Ranking of options of real estate use by expert assessments mathematical processing

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Abstract. The article is devoted to the development of the real estate assessment concept. In conditions of multivariate using of the real estate method based on calculating, the integral indicator of each variant’s efficiency is proposed. In order to calculate weights of criteria of the efficiency expert method, Analytic hierarchy process and its mathematical support are used. The method allows fulfilling ranking of alternative types of real estate use in dependence of their efficiency. The method was applied for one of the land parcels located on Primorsky district in Saint Petersburg.

1. Introduction

Efficient use of real estate requires comprehensive analysis of objects and elaboration of concrete proposals on their optimum use. In conditions of developed market relations of large cities in Russia, such as St. Petersburg, this matter is very important. Despite increasing population and city capacities, the territory is limited, so, it is necessary to use it as much rationally as possible.

According to the current legislation, the owner may use real estate object according to one of the resolved options established for each territorial zone by town-planning regulations. Because of variety of possible options, there is a question of efficiency of each of them. Considering efficiency, first of all, the economical efficiency of real estate use is taken into account. The economic aspect is very important not only for investors, but also for the Government as it provides large land payments. At assessment of the most effective use of the land plot the legal admissibility and physical feasibility of construction are analyzed, the project financial feasibility is checked, transport availability and competitive environment are investigated. On the basis of specified criteria assessment by each possible land use expert judges of the most effective option. There are no techniques which are accurately regulating this assessment, containing requirements for justification of the judgment. Often assessment of real estate use options comes down to subjective conclusions of an expert without corresponding researches and mathematical rational. Besides, as it has been noted above, use of a real estate object is variable, and the question of how effective this or that resolved option in comparison with others is interesting for all participants of real estate market. However, the similar comparative analysis and ranking of options of real estate use by degree of their efficiency are not carried out today.
The aforesaid has predetermined the goal of the research - development of a technique of assessment and ranking of real estate use options by efficiency of supporting administrative decisions with regard to an object. To achieve the goal, it is necessary to define the most expedient methods.

2. Methods
Assessment of preference of real estate use options by efficiency has to consider not only values of criteria for each variant, but also the importance of each criterion (weight). In this regard, there is a question: how to estimate importance of criteria? As an optimal variant, it is proposed using an expert method of Analytic hierarchy process by T.L. Saati (further – AHP). AHP is widely used in decision-making [1] in a variety of different spheres: marketing [2], transport [3], industrial engineering [4,5], monitoring of sustainable development of oil and gas enterprises [6,7], massive and individual real estate assessment [8,9], etc. It represents the theory which is based on expert estimates and judgments of individual participants or groups.

The method allows the person making the decision to structure a task in the form of hierarchy and to execute quantitative assessment of the available versions of the decision (alternatives). In AHP pairwise comparisons of alternatives are fulfilled. On the basis of them weights of alternatives are calculated by mathematical methods [10, 11].

Results of pairwise comparisons of elements form matrix \( A \) (Figure 1).

![Matrix of pairwise comparisons](image)

**Figure 1.** Matrix of pairwise comparisons

To calculate weights of elements, the following formula is used (1), (2):

\[
W_i = \frac{a_i}{\sum_{i=1}^{n} a_j}, \quad (1)
\]

\[
a_j = \prod_{i=1}^{n} a_{ij} = \prod_{i=1}^{n} a_{ij} \cdot \ldots \cdot a_{in} \quad (2)
\]

where \( a_{ij} \) – elements of matrix; \( n \) – number of compared elements.

A degree of coherence of expert’s assessment is checked by calculation of the relation of coherence (RC) by formula (3):

\[
RC = \frac{IC}{IC_{av}} \cdot 100\% \quad , (3)
\]

\( IC \) – index of coherence of expert’s assessment;

\( IC_{av} \) – average value of index of coherence which is calculated by experimental data.

Expert’s assessment is concerted if RC does not exceed 20%.

Index of Coherence (IC) is calculated by formula (4):
\[ IC = \frac{\lambda_{\text{max}} - n}{n - 1}, \quad (4) \]

\( \lambda_{\text{max}} \) - maximum eigenvalue.

Thus, weights of each estimated criterion of efficiency of real estate use are results of AHP. The integrated effectiveness ratio of real estate by options is offered to be counted by (6):

\[ K = \sum P_i \cdot V_i, \quad (6) \]

\( P_i \) - criterion weight;
\( V_i \) - criterion value.

