

Tree diversity along the Bîc River: ecological and aesthetic contributions to Chişinău's urban landscape

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Abstract

Urban ecosystems represent complex structures where natural and anthropogenic components interact within a fragile balance influenced by socio-economic, climatic, and spatial pressures. In this context, urban vegetation, particularly trees, plays a crucial role in maintaining environmental quality and regulating urban microclimates. In this study we investigate the diversity of urban trees and their ecological and aesthetic values along the Bîc River in Chişinău, focusing on the section between Albişoara Street and the Circ Bridge. We identified both native and exotic tree species, assessed their phytosanitary condition, and evaluated their ecological benefits as well as their ornamental significance in the urban landscape. The analysis further explores major challenges linked to urban sustainability, emphasizing its relevance as a core research direction in urban landscape ecology and the need for integrated management policies. Recommendations for the protection and revitalization of the river's green corridor are presented, emphasizing the restoration of riparian vegetation, the creation of continuous green buffers, and the implementation of integrated urban ecological management strategies. The findings highlight the potential of urban trees to enhance ecological resilience, aesthetic quality, biodiversity, and the sustainable development of Chişinău's urban landscape.

Keywords: blue-green infrastructures, riparian vegetation, biodiversity, urban landscape ecology

Introduction

There is an unprecedented acceleration of urbanization worldwide, with the urban population expected to increase significantly; projections suggest that by 2050, 70% of people will live in cities [18]. This rapid urbanization will require careful planning to create more livable urban environments. In the context of increasing competition between blue-green spaces and grey infrastructure, each individual tree or shrub represents an incontestable ecological and aesthetic value in the urban landscape. There are many variations in the proportion of these main components of urbanism, depending on the climate, landscape, history, financial resources, and cultural background of a city's inhabitants. Today, modern technologies allow urban planners and landscape architects to utilize the third dimension in space, creating green roofs and green walls as strategies to increase the ecological footprint in urban planning. However, in cities where spaces suitable for blue-green areas already exist, these spaces must be utilized and designed with the purpose of promoting a sustainable environment and a harmonious urban landscape.

Chişinău city, covering 120 km², serves as the capital of the Republic of Moldova and its principal economic and cultural hub, with an estimated metropolitan population of around 720,000 inhabitants in 2024 [19]. Located in the central region of the country at an altitude of approximately 85 meters above sea level within the East European Plain, Chişinău is notable for its extensive urban green spaces, which cover about 4,400 hectares, approximately 7.5% of the city's total area [3, 6].

The Bîc River represents a blue-green infrastructure element that flows from west to east across the city of Chişinău, dividing it into the right and left banks. It plays a vital ecological role in the urban environment and holds cultural significance, as the first settlement, later developing into the capital city, is believed to have emerged near the river. According to local elders, the Bîc River never used to dry up, and its banks were once densely forested; however, these forests have since disappeared [4, 17]. It originates from the Codrii Moldovei, natural reservation, near the village of Temeleuți in the Călărași district, at an altitude of approximately 315

meters above sea level. It has a length of about 155 km, a drainage basin of approximately 2,150 km², and an average discharge of about 0.7 m³/s, varying seasonally. It is a semi-natural watercourse with an anthropogenically modified hydrological regime, exhibiting several particularities in the distribution and composition of tree species along its banks. Near and in Chişinău, the riverbed has been regularized and partially channelized, and in the 1960s, the Ghidighici Reservoir, was constructed [1, 2]. The Bîc River flows into the Botna River, through which its waters reach the Nistru River and eventually the Black Sea [12].

Although the river was historically used for irrigation and to supply water to local communities in the area, today the Bîc River is considered one of the most polluted rivers in Moldova, particularly in the Chişinău region, due to wastewater discharges and solid waste accumulation [5, 14]. Despite its ecological issues, the Bîc River remains the main hydrological feature of Chişinău, playing a central role in the city's geographical, ecological, and urban structure.

Therefore, this study aims to investigate the diversity of urban trees and their ecological-aesthetic values along the Bîc River, in the sector between Albişoara Street and the Circ Bridge, highlighting the impact of anthropogenic factors on vegetation structure and its potential contribution to the ecological and landscape rehabilitation of the urban river corridor.

