Geoinformation Analysis of Investment Land Attraction of City

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Abstract. In this work, a sequence of application of geoinformation systems was developed for the assessment and analysis of integrated indicators of potential investment land attractiveness of cities taking into account changes in normative monetary valuation of settlements. It is shown that the use of GIS allows to visualize geospatial data and ensure communication of the obtained indicators with the input information. The potential investment land attractiveness of regional centers and identified cities whose land needs to increase investment attractiveness has been analyzed. A GIS-map was constructed based on indicators of potential investment land attractiveness of cities taking into account changes in the normative monetary valuation of settlements, which provides the basis for its monitoring.

1. Introduction

The development of a modern city, as a multidimensional process, needs to take into account a significant number of economic, social, urban, environmental factors, which are caused by significant differences in the structure, mechanisms and directions of investment activity in the area of land use in Ukrainian cities. Previous studies by many authors show that increasing the investment land attractiveness of cities is an effective way to ensure sustainable urban development. Therefore, research in this direction is relevant, expedient and promising.

In recent years, the volume of work on land valuation has been decreasing. According to the State Service of Ukraine on Geodesy, Cartography and Cadastre as at 1 January 2018, 28% of the lands of settlements require a normative monetary valuation, which, in comparison with the same period last year, increased by 2.2 times. At the same time, the reliability and completeness of information provision on the formation and distribution of land does not increase. The justification of the implementation of the areas of development of the territories is not high enough, which reduces the investment land attractiveness of cities.

In the works of foreign and domestic scientists, rational use of land resources is an important issue: M. Khvesika, G. Larson, V. Golian, L. Perovich, A. Smith, D. Ricardo, V. Mischenko, O. Novotvorova, M. Palamarchuk [1-5].

In addition, technologies for determining the investment attractiveness of urban land are not fully developed and applied. The definition and formation of investment land attractiveness of cities with GIS tools serve particular attention.
The purpose of the article is to determine the possibility and development of a sequence of application of geoinformation technologies for determination and increase of investment land attractiveness of cities.

2. Main Part

Geoinformation analysis, as a method for improving technology, allows systematizing information provision and taking into account spatial characteristics of land, to determine the investment attractiveness of urban land.

The results of the estimation of integrated indicators of potential investment land attractiveness of cities, taking into account changes in the normative monetary valuation of settlements, create the basis for conducting geoinformation analysis (Table 1).

**Table 1. Results of the definition of integral indicators of potential investment attractiveness of urban land.**

| №  | Name of settlement | Integral indicators of potential investment land attractiveness of cities taking into account changes in normative monetary valuation of settlements \( I_{inv} \) | Level of investment attractiveness of regional centers \( I_{inv} \) |
|----|-------------------|----------------------------------------------------------|--------------------------|
| 1  | Lviv              | 2,144                                                   | 3,662                    |
| 2  | Ivano-Frankivsk   | 1,067                                                   | 3,381                    |
| 3  | Odessa            | 1,810                                                   | 3,337                    |
| 4  | Vinnitsa          | 1,380                                                   | 3,266                    |
| 5  | Kyiv              | 3,258                                                   | 3,246                    |
| 6  | Dnepr             | 2,585                                                   | 3,243                    |
| 7  | Lutsk             | 1,032                                                   | 3,225                    |
| 8  | Kharkiv           | 2,082                                                   | 3,211                    |
| 9  | Chernigov         | 0,911                                                   | 3,195                    |
| 10 | Zhytomyr          | 1,346                                                   | 3,168                    |
| 11 | Ternopil          | 0,961                                                   | 3,102                    |
| 12 | Zaporizhzhia      | 1,899                                                   | 3,099                    |
| 13 | Rivne             | 1,262                                                   | 3,072                    |
| 14 | Sumy              | 1,003                                                   | 3,063                    |
| 15 | Mykolaiv          | 0,997                                                   | 3,040                    |
| 16 | Cherkasy          | 0,924                                                   | 2,996                    |
| 17 | Khmelnitsky       | 0,923                                                   | 2,948                    |
| 18 | Poltava           | 0,987                                                   | 2,935                    |
| 19 | Kirovograd        | 1,043                                                   | 2,935                    |
| 20 | Uzhhorod          | 1,535                                                   | 2,914                    |
| 21 | Kherson           | 1,242                                                   | 2,891                    |
| 22 | Chernivtsi        | 1,188                                                   | 2,859                    |

The spatial dependence of the obtained integral indicators of potential investment land attractiveness of cities was adopted for conducting GIS analysis in the study.
The peculiarity of the use of integral indicators for GIS analysis is their relationship with each other according to certain criteria of classification, which made it possible to determine their level in space by the values of the initial indicators. In this case, for the simulation and analysis by means of geographic information systems, a structure is determined that is used to observe in the space of integral indicators of the potential land investment attractiveness of cities taking into account changes in the normative monetary valuation of the settlements.

