Differentiation of Russian megalopolises by the level of urban environment quality and the standard needs of the population

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Abstract. The article discusses the study of differentiation between Russian megalopolises according to level of the quality of life and provision for standard needs of population. Having reviewed the existing literature on the quality of life indicators, authors provide a selection of the most important indicators. By analysing the indicators of the standard needs of population and existing the quality of urban environment, authors demonstrate significant differentiation between Russian megalopolises according to the achieved level of urban environment quality. Comparative analysis has been carried out using an economic and mathematical model that clusters megalopolises using indicators characterizing the level of accommodation of the standard needs.

1. Introduction

The ongoing global crisis has once again confirmed that it is crucial to undertake extensive research into such concepts as the quality of life and the quality of urban environment. Current studies (e.g. [1]) are still predominantly regarding the quality of life as the most important indicator for assessing socio-economic and territorial development, due to it being “a category that generally characterizes all the components of a person’s life: his potential, activity, and conditions of his existence in relation to an institutionalized standard or a standard that is perceived by the individual” [1]. Considering the recent developments in the “science of quality”, some researchers [1] highlight the trends of convergence and divergence in living standards among the regions as a research problem that requires the most attention. Studies that attempt to assess or propose measures for adjusting uneven socio-economic development and the discrepancies in the quality of life between various Russian cities and regions are becoming particularly important in connection with the pandemic that has spread across all countries. The ways and steps for creating safe and favorable living conditions today are among the most important research problems in quality management studies and practice [2,3]. However, such aspect of the quality of life as a sustainable and efficient system for accommodating residents’ standard needs, which is accounted for in urban planning, is usually left unnoticed by the majority of scholars, with a rare exception of studies [1] that include indicators that do assess housing provision and social infrastructure facilities, but do not single out urban environment quality indicators as a separate group.
Today, the priority of this “social” component of the quality of life, especially in healthcare provision, is becoming an indisputable fact. Previously the authorities were largely concerned with the quality of services provided to the population, and this was reflected in such indicators as, for example, the satisfaction with health services and the availability of doctors to the population. However, today these efforts are aimed primarily at using the existing financial instruments to create and enhance the very conditions for emergency medical care provision, namely - the healthcare facilities construction.

Target indicators that have been deployed in the strategies for the socio-economic development of Russian megalopolises and approved as the standard needs’ accommodation metrics, today are in need to be revised. The ongoing crisis makes us reconsider many taken for granted priorities for the development of the urban environment and criteria for assessing its quality. Since understanding of categories such as the quality of life and quality of urban environment is drastically changing, requirements for conditions that ensure the residents’ safety and comfort are changing as well, as does the need for studies that entail comparing reference and actual indicators of the population’s satisfaction with the facilities providing favorable living conditions. The sociospatial approach to assessing the quality of urban environment takes into account the socio-economic divides and differences between megalopolises and the need to level them out [4,5]; therefore, models that are based on this approach should reflect the differences in megalopolises in terms of discrepancies in indicators both of existing and planned quality levels.

2. Problem statement
Creation of conditions that ensure accommodation of reference (standard) needs of population largely depends on the criteria established by authorities for indicators of safe and favourable living conditions. Quantitative values of standard needs are shaped both externally, through regulatory requirements that are established in higher-level legal acts (federal and/or regional), and internally, according to specific characteristics of achieving urban development indicators of housing and social infrastructure amenities provision in each megalopolis. The tool for designing a comfortable environment for the population are urban planning standards that take into account the characteristics and particular local needs for social infrastructure. Urban planning standards already contain substantiated criteria for the reference (standard) needs in housing, education, and healthcare facilities, which are priority indicators for measuring the quality of life and, at the same time, quality of urban environment, that, according to the authors [5], “reflect the essence of the sociospatial approach to the formation of quality environment as a territory with safe and favourable living conditions”.

Works that aim at discovering the inequalities between Russian cities [6-10] and discussing the possibility of levelling out already existing spatial inequalities are becoming increasingly relevant, however, currently there are not very many studies in this area. As rightly noted by some authors [6], the main reason for this is, firstly, the lack of information on megalopolises. Secondly, the answer to the question “how significant are the differences between the leading megalopolises – Moscow and St. Petersburg and other Russian cities in terms of socio-economic development ...” [6] and whether it is possible to adjust differences between Russian million-plus cities, remains yet more or less rhetorical. Indeed, Moscow’s budget revenue is not comparable with other Russian megalopolises’ revenues, and as a result its superiority in current and perspective urban development will unlikely be affected. However, research on the urban development component of the quality of life, the inequalities between megalopolises in terms of the established standard needs and the existing quality of urban environment are posing certain scientific and practical interest. Comparative studies of Russian megalopolises must be conducted to assess the existing quality of life and the values of the standard needs approved in the urban planning standards. The choice of Russian megalopolises as a research object is justified by their status as loci for crucial integrational interactions that form diverse networked connections and structures in a socio-economic space and have significant influence on the quality of life formation in the internal and external environment.
The objective of the study is to execute a cluster analysis of Russian megalopolises according to the differences in the achieved and approved indicators of the standard needs, which, as we have demonstrated, characterize the formation of safe and favourable living conditions, and the human development index (hereinafter – the HDI).

