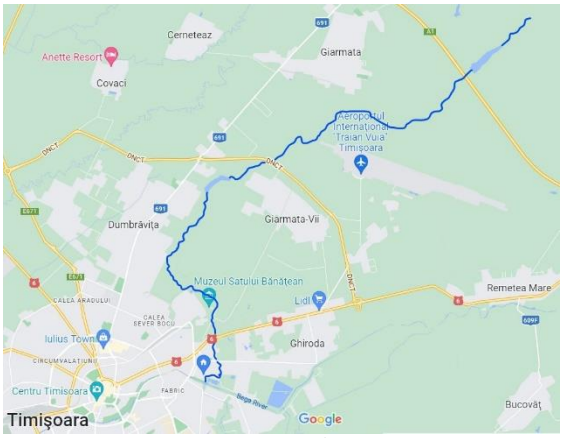

Fig. 2 - The entire stream of Behela River [20]

Behela River originates in the vicinity of Giarmata village and has a length of 26 km. It feeds the Dumbrăvița reservoir lake, crosses the Pădurea Verde and the Modern area and flows into the Bega Canal downstream of the Hydroelectric Plant. It is part of the Timiș-Bega hydrographic basin and is a direct tributary of the Bega River.
The potential of the green-blue corridor Behela – Bega is distinguished by the ecosystem services it can offer: management of the water cycle in nature (by absorbing and filtering water), biodiversity conservation (by creating a corridor for fauna, mobility of aquatic species, maintaining natural processes and trophic balance, which in turn contribute to the natural control of pathogens and pests) and socio-cultural benefits offered by a high quality, natural, recreation space [14].

Material and method

Lisbon, the capital of Portugal, has benefited from a massive development in the civil construction field since joining the European Union in 1986. In the last decade, however, due to the city's depopulation and economic pressures, a new urban development strategy was needed to revitalize the city. The Lisbon Strategic Plan 2010-2024 included three main directions for development, namely: regeneration of the city, adaptation to climate change and connectivity of green spaces [8].
These strategies materialized within a local legal framework, the "Master Plan of Lisbon", which provides for a "municipal ecological structure". It represents the concept of green urban infrastructure that ensures the connectivity of natural and anthropogenic green systems in the metropolitan area. The infrastructure currently includes a network of 190 hectares of new green spaces constituted in 6 urban ecological corridors and community gardens, as well as an extended set of bicycle paths, achieved both by equipping existing traffic routes and by creating new routes for cyclists.

Fig. 3 – Lisbon – bicycle paths and pedestrian walkways [21]

Fig. 4 – Lisbon – Community gardens at Granja [21]

The main green corridor connects Monsanto forest-park with Eduardo VII park and the city centre, covering a length of 2.5km, an area of 51 hectares and a network of 40 km of walking paths, representing Lisbon's largest green infrastructure.

Fig. 5 – Monsanto green corridor [21]

Fig. 6 – Monsanto green corridor [22]

In Lisbon, by prioritizing urban green infrastructure, both at local government level and in the non-governmental space, the strategic objective of connectivity has been achieved.

Current situation of the studied area

Fig. 7 – Behela undercrossing Ghirodei Alley [23]

The studied area of Behela borders to the north with the Pădurea Verde, upon exiting the forest the river undercrosses Calea Lugojului, crosses the area adjacent to Ștrandului Street, then undercrosses Ghirodei Alley, crosses the area adjacent to Cometei Street, then along Rozelor Street and flows into the Bega Canal near the Water Plant. The distance traveled by the river from the point of exit from Pădurea Verde to the confluence with the Bega River measures approximately 1.6 km long, with a variable width of green spaces from the river bed to the nearest built areas between 2 m and 20 m.
On the segment adjacent to Ștrandului Street, the two banks of Behela have a different structure. The right bank, the eastern one, is forested by a tree grove which is an extension of the Pădurea Verde. The left bank consists of two types of spaces. On the first portion, at the entrance to Ștrandului Street, the bank is asphalted until near the river bed (about 2 m from it), and is used as a parking lot. On the second section, at the end close to the intersection with Ghirodei Alley, there is an unmaintained green space, a vacant piece of land used for waste disposal and automobile parking.

