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Assessment of the quality of the urban environment in the process of construction project management

Fomichev A.N.* [1,2]

[1] Moscow Financial and Industrial University Synergy, Russia,
[2] Kaluga Branch of the Russian Academy of National Economy and Public Administration, Russia.

Abstract. Recently, the construction of residential buildings in the Russian Federation has been carried out at an accelerating pace, not only in large cities, but in almost all regions of our country. In the current conditions, the issues of rational planning of residential development within the framework of urban construction development are becoming increasingly relevant. At the same time, an important role is assigned to the methods of assessing the quality of such planning. The analysis of the available methods of this kind carried out by the author indicates that at the moment, there are practically no adequate and objective methods for quantifying the degree of accessibility of critical social infrastructure facilities of the city in relation to newly constructed or already existing residential buildings.

Based on the results of the applied research carried out within the framework of writing the presented scientific work, the author proposed an innovative method for quantifying the degree of accessibility of socially significant urban objects relative to residential structures. The proposed methodology is unique in that, thanks to the use of such a universal and statistically accessible indicator as the average level of wages, experts have the opportunity to conduct a comparative assessment of the degree of accessibility of social objects, not only located within a walking distance, but also at longer distances, involving the use of public passenger transport.

The application of the methodology proposed in the framework of writing this applied scientific work for assessing the quality of the urban environment for the accessibility of socially significant infrastructure objects relative to the location of residential buildings will allow, on a mathematically accurate quantitative basis, not only to assess the effectiveness of the work of regional state authorities and local self-government as qualitatively and objectively as possible, but also to conduct a comparative analysis of the quality layouts of newly designed residential neighborhoods. In addition, this technique may be of practical interest to realtors and developers in the development and practical implementation of various types of business processes, both in the field of housing construction and in the sale of residential buildings and premises.

Keywords: urban construction, urban environment, urban environment quality, social facilities, accessibility of social facilities, residential development layout

*Corresponding author E-mail: san2005a1@yandex.ru

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1. INTRODUCTION

To date, both the Government of the Russian Federation and regional public authorities pay close attention to the development of the housing and communal sector in general and the construction of new residential neighborhoods, in particular. At the same time, not only the aspects of the cost (price) and quality (reliability and durability) of the erected structures and facilities, but also the problems of optimal planning of newly created residential agglomerations are highly topical [1, 2, 3]. It is no coincidence that nowadays, not only in the capital city of our Motherland, but practically in all its regions, the issues of not only comfortable living in new houses, but also aspects of accessibility for residents of new neighborhoods of key infrastructure facilities, such as food and commodity stores, consumer service organizations, as well as medical, pre-school and educational institutions, are becoming increasingly relevant [4, 5, 6, 7]. The most striking example in this regard is the principle of walking distance, implemented in the process of designing and building new neighborhoods not only in Moscow, but also in other well-known megacities of the world [8].

In the light of the above, the subject of applied research on optimization of planning rationalization processes in the design and construction of new residential neighborhoods seems relevant and timely.

The main aim of the research conducted in this paper is to develop an author's methodology for quantitative assessment of the degree of accessibility of infrastructure facilities relative to residential buildings and structures.

In accordance with the content of the set aim, the following main tasks are solved in the work:

1. To study, summarize and systematize the theoretical materials available in the currently relevant works of domestic and foreign authors concerning the issue under study.
2. To diagnose and analyze key problematic issues related to the implementation of quantitative assessment of the degree of accessibility of infrastructure facilities relative to residential buildings within the designed, under construction or already commissioned neighborhoods.
3. To develop the author's proposals on the methodology of quantitative assessment of the degree of accessibility of infrastructure facilities relative to residential buildings.

2. METHODS AND MATERIALS

In the process of conducting the applied research described in the presented work, the author used such methods as the method of statistical observation, analysis and synthesis, calculation method, as well as methods of historical-urban research and generalization.

Megacities of the Russian Federation, such as Moscow [9], St. Petersburg [10], Pyatigorsk [11], Novosibirsk, Khabarovsk, Vladivostok, etc., as well as a number of foreign cities [12], were chosen as the object of the study. The subject of the study is the methodology for assessing the quality of urban environment in the field of accessibility for the population of critical social facilities of urban infrastructure.

