

*Research paper*

## Features of underground real estate use: infrastructural and regional aspects

Kostiantyn Meteshkin<sup>1</sup>, Volodymyr Shipulin<sup>2\*</sup>, Serhii Nesterenko<sup>3</sup>,  
Serhii Kobzan<sup>4</sup>

O.M. Beketov National University of Urban Economy in Kharkiv, Ukraine

<sup>1</sup>e-mail: [meteshkin@gmail.com](mailto:meteshkin@gmail.com), ORCID: <http://orcid.org/0000-0002-1170-2062>

<sup>2</sup>e-mail: [vshypulin@gmail.com](mailto:vshypulin@gmail.com)

<sup>3</sup>e-mail: [nesterenkog34@gmail.com](mailto:nesterenkog34@gmail.com), ORCID: <http://orcid.org/0000-0001-5124-9728>

<sup>4</sup>e-mail: [s.kobzan@gmail.com](mailto:s.kobzan@gmail.com), ORCID: <http://orcid.org/0000-0002-5257-8117>

\*Corresponding author: Volodymyr Shipulin

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**Abstract:** The transformation processes that occur in the technical, informational, and economic spheres of the regions require the development of new conceptual approaches to the development of a full-fledged land use system based on an analysis of the problems of using underground real estate. Determination of the features of land use of underground real estate is based on a quantitative basis, which is built on a systematic, integrated approach. Indicators that determine the condition and use of underground real estate are of particular importance for the development of the approach. A method of estimating a generalized indicator of the use of underground real estate in the system of land use of regions based on an integrated approach, which includes the method of expert assessments by applying qualitative indicators characterizing the status and level of use of underground real estate, considering urban, spatial, investment and innovation legal and safety features is developed. The assessment results of the integrated indicator of underground real estate land use, as well as the results of the assessment by region, showed a low level of use of underground real estate in the land use system of the regions. It is determined that most of the lands in the regions have low levels of underground real estate use. Besides, there is a need to increase the use of underground real estate by developing appropriate methodological recommendations.

**Keywords:** underground real estate, land use, integrated indicator, urban planning, assessment



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## 1. Introduction

The development process of land use in cities and regions reflects changes in the structural nature of specific land categories of zonal and regional levels. Current trends show a constant decrease in the overall balance of regional lands occupied by industrial zones, energy, defense facilities, or agricultural lands. Mainly, these principles apply to the lands of central and near-central territories of cities. There is also a constant decrease in the territory of manor buildings, as well as the areas of cottages and gardening. The condition of the above categories of urban land can be significantly improved by changing their functional use as a factor of forming an integrated criterion for urban land use assessment (Enemark, 1998; Gasiorowski and Bielecka, 2014; Maleta and Mościcka, 2018; Mamonov et al., 2019). In this case, it is necessary to consider the obstacles from legislative impacts on land and the complex mechanism for the distribution of land plots of cities with underground real estate.

Thus, there is currently a rapid increase in the level of high-rise buildings in cities and commercial institutions. The share of transport, recreational and recreational land is increasing. As before, this primarily concerns the lands of the central territories of the city (Pieri et al., 1996; Smyth et al., 1993; UNECE, 2005).

With the increase in land development, the assessment of the territory and the zone of their distribution in the city is continuously increasing. These phenomena are observed with each update of the master plan of the city. At the same time, in the process of development and construction of remote areas, there is a process of growth in the land assessment. Assessment, in this case, is considered as a dynamic quantity, which is influenced by a large number of factors. An example would be the increase in the value of a site as its current and planned costs decrease by increasing the degree of readiness for its construction or development. The attractiveness and value of land are enhanced by reducing the costs of efficient construction and rational planning.

Assessment and selection of city lands for various purposes and directions of their use depends on the influence of many criteria that can affect the development and planning of the functional sphere of the city. These criteria as follows: – the planning structure of the city; – the security of connections between the components of the city; – the functional convenience or security of land; – urban planning indicators; – spatial and environmental conditions.

All these factors directly affect the use of land in the city and form the direction of its development. Moreover, the condition and characteristics of land use depend on many factors. They, in a certain way, can characterize the cost indicators of land and have a direct impact on the planning of development, commercial use, and other sectors of the local level. The role and functions of the lands of settlements and regions in society are determined by the fact that these lands are intended to provide various types of human activity: – the satisfaction of physiological needs in recreational, cultural and social activities; – ensuring production activities organically related to life support and other areas.