Fig. 8. Behela River – Ștrandului Street – vacant land (personal archive)

Fig. 9. Behela River – Ștrandului Street – parking lot (personal archive)

On the segment adjacent to Cometei Street, the left bank is a generous green space with abundant vegetation, consisting of gardens and orchards informally maintained by the inhabitants of the area. On the right bank, houses and access roads are built, and a segment of the canal borders a cemetery.

Fig. 10. Behela River – Cometei Street – left riverbank – orchards, gardens and natural vegetation (personal archive)

Fig. 11. Behela River – Cometei Street – right riverbank – acces road and buildings (personal archive)

There are four places to cross Behela in the studied area, namely: two in the area of Ștrandului Street, one represented by Ghirodei Alley and another one near the cemetery, represented by a metal bridge, suitable only for pedestrian traffic.

Fig. 12. Behela River – bridge on Ghirodei Alley (personal archive)

Fig. 13. Behela River – Cometei Street – bridge near cemetery (personal archive)

The predominant vegetation in the riparian area of the Behela River is represented by species of reed (*Phragmites communis*, *Schoenoplectus lacustris*, *Glyceria maxima*, *Carex elata*, *Carex rostrata*, *Carex riparia* and *Carex Acutiformis*), diatomaceous algae, tree species such as *Salix alba* and *Populus alba*, as well as, in certain areas, domestic gardens and plum and walnut orchards.

Fig. 14. Behela River – reed species – *Carex sp.* (personal archive)

Fig. 15. Behela River – *Salix alba* (personal archive)

Fig. 16. Behela River – orchards with *Prunus sp.* (personal archive)

The fauna is specific to the wetlands of Banat, with species of zoobentos, amphibians and reptiles, as well as birds that live either permanently or at certain times of the year in this area - *Anas platyrhinchos*, *Fulica atra* and *Galinulla chloropus* are representative bird species for this area.

The anthropogenic pressure on the studied area is significant and is represented by trash disposal in and around the riverbed, buildings and roads erected close to the riverbed without an adequate protection area, as well as the urban works already carried out (asphalting of the western bank along Ștrandului Street up to the riverbed).

But the main threat to the integrity of Behela's ecosystems is the construction of the a major road (circulation ring IV – a freeway for the city of Timișoara), on the western bank of Behela, in the studied area, from the Pădurea Verde to Rozelor Street. The project is currently in execution for most of the route and in the planning stages on this particular section. The diversion of heavy traffic on this new route along Behela could have catastrophic implications for the existing flora and fauna, for the ecosystem services offered by this unique green-blue corridor in Timișoara, as well as for the inhabitants of the area. The project involves clearing the buffer zone of orchards and gardens from Ghirodei Alley to Rozelor Street and replacing this urban green space with a four-lane freeway, with intense traffic of heavy-duty vehicles.

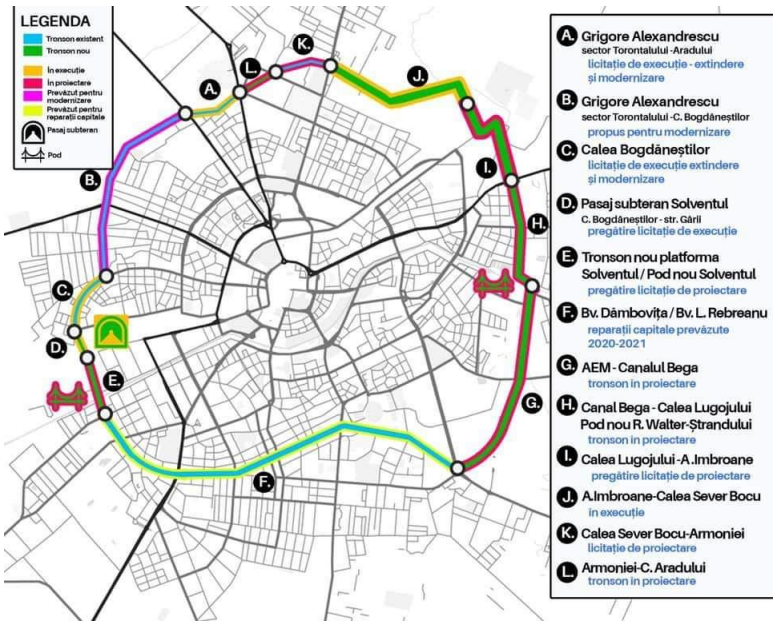

Fig. 17. Circulation ring IV for Timișoara – proposed route for segment H on Behela river banks [24]

Results and discussion

The set of proposed developments is centered around the concept of transforming the area into a sustainable urban mobility corridor, with bicycle lanes and promenade paths, a center for outdoor activities, as well as an ecological corridor. Thus, the green-blue area Pădurea Verde – Behela – Bega will fulfill multiple ecological and socio-cultural functions.