3. Data and methods
The methodological design of the study relies on the works by leading Russian and international scholars that conducted research on the quality of life and quality of urban development [11-17], digitalization and Smart City models development [18,19], assessing the standard needs accommodation [20]. Authors use statistical the Federal State Statistics Service database [21]; open data from public offices on urban development [22] and the HDI data [23]. The indicators of standard needs were carefully selected through expert assessment and review of several studies [11,19,20]. Cluster analysis of megalopolises is based on the mathematical operations with the matrix, the values of which include ranks of deviations of actually achieved the quality of life in several areas from the standard needs, and the human development index for each specific megalopolis.

4. Research results and discussion
Research on the quality of life in megalopolis is connected with the need to identify new phenomena and trends in the development of large cities and agglomerations, establish the ways in which external and internal factors influence quality of urban environment, and, consequently, the quality of life [12-14,24].

Having analysed a subset of scientific works on current increase in digital city management and the gradual Smart city models adoption [19], the authors [4,5] conclude that the accommodation of standard needs of the population is possible only through integrated development. The tendency that becomes increasingly obvious is a shift in the priorities urban development towards comprehensive and sustainable development of territories and creating favourable living environment, with the use of reasonable standard needs indicators [5].

Many studies [6-8,15] have noted that investing in human capital became one of the most conscious and significant goals in the strategic development of Russian cities. We claim here as well that the indicators of the social infrastructure development play extremely significant role in creating urban environment and are an indispensable indicator for assessing competitive advantages of a megalopolis.

After evaluating major quality of life indicators [11], Smart city models [18,19], and the results of expert and analytical assessment of indicators of favourable living conditions and their accessibility to the population [20], we have identified the priority indicators that ensure the standard needs of the population that characterize quality of urban environment in a megalopolis:

- average living floor area per one inhabitant, sq. m – \( x_1 \);
- number of places in pre-school educational institutions per 1000 persons – \( x_2 \);
- number of places in general educational schools per 1000 persons – \( x_3 \);
- number of admissions to polyclinics during one shift per 1000 persons – \( x_4 \);
- number of hospital beds per 1000 persons – \( x_5 \).

The indicator values come from [21-22], the Human development index for Russian megalopolises is drawn from [23].

The methodological design of the study contained three stages:
1. Deviations of the achieved provision of housing, education, and health facilities to the population from the indicators of standard needs in urban planning standards were calculated.
2. The obtained values of deviations for each indicator were assigned ranks, which range from 1 (the lowest deviation value) to 15 (the highest deviation value), and then summed up.
3. A matrix that demonstrates clusters of Russian megalopolises was compiled. Clusters were identified through aggregating the deviation ranks’ sums and the HDI values.
The results of the analysis of differences in achieved provision of housing in Russian megalopolises, the most important social infrastructure facilities, and the standard needs of the population, based on the aforementioned statistical data are provided in table 1.

Table 1. Comparative analysis of indicators of achieved provision of the population with housing, social infrastructure facilities and indicators of standard needs of the population.

| Megalopolis          | Deviation of the achieved provision of housing, education and health facilities for the population from the indicators of the standard needs of the population |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | $x_1$         | $x_2$         | $x_3$         | $x_4$         | $x_5$         |
| Volgograd             | -0.15         | -0.76         | -0.48         | 0.00          | 5.31          |
| Voronezh              | -0.10         | 0.01          | -0.06         | 0.71          | 0.00          |
| Yekaterinburg         | -0.17         | -0.07         | -0.14         | 0.87          | 1.03          |
| Kazan                 | 0.09          | -0.45         | -0.46         | 0.03          | -0.49         |
| Krasnoyarsk           | -0.17         | 0.11          | -0.19         | 0.82          | -0.11         |
| Moscow                | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          |
| Nizhny Novgorod       | -0.18         | 0.35          | -0.07         | 0.73          | 0.77          |
| Novosibirsk           | 0.00          | 0.12          | -0.16         | 0.42          | -0.15         |
| Omsk                  | -0.17         | -0.48         | -0.04         | 0.39          | -0.58         |
| Perm                  | 0.00          | 0.51          | 0.15          | 0.14          | 0.00          |
| Rostov-on-Don         | -0.17         | -0.32         | -0.19         | 0.00          | 0.00          |
| Samara                | 0.00          | 0.00          | 0.00          | 0.00          | 0.00          |
| St. Petersburg        | -0.16         | -0.29         | -0.32         | 0.18          | -0.05         |
| Ufa                   | -0.12         | -0.13         | -0.38         | 1.16          | 0.02          |
| Chelyabinsk           | 0.23          | -0.21         | -0.32         | 1.01          | -0.16         |

The ranking of the obtained deviation values for each of the indicators is shown in table 2.