Land in settlements acts as a spatial and operational basis and real estate object. Properties that are important for its functioning on the territory of settlements include soils (density, water permeability), groundwater (depth, chemical, bacteriological composition), terrestrial water, relief and division of the territory, vegetation, soil (pollution, salinization, quality).

The subject of urban land management, in general, is land use processes for various spheres of life (direction, character, technology, etc.). Regarding the subject of management on these lands, there are many reasonably specific features: a high concentration of various types of life activity per unit area (subjects of land relations), a variety of methods, technologies, time of consumption of land properties.

All this creates a large number of land management objects, phenomena, and processes. The object of management is a land plot on which a reasonably separate process of land use by one subject of land relations is carried out. As a result, land use, their parts that differ by the nature of use, legal status, or land plots, which are the part of the land of general importance, can be the object of management in the built-up territories. The subject of management in the private sector is the land use process, which within a specific point, provides the full diversity of the needs of its residents. Therefore, it is distinguished by a variety of aspects of state and urban governance. The main areas of land use:

1. The territorial organization of the land use process.
2. Information support of the land use process.
3. Establishment of the legal status of land (ownership, use, lease, restrictions, encumbrances).
4. Determination of land use types (extended use) based on the natural and economic condition of the land.

Particular attention in these areas should be given to spatial planning. This trend can lead to an increase in the value of the real estate as a result of the construction of new or improvement of existing buildings and their engineering communications, or as a result of permits to change the nature of land use, e.g., for construction of luxury housing, commercial, financial or other objects. The technical improvement of the houses only results in a slight increase in their market value compared to the changes in the character of the land use associated with the official approval of its change. The last action prevails in percentage terms and may be subject to a special tax. Cases of compensation for the "deterioration" of the characteristics of the property, for example, as a result of a decision to build a motorway or airport near the location of such property, are quite rare. For urban planning, the main issue is the future character of land use. Land use is the link between land rights and land management. It includes the use of land and the exercise of related rights. A prerequisite for creating a development plan is the study of the following issues:

- 1) to determine the type of land use;
- 2) to identify ongoing changes, their pace, e.g., in connection with the growth of cities;
- 3) to connect land use data with other technical and social data on urban development;

- 4) to conduct a quantitative analysis of land use of cities in different regions of cities using temporary methods and indicators;
- 5) to develop models of the city land-use system in time and space;
- 6) to ensure broad discussion and publicity of research findings.

Thus, directed impacts on the development and improvement of spatial planning will solve the problems of current land use and will create the basis for the formation of an informational and managerial basis in the development of cities and regions. In modern conditions of land use, the issues of determining the features of the use of underground real estate are becoming increasingly relevant. The transformation processes taking place in the technical, informational, and economic spheres of the regions and require the development of new conceptual approaches to the development of a full-fledged land use system based on an analysis of the problems of using underground real estate.

The definition of the features of the use of underground real estate land is based on a quantitative basis, which is built on a systematic, integrated approach. The indicators, which determine the condition and use of the underground real estate, are of particular importance for developing the systematic, integrated approach. Therefore, factors of influence are proposed that can be grouped according to the following signs and characteristics: condition, urban planning, spatial, investment and innovation, social and legal, security questions. In recent years, in large cities, land use efficiency issues have become increasingly important, given the significant population growth. In many developed countries, there is a growing interest in the use of underground space. Underground real estate objects can conditionally be divided into three categories: commercial underground real estate, engineering networks, transport infrastructure.

Today, the question of evaluating underground real estate is relevant, since real estate plays a special role in the economic and socio-cultural life of any society, acting as an essential resource and playing the role of a spatial environment in which any human activity is carried out. Information support should be understood as the process of collecting and providing information on land plots and related construction projects, on territorial zones, in order to fix them in documents of the state real estate cadastre, as well as exchange information between interested users in accordance with their information needs. The assessment of real estate is based on numerous sources of information. The availability of the necessary information allows the evaluator to comprehensively approach the assessment process and accurately justify the final value. The information, which is necessary for the assessment of real estate, can be divided into external and internal. External information is collected and analyzed in the following sequence: general, special.