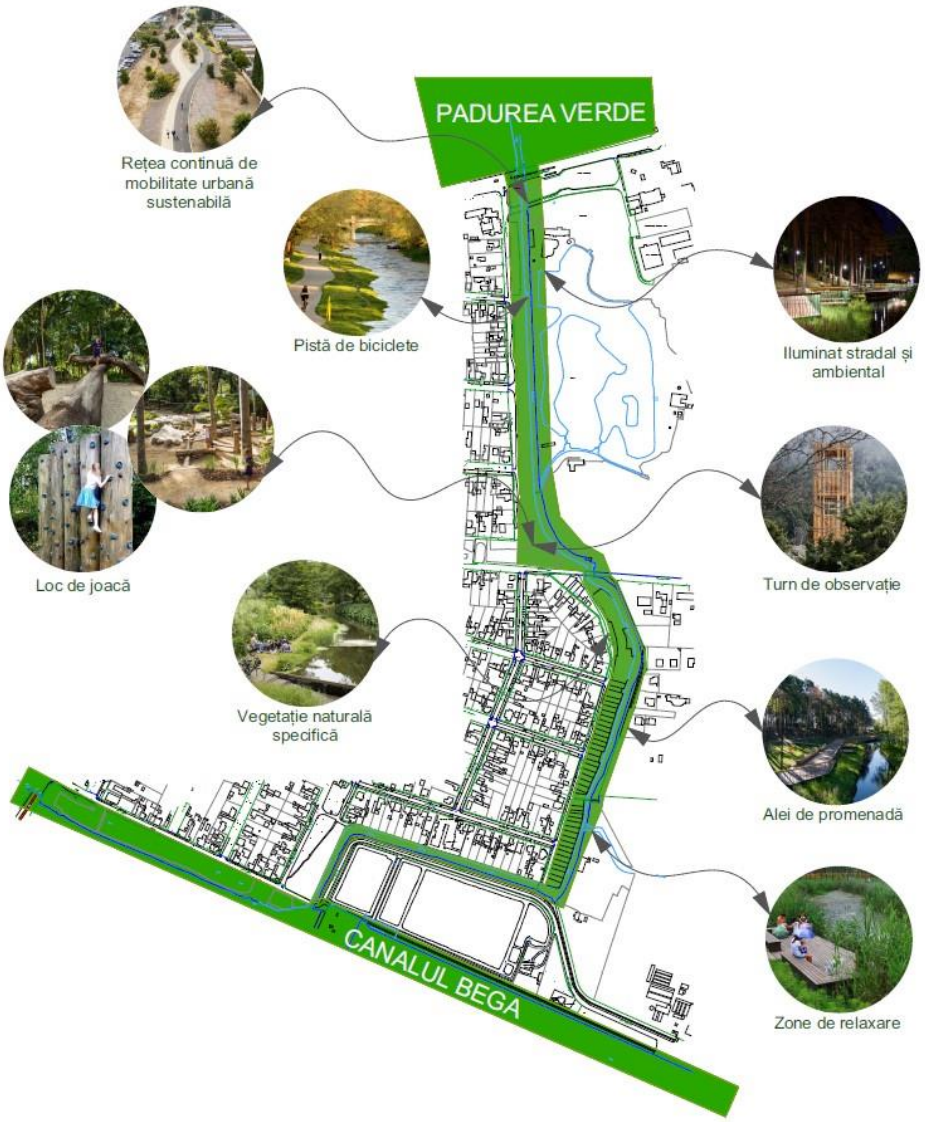

Fig. 18. Proposed concept for the Behela green corridor (personal archive)

Vegetation and riverbed maintenance

Minimal interventions are proposed in terms of vegetation in the immediate vicinity of the riverbed. Preserving and complementing the specific natural river meadow vegetation is an essential element of Behela's transformation into a green-blue corridor. The proposed vegetation thus consists of wetland plant species, such as reeds (*Phragmites communis, Schoenoplectus lacustris, Glyceria maxima, Carex elata, Carex rostrata, Carex riparia* and *Carex Acutiformis*) and tree species characteristic of riparian areas (*Salix alba, Populus alba, Ulmus laevis, Alnus glutinosa*).

