Provision of green spaces in urbanized areas of St. Petersburg

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Abstract. The article deals with the mathematical and statistical method for assessing green spaces in urbanized area. The role of green spaces in the sustainable development of urban area. The analysis of the provision of green areas in different administrative districts of St. Petersburg has been carried out. The provision of green spaces in the Admiralteysky district and its municipalities has been analysed in detail. In the future, the authors will continue to work to find criteria for assessing the condition of the urban environment. Based on the data obtained conclusions are made about the current system of assessing the quality of urban areas.

1. Introduction

The term “urbanization” plays a significant role in the current stage of world economic development. According to UN assumptions, about 68% of the world's population will live in cities by 2050 [1]. It is obvious that along with the growth of the urban population the importance of measures to preserve local ecosystems as one of the aspects of favorable conditions of life increases [2-4]. Activities carried out to improve the quality of life in cities, reduce and neutralize the negative effects of economic activity on the environment are united by the concept of “sustainable development of the territory”.

Sustainable development of the territory involves the creation of an urban environment that combines all the infrastructure safely and conveniently for citizens: transport, social, engineering, tourism, etc. One of the most important tasks of territory development is the availability of quality urban environment for all categories of citizens [5]. Particular attention in the planning of urbanized areas is paid to landscaping, including "green" infrastructure [6].

Sustainable development today is a multidimensional system, combining both planning, ecology, economy, social environment, and climatic and energy conditions of the territory [7]. At the same time, green spaces play a significant role in urban ecology [8, 9]. The ecological significance of green spaces lies in helping to conserve biodiversity, mitigate the effects of air pollution [10]. In addition to ecological functions, green spaces, affecting the value of real estate, also perform aesthetic, social and psychological functions, provide places for recreation of the population [11].

A large number of scientific works are devoted to green spaces. The issues of species biodiversity, planning and development of green spaces have been addressed in the works of such foreign scientists as Christiane Naaland [4], Cecil Konijnendijk van den Bosch [4, 12, 13], Peter MGroffman [14], as well as domestic ones: Kovyazin V F, Skachkova M E [15, 16], Prokopenko VV [17], Fedorova N B [18].
Today, special indicators - indicators of sustainable development of the territory - can be used to argue the feasibility and assess the consequences of decisions in the field of urban planning and spatial planning [19]. Indicators, each of which reflects a specific aspect of sustainable development, serve as the basis for the generation of an index - a general indicator that allows to judge the quality of urbanized areas, and on the basis of which it is possible to develop recommendations to improve the urban environment [7, 20, 21]. Specialists all over the world refer to various indicators: the level of air and water pollution, the availability and development of public transport, the impact of household waste on the environment, the quality of living conditions of citizens, the development of various urban infrastructures, the level of landscape management and maintenance, as well as the quality of landscape management and maintenance [7, 2, 3, 22].

In the Russian Federation, one of the tools for objective assessment of cities is an index of the quality of the urban environment [23], developed in 2019 in order to implement the provisions of the Presidential Decree "On the national goals and strategic objectives of the development of the Russian Federation for the period up to 2024" [24]. Within the framework of the methodology of forming an index of the quality of urban environment, 6 types of urban spaces are taken into account, each of which is evaluated according to 6 criteria: safety, comfort, environmental friendliness, diversity, modernity and efficiency of territory management (figure 1).

![Diagram](image1.png)

**Figure 1.** Urban spaces and their assessment criteria.

Thus, the index is calculated on the basis of 36 indicators, which, in turn, allows a comprehensive assessment of the level of comfort of living in an urbanized area [25]. Some of the indicators that make up the index, reflect in quantitative form the state of the green areas of the city. According to this indicator, it is possible to judge the situation in the city as a whole.

### 2. Methods and Materials

This paper analyzes the current state of the territories of St. Petersburg, occupied by public green spaces. The territories of municipal districts within the Admiralteysky district of St. Petersburg were chosen as the objects of the study.

Public greenery spaces (PGS) are publicly accessible territories intended for recreation of citizens: parks, gardens, boulevards, squares. The total area of PGS in St. Petersburg as of January 2020 amounted to more than 7500 hectares [26]. The Admiralteysky district is one of the districts with the smallest area of PGS (figure 2), which at the same time is one of the smallest by area (1381.92 ha) and the most densely populated districts [26]. Despite a high population density, there are about 6.9 sq. m of greenery per 1 inhabitant of the district, with a minimum standard of 6 sq. m/person [27].

Analyzing figure 2, we can conclude that in a number of built-up central districts of St. Petersburg (Central, Petrogradsky, Admiralteysky, Vasileostrovsky), due to the buildings density, narrowness of space occupied by streets and sidewalks, the traditional landscape management and maintenance of adjacent areas is limited. With proper adaptation, it is possible to take advantage of the experience of...
old European cities regarding the so-called vertical landscaping, using ampelous plants and other solutions that combine elements of landscape architecture [28].

| Municipal districts | The area of the urban PGS, ha | The area of PGS of local importance, ha | The total area of PGS, ha | District area, ha | Population, person |
|---------------------|-------------------------------|----------------------------------------|--------------------------|------------------|-------------------|
| Kolomna             | 6.75                          | 2.95                                   | 9.70                     | 249.9            | 39306             |
| Sennoi              | 5.14                          | 0.98                                   | 6.12                     | 109.8            | 22394             |
| Admiralteysky       | 17.03                         | 0.71                                   | 17.74                    | 209.46           | 23084             |
| Semenovsky          | 17.61                         | 2.53                                   | 20.14                    | 164.68           | 23667             |
| Izmaylovsky         | 7.41                          | 3.19                                   | 10.60                    | 318.82           | 26732             |
| Yekateringofskoye   | 42.54                         | 3.92                                   | 46.46                    | 329.26           | 24612             |
| **Total for the district** | **96.48**                   | **14.28**                              | **110.77**               | **1381.92**      | **159795**        |

