Study of Current Composition and Classification of Housing in a Large Siberian City

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Abstract. This article considers the issue of identification of the key factors determining the composition and classification of housing in a large city. The results of the analysis conducted made the authors conclude that the structure and classification of housing are primarily determined by the level of housing availability for local residents; it depends on the city population count, the average cost of 1 sq.m. of residential housing, and the average income level. The authors developed a multifactor linear regression equation that explains the 98.3% correlation between the parameters mentioned and can be used to forecast housing market development in cities. Based on the performed analysis of the key parameters of residential buildings that are being built in Krasnoyarsk, the authors provided recommendations for apartment parameters to be used when designing apartment blocks.

1. Introduction

Residential development is a complex social and economic system that can be defined as the area of interaction of economic entities (authorities, investors, professional community organizations, residents) participating in all life cycle stages of residential facilities. Currently, building high-quality and affordable homes in a comfortable urban environment is a key development aspect for the residential development industry. This, in its turn, requires the improvement of housing facility composition [1,2]. The key development areas for residential development are determined by the need to set the best proportions of apartment types depending on the economic, social, and demographic conditions.

The current composition and classification of housing have been studied and analyzed in a number of research papers, yet only some of them [3-11] review the problems of city’s housing stock classification, housing stock composition establishment and development, apartment floor area, and composition analysis depending on the period and local weather. The reviewed research works are not aimed at establishing strategic improvement areas for the housing stock management system in big cities based on the development of the best housing stock balance model taking into account the changeability of the nature, composition, and structure of high-quality housing parameters and depending on the changes in the current and forecast customer preferences. Most of the research works conduct the retrospective analysis of the key residential building and apartment types depending on the development stages of mass housing development. The authors conclude that market relations helped developers withdraw from the limitations of standards and averaged solutions and encouraged the
development of housing types and forms, the increase in its elements, the complication of its structure, and the improvement of quality and comfort.

Other research works on the formation of the best housing composition and classifications can be divided into two large groups. The first on [12-14] studies the specific aspects based on the architecture classification of rental housing within the housing development sector depending on the social status of the key consumers yet without a more detailed record of their preferences. The other group suggests considering the impact of the development of the “second” housing on the establishment of housing classification, architecture, and planning facilities within urban layouts through the identification of its new types and forms [15, 16]. However, the focus on the “second” housing did not allow the researchers to approach the analysis of the “first” housing classification and composition, even though it has the largest share in the overall housing stock.

The studies of housing composition and classification in the 40 largest cities of the USA show that the majority of homes (about 50%) is comprised of detached houses for 1-2 families, while only 10-25% of the entire housing stock is apartment buildings [17]. The analysis of the data from 28 EU countries shows that 41.9% of the population resides in urban apartments, 33.6% in detached houses and villas, 24% in row houses, and the remaining 0.5% in other, less common types of European housing [18]. In Canada, approximately 53% of the housing stock consist of single-family houses, and the share of low-rise residential buildings in this country is about 79% [19]. As a result, we may note that countries with a low population density tend to have individualized housing, however, a different structure of the society does not allow for the use of their results in Russian practices.

The analysis of the literature shows that the problems of housing composition and classification development taking into account the demographic and social factors characterizing the key consumer preferences of various social groups, their income levels, education, etc. have not been analyzed sufficiently. Thus, the key purpose of our research is to determine the key factors impacting the composition and classification of housing in a big city and to develop recommendations on the best number of rooms and their size to be used when designing apartment buildings.

2. **Materials and methods**

For this research, the authors selected Krasnoyarsk, a large city in Siberia and the capital of the Krasnoyarsk Territory. Its population count as of 01.01.2020 was 1,094,548 residents.

The research includes the following stages:

1. Identifying the factors that impact the composition and classification of housing. We used the expert evaluation method to form a list of factors to be analyzed. These factors include demographic, economic, and social ones.

