



# Determining Social and Environmental Criteria for the Restoration of Urban Embankments and Riverbank Areas to Achieve the Principles of Sustainable Development



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**Abstract:** The study examined riverine urban areas and spaces as a strategic factor in the sustainable economic development of cities situated along the major rivers of Central Russia—the Oka and the Volga. The study focuses on empirical data from three Russian cities—Nizhny Novgorod, Ryazan, and Samara. The study's purpose was to identify the most pressing problems of riverine urban areas and determine key criteria for their sustainable transformation. Through a comprehensive approach, combining literature review and an expert survey ( $n = 44$ ), the study identified six critical problems hindering the development of riverine areas and determined the priority criteria for sustainable restoration. The greatest significance was attributed to developing and improving the quality of life and attractiveness of the urban environment, green infrastructure, eco-friendly construction, and transport infrastructure. The findings suggest that a focus on these criteria will contribute to the revival of degraded embankment zones and catalyze socioeconomic development. The results demonstrate a high level of expert consistency ( $W > 0.6$ ,  $p < 0.01$ ) and can be used to develop sustainable development strategies for riverine urban areas in Russia and beyond.

**Keywords:** Environmental degradation; Revitalization; River; Riverine territories; Sustainable restoration; Urbanization

## 1 Introduction

In the second half of the 20th century, the development of riverbank cities was marked by a process closely linked to the revival of riverine areas and spaces, which was owed to the fact that houses in such cities faced rivers [1]. Recently, waterfront restoration has gained a global scale, changing our perception of the importance of riverbank areas [2]. These changes are associated with the recognition of new possibilities for using urban embankments, as cities strive to balance economic growth with environmental preservation and historical and cultural traditions. Riverine areas become the subject of discussions, analyses, and projects related to urban planning and architecture [3] and the protection of the natural and residential environment [4, 5].

The revival of riverine areas and the renewal of spatial and functional connections between the city and the river are among the main tasks facing riverbank cities [6]. In riverbank cities where development and spatial structure are centered around the river, riverbank areas have now significantly degraded. This necessitates research into the issues of spatial and functional transformations and the methods of developing areas adjacent to water bodies, the so-called embankments, considering the interests of urban area development.

These problems are solved based on the principle of sustainable urban development. This involves the priority of rational use of urbanized territories and limits urban territorial expansion by transforming its inner spatial structures and adapting degraded territories to the new urban functions [7, 8]. This situation is characteristic of central city districts, residential areas, post-industrial, post-communicational, and post-port areas and structures, green zones, and public spaces [9]. Territories near rivers, canals, and other water bodies also undergo more transformations.

Nowadays, the available evidence on riverfront redevelopment in Russian cities is largely fragmented and project-based, with limited evaluation of outcomes in relation to clearly defined sustainability criteria. Systematic assessment of implemented projects and their social, environmental, and economic effects remains insufficiently developed.

Thus, the study is aimed at finding opportunities to promote sustainable urban development, environmental restoration, the adaptive use of historical infrastructure, and the creation of inclusive public spaces [5]. The revitalization of urban embankments embodies these principles and represents a unique opportunity to address environmental issues [10], improve living conditions in cities [11], and stimulate economic renewal. This study focuses on identifying the main problems in riverbank areas in the central districts of major Russian cities located on the rivers of Central Russia.

Thus, the purpose of our study was to identify a set of criteria focused on the sustainable development of large Russian cities situated along rivers while complying with the principles of ecological urbanism and the United Nations (UN) Sustainable Development Goals (SDGs). This research contributes to the evolving discourse on sustainable riverbank development.

## 2 Literature Review

Riverine urban areas are territories that are directly adjacent to a river and depend on its advantages and risks. This concept encompasses developed sections of the banks that open the expanse of the river, creating its functional and visual framing. The contours of riverine areas are marked by the facades of adjacent buildings and green plantings or other compact complexes of objects that can be viewed as a wall shielding the internal landscape extending along the river [12].

In the past, riverine territories used to play a critical part in the economic and spatial development of cities and were continuously going through functional change. Historically, rivers and riverine zones served defensive, transport, commercial, industrial, municipal, recreational, tourist, environmental, identification, and representative functions [13].