At the next stage, based on current regional legislation [27], a list of green spaces on the territory of the Admiralteysky District was formed, a fragment of which is shown in table 2.

| The registry number of PGS | Name, location of PGS | Area, ha |
|---------------------------|-----------------------|----------|
| 1013                      | Alexeevsky garden between Pisareva Street and 2 Angliysky Ave. | 1.12     |
| 1014                      | Pokrovsky Square on Turgenev Square | 1.55     |
| 1016                      | Kalinka Square on Repina Square | 0.37     |
| 1036                      | Voskresensky Square on Kulbin Square | 0.71     |
| 1038                      | Yelena Obraztsova Square at the intersection of Pisareva Street and Dekabristov Street | 0.20     |

Using methods of mathematical and statistical analysis, the following indicators were determined:
1. The area of public green spaces per person within the administrative district of an urbanized area (1):

$$\text{APGS} = \frac{S_{\text{PGS}}}{N}.$$  \hspace{1cm} (1)

where, $S_{\text{PGS}}$ - approximate area of green spaces within the boundaries of the administrative district, sq.m.; $N$ - population of the district, people; APGS - area of public green spaces per resident of the district, sq.m.

2. Percentage indicator of the level of greening of the territory (2):

$$\text{IG} = \frac{S_{\text{PGS}}}{S_{\text{da}}}.$$  \hspace{1cm} (2)

where $S_{\text{PGS}}$ - area of green spaces within the boundaries of the administrative district, sq.m.; $S_{\text{da}}$ - area of the administrative district, sq.m., IG - an indicator of the level of greening of the district, %.

3. Results and Discussion

The urbanized territory of Saint Petersburg is divided into almost two dozen administrative districts, each of which differs significantly in the availability of green spaces. The same pattern holds true for the municipalities of the city. For example, consider the Admiralteysky district. The district consists of six municipal districts, each of which has a different area of green spaces (figure 3).

Figure 3 shows that almost half of the area of the Admiralteysky District PGS is in the Yekaterinhof District, and the largest site of greenery is located there - the only park in the district, Yekaterinhof Park, which occupies 14% of the territory of the municipal district.

The least greened districts, in terms of PGS area, are Kolomna, Sennoi District, and Izmaylovskoye. The area of PGS in these territories occupies less than 10% of the total area of the district. Taking into account the population size in the administrative-territorial units under consideration, a graph illustrating the differences in the provision of citizens was constructed with PGS (figure 4).
As in the case of the total area of PGS, Kolomna District, Izmailovskoe and Sennoi District are the least favorable in terms of the area of green areas per citizen: the provision of green areas in these territories is significantly lower than the normative for the area under consideration. Green areas need a certain area for growing. Only in these conditions, they can effectively perform their functions: absorb carbon dioxide and release oxygen, retain dust and humidify the air, emit phytoncides and deliver aesthetic pleasure to the person [28]. But in a modern city with a high density of buildings it is difficult (figure 5).

For example, in the Izmailovsky district a significant part of the territory is occupied by objects of the railway transport system - the station tracks of St. Petersburg - Baltiysky station, the section of the railroad "Varshavsky station-M.Mitrofanovskaya street", within the limits of the right of way of which it is not allowed to place objects of greenery that impair the visibility of the railroad track.
For urbanized areas we propose to calculate an index of urban environment quality, taking into account the indicators of landscaping of the territory. As indicators of the quality of landscaping we consider it necessary to consider the following indicators: the proportion of green areas to the total area of the district, the condition and attractiveness of green spaces. It has been established that green areas are important for the sustainable development of urbanized area, as well as have a positive impact on the well-being, health and longevity of citizens [2-4]. However, the index of the quality of the urban environment takes into account only quantitative indicators of green spaces. And to assess the attractiveness of the green space, the number of photo publications in social networks is taken into account, but the opinion of citizens on the quality of a green space and the level of management and maintenance is not taken into account.

Some researchers (Martin MwirigiM'Ikiugu, IsamiKinoshita, YoritakaTashiro) [29] consider such factors as the shape of the landscape, diversity and forms of landscape elements in the integrated assessment of urbanized areas. The studies use remote sensing data (RSD) to form conclusions about the density of green spaces, their spatial position relative to built-up areas [29, 30]. Opinion on the impact of various forms of managing green spaces on the well-being and health of citizens is recommended to be taken into account by means of the expert method [31]. Only recently, scientists have drawn their attention to how the inhabitants of megacities perceive life in the urban environment and how they relate to green spaces[4].

4. Conclusion
According to the results of studies, we can conclude that, to assess the quality of the urbanized environment in megacities, the area of green spaces per inhabitant should be used as a criterion. Interest in the quality of green spaces in urbanized areas is increasing among the scientific community, regional and local authorities.

For the Admiralteysky district of St. Petersburg, the smallest in area and densely populated, the degree of landscaping of the territory meets the standards, but in the context of the municipal districts it was found that in three administrative-territorial units the indicator under consideration is much lower than the requirements of urban planning.

St. Petersburg is the largest metropolis in North-West Russia, to assess the index of urban environment quality cannot be limited only to the standard area of green spaces, you need additional comprehensive criteria, the search for which the authors are currently engaged.

The results are the basis for further analysis and comprehensive assessment of urbanized areas. In the future, we will propose new indicators for taking into account the qualitative and quantitative indicators of green spaces, which will allow to more accurately calculate the index of urban environment quality, both for St. Petersburg as a whole - a city of federal importance, and for individual administrative-territorial units - municipal districts. Justification of environmental quality indicators is the subject of our further research.

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