Table 2. Ranking of Russian megalopolises according to deviations in the provision of housing and social infrastructure from the standard indicators.

| Megalopolis          | Megalopolis rank by the results of a comparative analysis of achieved and standard indicators of the quality of the urban environment |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | $x_1$         | $x_2$         | $x_3$         | $x_4$         | $x_5$         | Total rank |
| Volgograd             | 9             | 15            | 15            | 12            | 1             | 52         |
| Voronezh              | 7             | 5             | 5             | 6             | 7             | 30         |
| Yekaterinburg         | 12            | 8             | 7             | 3             | 2             | 32         |
| Kazan                 | 2             | 13            | 14            | 11            | 14            | 54         |
| Krasnoyarsk           | 11            | 4             | 9             | 4             | 11            | 39         |
| Moscow                | 3             | 7             | 2             | 12            | 6             | 30         |
| Nizhny Novgorod       | 15            | 2             | 6             | 5             | 3             | 31         |
| Novosibirsk           | 6             | 3             | 8             | 7             | 12            | 36         |
| Omsk                  | 13            | 14            | 4             | 8             | 15            | 54         |
| Perm                  | 5             | 1             | 1             | 10            | 5             | 22         |
| Rostov-on-Don         | 14            | 12            | 10            | 12            | 9             | 57         |
| Samara                | 4             | 6             | 2             | 12            | 8             | 32         |
| St. Petersburg        | 10            | 11            | 11            | 9             | 10            | 51         |
| Ufa                   | 8             | 9             | 13            | 1             | 4             | 35         |
| Chelyabinsk           | 1             | 10            | 12            | 2             | 13            | 38         |

As the next step of the research design we have clustered Russian megalopolises according to both the calculated data (see table 2) and the HDI indicator.
The interval step is determined by the formula:

\[ h = \frac{(x_{\text{max}} - x_{\text{min}})}{n}, \]  

where \( x_{\text{max}}, x_{\text{min}} \) – maximum and minimum values, \( n \) – number of groups.

The number of groups is determined by the Sturges’ formula:

\[ n = 1 + 3.322 \lg N, \]  

where \( N \) – number of population units.

After executing formulas (1-2) the HDI values (table 1) were divided into 5 groups with an interval of 0.020.

\[ n = 1 + 3.322 \lg 15 = 5, \]

\[ h = \frac{0.949 - 0.851}{5} = 0.020. \]

The set of values of the multidimensional average (table 2) is divided into 5 groups with an interval of 6.

\[ n = 1 + 3.322 \lg 15 = 5, \]

\[ h = \frac{121 - 93}{5} = 6. \]

The performed cluster analysis of the human development index and rank, obtained by summing deviations of the achieved indicator of the quality of life from accepted indicators of standard needs of the population, has thus resulted in the following 8 clusters of Russian megapolises (see table 3): Cluster 1 - Moscow; Cluster 2 – St. Petersburg; Cluster 3 – Kazan; Cluster 4 – Krasnoyarsk; Cluster 5 – Perm; Cluster 6 – Nizhny Novgorod, Voronezh, Yekaterinburg, Novosibirsk, Ufa, Samara; Cluster 7 – Chelyabinsk; Cluster 8 – Volgograd, Rostov-on-Don, Omsk.

Table 3. Differentiation of Russian megalopolises in assessing the quality of life and quality of urban environment.

| HDI       | Total value of ranks by deviation of achieved provision of the population from standard indicators |
|-----------|------------------------------------------------------------------------------------------------|
| 0.932-0.951 | Moscow                                                                                         |
| 0.912-0.931 | St. Petersburg                                                                                 |
| 0.892-0.911 | Kazan                                                                                          |
| 0.872-0.891 | Krasnoyarsk                                                                                   |
| 0.851-0.871 | Nizhny Novgorod, Voronezh, Yekaterinburg, Novosibirsk, Ufa, Samara                             |
|           | Perm, Chelyabinsk                                                                              |
|           | Volgograd, Rostov-on-Don, Omsk                                                                  |

5. Conclusions

Increased attention to the globalization of cities and significant gaps in the methodology for assessing the quality of life firmly substantiates further research on the tools to ensure the economic security of megalopolis. The most difficult task is to study differentiation of Russian megapolises based on comparative studies of urban development using indicators using the data on both the achieved quality of living and standard needs of the population. The proposed model allows for a comparative analysis
of Russian megalopolises by the level of approved and achieved the quality of life based on accepted indicators of standard needs of the population. The obtained results allow us to conclude that there is a significant differentiation between Russian megalopolises in terms of the quality of life and the quality of urban environment: a significant gap between the levels of those in Moscow and St. Petersburg and the quality of life in other megalopolises remains stable, the potential of Kazan is quite high, and the lowest potential is noticed in the cities Volgograd, Rostov-on-Don and Omsk.

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