The analysis of urban tree diversity along this section of the Bîc River is relevant from both ecological and aesthetic perspectives. Identifying dominant species, assessing their phytosanitary condition, and evaluating their role in the urban landscape contribute to the foundation of sustainable green space management policies. Additionally, determining the aesthetic values associated with different tree species allows the integration of ecological and visual criteria into urban planning, optimizing the relationship between the natural environment and the built structure of the city.

Material and Method

A bibliographic study on the Bîc River was undertaken to establish the theoretical and contextual framework of the research. Subsequently, a series of field surveys were conducted to obtain direct observations and empirical data. The fieldwork involved: (i) the observation and analysis of urban landscape diversity; (ii) the identification and characterization of tree species composition; and (iii) the photographic documentation of relevant features. These activities provided the basis for the analysis and description of the landscape, as well as for the selection and presentation of the most representative tree species within the study area.

Site Description and Data Collection

The Bîc River traverses the central area of Chişinău in a northwest–southeast direction, forming the city's principal hydrological axis over a length of approximately 26 km, as shown in Fig. 1. Within the municipal boundaries, the river is crossed by about twenty road bridges, as well as several pedestrian crossings. Over time, its course has undergone significant anthropogenic modification, being regularized and partially channelized, mainly in the central sector and along Albişoara Street. These interventions have substantially altered the natural dynamics and ecological integrity of the riparian zone, directly impacting the structure and diversity of bank vegetation.

Field investigations focused on the Albişoara corridor, located in the central–western part of the city, and included an analysis of tree species diversity. This area is characterized by dense urban infrastructure, high traffic intensity, and close proximity to both industrial and residential zones. The section near the Circ Bridge exemplifies a typical urban landscape subject to ongoing morphological and ecological transformation. Here, riparian vegetation exhibits fragmentation, soil compaction, and increased atmospheric and water pollution, as shown in Figure 2.