3. Results

Assessment and ranking of options of real estate use on degree of efficiency is carried out by the example of the land parcel located in Primorsky district of St. Petersburg by address: 2nd Nikitinskaya Street, site 6.

There are no constructions on the land parcel. There are high-rise regulations – background height of 15 m. Restrictions for land parcel use is security zone of electrical networks.

The following criteria are analyzed: legal admissibility, physical feasibility, financial feasibility, transport availability, competitive environment.

Possible options of land use are the following: business center, supermarket, parking, sport center, restaurant.

According to the functional zoning of the Rules of building and land use in the city of St. Petersburg, an object is located in zone 1ZhD (subspecies of the territorial zone T1Zh2-2).

This area is allocated for development of the low housing estate, social and cultural and community service and also for placement of engineering and transport objects.

Results of pairwise comparisons of criteria on their importance in assessment and the eigenvector are presented in Table 1.

| Criteria                        | 1  | 2   | 3   | 4   | 5   | \( W_i \) | \( \lambda_i \) |
|---------------------------------|----|-----|-----|-----|-----|-----------|----------------|
| Physical feasibility (1)       | 1  | 1/5 | 1/4 | 1/3 | 1/4 | 0.05      | 0.83           |
| Legal admissibility (2)        | 5  | 1   | 1/3 | 3   | 4   | 0.27      | 1.28           |
| Financial feasibility (3)      | 4  | 3   | 1   | 6   | 4   | 0.45      | 0.91           |
| Transport availability (4)     | 3  | 1/3 | 1/6 | 1   | 1/6 | 0.07      | 1.17           |
| Competitive environment (5)    | 4  | 1/4 | 1/4 | 6   | 1   | 0.16      | 1.50           |
| \( \Sigma \)                   | 17.00 | 4.78 | 2.00 | 16.33 | 9.42 | 1.00 | 5.68 |

The degree of coherence of expert’s assessment: IC = 0.17, RC = 15.13% < 20% - assessment is concerted.

Further, it is necessary to carry out numerical assessment of criteria.

Assessment of legal admissibility of real estate use by options is carried out with using binary scale with two possible values: yes (it’s admissible) and no (it’s not admissible). Thus, to the options resolved according to town-planning regulations the value 1 is appropriated, to other options – value 0.

As a result of the analysis, it has been admitted that all estimated options are legally admissible.

For assessment of physical feasibility, the criterion scale with two possible values is offered: "does not demand additional changes of conditions" (the appropriated value - 1), "option is admissible taking into account investments" (the appropriated value - 2).

As the estimated real estate object has the optimum form and relief, value 2 is appropriated to all the options.
To compare options by the criterion of financial correctness, the market rental rate which significantly depends on real estate use is proposed. For the options, St. Petersburg average rental rates are determined (Table 2). Standardized values of average rental rates are calculated by formula (5):

$$\lambda_\phi = \frac{A_i}{\sum A_i} \quad (5)$$

$A_i$ – rental rate (rubles per 1 sq.m a month).

**Table 2.** St. Petersburg average rental rate broken down by each option of real estate use.

| Option of real estate use | Rental rate, rubles per 1 sq.m a month | Standardized value |
|--------------------------|----------------------------------------|--------------------|
| Parking                  | 210                                    | 0.10               |
| Supermarket              | 658                                    | 0.29               |
| Restaurant               | 350                                    | 0.15               |
| Sport centre             | 350                                    | 0.15               |
| Business centre          | 708                                    | 0.31               |

Considering transport availability as one of the criteria of efficiency, it is established that the land parcel is in the maximum proximity with public transport stops and has income roads. By each option, it is expedient to apply an expert method to determine values of the criterion. Methodology and the sequence of carrying out are similar in determining scales of criteria. An expert should answer the following question: to what extent does transport availability impact this or that option of land use?

Results of pairwise comparisons on transport availability are presented in Table 3.

