Methodology for assessing quality of urban park functional zoning by factors affecting park environment comfortability

R V Silin¹, V F Kasyanov²

¹Department for Professional Competencies Development within the Institute of Continuing Education, Inter-State Educational Institution of Higher Education Belarusian-Russian University, 43, Prospect Mira, Mogilev 212033, Belarus
²Housing and Utility Complex Department, National Research Moscow State University of Civil Engineering, 26, Yaroslavskoye Shosse, Moscow 129337, Russia

E-mail: silinruslan@gmail.com

Abstract. The decision made by the architect on the location of recreational areas on the park layout can subsequently have a significant impact on people’s comfort and is one of the conditions for the high level of park attendance and visitor satisfaction. However, since each factor affecting comfortability of the environment manifests differently in different parts of the park, it is quite difficult to take into account and not leave out every factor affecting comfort at the design phase. The aim of this study is to develop a methodology that can be used for quantitative assessment of the quality of functional zoning in existing urban parks, to provide a more complete account of sanitation and hygiene, ergonomic, morphological and natural factors affecting the park environment comfortability. This goal is achieved by building planograms which reflect the impact of each factor on the park grounds and their subsequent summation in accordance with the requirements for location of each functional zone of the park set by the designer. The methodology proposed in this paper was used to assess the quality of the existing functional zoning in the Lida town park.

1. Introduction

Today, multifunctional urban parks can be found in every town or city of Belarus. These objects were created during the USSR period and according to architectural concepts influenced by the state ideology. The change in the country’s model of economic development that occurred after the collapse of the Soviet bloc changed the views of residents on recreational conditions and required that the park design concepts be adjusted. Unfortunately, the short period of total commercialization of all aspects of life of the society had an adverse impact on planning structure of urban parks. The reduction in park area due to residential development or the placement of various shopping facilities in park areas further hindered the use of parks as places for recreation and sources of environmental benefits. All these negative social phenomena, together with natural processes of physical aging and obsolescence of the park infrastructure, inevitably reduced the comfort of the urban recreational environment. All these circumstances along with other reasons caused the Council of Ministers of the Republic of Belarus to develop and approve regulations on general improvement of the territory and landscaping [1] in 2015, to adopt the Comfortable Housing and Favourable Environment State Programme [2] in 2016 and the National Strategy for Sustainable Social and Economic Development of the Republic of Belarus for the period until 2030 [3] in 2017. All these efforts of the civil society of Belarus comply with the basic principles of the European Spatial Development Perspective [4].
2. The research problem and purpose statement
At present, some parks in Belarusian towns and cities do not meet the needs of residents for comfortable recreation. One of the reasons for this is spontaneous functional zoning in urban parks, which adversely affects visitors’ comfort. A number of programs aimed at improving the urban environment, which are already in process of implementation as well as those to be implemented at the national and local levels, open up the possibility of financing the development of new master plans for the parks and their subsequent reconstruction. As a result, in the coming years there will be an opportunity to turn the urban parks of Belarus into really comfortable places for people’s recreation. In this regard, it becomes important to find new planning approaches that will comprehensively take into account various factors affecting the park environment comfortability.

Our approach to finding the best places for recreational areas in parks is based on the understanding of the fact that, in addition to the factors determined by the architect’s conception and evoking the expected aesthetic responses in park visitors (we called them qualitative factors), when carrying out park zoning, the designer takes into account a number of factors that affect the physical comfort of park visitors and can be quantified. These are ergonomic, sanitation and hygiene, geomorphological factors as well as the factor of presence of natural objects in the park. Therefore, the present study was aimed at developing a methodology that would help divide park grounds into areas with different levels of comfortability for different activities practised by park visitors: quiet recreation, active recreation, public events, children’s activities. This methodology can help assess the quality of the existing park zoning and can be used in the development of new master plans for parks to be reconstructed. In this study we used planograms as a tool for developing the methodology. Planograms are often used in planning and design or in urban management to track changes in the level of manifestation of a factor in the area under consideration [5-8].

3. Study
To achieve the aim of the study, a number of objectives were set. The first objective was to find criteria for assessing the quality of functional park zoning that can ensure the park environment comfortability. For this purpose, an analysis of literary sources was performed and the recommendations on zoning that were most often taken into account when designing parks were selected as criteria (table 1) [9-14].