2. Studying the change pattern of the factors identified in Krasnoyarsk in retrospect and using the statistical analysis methods. To model and forecast the unavailable data, we used interpolation and extrapolation.

3. Identifying the key factors that have the largest impact on the composition and classification of housing in Krasnoyarsk through the mathematical instruments of correlation and regression analysis. Using controlled impacts on the identified key factors shall help forecast and design housing units that will be popular among the residents.

4. Analyzing the key parameters of the apartments built in Krasnoyarsk and developing recommendations on the best apartment composition and classification in apartment buildings.

3. **Results and discussion**

Having worked with experts and processed their opinions, we prepared the following list of factors impacting the composition and classification of housing to be analyzed: 1. Demographics; population count; migration gain (loss); natural increase (decrease). 2. Economic: average monthly income; housing costs; the amount of residential buildings commissioned. 3. Social: the number of families registered as requiring housing facilities; the availability of housing floor area per one resident; average apartment size.
The change pattern for the proposed list of indicators is shown in Table 1.

**Table 1.** Factors impacting the composition and classification of housing in Krasnoyarsk [20]

| Name                                      | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  |
|-------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Population count, thousands of residents | 979.6 | 998.1 | 1017.2| 1036.6| 1053.2| 1067.9| 1083.8| 1091.6| 1096.1| 1094.5|
| Migration gain (loss), thousands of residents | 16.3  | 15.8  | 15.4  | 12.1  | 9.3   | 10.7  | 4.8   | 2.5   | -2.4  | 1.8   |
| Natural increase (decrease), thousands of residents | -     | 3.3   | 3.9   | 4.5   | 5.4   | 5.2   | 3.0   | 2.0   | 0.9   | -2.3  |
| Average monthly income, thousands of rubles | 28.8  | 32.5  | 35.8  | 38.3  | 39.7  | 41.7  | 44.4  | 50.6  | 54.6  | 58.6  |
| Average cost of 1 sq. m. of housing, thousands of rubles | 43.1  | 48.1  | 52.7  | 55.7  | 55.1  | 49.7  | 49.8  | 52.4  | 56.1  | 62.2  |
| Commissioning of residential buildings, thousands of sq. m. | 688.9 | 703.6 | 708.3 | 614.4 | 707.8 | 922.3 | 676.9 | 741.5 | 893.3 | 737.2 |
| Number of families registered as requiring housing, thousands of people | 11.3  | 8.1   | 7.3   | 7.2   | 7.2   | 9.7   | 9.7   | 9.9   | 10.2  | 9.9   |
| Average total floor area per one resident, sq. m. | 21.8  | 22.0  | 22.2  | 22.6  | 23.3  | 23.7  | 24.1  | 24.6  | 25.3  | 25.9  |
| Average size of one apartment, sq. m. | 55.6  | 55.8  | 54.7  | 53.4  | 48.5  | 48.5  | 49.2  | 52.8  | 50.9  | 52.2  |

The analysis of the data shown in Table 1 allows us to state that since 2011, the floor area of residential units per one resident increased by 19% (up to 25.9 sq. m.) However, if we compare this figure with the most developed countries of Europe (housing availability of 46-54 sq. m. per one resident) and the USA (housing availability of over 85 sq. m. per one resident), we can conclude that the residents of Krasnoyarsk face extremely low housing availability [21]. To increase housing availability, it is necessary to increase the overall amount of new housing units being built, adjusted to the forecast population increase.

When analyzing the data, strength and areas of interactions between the factors identified, the authors realized that the structure and classification of housing in a big city are primarily determined by the level of housing availability to local residents that depends on the city population count, the average cost of 1 sq.m. of residential housing, and the average income level. Following the results of the correlation analysis of the identified key factors impacting the composition and classification of housing, we concluded that the average monthly income has the largest impact on housing availability.
To conduct a numerical simulation for the impact of the key factors on the average total floor area of housing units per one resident and forecast its level, the authors constructed a multifactor linear regression equation (1).

\[
Y = 15,5496 + 0,0035\times X_1 - 0,0369\times X_2 + 0,1469\times X_3
\]  

In equation (1) \( Y \) is the average total residential unit floor area per one resident; \( X_1 \) is the population count; \( X_2 \) is the average cost of 1 sq. m. of housing; and \( X_3 \) is the average monthly income.