General information is necessary to study the state and general trends in the functioning of the economy and the real estate market. This is descriptive information that is used directly to determine market value. Specific information is presented, as a rule, in the form of numbers, which is used for calculations in a particular method. The formation of an array of external information for real estate assessment is carried out based on four levels of analysis of real estate:

- a) city analysis;
- b) analysis of the real estate market;

- c) market segment analysis;
- d) analysis of the land plot.

An analysis of the city is carried out to study the current state of the functioning of its real estate environment. Analysis of the real estate market is carried out to determine the situation and prospects for the development of the real estate market. The purpose of analyzing a market segment is to identify trends, which have developed in the segment to which the valuation object belongs, as well as to gather information about similar objects. Land parcel analysis involves determining the legal, technical, and economic parameters of the valuation object by comparing it with similar market segment objects. Depending on the type of analysis, external or internal information is used.

At the level of the analysis of the city, external information is used, including:

- the rate of economic growth; inflation rate;
- business activity index;
- the investment climate in the country; change in the national currency rate;
- population income level, etc.

To analyze the real estate market, data on market conditions, price dynamics in the real estate market, the regulatory framework for the regulation of property relations are collected and analyzed. The analysis of the real estate market segment is conducted based on information about the general market situation in the given market segment, the dynamics of prices in the market segment, the level of costs for the operation of the object, average occupancy of real estate, the tax climate, the level of costs of reproduction or replacement of the object, the indexes of recalculation of the estimated value, etc.

The sources of external information are:

- data from government organizations;
- public records;
- published market research data;
- analytical reviews of news agencies;
- data published in periodicals or posted on the Internet;
- specialized reference books and collections;
- data of insurance companies;
- information databases of management companies, realtors, appraisers.

Internal information is a combination of legal, physical, and economic characteristics of the property:

- the legal status of the facility;
- physical parameters of the object;
- the state of the land;
- data on the components of the real estate object;
- the location of the object.

The sources of internal information are primary information about the real estate object: technical, economic, and legal documentation on the object, information received from the owner or manager of the real estate object. A unified information space is provided by:

- agreements between various departments on the conditions for the exchange of information resources;

- development of a unified methodology for identifying real estate at all territorial levels;
- formation of a single structure of data banks, formats, classifiers, reference books for all structures in the field of real estate property management;
- software and hardware consistency and compatibility of information interaction technologies;
- the spatial reference of departmental information in a digital topographic basis of the real estate cadastre.

The formation of unified information support is a multi-purpose task, and all agencies must solve it at all levels of government. The main problem here is the coordination of work related to real estate because the departmental separation creates duplication, excess, lack of proper quality and reliability of the information. Besides, there are differences in hardware and software, in the technology for cadastral and technical registration of real estate, as well as in the level of professional training of management services personnel.

Such informational support will make it possible to provide the real estate valuation sphere with the necessary high-quality, relevant information, obtain reasonably calculated evidence-based assessment results and significantly improve the quality of valuation work, minimizing the subjective assumptions of the appraiser. The developments of Ukrainian and foreign experts, as well as modern achievements in the field of information, geoinformation technologies, and methodological support for real estate valuation, create all the prerequisites for the introduction of universal, comprehensive information support designed to perform real estate valuation.

## **2. Materials and methods**

The system of factors of underground real estate land use consists of the following elements:

1. The state of the underground real estate:
  - determining the physical deterioration of underground objects of real estate;
  - determining the obsolescence of underground real estate;
  - determining the level of communication with the ground communication facilities;
2. Urban development characteristics of underground real estate lands:
  - determining the level of underground real estate use;
  - determination of the level of formation of engineering characteristics of underground real estate;
  - determining the level of influence of architectural characteristics on the formation of underground real estate;
  - determining the level of formation of the legal regime for the use of underground real estate;
  - determining the level of consideration of the historical and architectural value of underground real estate objects;

- determining the level of provision of town planning documentation for the operation of underground real estate objects;
- determining the level of legal regulation of the use of the underground space;
- 3. Spatial characteristics of underground real estate:
  - determining the level of location of underground real estate within the city or region;
  - determination of geometric parameters of underground real estate objects;
  - determination of geospatial characteristics of underground real estate land use;
- 4. Investment-innovative characteristics of underground real estate objects:
  - determining the level of investment attractiveness of lands placement of underground real estate;
  - determining the level and condition of innovations in underground real estate;
- 5. Social and legal characteristics of the use of underground real estate:
  - determining the legal status of the use of underground real estate;
  - determining the level of the ratio of socialization to the object of underground real estate;
  - determining the level of influence of the object and land of underground real estate on socialization;
- 6. Safety issues of the underground real estate use:
  - determining the level of the general safety of the use of underground real estate;
  - determining the level of environmental safety of the use of underground real estate;
  - determining the level of financial and economic security of the use of the underground real estate.