At present, a leading problem in the development of riverine cities is the renewal of the spatial and functional ties between the city and the river [14, 15] by reusing (revitalizing) riverine areas and building new functional and spatial relationships with the river [16]. Kornienko [17] believed that the primary goal of revitalization is harmonious and multifaceted development by adapting old resources to serve new functions [18]. Revitalization refers to planned measures to change the spatial and functional structure of degraded urban territories and achieve socioeconomic revival [19]. Revitalization should reincorporate degraded areas into the urban structure [20]. However, revitalization is not limited to the spatial aspect. To make revitalization comprehensive, it is important to create a new image using architectural [21], urban planning [22], and landscape solutions, but also address the functional, economic, social [23], cultural, and environmental aspects [24, 25]. The location has to be given a purpose that fits its potential and usefulness. This purpose can be a new function and a historical reference [26]. Both cultural factors relating to preserving cultural heritage and adaptation in response to the historical development of the territory play important roles [27].

These goals are achieved through specialized projects for the revitalization of areas (port and industrial areas [28]), the reconstruction of old buildings near rivers, and the development of embankments. The goal of such projects is to increase the attractiveness of riverine spaces and improve their development and aesthetics, to create new modern spatial and functional communication links, and to develop new activities, such as water tourism, recreation, and water sports. These projects positively affect the quality of life. They create new public spaces that are interesting to people today, make full use of proximity to water (e.g., riverbank boulevards, pedestrian and bicycle paths, gardens, water parks, etc.), build new social relationships with the river, and preserve and protect the resources and recreational value of surface water [29]. These efforts also stimulate residents and involve them in revitalization measures [19].

The process of revitalization must consider these aspects. In addition, the scale and intensity of the measures have to be adapted to the needs of the city. The revitalization of urban riverine areas is influenced by many factors, including the features and size of the city, the size of the river, and the location and role of riverine areas in the urban

spatial and structural frame [26].

The revival of urban riverine areas is increasingly linked to the idea of integrated urban development. In the context of our research, it necessary to pay attention to the ecological aspect of the revival of riverine areas, which deals with restoring polluted waters [30, 31] and degraded shores within the city through their reclamation and cleaning [32], restoring natural balance on land and water, restoring and reducing energy and resource consumption (land restoration) through compact development, and optimizing existing infrastructure facilities.

### 3 Goals and Methods

Proceeding from the established research goal (to identify a set of criteria focused on sustainable development), we collected data on the potential of environmental and infrastructural revitalization of urban embankments in three Russian cities situated along the Oka (Ryazan) and Volga (Nizhny Novgorod and Samara) rivers.

Nizhny Novgorod, Ryazan, and Samara are large and historically significant Russian cities located on major rivers, the Volga and the Oka, which have traditionally played a central role in their spatial structure, economic development, and regional identity. For a long time, rivers determined the economic and functional organization of these cities; however, the development of transport infrastructure, natural constraints, and urban planning concepts aimed at intensive industrialization in the 20th century [33] led to urban expansion and the ecological degradation of many river-adjacent areas. As a result, many riverbank areas became degraded or fragmented. Today, these territories represent key zones where environmental restoration, preservation of historical heritage, and urban development interests intersect, which makes them relevant cases for examining sustainability-oriented approaches to riverfront transformation.

To meet this goal, we used a comprehensive methodological approach combining literature review and an expert survey to study the issue of revitalizing riverine areas and spaces in city centers as a factor in sustainable economic development.

The goal of the study was to summarize the results on specific research questions:

(1) What problems are faced concerning riverine areas and spaces in the studied cities?

(2) What criteria should be considered when designing the sustainable development of riverine areas and territories in the studied cities?

The first stage of our research was the review of literary sources found in citation databases (RSCI, Scopus, WOS). The collected materials were subjected to qualitative analysis to identify existing problems in riverine areas and spaces, as well as the criteria that should be considered when designing the sustainable development of riverine urban areas.

At the next stage, following the set research goal, we attempted to establish the significance of existing problems in urban riverbank areas and spaces and the importance of different criteria that should be considered when designing the sustainable development of these areas. These objectives were fulfilled using an expert survey on a sample of 47 people. The sampling criterion for the expert pool was to have at least three publications in peer-reviewed journals relevant to our research problem or management experience in urban planning in the studied cities [34]. The experts were invited to take part in the study via email. A total of 44 respondents agreed to participate. The selection criteria included at least three peer-reviewed publications relevant to the research topic or practical experience in urban planning and development in the studied cities no less than 10 years. The experts assessed each identified problem using a 10-point scale, where 1 indicated the lowest importance and 10 indicated the highest importance. Based on the obtained scores, average values were calculated and normalized to determine the relative weights of each problem.