The works of domestic [13, 14, 15] and foreign [16, 17, 18] authors concerning the issue under study were used as theoretical materials of the study. The factual basis of the study was formed by statistical data characterizing the practice of application of methods for assessing the quality of urban environment in the leading megacities of the Russian Federation.

3. RESULTS AND DISCUSSION

Over the last few decades, there has been a steady trend of urban population growth. The retrospective dynamics of this process combined with a forward-looking forecast is represented by the diagram shown in Fig. 1.

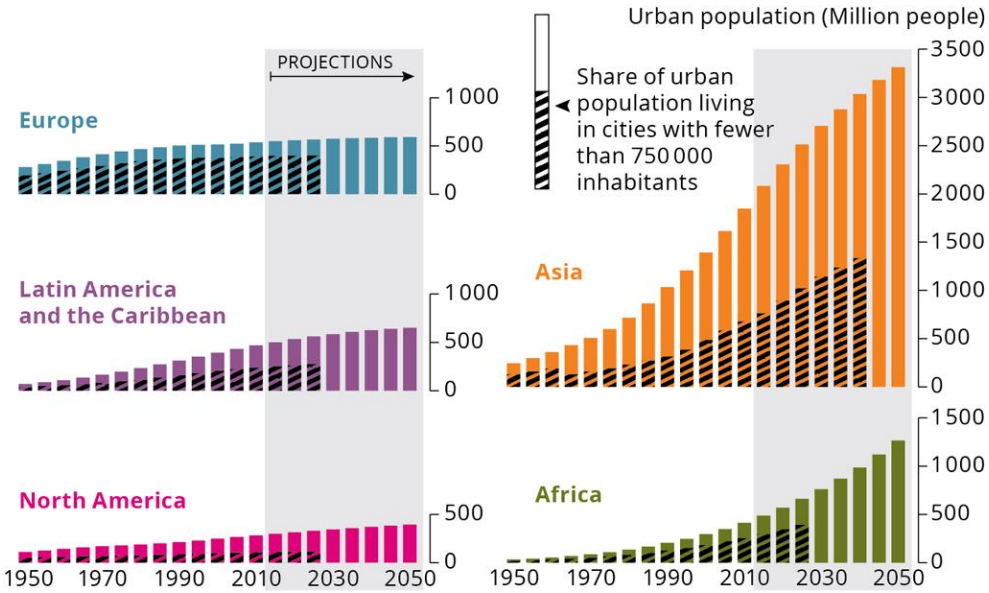

Fig. 1. Dynamics of the urban population [32].

The increase in urban population inevitably leads to an increase in the rate of housing construction (see Fig. 2).