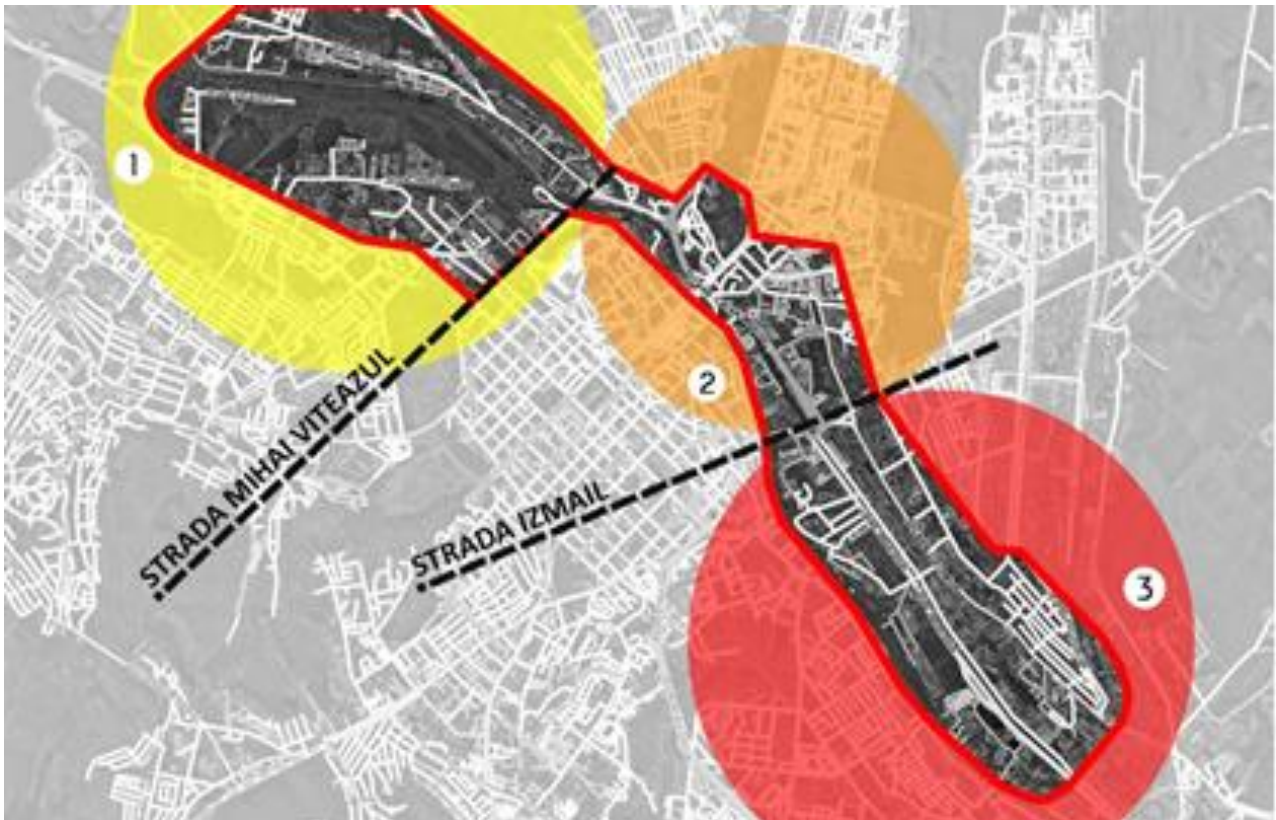


Figure 1. Segmentation of the Bîc River within Chişinău city limits, delineated by Mihai Viteazul and Izmail Streets [20]



Figure 2. Major anthropogenic alterations in the Bîc River ecosystem

Results and Discussion

Urban tree diversity along the Bîc River banks and its ecological value

The current structure of the riverbanks tree vegetation is influenced by urban-specific environmental factors: air and water pollution, soil compaction, oxygen deficit in the rhizosphere, and periodic clearing and replanting interventions [7]. In the Albişoara – Circ Bridge zone, vegetation is unevenly distributed, with densely wooded sections interspersed with areas devoid of trees due to road and hydraulic infrastructure works, as shown in Fig. 3.



Perspective of the Bîc River and Albișoara Street from the Renasterii Nationale Bridge



Perspective of the Bîc River from the Bridge on Petru Rares Street

Figure 3. Perspectives of the analyzed sector of the Bîc River banks

We identified an association of indigenous and allochthonous tree species along the Bîc River banks, each adapting differently to urban conditions and the specific microclimate of the riverbanks, as summarized in Table 1. Among the native tree species, *Salix alba*, *Populus nigra*, and *Acer platanoides* are particularly representative, as they tolerate high moisture levels and play a key role in bank stabilization. Allochthonous species, including *Ailanthus altissima*, *Robinia pseudoacacia*, and *Acer negundo*, although tolerant of urban stress, can become invasive and potentially diminish native species diversity.

Despite these disturbances, trees contribute significantly to ecological stabilization, helping to reduce erosion. The well-developed root systems of species such as *Salix alba*, *Populus nigra*, and *Fraxinus excelsior* play a crucial role in reinforcing the alluvial substrate and maintaining local hydrological balance. The vegetative mass of these trees promotes the interception of suspended particles and dust, reduces carbon dioxide concentrations, and improves air quality. Additionally, trees help regulate the local microclimate, mitigating the “urban heat island” effect characteristic of densely built areas of Chișinău, while enhancing the urban landscape and providing habitats for birds, insects, and microorganisms, thereby supporting biodiversity conservation in a heavily modified urban environment. Furthermore, trees act as a natural sound barrier, reducing the impact of noise from heavy traffic along Albișoara Street.

The diversity of tree species, even if moderate, reflects the urban system’s capacity to support a functional vegetative ensemble, serving as an ecological corridor that connects various green areas within the city.

Additionally, numerous herbaceous plant species were identified, including those presented in Table 2.

