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# Development of Environmental Practices and Green Projects to Achieve the Principles of Sustainable Urban Public Spaces

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**ABSTRACT**

*Urbanization creates a significant burden on the environment of urban areas, calling for innovative approaches to the management of public spaces. The purpose of the study was to assess the degree of implementation of environmental practices under the framework of the circular economy in Russian urban projects based on specialist assessments. The subjects of the study were three major public space improvement projects: Zaryadye Park (Moscow), the embankment of Kaban Lakes (Kazan), and New Holland Island (St. Petersburg). The panel of experts consisted of 18 specialists in ecology, landscape architecture, hydrology, and urban studies, who evaluated five categories of practices: water resources management, the use of recycled materials, energy efficiency, support for biodiversity, and modular infrastructure. Statistical data processing was carried out with non-parametric methods (Kendall's coefficient of concordance and the Friedman test). The results revealed significant variability in the degree of implementation of different practices between projects with a high consistency of expert assessments (W = 0.76). Zaryadye Park was the leader in biodiversity, the New Holland project performed best in the use of recycled materials, and Kaban Lakes were superior in water resource management solutions. Statistically significant differences in all categories show the lack of a universal methodological approach. The study substantiates the need to develop standardized requirements for the environmental management of urban areas.*

**Keywords:** *Green infrastructure, Nature-based solutions, Biodiversity, Recycled materials, Ecosystem services.*

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## INTRODUCTION

Twenty-first-century urbanization puts an unprecedented strain on the environment, as cities accumulate about 70% of global $CO_2$ emissions, consume 60% of the world's resources, and generate half of all waste (Ellen MacArthur Foundation, 2019; Yermekov *et al*., 2020). According to forecasts, by 2050, 68% of the world's population will be urban, which will demand a radical revision of approaches to managing the ecological state of urban areas (Korotun & Goncharov, 2024; Krasnikov & Korotun, 2024; Meegle, 2025). Meanwhile, the traditional model of urban development based on linear resource consumption (take-use-dispose) entails the depletion of natural systems, the accumulation of waste, and the degradation of the urban environment (Rozhkova *et al*., 2021; Krasnikova *et al*., 2024; Abdykadyrov *et al*., 2025).

Urban public spaces, such as parks, embankments, and squares, are a key element of the city's environmental management system (Krasnikova & Beresneva, 2024; Rimskiy *et al*., 2025).

These areas serve multiple ecological functions: microclimate management, stormwater management, biodiversity maintenance, and air and soil pollution reduction (Faizulina *et al*., 2024). Despite this, traditional public space design often focuses on the aesthetic and recreational aspects, overlooking their ecological potential. In turn, the principles of a circular economy (closed-loop material cycles, the reuse of resources, and the minimization of waste) are designed to strengthen the ecological function of public spaces and reduce their negative environmental impact (Rozhkova *et al*., 2025).

The research goal in this study was to determine and assess the degree of implementation of environmental practices in the framework of the circular economy in the development of urban public spaces.

*Research objectives*

1. To systematize theoretical approaches to the application of circular economy principles to reduce the environmental burden of urban areas and to develop green infrastructure.
2. To assess the degree of implementation of specific environmental practices in each project under study (water resources management, the use of recycled materials, energy efficiency, support for biodiversity, and modular infrastructure).
3. To conduct a comparative analysis of the identified practices to determine the most effective solutions in the field of environmental management of public spaces in Russian cities.

*Literature review*

A significant component of green infrastructure design is the principles of multifunctionality, under which a single space solves several problems at the same time; the incorporation of infrastructure elements into the ecological network; and the maximum species diversity with the priority of local species (Hansen & Pauleit, 2014; Kuandykova *et al*., 2024).

The environmental efficiency of urban vegetation is supported by research indicating that properly designed green spaces can sequester up to 7% of the city's annual carbon emissions (Logachev & Krylova, 2023; Ariluoma *et al*., 2024; Logachev & Beresneva, 2024). Even amid dense development, the integration of green infrastructure can increase the share of green areas by 5%, making it possible to stabilize ecosystem services despite population growth (van Oorschot *et al*., 2024).

Stormwater management through nature-based solutions is becoming a key element of sustainable urban development. Technologies such as bio-rain gardens, infiltration trenches, and permeable paving simulate natural hydrological processes, reducing the load on centralized water disposal systems (Logachev *et al*., 2023; Akhmetshin *et al*., 2024; World Wildlife Fund, n.d.). A particularly promising approach is the integration of gray (engineering) and green (natural) infrastructure, which increases flood resilience by a third with lifecycle costs rising by less than 10% (Krasnikov *et al*., 2023; Wang *et al*., 2025). The accumulated experience shows that well-designed rainwater collection systems intercept up to three-quarters of precipitation from the roofs, redirecting it to irrigation and reducing the load on water supply networks (Denchak, 2022). In the context of climate change, decentralized green-blue systems prove highly adaptable even to extreme precipitation (Liu & Zhang, 2025).