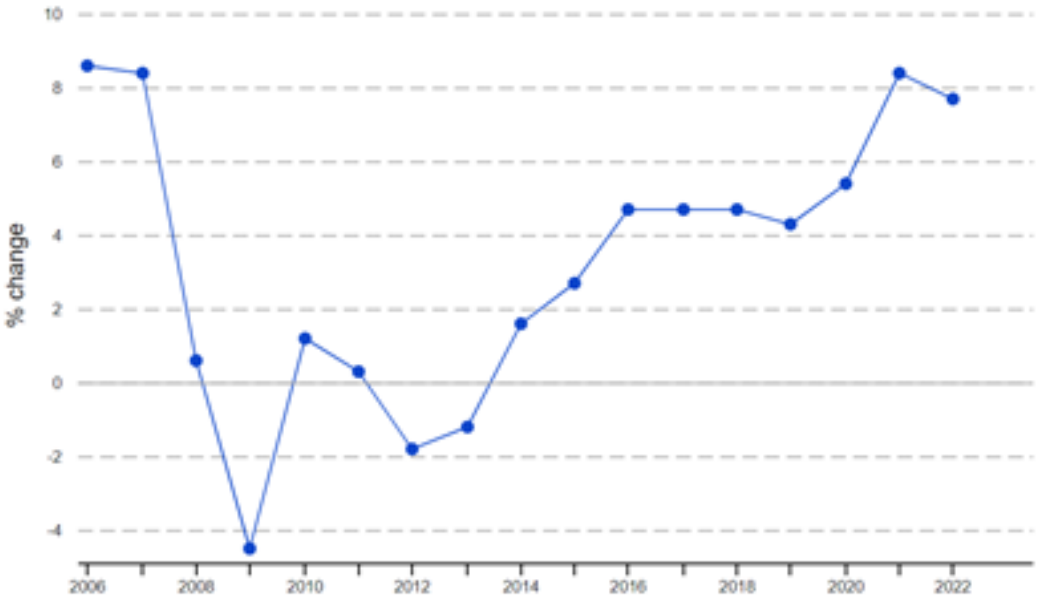

Fig. 2. Growth rates of housing construction [31].

The described changes cannot but affect the dynamics of the use of the urban development area, the features of which are presented in Fig. 3.

As it can be seen from the content of the presented diagram, there is a steadily growing trend in the share of residential neighborhoods in the total area of urban development. This fact, in turn, necessitates the development and implementation of innovative approaches to the design of urban residential development. Thus, the role of methods of objective quantitative assessment of the quality of such design is significantly increasing. Moreover, the development and implementation of such methods should be carried out on a comprehensive, systematic basis, covering the whole range of aspects and factors affecting the quality and comfort of urban housing environment.

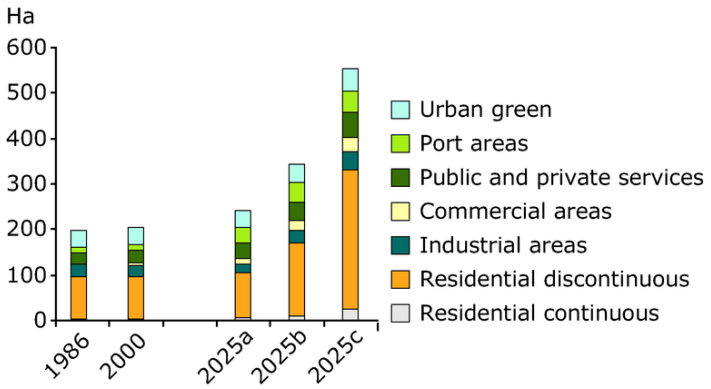

Fig. 3. Redistribution of urban space areas [29].

Consequently, in the current conditions of urban development, the need to develop a universal and objective methodology for quantitative assessment of the degree of accessibility of social infrastructure elements becomes more and more important.

At first glance, there should be no problems in this regard. After all, there are many developments in this area, both domestic and foreign experts offering their own author's methods or innovative approaches to solving applied problems in the field of assessing the quality of urban housing environment in modern socio-economic conditions.

As an example, we give the methodology of Fang X., Shi X., Phillips T.K., Du P., Gao W. presented in Fig. 4. Without question, the undoubted advantage of this methodology is its comprehensive nature. It includes not only a detailed description of each of the key stages of urban environment quality assessment, but also a thorough analysis of critical factors investigated within each of the stages.