Table 1. Tree species diversity along the analyzed sector of the Bîc River banks

No.	Tree Species	Ecological and aesthetic aspects
1	<i>Aesculus hippocastanum</i>	Aesthetic; flowers attract pollinator fauna.
2	<i>Ailanthus altissima</i>	Fast-growing deciduous tree (20–25 m); highly adaptable; tolerates poor, sandy, or polluted soils.
3	<i>Alnus glutinosa</i>	Water-loving, nitrogen-fixing tree; protects riverbanks.
4	<i>Acer platanoides</i>	Ornamental foliage; attractive autumn colors.
5	<i>Acer pseudoplatanus</i>	Ornamental tree; tolerant to various soils; contributes to urban biodiversity.
6	<i>Betula pendula</i>	Tree with white bark and small, serrated leaves; indicator of moist soils.
7	<i>Fraxinus excelsior</i>	Tall tree with compound leaves and wide crown; decorative; provides good shade; tolerant to various soils.
8	<i>Frangula alnus</i>	Spontaneous shrub with glossy leaves and black fruits; ecologically important.
9	<i>Juglans regia</i>	Large tree with compound leaves and edible fruits; ecologically and economically valuable.
10	<i>Malus sylvestris</i>	Small tree with tart fruits; important for biodiversity.
11	<i>Maclura pomifera</i>	Exotic tree with green spherical fruits; decorative and drought-resistant.
12	<i>Olea europaea</i>	Pollution-resistant; ornamental.
13	<i>Populus alba</i>	Fast-growing; stabilizes soil; contributes to erosion control.
14	<i>Populus nigra</i>	Fast-growing; tolerant to urban environments; erosion protection; stabilizes soil and filters air.
15	<i>Prunus avium</i>	Tree with white flowers and red fruits; attracts birds and pollinators.
16	<i>Prunus padus</i>	White flowers; attracts birds and pollinating insects.
17	<i>Robinia pseudoacacia</i>	Honey-producing, drought-resistant tree; fixes nitrogen in soil.
18	<i>Salix alba</i>	Water-loving tree with long, flexible branches; protects riverbanks from erosion.
19	<i>Salix fragilis</i>	Hydrophilic species; stabilizes banks; provides dense shade.
20	<i>Tilia cordata</i>	Filters pollutants; pleasant scent; attractive for urban beekeeping; enhances biodiversity.
21	<i>Tilia platyphyllos</i>	Pollutant filtration; supports urban pollinators; decorative and shade-providing.
22	<i>Tilia tomentosa</i>	Ornamental foliage; tolerant to different soils; attractive for urban beekeeping; enhances biodiversity.
23	<i>Ulmus glabra</i>	Large tree with oval, serrated leaves; used for shading and soil stabilization.

Table 2. Herbaceous plant species identified along the analyzed sector of the Bîc River banks

No.	Species	Ecological and aesthetic aspects
1	<i>Artemisia ludoviciana</i>	Perennial herbaceous plant with silvery, aromatic leaves; also used medicinally.
2	<i>Phragmites australis</i>	Tall aquatic plant with thick stems and long, narrow leaves.
3	<i>Typha latifolia</i>	Perennial aquatic plant with broad leaves and cylindrical brown inflorescence; used for natural water purification and ornamental purposes.

Distribution of trees along the Bîc River banks

The distribution of trees along the Bîc River reflects both local ecological conditions and the accumulated anthropogenic impact over time. In the studied sector, between Albișoara Street and the Circ Bridge, the tree vegetation exhibits a heterogeneous spatial structure, determined by the geomorphological features of the riverbanks, hydraulic works, and the degree of urbanization in the area. In sections where the banks are wider and have uncompacted alluvial soils, tree density is higher, with a predominance of native species such as *Salix alba*, *Populus nigra*, *Acer platanoides*, and *Fraxinus excelsior*. These species form relatively stable riparian plant associations that perform important functions in soil stabilization and erosion

reduction. In contrast, in areas with intense road infrastructure and limited space for root development, such as the segment between the Circ Bridge and Petricani Street, trees are sparse, fragmented, and often replaced by pollution-tolerant species such as *Ailanthus altissima* or *Robinia pseudoacacia*. Tree distribution is also influenced by microclimatic factors specific to the urban environment [8, 10, 11]. On the right bank, which is more exposed to sunlight and traffic-related pollution, vegetation shows deficient phytosanitary conditions, characterized by partial canopy drying and reduced leaf density. In contrast, the left bank, partially shaded and less affected by road infrastructure, retains larger trees and greater species diversity, as shown in Fig. 4.



Figure 4. Tree distribution along the Bîc River banks

Overall, the distribution of trees along the Bîc River reflects the interaction between the natural dynamics of the ecosystem and anthropogenic urbanization processes [15, 16]. Areas with denser and more diverse vegetation have higher ecological capacity and significantly contribute to the functioning of the urban green corridor.

Species such as *Typha latifolia* and *Phragmites australis*, along with other herbaceous plants like *Artemisia ludoviciana* form an integral part of the Bîc River ecological corridor, contributing to bank stabilization, habitat provision, and the overall biodiversity of the riparian zone as shown in Fig.5.