Preservation of the plots planted with plum and walnut orchards in the area of Cometei Street, as well as the vegetable gardens maintained by the inhabitants of the area is important, as these are part of the fabric of the neighborhood and contribute to biodiversity. Using cultivated areas as spaces for teaching, recreation and bringing people closer to their food can also give them a special socio-cultural role.

Maintenance of the existing canal is another important element of the layout. Desilting and rehabilitation on portions, as well as proper maintenance of vegetation, cleaning the waste in the water and on the banks will create an attractive environment for people and suitable for the development and diversification of specific flora and fauna.

Landscaping the vacant land

The generous empty space in the area of Ștrandului Street, near Ghirodei Alley, where extensive paving works have not been carried out, is suitable for creating a small park as a recreational space for children and adults.

The proposed landscaping includes species of ornamental trees (*Prunus sp., Acer sp., Salix sp., Betula sp.* etc), shrubs (*Photinia sp., Spirea sp., Juniperus sp., Euonymus sp., Pinus sp.* etc) and perrenial herbaceous species (*Phlox sp., Hydrangea sp., Carex sp., Veronica sp., Echinacea sp., Rudbeckia sp., Sedum sp., Caryopteris sp.* etc).

Building a playground

The arrangement of a playground for children will be done according to the principles of natural playgrounds – the vegetation lines will be followed and natural materials will be used, both for pavements (tree bark and sand) and for playground equipment (*Robinia sp.* wood). The use of playground equipment suitable for several age groups is recommended. Climbing structures, balance beams, swings and seesaws are proposed for the playground.

Chalet De Rosse Eekhoorn [25]

Centenary Lakes Nature Play [26]

Centenary Lakes Nature Play [26]

Fig. 19. Natural playground – climbing and balance structures

Sustainable urban mobility

One of the main pillars of the proposed development is to equip the area for sustainable urban mobility. Bike lanes and walking paths are recommended along the entire length of the green corridor. They continue the promenade areas and bicycle paths from the banks of the Bega Canal to inside the Pădurea Verde. Now these routes are fragmented, there is no possibility of a continuous crossing from Bega to the Pădurea Verde. The paving for both pedestrian and bicycle paths will use porous materials, which allow water infiltration into the soil.

Fig. 20. Proposed landscaping of bicycle paths [27]

Fig. 21. Proposed landscaping of pedestrian paths [28]

Pedestrian and bicycle crossings will be arranged and properly signaled on Ghirodei Alley and Calea Lugojului streets, where safe access is now unavailable. The crossing bridges over Behela (near the cemetery and on Ștrandului Street) will be refurbished to be safe and accessible for both pedestrians and bicycles.

Spaces for rest and relaxation

Along the promenade paths, benches made of organic materials (wood) and spaces for rest, relaxation and observation of nature will be provided. Wooden decks will bring the viewer closer to the water and will offer the opportunity to relax in the middle of nature.

Fig. 22. Wooden deck set-up [29]

Fig. 23. Places for rest and relaxation [30]

Materials and utility equipment

An adequate public lighting system cannot be missing in an urban area with abundant vegetation, both for security reasons and for a pleasant atmosphere in the evenings. The proposed design recommends the installation of street lamps along pedestrian alleys and bicycle paths, and ambient lighting around the decks and relaxation areas. The lighting is based on efficient solutions, using LED technology, photovoltaic panels and self-programmable lights.

Recharging stations for electronic devices will be provided in the area of the children's playground and relaxation areas.

The materials used in the landscaping will be natural and ecological – especially durable wood for urban furniture elements and pavements made of porous materials for pedestrian and bicycle paths.

The entire area will be equipped with trash bins to prevent waste disposal in the green spaces and the riverbed, a pressing current problem in the area.

Informational posters will be placed along the pedestrian route, containing relevant information about the role and benefits of the green corridor, as well as the flora and fauna present.

Conclusions

An ecologically minded and landscape appropriate development will transform Behela's riparian area into an important green-blue corridor. It will provide the inhabitants of the area and of the city with multiple valuable ecosystem services, a sustainable urban mobility corridor and a green area for outdoor activities. The implementation of a project of such magnitude necessitates the involvement and agreement of local authorities, as well as a participatory design process, together with the local community and non-governmental organizations to ensure sustainability over time for the proposed landscaping solution.

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