It should be noted that the system of land use indicators for underground real estate determines the status and level of underground real estate use, considering urban, spatial, investment-innovative, social and legal, and safety characteristics (Bober et al., 2016; Calka and Bielecka, 2016; McCalla and Ayres, 1997; Mingming et al., 2019). To evaluate the indicator of the use of underground real estate lands, it is proposed to apply an integrated assessment approach, including a group of analytical and expert assessment methods. The indicators were evaluated based on the expert assessment method. The significance of indicators of the state and use of underground real estate within the components was determined by weight coefficients using the hierarchy analysis method. The assessment of the integrated indicators of underground land use was performed by determining the mutual influence of each group of indicators and assessing the generic indicators of urban, spatial, investment-innovative, social-legal and safety characteristics (Nesterenko and Plugin, 2017; Nesterenko and Radzłnskaya, 2018; Rockström et al., 2010).

### **3. Results**

Thus, a method for assessing the generalized indicator of underground real estate land use, based on an urban planning, which includes a method of expert assessments by

applying qualitative indicators characterizing the state and level of underground real estate land use, considering urban planning, spatial, investment-innovative, social-legal and safety characteristics were proposed.

The proposed method consists of the following steps:

1. Determination of indicators of the underground real estate land use;
2. Assessment of generalized indicators using analytical and expert methods;
3. Determination of impact coefficients of generalized indicators;
4. Assessment of integrated indicators of the level of the underground real estate land use;
5. Assessment of the integrated indicators the underground real estate land use was carried out by determining the mutual influence of each group of indicators.

Within the framework of the proposed assessment method, a hierarchy analysis method is used, which allowed considering the weight of each of the indicators affecting the generalized integrated indicator of underground real estate land use. The proposed method creates a methodological basis for an integrated assessment of the use of underground real estate in the land use system of the regions. According to the proposed method, the integrated indicators of the level of use of underground real estate land are estimated, the results of which are presented in Table 1.

Table 1. The assessment results of integrated indicators of the level of underground real estate land use, rel. units

| Integrated indicators                | Value |
|--------------------------------------|-------|
| The state of underground real estate | 1.68  |
| Urban planning                       | 1.31  |
| Spatial                              | 1.45  |
| Investment and innovation            | 3.26  |
| Social and legal                     | 3.1   |
| Security issues                      | 2.32  |

#### 4. Discussion

As a result of calculating the generalized indicators of underground real estate land use, the value of the integrated indicator was obtained, the value of which was 1.465. The scale by which the level of underground real estate land use is determined is presented in Table 2.

As a result of the assessment, a low level of use of underground real estate lands in the land use system of the regions was determined. In this case, significant prerequisites are observed for the emergence of opportunities for its formation. In such circumstances, it becomes crucial to develop and implement measures to:

- strengthening the state and efficient use of underground real estate lands;



Table 2. Scale for determining the status and level of use of underground real estate, rel. units

| The value of the integrated indicator | Level of use of the underground real estate |
|---------------------------------------|---|
| 0                                     | no underground real estate                  |
| 0.01–2                                | low   |
| 2.01–4                                | insignificant                               |
| 4.01–6                                | mediocre                                    |
| 6.01–8                                | significant                                 |
| 8.01–9.99                             | high  |
| 10                                    | absolute                                    |

- ensuring implementation of urban-planning directions considering the engineering characteristics of underground real estate lands, the influence of architectural characteristics on the formation of underground real estate lands, the formation of the legal regime, the historical and architectural value of objects, the level of providing urban planning documentation, legal regulation of underground real estate, the establishment of boundaries and restrictions on the use of underground real estate, construction features, and technical and technological characteristics;
- definition and improvement of the system for ensuring and accounting the spatial characteristics of the underground real estate lands;
- increasing the attraction of investment resources in the field of underground real estate use, considering the innovative development trends;
- the increasing importance of social and legal factors;
- strengthening the security features of underground real estate.