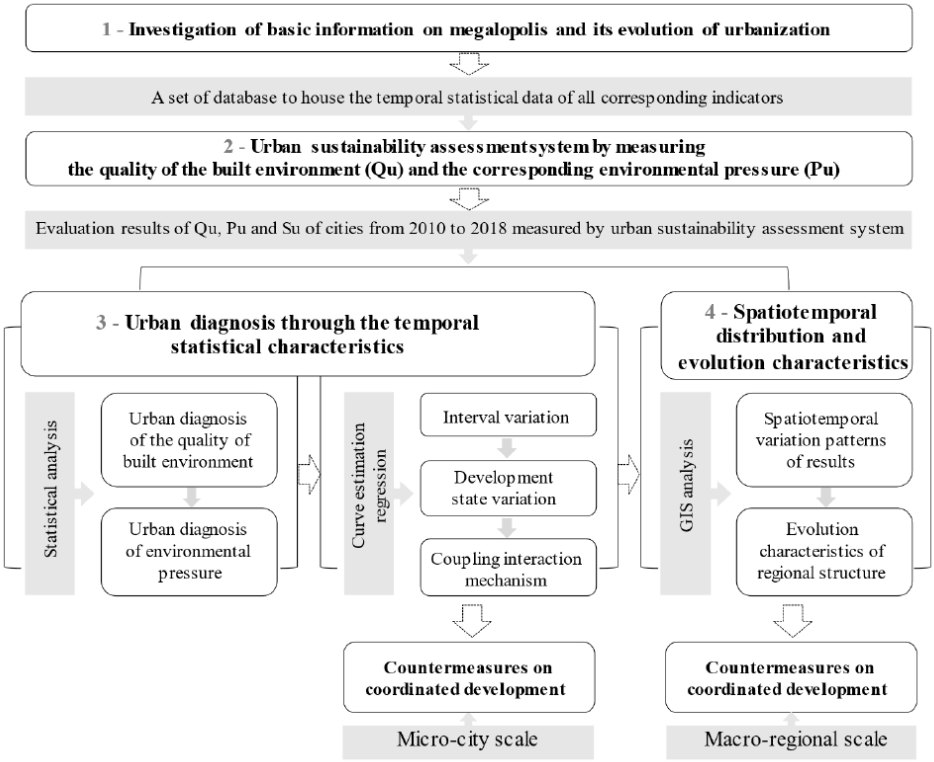

Fig. 4. Workflow of research on spatial and temporal variation characteristics of urban sustainability [1].

In addition, the methodology for assessing the quality of urban environment of Azeez S.A., Mustafa F.A., Ahmed R.M., shown in Fig. 5, is also of interest.

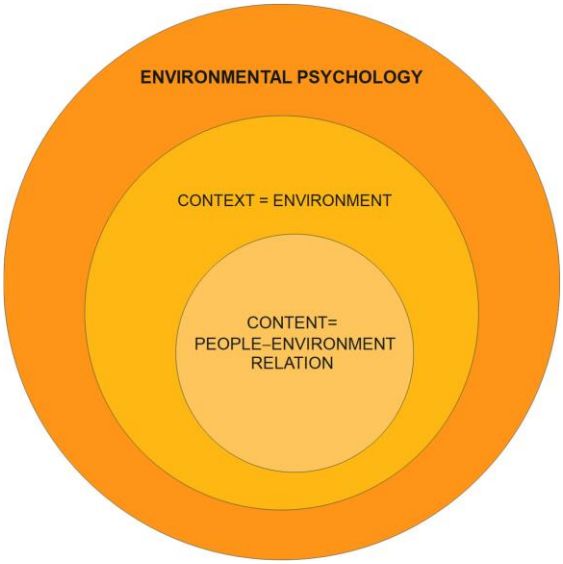

Fig. 5. Model for assessing environmental parameters of the urban environment [7].

On the surface, the validity of applying a simple method of time costs can be seen. This method should be based on the principle of inverse correlation between the time costs of getting to the key elements of social infrastructure and the degree of comfort of the urban environment of a particular neighborhood or a separate residential building. In other words, the more time it takes a citizen to get from his residential building to the necessary elements of the urban social infrastructure, the lower the index of comfort of living in this neighborhood. And, accordingly, vice versa.

It is not by chance that the annex to the Decree of the President of the Russian Federation No. 68 dated 04.02.2021 "On the assessment of the effectiveness of senior officials (heads of senior executive bodies of state power) of the subjects of the Russian Federation and the activities of executive authorities of the subjects of the Russian Federation" defines a list of twenty key indicators that characterize the degree of comfort and attractiveness for living of certain settlements and regions of the Russian Federation. Moreover, the thirteenth number of these indicators includes the quality of the urban environment [19].