Figure 5. *Typha latifolia* and *Phragmites australis* in shallow Bîc River waters

Therefore, the conservation and expansion of these plant associations are essential for preserving both the ecological integrity and the aesthetic quality of Chişinău's urban landscape.

The aesthetic value of trees along the Bîc River is expressed through the diversity of canopy forms, variation in leaf texture and color, and the seasonal dynamics of the landscape. Species such as *Acer platanoides*, *Tilia cordata*, and *Betula pendula* contribute significantly to the visual appeal, giving the area a more harmonious and attractive landscape for pedestrians. In contrast, the presence of invasive species like *Ailanthus altissima*, although providing rapid coverage, negatively affects aesthetic and ecological balance by homogenizing the landscape and reducing authentic ornamental value. The aesthetic value of trees in the Albișoara – Circ Bridge sector is determined by species diversity, phytosanitary condition, and integration into the urban landscape as shown in Fig. 6.



Figure 6. Aesthetic compositions of trees along the Bîc River banks

Improving these aspects requires planned interventions based on ecological and landscape criteria, such as selecting native species, rehabilitating degraded areas, and creating a continuous green corridor along the Bîc River. In this way, tree vegetation can become a key element in reconnecting the city with its natural environment and strengthening Chişinău's ecological identity.

The Role of the Bîc River in Chişinău. Local Issues

The Bîc River is the main hydrological feature of Chişinău, playing a major role in the city's geographic, ecological, and urban structure [13]. It significantly influences urban spatial organization, local relief formation, and the functioning of urban ecosystems. Ecologically, the river could act as a green corridor connecting fragmented green spaces across different city sectors, facilitating species migration and the circulation of energy and matter within the urban ecosystem.

However, the ecological value of the Bîc River has been considerably diminished by urbanization and accumulated anthropogenic pressure over recent decades. Channel regularization, riverbed concreting, and partial diversion of natural flow have transformed the river into a collector for stormwater and wastewater, severely affecting its ecological and landscape functions. In densely built areas, such as Albişoara and the Circ Bridge sector, the impact of road infrastructure, stormwater channels, and diffuse pollution sources is reflected in poor water quality and degraded riparian habitats.

Major problems identified include chronic water pollution with suspended solids, hydrocarbons, heavy metals, and urban waste, originating from surface runoff and uncontrolled discharges. Additionally, fragmentation and degradation of the riverbank, caused by construction, parking areas, and the absence of protective vegetated strips, reduce biological diversity and compromise ecological connectivity. Moreover, poor maintenance of green spaces and uncontrolled tree cutting accelerate landscape and ecological degradation.

Under current conditions, the Bîc River no longer fully fulfills its natural functions of hydrological regulation, biotic filtration, and urban recreation. Nevertheless, it remains a strategic element for Chişinău's sustainable development. Ecological rehabilitation of the riverbed, restoration of riparian vegetation, and transformation of the Bîc corridor into a multifunctional green axis could significantly improve urban life quality, reduce pollution, and create a coherent ecological identity for the city.

Challenges and Threats

The Bîc River area, especially the section crossing Albişoara Street and the vicinity of the Circ Bridge, faces a series of complex challenges and threats, mainly generated by accelerated urbanization and inadequate environmental management. These issues manifest both ecologically and socio-urbanistically, directly affecting the functioning of the urban ecosystem and the quality of life of residents.

The Bîc River is affected by continuous pollution from stormwater, insufficiently treated wastewater, and accidental industrial discharges. Accumulation of polluted sediments in the riverbed and the lack of aquatic-riparian vegetation reduce the ecosystem's natural self-purification capacity. Consequently, both aquatic and terrestrial biodiversity in the area is declining, and the system's biogeochemical balance is disturbed.

Hydraulic interventions, channel regularization, and road infrastructure expansion have led to riverbank concreting and loss of the area's natural character. The absence of a continuous green protective strip along the river limits species movement, fragments the ecosystem, and diminishes its regenerative capacity.

The high density of buildings and heavy traffic in the Albişoara area cause significant noise and air pollution, to which the existing vegetation responds with physiological stress and reduced tree lifespan. Uncontrolled selective cutting, lack of systematic replanting, and insufficient maintenance further exacerbate the degradation of the urban landscape.