In the context of determining the condition and use of underground real estate lands in the regions of Ukraine, an integrated indicator is presented, which varies in accordance with the level of development. The results of this indicator evaluation are presented in Table 3. According to the indicator assessment of the land development level, the results of the integrated indicator of underground real estate land use by region are obtained, which are presented in Table 4.

According to the results of evaluating the integrated indicator of underground real estate land use and the results of the assessment by region, a low level of underground real estate use in the land use system of the regions is determined. The study found a positive impact of systematic spatial, urban, investment, environmental indicators on the integrated indicator of land use in the regions. The necessity of considering the directions of the formation and use of underground real estate lands in the land use system of the regions is determined. It is proved that underground real estate forms a component of the system for complex assessment of land use in the regions, except for which the elements are: real estate, external and internal environment, which is located around. Spatial, urban, investment, and environmental factors are identified. This created the basis for the formation of information and analytical support for land use in the regions.

Table 3. The results of the evaluation of the level of land development by region, rel. units

| Region          | Building level value, rel. units | Region      | Building level value, rel. units |
|-----------------|----------------------------------|-------------|----------------------------------|
| Vinnitsia       | 0.04                             | Mykolaiv    | 0.039                            |
| Volyn           | 0.03                             | Odessa      | 0.019                            |
| Dnipropetrovsk  | 0.058                            | Poltava     | 0.039                            |
| Donetsk         | 0.074                            | Rivne       | 0.027                            |
| Zhytomyr        | 0.029                            | Sumy        | 0.035                            |
| Zakarpattia     | 0.035                            | Ternopil    | 0.046                            |
| Zaporozhye      | 0.025                            | Kharkiv     | 0.042                            |
| Ivano-Frankivsk | 0.022                            | Kherson     | 0.024                            |
| Kyiv            | 0.048                            | Khmelnyskyi | 0.04                             |
| Kropyvnytskyi   | 0.036                            | Cherkasy    | 0.04                             |
| Lugansk         | 0.013                            | Chernivtsi  | 0.048                            |
| Lviv            | 0.052                            | Chernihiv   | 0.036                            |

Table 4. Assessment results of the integrated indicator of underground real estate land use by region, rel. units

| Region          | Building level value, rel. units | Region      | Building level value, rel. units |
|-----------------|----------------------------------|-------------|----------------------------------|
| Vinnitsia       | 1.505                            | Mykolaiv    | 1.504                            |
| Volyn           | 1.495                            | Odessa      | 1.484                            |
| Dnipropetrovsk  | 1.523                            | Poltava     | 1.504                            |
| Donetsk         | 1.539                            | Rivne       | 1.492                            |
| Zhytomyr        | 1.494                            | Sumy        | 1.5                              |
| Zakarpattia     | 1.5                              | Ternopil    | 1.511                            |
| Zaporozhye      | 1.49                             | Kharkiv     | 1.507                            |
| Ivano-Frankivsk | 1.487                            | Kherson     | 1.489                            |
| Kyiv            | 1.513                            | Khmelnyskyi | 1.505                            |
| Kropyvnytskyi   | 1.501                            | Cherkasy    | 1.505                            |
| Lugansk         | 1.478                            | Chernivtsi  | 1.513                            |
| Lviv            | 1.517                            | Chernihiv   | 1.501                            |

## 5. Conclusions

Thus, the method of generalized indicator estimation of underground land use in the system of land use of regions based on the integrated approach is developed, which includes the method of expert assessments by applying qualitative indicators characterizing the

status and level of use of underground real estate, taking into account urban, spatial, investment innovative, social-legal and safety characteristics. Within the framework of the proposed valuation method, a method of hierarchy analysis was used, which made it possible to determine the importance of each of the indicators affecting the overall integrated indicator of underground real estate use. The proposed method creates a methodological basis for the integrated assessment of the use of underground real estate in the system of land use in the regions.

It is determined that most of the lands in the regions have a low level of use of the underground real estate. Besides, there is a need to increase the use of underground real estate by developing appropriate methodological recommendations.

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