Moreover, the detailed methodology for calculating this indicator is approved by a special decree of the Government of the Russian Federation No. 510-r dated March 23, 2019. According to this decree, a score system is used to assess the quality of the urban environment, based on the following formula [20].

$$Xn = ((Max - Min) : 10) + Min + (N \times (Max - Min) : 10),$$

there:

n – ordinal score number;
Xn – threshold value of the calculated score;
Max – maximum value in the data array;
Min – minimum value in the data array

Moreover, 36 different indicators are subject to scoring, and it does not make scientific sense to describe them in detail within the framework of this study. We should only note the fact that only one parameter, namely, the index of pedestrian accessibility, located in the general list at number eleven (Fig. 6), is allocated as an indicator of the optimality of the placement of residential buildings on the territory of the city.

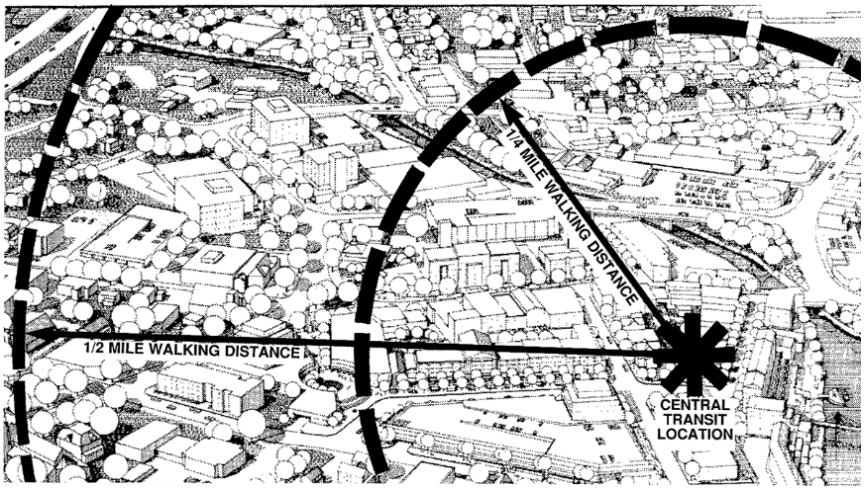

Fig. 6. Example of implementing the walkability principle in transit zone design.

At first glance, the index of pedestrian accessibility should reflect the degree of efficiency and comfort of residential buildings in the designed and under construction neighborhoods. Nevertheless, a more detailed analysis of this index shows that it is calculated "for each residential building, the average value of the values obtained by calculating the ratio of the length of the shortest pedestrian route to the length of the limiting route to the points of attraction within an 800-meter zone, taking into account the topology of the street and road network, then the average value for the entire city is calculated".

Thus, the problem is that the Government of the Russian Federation has established not socially significant organizations and institutions of urban infrastructure, but so-called points of attraction as the key objects for calculating the pedestrian accessibility indicator [21]. Moreover, there is no interpretation of the definition of the term "point of attraction" in the mentioned Decree. For this reason, it is not quite clear what exactly is meant by points of attraction.

It is possible to assume that number 34 in the annex to this Decree is the indicator "number of centers of attraction for the population" and this indicator is a complete synonym for "points of attraction". But, unfortunately, even in this case, the indicator number 11 "Pedestrian Accessibility Index" does not become more informative.

The fact is that it is suggested to choose these centers; they are also points, by the number of photos posted, but not by social significance. Thus, the Appendix states explicitly that the number of centers of attraction for the population "is calculated as the number of places where the largest number of photos are concentrated, but in total not exceeding 75 percent of all photos in the city" [20]. Apparently, in this case we are referring to the photos of tourist attractions posted in social Internet networks and on publicly available online maps. And such photos absolutely do not reflect the social significance of these objects for the population of the city, emphasizing only their tourist attraction. After all, it is obvious that most often such photos are taken not by residents of the city, but by tourists visiting it. Not to mention the fact that the most socially unprotected strata of the population in general, such as people with disabilities and elderly citizens, are not inclined to take photos of the area and even less inclined to post them on the Internet.