In the context of the using GIS to determine the integral indicators of potential investment attractiveness of urban land and modeling the impact of groups of factors that form the integral criterion of investment attractiveness of urban land, an algorithm has been developed that consists of the following main stages:

1. Creation of a source information base for analyzing the investment attractiveness of regional centers:
   - Use of integral indicators of potential investment land attractiveness cities taking into account changes in normative monetary valuation of settlements;
   - bindings of defined indicators to regional centers;
   - definition of zones of formation of integral indicators for regional centers.
2. An analysis of integral indicators:
   - visualization of the estimation data of integral indicators of potential investment land attractiveness of cities taking into account changes in the normative monetary valuation of the settlements;
   - development of scale of levels of potential land attractiveness of cities;
   - comparison and analysis of integral indicators of potential investment land attractiveness of cities taking into account changes in the normative monetary valuation of the land of settlements by territorial features.

To assess the investment attractiveness of urban land, a model (see Fig. 1) is developed that allows us to present and consistently apply the provisions for creating a source information base for analysing the investment attractiveness of regional centers of Ukraine.

**Figure 1.** The model of implementation of the algorithm for creating an initial information base for analyzing the investment attractiveness of regional centers.
An algorithm model for creating an initial information base for analyzing the investment attractiveness of regional centers is a set of interrelated operations and a set of closed processes of the geographic information environment, implemented on the basis of the ArcGIS software product. At the same time, the value of the integral criterion of investment land attractiveness of cities and certain changes in the normative monetary valuation of the land of cities allowed to create a database of integrated indicators of the potential investment land attractiveness of cities, taking into account changes in the normative monetary valuation of the settlements' land and the basis of geospatial indicators.

This made it possible to form data on changes in the normative monetary valuation of land and to bind the corresponding integral indicators in administrative zones, which made it possible to build information support for the analysis of investment attractiveness of regional centers of Ukraine.

The system of geoinformation providing of investment land attractiveness of cities [7 - 9] in general was developed on the following components:
1. GIS software.
2. Geodata bases of integrated indicators of potential investment land attractiveness of cities taking into account changes in normative monetary valuation of settlements.
3. The legal basis for determining investment attractiveness of the land bridge.
4. Technologies for estimating integral indicators.
5. Software suite;
6. Administration of the system.

The general scheme of geoinformation analysis of investment attractiveness of land of cities (stage 2) is presented in the form of a flowchart (see Fig. 2). As the flowchart shows, the use of geoinformation systems to evaluate and analyze the integral indicators of the potential investment attractiveness of urban land, taking into account changes in the normative monetary valuation of settlements, gives the opportunity to visualize the obtained geospatial data and to ensure the connection of the obtained indicators with the input information. This, first and foremost, has created a sound basis for monitoring the investment land attractiveness of Ukrainian cities and showed the perfection and the possibility of using this method along with traditional mathematical methods and models.
Thus, the presented results of the estimation of integral indicators (see Table 1) and previous authors' work [10 - 12] allowed to conduct a geoinformation analysis and construct a GIS map of potential investment land attractiveness of cities taking into account changes in the normative monetary valuation of lands of settlements of Ukraine (see Fig. 3). The presented map allows to visualize the data of estimation of indicators and creates the basis for their comparison and analysis.
on territorial grounds, and also allows monitoring taking into account changes in normative monetary valuation of the land of settlements of Ukraine depending on the normative estimation.

The scale of levels of potential land attractiveness of cities is developed, which is determined on the basis of integral indicators of potential investment land attractiveness of cities by regional centers of Ukraine. It is established that the land of Kyiv is of absolute attractiveness (3,258); Characterized by the high land attractiveness of cities: Kharkiv (2,082), Dnipro (2,585), Zaporizhia (1,899), Lviv (2,144), Odessa (1,810); Mediocre attractive are the land of cities: Kherson (1,242), Chernivtsi (1,188), Uzhgorod (1,535), Vinnytsia (1,380), Zhytomyr (1,346), Rivne (1,262); The cities are characterized by low attractiveness: Ternopil (0,961), Khmelnitsky (0,923), Lutsk (1,032), Ivano-Frankivsk (1,067), Chernigov (0,911), Sumy (1,003), Poltava (0,987), Cherkasy (0,924), Kirovograd (1,043) and Nikolaev (0,997).

It is determined that most of the lands of regional centers have mediocre or high attractiveness. Along with this, there is a need to increase the investment attractiveness of land with low investment attractiveness by developing appropriate methodological recommendations.

It should be noted that to increase the investment attractiveness of the regions, the use of geoinformation systems for the formation of spatial models of the level of engineering and infrastructure provision of cities is essential.

The proposed model of the influence of pipeline engineering provision of the territory on the land evaluation (pic. 3) is proposed by bringing the elements of the engineering network to a single cost system (1):

\[
R_i = \frac{S \cdot V_i}{2 \sum_{i=1}^{n} (V_i \cdot L_i)}.
\]  

(1)

\(V_i\) - the cost of 1 meter of pipes; \(L_i\) - the length of pipes of a specific diameter; \(S\) - the area of servicing the territory by a certain type of pipeline engineering facilities of the territory; \(R\) is the buffer depth.