Climate change, through rising average temperatures and increased frequency of extreme events (heavy rainfall, drought periods), amplifies the risk of flooding and erosion along unprotected sections of the river. At the same time, reductions in base flow and riverbed siltation negatively affect the ecological functions of the watercourse.

The absence of an integrated restoration plan for the Bîc River, based on urban ecology and sustainable development principles, perpetuates existing imbalances. The lack of effective collaboration between authorities, the scientific community, and civil society makes it difficult to implement ecological restoration measures and restore the urban green corridor.

Overall, the identified challenges and threats depict a vulnerable ecological system but also reveal significant potential for sustainable interventions. Overcoming these difficulties requires an integrated approach, based on green infrastructure solutions, ecological rehabilitation of the riverbanks, and active involvement of the local community in protecting the Bîc River as an identifying and functional element of Chişinău's urban landscape.

Recommendations for Protecting the Bîc River Green Corridor

Protecting and revitalizing the Bîc River green corridor is a strategic priority for the sustainable urban development of Chişinău. Considering the anthropogenic pressures and ecological degradation observed in the Albişoara – Circ Bridge area, a set of integrated measures is required, combining ecological, landscape, and socio-economic aspects.

Gradual rehabilitation of riverbank areas is recommended, including the removal of concrete structures where possible, restoration of natural substrate, and reintroduction of vegetation characteristic of riparian ecosystems. Planting native species such as *Salix alba*, *Populus nigra*, *Fraxinus excelsior*, and *Alnus glutinosa* will help stabilize banks, increase biodiversity, and restore the river's ecological functions.

A protective ecological zone should be established along both banks of the Bîc River, with widths adapted to local conditions (minimum 15–30 m). This should include trees, shrubs, and perennial grasses serving as biological filters to reduce diffuse pollution from traffic and stormwater runoff. Connecting these green strips to adjacent green spaces will create a continuous urban ecological corridor, facilitating species movement and maintaining the microclimate.

A management plan for the Bîc River should be developed, based on urban ecology principles, including continuous water quality monitoring, pollution source control, periodic replanting, and tree maintenance. Collaboration among municipal authorities, ecology and urban planning specialists, environmental NGOs, and the local community is essential for ensuring sustainable protection.

Promoting pedestrian and cycling paths along the Bîc River, equipped with eco-friendly urban furniture, information panels, and observation zones for flora and fauna, can transform the green corridor into a multifunctional space, both ecological and recreational. In this way, the river becomes an active component of urban life and a vector for environmental awareness among citizens.

Protection measures should also adapt the green corridor to climate risks through controlled stormwater retention, creation of temporary wetlands, and selection of plant species resistant to drought and pollution. These nature-based solutions will reduce flood risk and improve the climate regulation functions of the urban ecosystem.

Conclusions

The analysis conducted along the Bîc River, especially in the Albişoara – Circ Bridge sector, highlights the complex interaction between natural and anthropogenic environments within Chişinău's urban landscape. Although the river course and riparian zones have undergone long-term morphological and ecological transformations, they retain significant potential for regeneration and development of a functional urban blue-green corridor.

Tree diversity within the Albişoara–Circ Bridge sector of the Bîc River corridor demonstrates a moderate yet ecologically significant assemblage, dominated by species capable of withstanding urban stressors. The persistence of mature native specimens highlights the system's inherent resilience and its potential for ecological recovery. Through their multifaceted functions, including bank stabilization, air quality improvement, microclimate regulation, and habitat provision, trees serve as essential structural and functional components of Chişinău urban ecosystem. Strengthening the conservation and diversification of vegetation in this area is therefore crucial for enhancing ecological stability, promoting urban sustainability, and advancing the development of a continuous, resilient green infrastructure along the Bîc River.

Despite its ecological value and regenerative potential, the Bîc River corridor remains under considerable environmental stress. To mitigate water pollution, green space fragmentation, and the expansion of grey infrastructure, it is imperative to adopt an integrated and interdisciplinary management strategy focused on riverbank rehabilitation, restoration of native vegetation, expansion of continuous blue-green corridors, and implementation of multifunctional green infrastructure.

Active participation of local authorities, experts, and the community is equally essential to restore the ecological and aesthetic functions of the Bîc River and to reestablish it as a defining element of a sustainable, green, and resilient Chişinău.

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