The survey collected expert assessments concerning two key aspects:

(1) The most acute problems affecting the development of riverine areas and spaces;

(2) Priority guiding criteria for programs for the sustainable restoration and development of the considered cities.

The agreement of expert opinions was tested with Kendall's coefficient of concordance, which indicated strong consistency ( $W = 0.62$  and  $0.65$ ,  $p < 0.01$ ) in both sections of the survey. These methodological steps ensured the reliability of findings and created the foundation for well-grounded recommendations on the urban planning and sustainable development of the cities.

### 4 Results

**Table 1.** Key problems in riverine territories and urban district spaces

Problem	Rank	Weight
The need to repair and modernize historical urban areas	1	0.22
Industrial facilities with a negative environmental impact	2	0.19
Lack of greenery, open spaces, and parks	3	0.17
A complicated communications infrastructure hindering the consolidation of riverine territories	4	0.15
Lack of urban planning	5	0.14
Commercialization of river embankments	6	0.13

Note: The coefficient of concordance  $W = 0.62$  ( $p < 0.01$ ), indicating a strong consistency of expert opinions. Source: The results of the study and the expert survey.

The expert survey identified six key problems in restoring waterfront territories in Nizhny Novgorod, Ryazan, and Samara (Table 1).

The experts identified six key criteria for managing the sustainable and environmental development of urban river embankments (Table 2).

**Table 2.** Key criteria for managing programs for sustainable urban recovery and development

Sustainability Criterion	Rank	Weight
Improved quality of life and attractiveness to residents and tourists	1	0.27
Preserving cultural heritage	2	0.22
Development of green infrastructure and environmentalism	3	0.17
Focus on eco-friendly construction	4	0.13
Development of infrastructure and communications	4	0.13
Implementation of special programs for businesses to support the territory	5	0.08

Note: The coefficient of concordance  $W = 0.65$  ( $p < 0.01$ ), indicating a strong consistency of expert opinions. Source: The results of the study and the expert survey.

## 5 Discussion

The cross comparison of the results of the experts from Nizhny Novgorod, Ryazan and Samara shows that, despite the differences in size, historic development and functional structure of the waterfront areas, the importance of the identified problems and criteria for sustainable development is almost the same. Deviations can only be found in the extent and strength of the individual problems, e.g., in Samara, the industrial facilities are of greater importance, and for Nizhny Novgorod, the preservation of historical embankments is more important. This coincidence suggests the similar spatial and institutional qualities that have frustrated efforts to regenerate the riverfronts of both cities and merits their consideration within a common analysis.

The revival of riverine urban areas and spaces has become a central theme in contemporary urban planning and the discourse on sustainable development [35]. Projects for the reconstruction of riverine urban areas and spaces often aim to connect environmental restoration with economic impact, relying on interdisciplinary approaches that combine urban design, landscape architecture [13, 36], and historical memory preservation.

In the context of Russia, research highlights issues related to outdated infrastructure, fragmented urban policy, and limited public access to embankments [9, 17]. Recent studies emphasize the need for integrative strategies [37] that prioritize environmental sensitivity [38], the preservation of cultural heritage, and public engagement [26, 39].

Revitalization is also closely linked to the broader frameworks of sustainable development, including UN SDGs, particularly goals 11 (Sustainable cities and communities), 13 (Climate action), and 15 (Life on land). Effective revitalization required determining locally significant criteria, such as green infrastructure, low-emission transportation, adaptive reuse of cultural assets, and improving the quality of life.

The findings confirm the need for a comprehensive approach to revitalizing riverine areas. The expert survey identified the key problems and priority directions of sustainable development with a high consistency of opinions in the professional community. This allows us to argue that the process of environmental and social infrastructure transformation of embankments can focus on long-term change, responding to the needs of the environment, urban residents, and natural ecosystems.

One of the most acute problems, indicated by the experts, was the need to repair and modernize historic urban areas. This points to the high vulnerability of cultural heritage in the context of modern urban development. The restoration and adaptation of historical buildings to new functions should be the foundation of sustainable design in riverbank areas. This approach is particularly critical in Nizhny Novgorod and Samara, where historic buildings have cultural and city-forming significance.