The geoinformation models of providing the territory of the city of Kharkov with engineering networks are constructed with water, gas, heat supply and drainage (see Fig. 4), which allow justifying the calculation of the zonal coefficient of engineering and infrastructure provision of the territory.
The distribution of zones of local coefficients by type of values for heterogeneous (with continuous change in the space of values of local coefficients) and homogeneous (with single values of local coefficients) was conducted at the local level, which allowed taking into account the peculiarities of the influence of spatial factors and constructing the corresponding models.

![Spatial models of engineering and infrastructural provision of Kharkiv city.](image)

**Figure 4.** Fragments of spatial models of the level of engineering and infrastructural provision of the Kharkiv city.

It should be noted that the investment land attractiveness of the regions is influenced by the level of direction of the functioning of the construction industry. In particular, over the past seven years, the construction product index had a wave-like character.

So for 2011-2014, there was a decrease in the indicator, from 2015 to 2017 - there is an increase. Similar trends are observed with the volume of construction work performed. The growth in the volume of residential housing accepted by 2015 has increased by 27% compared to 2011, in recent years it has decreased by 8%.

The resultant criterion characterizing the intensity of development of the territories of regions of Ukraine is the corresponding level of development.

As a result of the study, it was found that the following areas have the highest levels of developments:
- Donetsk – 0.074;
- Dnipropetrovsk – 0.058;
Lviv – 0.052;
Kyiv and Chernivci – 0.048.
The lowest value of the indicator was in the following regions:
Lugansk – 0.013;
Odesa – 0.019;
Ivano-Frankivsk – 0.022;
Kherson – 0.024;
Zaporozhia – 0.025.

The indicator of the level of development of territories testifies to the low density of the use of lands of settlements, which affects the directions of their development. In such circumstances, the use of tools for increasing the effectiveness of land formation, use, development, and evaluation, taking into account offered factors and peculiarities of interaction between groups of interested persons operating in the field of land relations, becomes of particular importance.

It should be noted that the reflection of directions and features of the development of territories of settlements is their investment attractiveness, which is determined by the results of the normative monetary valuation of land. As of 01.01.2017, the normative monetary estimate of 3748 settlements is required, which is 12.6% of the total number.

By the analysis, it is determined that they actively work on the implementation of normative monetary valuation of land in Odessa, Zaporizhia, Ternopil, Luhansk regions, where the proportion of settlements in need of a normative monetary assessment in their total number is 0.001, 0.019, 0.022, 0.036. Also, the highest value of the indicator was observed in the following regions:
Ivano-Frankivsk – 0.251;
Volin – 0.229;
Lviv – 0.184;
Khmenitsk – 0.181;
Cherkasy – 0.173.

In general, most of the settlements have a normative monetary valuation, but there is a high level of these items that require an assessment that negatively affects the development of territories. Also, the results of the normative monetary evaluation influence the formation, distribution, and use of land in cities, where it is necessary to take into account the spatial factors that operate in the field of land relations.

As a result of the analysis, it was determined that the largest average (basic) cost per square meter of the locality was characterized by regional centers:
Lviv - 479.29 UAH/m2;
Kyiv - 385.8 UAH/m2;
Uzhgorod - 318.69 UAH/m2;
Kharkiv - 291.18 UAH/m2;
Vinitsa - 290.8 UAH/m2.
Along with this, the following values were determined for the lower values of the average (basic) cost per square meter of the settlement:
Zhytomyr - 102.38 UAH/m2;
Cherkasy - 127.48 UAH/m2;
Luhansk - 128.38 UAH/m2;
Ternopil - 132.62 UAH/m2;
Sumy - 144.72 UAH/m2;
Lutsk - 158.14 UAH/m2;
Poltava - 157.0 UAH/m2.

Thus, there is a significant imbalance between the largest and the lowest average (basic) cost per square meter of the settlement at 379.91 UAH/m2, which indicates a lack of stability in the area of cost parameters of cities. This negatively affects the assessment and use of land in the metropolis.
3. Conclusions
The article presents the results of estimation of integral indicators of potential investment land attractiveness of cities taking into account changes in the normative monetary valuation of the settlements, which created the basis for conducting geoinformation analysis. Identified opportunities and developed a sequence of application of geoinformation technologies for determination and increase of investment land attractiveness of cities. A GIS map of potential investment land attractiveness of cities is developed, which allows to visualize the data of the estimation of indicators and provides the basis for their comparison and analysis according to the territorial features, and also makes it possible to monitor the changes taking into account changes in the normative monetary valuation of the land of settlements of Ukraine depending on the normative assessment of their lands. The scale of levels of potential land attractiveness cities is developed, which is determined on the basis of integral indicators of potential investment land attractiveness of cities by regional centers of Ukraine. Thus, the purpose of the article is achieved.

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