As can be seen from table 1, the set of criteria that influence the location of functional zones is determined by the processes occurring in them and can be unique for each area. The given set of criteria is definitely very approximate and is subject to change depending on the activities practised in the park, the architectural concept, the terrain features, natural objects available in the park, the position of the park relative to surrounding urban buildings and utility facilities, etc.

The second objective of the study was to create planograms depicting the impact of the factors on the park selected for the study. The park of the town of Lida was chosen as an object of the study. A satellite image of this park was derived from Google Earth Pro. Then it was inserted as a sheet background in Microsoft Excel environment of the Microsoft Office software product. The cells of the table superimposed on the satellite image were filled with numbers indicating the level of impact of the factor on each “square” of the park. The side of the square corresponded to 15 meters on the scale of the satellite image. The impact assessment was performed using a 5-point scale. When assessing the negative impact of the main streets on the park, published research findings of other authors [15], as well as the information provided in the methodological recommendations for improving urban areas of Belarus and Russia [16-18], were taken into account.

As a result of this stage of the study, a description of the impact of each factor on the park using the planograms shown in table 2 was obtained. As seen from the table, each planogram obtained has an array of data which is a mathematical two-dimensional nonzero matrix (formula 1).

Table 1. Criteria for assessing the quality of functional park zoning.
| Park recreation area | Factor affecting the park grounds | Criterion (recommendations on location of park recreational areas) | Matrix No. |
|---------------------|----------------------------------|---------------------------------------------------------------|------------|
| Quiet recreation area (walking area) | Sanitation and hygiene factor | Protection from sources of discomfort (main streets) +K1 | |
| | Factor of natural object proximity | Location in direct contact with natural objects (plants and ponds) +K2 | |
| | Ergonomic factors | Remoteness from recreational areas, entertainment areas and from areas with the most intensive pedestrian traffic (park entrances) -K3 | |
| | | Remoteness from park support facilities -K4 | |
| Active recreation area (sports, physical education, picnics) | Geomorphological factor | Flat terrain of the park section +K5 | |
| | Ergonomic factors | Lack of natural objects or their small numbers -K2 | |
| | | Lack of support facilities -K4 | |
| Area for entertainment and public events | Geomorphological factor | Flat terrain of the park section +K5 | |
| | Ergonomic factors | Proximity to park entrances +K3 | |
| | | Lack of natural objects or their small numbers -K2 | |
| | | Lack of support facilities -K4 | |
| Children’s area | Geomorphological factor | Flat terrain of the park section +K5 | |
| | Ergonomic factors | Proximity to park entrances +K3 | |
| | | Lack of support facilities -K4 | 

$$K_j = \sum_{i=1}^{n} K_i = a_{i1} a_{i2} \ldots a_{im} + b_{i1} b_{i2} \ldots b_{im} + d_{i1} d_{i2} \ldots d_{im}$$

Since all matrices describing the impact of various factors on the park have equal dimensions, i.e. have the same number of columns and the same number of rows, mathematical operations of summation can be performed according to formula 2. This is important for the next step in the development of the methodology.

$$K_j = a_{i1} a_{i2} \ldots a_{im} + b_{i1} b_{i2} \ldots b_{im} + d_{i1} d_{i2} \ldots d_{im}$$

Table 2. Planograms and impact matrices determining the environment comfortability in Lida park.
| Description of planograms | Park area satellite image with planograms and matrices |
|---------------------------|-------------------------------------------------------|
| 1                         | 2                                                     |

A satellite image of the Lida park area divided into grid squares of 15x15m

Planogram of protection of the park from noise impact of the main streets and the corresponding matrix K1

Planogram of distribution of natural objects in the park and the corresponding matrix K2

Continuation of table 2
The third objective of the study was to create planograms of the impact of a set of factors determining the comfortability of the environment in each recreational area of the park. This problem was solved by adding the matrices corresponding to the planograms of the impact of factors on the park grounds. To find park sections with the environment most comfortable for allocating a specific recreational area, the matrices that describe the distribution of the factors identified as important for the recreational area visitors’ comfort over the park grounds were added (according to the list in column 4 of table 1).