To be fair, it should be noted that the problem of socially important facilities is addressed by the indicator number 12, provided for by the Annex to the above-mentioned Decree of the Government of the Russian Federation. However, this parameter is designed to assess not the geographical remoteness of socially significant facilities from residential buildings, but only the degree of their accessibility for people with disabilities. This fact is illustrated by the corresponding formula for calculating this indicator:

$$Apd = (Ps/P)*100\% \text{ [20]},$$

there Ps – the number of priority social, transportation and engineering infrastructure facilities accessible to disabled people and other low-mobility groups.

P – total number of priority social, transportation and engineering infrastructure facilities.

Thus, this "indicator allows us to assess the adaptability of the urban environment for unimpeded movement and obtaining necessary services for low-mobility groups".

The principle of walkability realized in the capital city that is undoubtedly an advanced achievement in the system of domestic urban development, although it directly concerns socially significant objects, but, at the same time, does not give us an objective methodology for quantitative assessment of the efficiency of residential buildings. According to this principle, all critical socially important facilities should be located no further than 800 m from residential buildings, or within a 10-minute walk at an average pace [22]. In addition, the principle of walkability cannot always be realized in practice in other regions of the Russian Federation.

We cannot ignore the fact that in addition to the officially approved by the state [19, 20] in the Russian Federation a number of alternative methodologies for assessing the quality of urban environment are used. As one of the most effective among the mentioned methodologies, we can highlight the methodology for assessing the ESG-safety of urban economy [23]. The abbreviation ESG, embedded in the name of the mentioned methodology, is designed to speak for itself. In English, these letters directly mean the following [24]. E – environment, it implies a responsible attitude towards the environment.; S – social, it implies high level of social responsibility. Finally, G – governance, it requires ensuring high quality corporate governance. As it can be seen from the above transcript, the ESG methodology involves a comprehensive assessment of human-environment interactions, including in the implementation of integrated urban housing programs [25].

This methodology is of genuine interest in terms of assessing the quality of the urban environment in general and the efficiency of residential development planning in particular. ESG-methodology involves the assessment of urban environment by such ecologically and socially important parameters as the architecture quality, the internal environment comfort, life safety, waste disposal, environmental management, environmental protection, and rational water use and, what is most interesting and important for the purposes of our study, the quality of the external environment [26]. Moreover, one of the significant quantitative foundations of the above methodology is the following formula [27].

$$Eq = \frac{\frac{1}{\text{Catm}} + \frac{1}{\text{Cwat}} + \text{Cwas} + Cfor}{4} \times 100\%,$$

there Catm – coefficient of atmospheric air pollution,

Cwat – water pollution factor,

Cwas – waste management quality factor,

Cfor – forest potential conservation rate.

Nevertheless, as it can be seen from the above formula and its description, the quality of the external environment from the point of view of ESG-safety methodology is assessed solely by environmental parameters, without affecting the problematic aspects of social welfare of the population.

Other methods of comprehensive assessment of the quality of urban environment [28, 29, 30] in terms of residential development of new neighborhoods also do not provide an objective idea of the degree of comfort of placement of social infrastructure objects relative to residential buildings. The author of the presented work has also previously conducted research in the field of urban environment quality assessment [31, 32], but exclusively in the field of passenger transportation.

All the above facts determine the need to develop an innovative author's methodology for quantitative assessment of the degree of accessibility of socially significant objects in the process of design and construction of new residential neighborhoods.

Naturally, when developing this technique, the method of simple time estimation lies on the surface. By means of the mentioned method, it is possible to determine and conduct a comparative assessment of the time spent by a citizen on the way from the place of residence to socially significant

objects. With such a methodology, the formula for calculating the degree of accessibility of socially significant objects can have the following form:

$$D = \sum Tn,$$

there n – conditional serial number of the socially significant object;

Tn – average travel time from a residential building to the relevant socially important object.

It is possible to simplify this formula significantly and increase its objectivity if it is based not on timing, but on geographical distance. Then this formula will take the following form:

$$D = \sum Pn,$$

there Pn – geographical distance from a residential building to a socially significant object.

Moreover, a relatively accurate identification of spatial, geographical and temporal characteristics of the route necessary for the calculations according to the above formulas can be obtained in two ways. The first way is to refer to online navigation systems in open Internet sources, as shown in Fig. 7.