Recycled materials in landscape architecture solve two problems, reducing both the embodied energy of objects and the flow of construction waste to landfills (McNeill Engineering, 2024; Abdimomynova *et al*., 2025). Recycled concrete aggregates, recycled plastics and rubber, regenerated wood, and local low-carbon materials are successfully integrated into landscape elements, from paving to small architectural forms (Zakharov & Zabalueva, 2025). The experience of already implemented projects reveals that with the competent use of construction and dismantling waste, it is possible to return up to 60% of materials to the production cycle (Mohamed *et al*., 2024; Sergeeva *et al*., 2024; Kuznetsov *et al*., 2025). Design for disassembly and modular infrastructure also continue to be valuable, providing the possibility of reconfiguration without significant waste (UrbanDesignLab, 2024). In turn, the adaptive reuse of post-industrial territories is not limited to the conservation of historical structures but includes their environmental rehabilitation through modern green technologies (Zhang *et al*., 2025).

Evaluating the environmental performance of green infrastructure typically involves expert-led methodologies that synthesize insights from diverse disciplines, including urban planning, ecology, sociology, and hydrology (Fu *et al*., 2021; Atasheva *et al*., 2024). Through matrix models, researchers identify critical connections between various infrastructure types and ecosystem services, thereby highlighting priority zones for effective urban environmental management (Elliott *et al*., 2020; Saparov *et al*., 2024; Karshalova *et al*., 2025). Furthermore, incorporating the Analytic Hierarchy Process (AHP) alongside expert evaluations enables the calculation of specific weighting coefficients for environmental indicators, which significantly enhances the objectivity of comprehensive assessments (Xue *et al*., 2024; Pakhomova *et al*., 2025). Despite a burgeoning literature regarding green infrastructure and circular frameworks, Russian urban public spaces that utilize circular economy principles remain under-researched, lacking a systematic and holistic analysis. Consequently, this study addresses this significant research gap by investigating these specific practices to establish their broader relevance within the current academic and practical discourse (Al-Mubarak *et al*., 2024; Belfiore *et al*., 2024; Chakraborty & Rajasekar, 2024; Ati *et al*., 2025; Liedekerke *et al*., 2025; Mohammad *et al*., 2025; Nguyen, 2025; Abusanna *et al*., 2026; Alhindi *et al*., 2026; Kanta *et al*., 2026).

## MATERIALS AND METHODS

The study employed the expert assessment method to analyze the degree of implementation of environmental practices based on the principles of the circular economy in Russian urban projects.

In recent years, Russian cities have completed a number of large-scale public space improvement projects incorporating various environmental solutions. Among such projects are Zaryadye Park in Moscow (2017), New Holland Island in St. Petersburg (reconstructed in 2016–2020), and the embankment of Kaban Lakes in Kazan (2017–2020). The reason these specific projects were chosen for this study was that while they do integrate water management technologies, recycled materials, energy-saving systems, and nature-like solutions, the degree and quality of implementation of these environmental practices have not been systematically assessed.

The panel of experts consisted of 18 specialists: six ecologists, five landscape architects, four urbanists, and three hydrologists. Each specialist was required to have at least 5 years of experience in the field of sustainable urban development. The interdisciplinary composition of the expert sample ensured a comprehensive assessment of the various aspects of environmental practices.

A structured questionnaire was developed to assess five categories of practices: (1) water resources management, (2) the use of recycled materials, (3) energy efficiency, (4) support for biodiversity, and (5) modular infrastructure. Each practice was rated on a five-point Likert scale with detailed criteria for each score. The experts were provided with reference materials on the technical solutions used in the projects.

Statistical data processing was carried out using non-parametric methods due to the nature of expert assessments (ordinal scale) and the relatively small sample size. Medians and interquartile spans were calculated for each category of practices. The consistency of expert opinions was tested with the non-parametric Kendall's coefficient of concordance (W), where W > 0.7 indicates high consistency. Statistically significant differences between the three projects were detected with the non-parametric Friedman test for related samples. Comparative analysis was conducted to identify the most well-developed practices and the regional specifics of their implementation.

## RESULTS AND DISCUSSION

The expert assessment of the degree to which the three Russian projects implemented the environmental practices of the circular economy reveals different patterns of implementation of sustainable solutions depending on the context and scale of the project **(Table 1)**.