**Table 3.** Results of pairwise comparisons on criterion of transport availability.

| Option of real estate use          | 1    | 2    | 3    | 4    | 5    | $a_i$ | $W_i$ | $\lambda_i$ |
|-----------------------------------|------|------|------|------|------|-------|-------|-------------|
| Business centre (1)               | 1    | 1/2  | 1/3  | 2    | 1    | 0.80  | 0.15  | 1.14       |
| Supermarket (2)                   | 2    | 1    | 1    | 1/3  | 1/2  | 0.80  | 0.15  | 1.14       |
| Parking (3)                       | 3    | 1    | 1    | 3    | 2    | 1.78  | 0.34  | 1.07       |
| Sport centre (4)                  | 1/2  | 3    | 1/3  | 1    | 1/2  | 0.76  | 0.14  | 1.19       |
| Restaurant (5)                    | 1    | 2    | 1/2  | 2    | 1    | 1.15  | 0.22  | 1.09       |
| $\sum$                            | 7.50 | 7.50 | 3.17 | 8.33 | 5.00 | 5.29  | 1.00  | 5.62       |

IC = 0.15  RC = 13.79 <20%

For criterion of competitive environment, it is offered to use a numerical scale with values, inversely proportional to quantity of available objects in a service area. For objects, which have no competitors in the specified area, the value of criterion is equal to 1 (Table 4).

**Table 4.** Values of criterion of competitive environment.

| Option of real estate use          | Number of objects located on the competitive area. | Value of criterion |
|-----------------------------------|---------------------------------------------------|--------------------|
| Parking                           | 3                                                 | 0.33               |
| Supermarket                       | 0                                                 | 1                  |
| Restaurant                        | 5                                                 | 0.20               |
**Table 5.** Calculation of integrated effectiveness ratio of real estate.

| Criterion                  | Business centre | Supermarket | Parking | Sport centre | Restaurant |
|----------------------------|-----------------|-------------|---------|--------------|------------|
| **Physical feasibility**   |                 |             |         |              |            |
| Weight $P_i$               | 0.03            |             |         |              |            |
| Value $V_i$                | 2               | 2           | 2       | 2            | 2          |
| $P_i \cdot V_i$            | 0.06            | 0.06        | 0.06    | 0.06         | 0.06       |
| **Legal admissibility**    |                 |             |         |              |            |
| Weight $P_i$               | 0.27            |             |         |              |            |
| Value $V_i$                | 1               | 1           | 1       | 1            | 1          |
| $P_i \cdot V_i$            | 0.27            | 0.27        | 0.27    | 0.27         | 0.27       |
| **Financial feasibility**  |                 |             |         |              |            |
| Weight $P_i$               | 0.45            |             |         |              |            |
| Value $V_i$                | 0.31            | 0.29        | 0.10    | 0.15         | 0.15       |
| $P_i \cdot V_i$            | 0.14            | 0.13        | 0.05    | 0.07         | 0.07       |
| **Transport availability** |                 |             |         |              |            |
| Weight $P_i$               | 0.07            |             |         |              |            |
| Value $V_i$                | 0.15            | 0.15        | 0.34    | 0.14         | 0.22       |
| $P_i \cdot V_i$            | 0.01            | 0.01        | 0.02    | 0.01         | 0.02       |
| **Competitive environment**|                 |             |         |              |            |
| Weight $P_i$               | 0.16            |             |         |              |            |
| Value $V_i$                | 0.33            | 1           | 0.33    | 1            | 0.20       |
| $P_i \cdot V_i$            | 0.05            | 0.16        | 0.05    | 0.16         | 0.03       |
| $\sum P_i \cdot V_i$      | 0.53            | 0.63        | 0.45    | 0.57         | 0.45       |

Thus, the most effective option of land parcel use is supermarket. Further ranking of alternatives by the degree of efficiency has yielded the following results (in the process of reduction of efficiency): sport center, business center, restaurant and parking.

**4. Conclusion**

St. Petersburg is the second-large city of Russia, which is characterized by considerable territorial and immovable potential. The developed real estate market of the city causes high degree of land turnover, great demand for the real estate. In these conditions, the matter of rational and effective use of the urban area is particularly acute. The importance of results for the city is connected with need of adoption of qualitative administrative decisions concerning land and property fund on the basis of comprehensive assessment of efficiency of possible options of use for various aspects.

Application of the method offered by authors has to promote an increase in objectivity and validity of expert judgments of real estate use efficiency that, in turn, will positively affect quality of administrative decisions concerning real estate.
Analysis and assessment of criteria of effective use is expedient to carry out by means of spatial analysis and modeling of geographic information system. Application of GIS allows one not only to accelerate work of the appraiser, but also to make the analysis more convenient and evident.

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