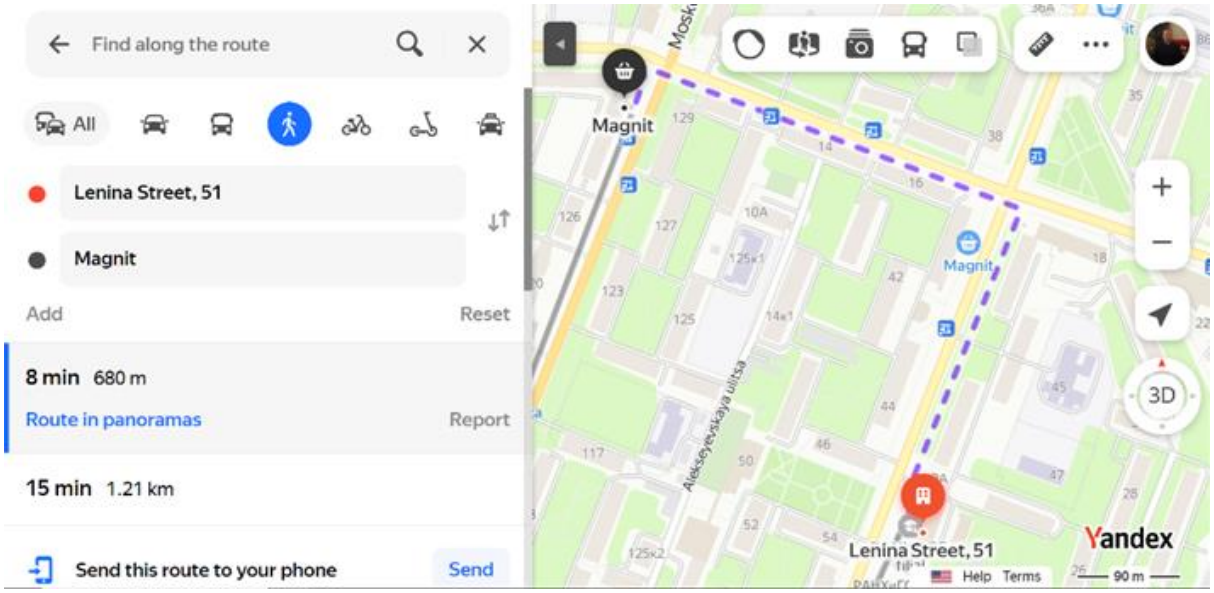

Fig. 7. Determination of the geographical distance and the average time of a walking route using an online navigation system.

The essence of the second method is based on the use of reference table 1.

Table 1. Correspondence of average time expenditure to geographical distance when walking.

№	Distance, km	Time, min	Note
1	0.5	6	
2	1	12	
3	1.5	18	
4	2	24	

Nevertheless, such a primitive methodology can objectively reflect the degree of comfort of the urban environment and can be effectively applied only if the principle of walkability is strictly implemented in practice. And as mentioned above, this is not always possible even in the capital region, and even more so in other subjects of the Russian Federation.

In modern Russian reality, it is not uncommon to get to socially significant objects not only on foot, but also using personal or public passenger transport.

This situation is characterized not only by geographical and spatial limitations and time costs. Here the financial factor also comes into its legal rights.

In the framework of the ongoing applied research we will try to develop a formula for assessing the degree of accessibility of socially important objects of urban infrastructure, integrating in its composition spatial-geographical, temporal, and early financial and economic factors.

According to the author of the study, this formula may have the following form:

$$D = \sum ((Rav/Fwr)*Tn + Cn),$$

there Rav – officially recorded average salary level in the region in the reporting period.

Fwr – working time fund for the reporting period.

Cn – the cost of public transportation to the socially significant object numbered n.

At the same time, the time cost of the route, it is also possible to determine by online navigation systems in open Internet sources, as it is shown in Fig. 8.