**Table 1.** Median estimates of the degree of implementation of environmental practices by project

| Category of practices | Zaryadye (Moscow) | Kaban (Kazan) | New Holland (St. Petersburg) |
|---|---|---|---|
| Water resources management | 4.5 | 4.0 | 3.5 |
| Using recycled materials | 3.0 | 3.5 | 4.5 |
| Energy efficiency | 4.0 | 3.0 | 4.0 |
| Support for biodiversity | 5.0 | 3.0 | 3.5 |
| Modular infrastructure | 3.5 | 3.0 | 4.5 |
| **Total median** | **4.0** | **3.0** | **4.0** |

Note: scores on a scale of 1 (minimum implementation) to 5 (maximum implementation)

The distribution of assessments within each project highlights priority areas of environmental practices **(Table 2)**.

**Table 2.** Ranking of environmental practices by the degree of implementation in each project

| Rank | Zaryadye | Kaban | New Holland |
|---|---|---|---|
| 1 | Biodiversity (5.0) | Water resources (4.0) | Recycled materials (4.5) |
| 2 | Water resources (4.5) | Recycled materials (3.5) | Modularity (4.5) |
| 3 | Energy efficiency (4.0) | Biodiversity (3.0) | Energy efficiency (4.0) |
| 4 | Modularity (3.5) | Energy efficiency (3.0) | Water resources (3.5) |
| 5 | Recycled materials (3.0) | Modularity (3.0) | Biodiversity (3.5) |

The assessment of expert consistency found a high degree of consensus across most of the categories **(Table 3)**.

**Table 3.** Consistency of expert assessments (Kendall's coefficient of concordance)

| Category of practices | Kendall's W | Interpretation |
|---|---|---|
| Water resources management | 0.82 | High consistency |
| Using recycled materials | 0.76 | High consistency |
| Energy efficiency | 0.71 | High consistency |
| Support for biodiversity | 0.85 | High consistency |
| Modular infrastructure | 0.68 | Acceptable consistency |
| **Total consistency** | **0.76** | **High consistency** |

Note: W > 0.7 indicates high consistency of expert assessments

Statistical analysis revealed significant differences between projects across individual practice categories **(Table 4)**.

**Table 4.** Friedman test for comparisons between projects

| Category of practices | $\chi^2$ | p-value | Conclusion |
|---|---|---|---|
| Water resources management | 12.4 | 0.002 | Significant differences** |

| | | | |
|---|---|---|---|
| Using recycled materials | 15.8 | <0.001 | Significant differences*** |
| Energy efficiency | 8.6 | 0.014 | Significant differences* |
| Support for biodiversity | 18.2 | <0.001 | Significant differences*** |
| Modular infrastructure | 11.3 | 0.004 | Significant differences** |

Note: * p < 0.05; ** p < 0.01; *** p < 0.001

The characteristic profiles of environmental practices for each project were identified through comparative analysis **(Table 5)**.

**Table 5.** Strengths and weaknesses of environmental practices by project

| Project | Strengths (median ≥ 4.0) | Weaknesses (median < 3.5) |
|---|---|---|
| Zaryadye | • Support for biodiversity<br>• Water resources management<br>• Energy efficiency | • Using recycled materials |
| Kaban | • Water resources management | • Energy efficiency<br>• Biodiversity<br>• Modularity |
| New Holland | • Using recycled materials<br>• Modularity<br>• Energy efficiency | — |

The research findings indicate that the degree of implementation of environmental practices based on the principles of a circular economy varies by the type of project and urban context, with expert assessments remaining highly consistent in all categories (Figueroa-Valverde *et al*., 2024; Karatas, 2024; Kęska & Suchy, 2024; Lee & Ferreira, 2024; Negreiros & Ory, 2024; Noor *et al*., 2024; Abdullah *et al*., 2025; Jagsi *et al*., 2025; Schneider & Krüger, 2025; Wong *et al*., 2025). As the expert assessment reveals significant variability in the degree of implementation of the environmental practices of the circular economy between the examined projects, we can conclude that the environmental management of urban public spaces in Russian cities does not adhere to a universal methodological approach. The high consistency of expert assessments (W = 0.76) is indicative of professional consensus on environmental efficiency criteria, which provides a basis for standardized approaches to the evaluation of sustainable solutions.