For example, the resulting matrix for creating a planogram depicting the park favourability for location of a quiet recreation area (table 3) was obtained by adding the matrices:

$$K_1 + K_2 - K_3 - K_4 = K_{QRA}$$  \hspace{1cm} (3)
where $K_1$ is the matrix describing the planogram of the park protection; $K_2$ is the matrix describing the planogram of natural object location; $K_3$ is the matrix describing the planogram of the area proximity to the park entrances; $K_4$ is the matrix describing the planogram of location of the park support facilities; $K_{QRA}$ is the resulting matrix describing the planogram of the favourability of the park grounds for location of a quiet recreation area.

Matrices $K_3$ and $K_4$ in formula (3) are taken with a negative sign, because sections located most remotely from the park entrances and support facilities are preferred for a quiet recreation area. In this case, the value of the element of the resulting matrix equal to $5 + 5 - 0 = 10$ points corresponds to the most favorable conditions. The value of $0 + 0 - 5 = -10$ points corresponds to the least favorable conditions.

The created planograms and resulting matrices for assessing the favourability of the Lida park for location of recreational areas are shown in table 3.

**Table 3.** Planograms and matrices describing the favourability of the Lida park for location of recreational areas.

| Description of planogram (matrix) | Planograms (matrices) obtained from calculations |
|-----------------------------------|-----------------------------------------------|
|                                   | ![Planograms](image)                           |
| The resulting matrix $K_{QRA}$ and the planogram of the park favourability for location of the quiet recreation area | ![Planograms](image)                           |
| The resulting matrix $K_{ARA}$ and the planogram of the park favourability for location of the active recreation area | ![Planograms](image)                           |

Continuation of table 3.
The resulting matrix $KEPEA$ and the planogram of the park favourability for location of the entertainment and public event area

The resulting matrix $K_{ChPA}$ and the planogram of the park favourability for location of the children’s play area

The last objective of the research was to assess the quality of the Lida park zoning. For these purposes, the existing functional zoning scheme of the park was superimposed alternately on each of the planograms of the park favourability for each type of recreational activity (shown in table 3). The planograms were created at the same scale. The number of squares within the boundaries of the functional zone under assessment as well as the sum of the assessment values of these squares and the maximum possible assessment value the square on the planogram can obtain were calculated. By summing the assessment values of all the squares confined within the functional zone (on the corresponding planogram), a point-based absolute assessment of the location of each zone in the park layout plan was obtained. The product of the number of these squares and the maximum possible assessment value of one square determined the maximum possible assessment value for the quality of location of each functional zone. And the relative value characterizing the quality of location of each functional zone in the park layout plan, expressed as a percentage, was obtained from the ratio of the absolute assessment to the maximum possible assessment. The calculation was carried out according to the formula (4):

$$A_j = \frac{\sum_{i=1}^{n} a_i}{n \cdot a_{\text{max}}} \times 100\%$$  \hspace{1cm} (4)

where $a_i$ is the absolute assessment value of the $i$-th square on the planogram;

$a_{\text{max}}$ is the maximum possible absolute assessment value of the $i$-th square on the planogram;

$n$ is the number of squares of the planogram within the boundaries of the functional zone;

$A_j$ is the relative assessment value of the location of the $j$-th functional zone on the park layout plan according to the comfortability factors.
The obtained relative assessments of the park zoning quality range from 0% to 100% (shown in table 4). The assessment of the location of the active recreation area was not made, as such a zone is not provided in the park. The location of the children’s area in the park layout plan received the highest assessment value of 78.33%, as the existing location of this zone in the park is close to the \( K_{\text{CSPA}} \) recommended in the planogram.

Table 4. Quality assessment of Lida park recreational area location.

| Park recreational area | Quiet recreation area (walking area) | Active recreation area (sports, physical education, picnics) | Entertainment and public event area | Children’s play area |
|------------------------|--------------------------------------|-------------------------------------------------|----------------------------------|---------------------|
| Relative assessment of the quality of the zone on the park layout plan, % | 27.00% | - | 39.02% | 78.33% |

4. Conclusion
The proposed methodology for assessing the functional zoning quality of existing parks by creating planograms of the impact of factors determining comfortability of the park environment contributes to making more reasonable design decisions and can be used at the pre-design phase when developing architectural and planning concepts for parks, as well as an integral part of multicriteria methodologies for a comprehensive assessment of the park environment comfortability for visitors [19,20].