The determination coefficient of this regression equation is 0.983. This signifies that the calculated parameters of the equation explain 98.3% of correlations between the parameters in question. The value of regression coefficients in equation (1) signifies the following: a) if the population of Krasnoyarsk increases by 1 thousand residents, the average housing availability per one person will increase by 0.0035 sq. m.; if the average cost of 1 sq.m. of housing increases by 1 thousand rubles, the housing availability will decrease by 0.0369 sq. m.; if the average monthly income increases by 1 thousand rubles, the average housing availability per one resident will increase by 0.1469 sq. m.

When reviewing the key parameters of apartments, we must note that, according to the results of the all-Russian public opinion poll, most of the demand (85 %) is currently shifting towards 2-room apartments with floor areas of 45-70 sq. m. and 3-room apartments with floor areas of 60-90 sq. m. Only 6% of the respondents said they would like to buy a 1-room apartment with a floor area between 35 and 50 sq. m. [22]. Currently, 2-room apartments with an average floor area of 58.4 square meters make up the highest share of the new housing units in Krasnoyarsk (39%), while large apartments with an average floor area of 113.3 sq. m. have the smallest share (Figure 1). At the same time, the share of 3-room apartments is 3% higher than the share of 1-room apartments.

![Number of rooms and Average floor area](image)

**Figure 1.** The key parameters of apartments being built in Krasnoyarsk.

We must note that the size of apartments is influenced by many factors. The most important of those include the location of the building, housing facility grade, and the real disposable income levels among the population. Taking into account the current trends, effective demand, and the changes in the key factors impacting the composition and classification of housing in Krasnoyarsk, the authors recommend using apartment parameters shown in Table 2 when designing apartment buildings.
Table 2. The recommended apartment parameters for the designing of apartment buildings in Krasnoyarsk.

| Number of rooms       | Floor area range, sq. m. | Share in the total area, % |
|-----------------------|--------------------------|----------------------------|
| Studios               | 23-28                    | 1-2                        |
| 1 room                | 34-39                    | 4-6                        |
| 2-room studios        | 35-47                    | 16-18                      |
| 2 rooms               | 50-56                    | 19-21                      |
| 3 rooms               | 55-72                    | 38-40                      |
| 4 rooms or more       | 80-100                   | 12-15                      |
|                       |                          | 2026-2030                  |
| Studios               | 23-28                    | 1-2                        |
| 1 rooms               | 34-39                    | 2-4                        |
| 2-room studios        | 35-47                    | 16-18                      |
| 2 rooms               | 50-56                    | 16-18                      |
| 3 rooms               | 55-72                    | 40-42                      |
| 4 rooms or more       | 80-100                   | 16-18                      |

The apartment parameters shown in Table 2 take into account the current trends and consumer preferences. They are aimed at increasing the share of apartments with a large number of rooms and retaining comfortable apartment floor areas at the same time.

4. Conclusion
The results of the study performed show that the composition and classification of housing in a big city are determined by the level of housing availability to local residents that primarily depends on the city population count, the average cost of 1 sq.m. of residential housing, and the average income level in the city. The performed correlation and regression analysis helped confirm the close link between the dependent variable and the identified parameters, and construct an adequate linear regression equation with the determination coefficient of 0.983. The analysis of the key parameters of apartments being built in Krasnoyarsk showed that 2-room apartments with an average floor area of 58.4 sq. m are the common housing units in the city. Based on the data obtained, we suggested apartment parameters for the designing of apartment buildings up to 2030. The results of the research can be used to elaborate a development program for the residential development in large cities of Russia.

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