The most pronounced differences between the projects were observed in the category of biodiversity support. While Zaryadye Park received maximum scores, the Kaban Lakes embankment and New Holland Island achieved significantly lower results. This gap can be explained by differences in the priorities of the projects. In the case of Zaryadye, biodiversity was a cornerstone of the project from its inception, realized in practice through the integration of four climatic zones of Russia and the use of more than 800 plant species. International experience confirms the crucial role of species diversity in maximizing the ecosystem services provided by urban vegetation. Studies show that competently designed multi-species spaces provide higher carbon sequestration and show greater resilience to climate stress (Ariluoma *et al*., 2024; Sizintsev, 2024). These findings point to the need for a stronger emphasis on biodiversity in the design of new public spaces, particularly in regional cities where this practice is so far underappreciated (Agrawal *et al*., 2024; Ghiga *et al*., 2024; Khan *et al*., 2024; Kounatidis *et al*., 2024; Qiao *et al*., 2024; Musa *et al*., 2025; Petronis *et al*., 2025; Raza *et al*., 2025; Yu *et al*., 2025).

In contrast, the leader in the use of recycled materials is New Holland Island. This result is consistent with the concept of adaptive reuse of post-industrial territories, which does not boil down to the conservation of historical structures but involves their ecological rehabilitation by means of modern circular solutions (Zhang *et al*., 2025). The experience of New Holland demonstrates the great potential of reconstruction projects to implement circular economy principles due to the availability of locally sourced recycled materials. Given that the construction sector generates up to 60% of materials during renovation (Mohamed *et al*., 2024), the targeted use of this resource can substantially reduce the environmental footprint of new projects. A practical recommendation for municipal governments would be to develop regulatory requirements (Eremin *et al*., 2023; Sovetov & Makarov, 2024) to encourage the use of a certain share of recycled materials in the improvement of public spaces (Logachev, 2023).

High scores on water resources management were given to the Zaryadye Park and Kaban Lakes projects, reflecting a growing recognition of the role of nature-based solutions for adaptation to climate change (Krasnikov & Smirnova, 2024). The integration of gray-green infrastructure has proven to be effective in improving flood resilience at minimal additional costs (Denchak, 2022; Rusev, 2024), which makes this approach economically viable for Russian conditions (Aliev & Baldin, 2024). On the other hand, the relatively low score of New Holland Island in this category indicates insufficient attention to water aspects in the reconstruction of historical territories and the need for adjustments in future projects (Bona & Lozano, 2024; Alves *et al*., 2026; Petrov *et al*., 2026).

In the category of energy efficiency, all of the projects achieved modest results, which indicates potential for improvement. Foreign experience demonstrates the possibilities of integrating renewable energy sources into landscape architecture, including photovoltaic elements in small architectural forms and geothermal systems to maintain the microclimate. In this area, the priority direction of development should be the addition of energy efficiency requirements to urban planning regulations for public spaces (Rusev, 2024; Sereda, 2024).

The relatively low scores of the Zaryadye and Kaban projects on infrastructure modularity show the predominance of the traditional approach to design with fixed solutions. Meanwhile, modularity provides an opportunity to adapt urban systems to changing needs without generating significant waste (UrbanDesignLab, 2024). The success of New Holland Island in this respect can be used as a reference in future projects, especially given the uncertainty of long-term scenarios for the use of urban spaces.

The results of the study thus confirm the need for a systematic approach to the environmental management of urban public spaces that would integrate all five categories of circular economy practices. The fact that none of the analyzed projects received uniformly high scores across all categories indicates fragmentation in the implementation of sustainable practices. To overcome this hindrance, comprehensive standards for the environmental design of public spaces need to be developed at the federal level with clear indicators for each category of practices.

## CONCLUSION

The conducted expert assessment of the degree of implementation of the environmental practices of the circular economy in three Russian urban projects revealed significant variability in the implementation of sustainable solutions. Zaryadye Park took the lead in supporting biodiversity and managing water resources, New Holland Island performed best in the use of recycled materials and the modularity of the infrastructure, and the embankment of Kaban Lakes achieved great results predominantly in water resources management solutions. The consistency of expert assessments is indicative of professional consensus. Meanwhile, statistically significant differences between projects show the lack of a single methodological approach to the environmental management of urban spaces in Russia.

The key limitations of the present study are determined by the small size of the sample of projects (only the largest cities), which prevents the extrapolation of conclusions to medium and small cities. The method of expert assessment, with all the consistency of opinions, remains subjective and does not substitute instrumental measurements of actual environmental effects, i.e., carbon sequestration, temperature reduction, and the volumes of retained stormwater. Furthermore, the assessments were made without long-term monitoring, which leaves changes in indicators over time beyond the scope of the study.

Prospects for further research include geographical expansion to cover projects from different climate zones and the integration of quantitative methods to evaluate environmental effects (instrumental measurements, GIS modeling). In addition, there is a need to develop a comprehensive methodology combining expert assessments with ecosystem services modeling. Finally, the long-term monitoring of completed projects will make it possible to test the sustainability of environmental solutions under the influence of climate changes and anthropogenic loads in order to develop science-based recommendations for the management of urban public spaces.

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