References
[1] Resolution of the Council of Ministers of the Republic of Belarus No. 428 of 21.05.2015 On general improvement of the territory and landscaping National Legal Internet Portal of the Republic of Belarus. http://www.pravo.by/
[2] The Decree of the President of the Republic of Belarus No 334 of 05.09.2016 The main directions of the state urban development policy of the Republic of Belarus for 2016–2020 National legal Internet portal of the Republic of Belarus. http://www.pravo.by/
[3] National Strategy for Sustainable Social and Economic Development of the Republic of Belarus for the period until 2030. Approved Minutes of Meeting of the Presidium of the Council of Ministers of the Republic of Belarus dated May 2, 2017 No. 10 Ministry of Economy of the Republic of Belarus June 17, 2020. http://www.economy.gov.by/uploads/files/NSUR2030/Natsionalnaja-strategija-ustoichivogo-sotsialno-ekonomicheskogo-razvitija-Respubliki-Belarus-na-period-do-2030-goda.pdf.
[4] The European Spatial Development Perspective (ESDP): The Council of Europe Conference of Ministers responsible for Regional Planning May 1999. Electronic fund of legal and regulatory and technical documentation. http://europa.eu.int
[5] Merlin P 1977 City. Quantitative methods of study (Moscow: Progress) p 262
[6] Krogius V R, Ebbot D, Pollit K et al 1988 Hillside Urban Planning (Moscow: Stoyizdat) p 328
[7] Sosnovskiy V A, Rusakova N S 2006 Applied Methods of Urban Research (Moscow: Architecture-S) p 112
[8] Sosnovskiy V A 1988 Urban Planning (Moscow: Vysshaya Shkola) p 104
[9] Rudenko I N, Elenskaya N A, Aleksandrov S B et al 1980 Park Design Guide (Minsk: Belarusian State Research and Design Institute of Urban Planning) p 140
[10] Vergunov A P 1982 Large City Architecture and Landscaping (Leningrad department: Stroyizdat) p 134
[11] Gostev V F, Yuskevich N N 1991 Design of Gardens and Parks (Moscow: Stroyizdat) p 340
[12] Bogovaya I O, Teodoronskiy V S 2012 Residential Area Landscaping (St. Petersburg: Lan publishing house) p 240
[13] Belousov V N 1978 Urban Development (Moscow: Stroyizdat) p 367
[14] Lunts L B 1974 *Urban Green Development* (Moscow: Stroyizdat) p 289

[15] Gorodkov A V 2000 Environmental protection and landscaping and its impact on ecological state of large cities in central Russia Thesis for Doctor of Agricultural Sciences 03.00.16 (Bryansk) p 404

[16] Requirements for improvement and maintenance of residential areas Approved by Resolution of the Council of Ministers of the Republic of Belarus on November 28, 2012 No 1087 (ConsultantPlus: legal reference system)

[17] Residential area landscaping requirements Design Guidelines Ministry of Architecture and Construction of the Republic of Belarus Order of the Ministry of Construction and Architecture of the Republic of Belarus of May 1, 2016 No. 101 Retrieved May 16, 2020. http://www.mas.by/ru/prikazy/

[18] On Approval of Methodological Guidelines for Development of Norms and Requirements for Improvement of Municipal Formations Order of the Ministry of Regional Development of the Russian Federation of December 27, 2011 No 613 (as amended on March 17, 2014) (ConsultantPlus: legal reference system)

[19] Silin R V, Kasyanov V F 2018 Development of methodology for assessing urban park quality in the context of ensuring sustainable development of urban settlements *Bulletin of Belgorod State Technological University named after Shukhov* 6 57–64

[20] Kasyanov V F, Silin R V 2019 Method for multi-criteria evaluation of urban parks *IOP Conf. Series: Materials Science and Engineering* 687 055040