The second most important problem was the environmental impact of industrial facilities located near water. This factor limits the recreational and aesthetic use of these areas and threatens biodiversity and the sanitary condition of water bodies [40, 41]. In this context, particular value is gained by such nature-based solutions as buffer strips, filter plantings, and bioremediation systems [42]. It is important to consider the principles of the circular economy concerning the infrastructure of riverbank industries.

The third group of problems, including the lack of greenery, complicated communications infrastructure, and the shortcomings of urban planning, points to the fact that riverbank zones are often spatially and functionally isolated. Such areas can be incorporated into the urban fabric only through comprehensive work on the landscape frame, green corridors, and a system of bicycle and pedestrian routes coupled with a focus on public transport. Thus, the emphasis shifts from commercial construction to developing public spaces accessible to the public.

Particularly notable is the issue of the commercialization of riverine areas. Despite receiving the lowest rank from experts, it plays a key part in the distortion of priorities in spatial development. The loss of open access, the growing

gentrification, and social stratification relate to unregulated investor activity.

## 6 Policy Implications

The findings of this research may act as a guide for cities and municipalities engaged in coastal redevelopment, as authors identify and rank barriers and drivers. The study also provides a framework for integrated coastal area development policies for large cities with different coastal forms.

They also laid out some criteria which local authorities and planners can use in specifying environmental restoration objectives and social objectives and reconciling them with economic development. These criteria can also be used to review existing projects, prioritize public investment projects, and harmonize planning environmental and cultural heritage policies.

In practical terms, a possible solution is to implement mechanisms to regulate urban planning [43], including zoning, establishing the ratio of public spaces and obligations to create green spaces, and implementing the concepts of the just city [44]. Considering the sustainable development criteria, the experts gave the highest rank to improving the quality of life and the attractiveness of the areas. This result stresses the priority of a human-centered approach to urban planning, focusing on access to green zones, safety, visual and physical connections, leisure, and culture. High importance was also attributed to preserving cultural heritage, which supports the relevance of the contextual approach to redevelopment.

High ratings were given to eco-friendly infrastructure and sustainable construction, which are important aspects of climate change adaptation. These aspects are especially relevant against the backdrop of the intensification of urban heat island effects, pollution, and biodiversity loss. Expert assessments testify to the need to use locally sourced and recycled materials and energy-efficient solutions [45], reducing the share of waterproof coatings, and increasing the role of natural components.

Our discussion confirms that the environmental revitalization of riverine areas requires not only architectural solutions but also a sustainable institutional environment, the engagement of city communities, interdisciplinary design, and support at the state level [46]. These multilayered models will be key to balancing the natural environment, economic interests, and societal needs.

## 7 Conclusions

Having identified both the key problems and priority criteria of sustainability, our study provides a structured foundation for managing embankment reconstruction projects, considering the need to preserve cultural heritage and promote eco-friendly design methods, which ultimately contribute to achieving the principles of sustainable development. However, our study has some limitations due to its exclusive focus on expert opinions without mass surveys of residents in the studied cities.

The ecologically determined revitalization of embankments is closely associated with the global transition to sustainable cities. The criteria and problems put forward in this paper can be used in national policies, municipal planning, and public initiatives, contributing to a sustainable and inclusive approach to the restoration of riverbank zones.

Another limitation of this study is the use of aggregated expert assessments for multiple cities, which does not allow for a detailed city-specific comparison of priorities. Although expert evaluations took into account local geographic and economic contexts, differences between Nizhny Novgorod, Ryazan, and Samara were reflected mainly in the intensity and manifestation of individual problems rather than in the overall hierarchy of sustainability criteria. As a result, the analysis focuses on shared structural challenges characteristic of large riverbank cities. Future research could extend this approach by conducting city-level comparisons or integrating spatial and economic indicators to examine how local context more precisely shapes riverfront development priorities.

## Author Contributions

Conceptualization, G.B. and T.T.; methodology, I.R.; software, D. Stepanova; validation, E.V. and D. Semikin; formal analysis, N.Kh.; investigation, E.K.; resources, T.T.; data curation, I.R.; writing—original draft preparation, G.B., D. Stepanova, and N.Kh; writing—review and editing, E.V. and D. Semikin; visualization, E.K.; supervision, project administration, G.B. All authors have read and agreed to the published version of the manuscript.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare no conflict of interest.

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