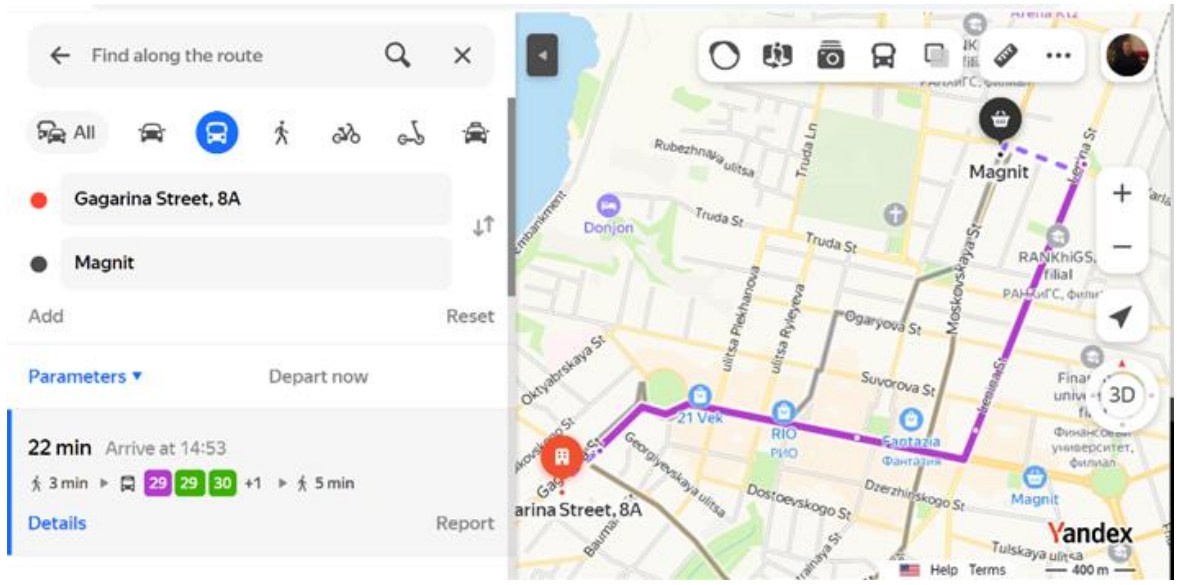

Fig. 8. Determination of geographical distance and average travel time of a mixed route using an online navigation system.

As a result, the mathematical matrix of calculation according to the proposed methodology will take the form presented in Table 2.

Table 2. Mathematical matrix for calculating the costs of traveling to socially significant objects along mixed routes.

№ of socially object	Rav	Fwr	T	S	D	Note
1	Rav_1	Fwr_1	T_1	S_1	D_1	
2	Rav_2	Fwr_2	T_2	S_2	D_2	
3	Rav_3	Fwr_3	T_3	S_3	D_3	
…	…	…	…	…	…	
n	Rav_n	Fwr_n	T_t	S_t	D_t	
Total					∑D	

The proposed methodology is unique in that due to the use of such a universal and generally available from a statistical point of view indicator as the average wage level, experts have the opportunity to conduct a comparative assessment of the degree of accessibility of social facilities, not only located within walking distance, but also at longer distances, involving the use of public passenger transport.

4. CONCLUSIONS

The application of the proposed methodology for assessing the quality of urban environment for the accessibility of socially important infrastructure objects in relation to the location of residential buildings will allow on a mathematically accurate quantitative basis not only to maximize the quality and objectively assess the effectiveness of regional public authorities and local self-government, but also to conduct a comparative analysis of the quality of planning of newly designed residential neighborhoods. In addition, the above methodology may be of practical interest to realtors and developers in the development and practical implementation of various business processes, both in the field of housing construction and in the sale of residential buildings and premises.

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INFORMATION ABOUT THE AUTHOR

Fomichev A.N., e-mail: s an2005a1@yandex.ru, tel.: +7(903) 635-49-66, ORCID ID: 0000-0001-7123-2093, SCOPUS: https://www.scopus.com/authid/detail.uri?authorId=57933912900, Moscow Financial and Industrial University Synergy, Kaluga Branch of the Russian Academy of National Economy and Public Administration, Candidate of Economic Sciences (Ph.D.), Professor