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3D CADASTRE AS A TOOL FOR REGULATING PROPERTY RELATIONS AND A SPATIAL INFORMATION BASE FOR MULTIPURPOSE CADASTRAL SYSTEM

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ABSTRACT

Aim of the study

The purpose of the study is to prove the importance and necessity for the transformation of the national cadastral system of Ukraine and the introduction of 3D cadastre technology for measuring real estate objects in real time. Previous studies of domestic and foreign scientists in the field of 3D modeling of real estate objects were analyzed, leading 3D modeling systems of real estate objects were compared, legal rights of the parties in creating and maintaining a 3D cadastre of real estate objects were determined, and recommendations were developed on the need for their use in Ukraine. An analysis of existing standards and approaches to the methods and construction of three-dimensional models of real estate objects was carried out, as well as an analysis of the possibilities of introducing three-dimensional objects into a multi-purpose cadastral system, based on international standards within the regulatory and legal system of Ukraine. Using the example of a specific plot of land, the effectiveness of operating with different property interests in relation to it in 3D space, rather than on a 2D plane, is demonstrated.

Materials and methods

The theoretical basis consists of the scientific works by domestic and foreign scientists in the field of 3D modeling of real estate objects, methodological and instructional materials for the implementation of 3D cadastre technology, which will make it possible to introduce the measurement of real estate objects in real time, as well as to register ownership rights to real estate objects located above and below the surface of the earth. In selecting the references for this study, a systematic approach was used to ensure the relevance and credibility of the sources. First, we conducted a comprehensive search of peer-reviewed articles, books, and reports published in the last 20 years, focusing on topics directly related to 3D cadastral systems, real estate object modeling, and relevant legal frameworks. The primary databases used included Scopus, Web of Science, and Google Scholar, ensuring a wide scope of global research coverage. Studies were selected based on their contribution to the theoretical, methodological, and practical advancements in the field, with an emphasis on recent developments in 3D cadastre technology. Additionally, priority was given to works with high citation rates and publications by leading experts in the field. The final selection of references reflects both foundational theories and cutting-edge innovations, which support the study's objectives and pertinent discussion.

Taking into account the peculiarities and realities of the post-war reconstruction of Ukraine, we conducted an analysis of best practices (in terms of research), focusing on those whose practical achievements can become the basis for new domestic research on the territory of our state, taking into account the existing regulatory and legislative framework. From this point of view, foreign experience is interesting, confirming

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the effectiveness of such a system in the complex management of resources at the level of municipalities; increasing the investment attractiveness of territories due to the fact that owners are guaranteed the realization of all rights to any three-dimensional real estate object; as well as reducing the number of property disputes, since the height coordinate is a control and 98% protects the cadastral system from overlays and false registration of object boundaries.

Monographic analysis was used for the study and generalization of existing scientific approaches to the problem of 3D modeling of real estate objects, the possibilities of introducing three-dimensional objects into the multi-purpose cadastre system, taking into account the realities of today in Ukraine with the prospect of the possibility of a more rapid development of a socially oriented market economy after the war.

The synthesis method is manifested due to the comprehensive deepening of the theoretical, methodological and methodical foundations of the national cadastral system and its transformation. The cadastre is always connected with the land, which is the spatial basis of human life. However, cadastral information is not only the basis for the rational use and protection of land, but also the basis for accounting for real estate objects and other land improvements. It is with the use of the synthesis method that the role of the multipurpose 3D cadastre has been proven as an effective tool for accounting for land plots, immovable property, as well as rights to them and their encumbrances.

Systematic approach implies that 3D cadastre databases can be used by those involved in land development processes, including surveyors, architects, developers, designers, real estate agents, local government structures and corporate owners. The 3D cadastre system can provide important information for various aspects of land and property management.

The research methodology is based on the main principles: general dialectical principle of general connection and interaction; the principle of causality, which is connected with the principles of general communication and development; principles of systematicity in cognition.

Results and conclusions

The intensive development of cities in Ukraine, combined with complex cases of spatial demarcation, from the point of view of property rights, requires a new approach to land management, which would make it possible to register real estate objects and rights to them in 3D format – keeping cadastral records with a three-dimensional presentation of information. Therefore, creation of a 3D cadastre system, which will be able to solve the problems of ambiguity present in the maintenance of 2D cadastre, is essential. To create a 3D cadastre in Ukraine, it is necessary to improve the national cadastral system, in particular to fill it with information about buildings and structures, as well as to combine registers that contain information about land plots and real estate objects located on them with information about property rights.

Keywords: 3D cadastre, multi-purpose cadastre, vertical distribution of interests, protection zones, engineering communications, 3D modeling

INTRODUCTION

In international practice, the definition of the land cadastre, approved by the UN together with the International Federation of Surveyors (International Federation of Surveyors, FIG), is universally accepted. According to that definition, "the cadastre is, as a rule, a constantly updated information system of land data, divided into plots (parcels), in which entitlements to real estate are registered (including rights, restrictions, and responsibilities)".

In Ukraine, technical support for the formation and maintenance of the state land cadastre and registration of rights to real estate significantly lags behind the needs and the practice of regulating property relations. It continues to remain insufficient, in particular, it is often changeable, contradictory and, as a result, ineffective, opening possibilities for manipulation of land and rights to land plots and other real estate. 3D cadastre is an effective alternative to the modern cadastral and registration system.

In the conditions of the twenty-first century, any cadastre is no longer just a list or summary of data. Instead, it is a geoinformation system of information about geospatial objects that exist in reality, are characterized by a certain position on Earth, and are

defined in the established system of spatio-temporal coordinates (Verkhovna Rada of Ukraine, 2011a). The main task of creating a real estate cadastre is the formation of a unified information space for the use, disposal and ownership of real estate objects for the purpose of managing the development of the city, the land and property complex, as a complex dynamic system. In recent years, many scientific works have been devoted to three-dimensional modeling in multipurpose cadastre systems. But in practice, most countries use the usual two-dimensional cadastral system. Therefore, the question arises whether it is expedient to use three-dimensional systems, taking into account the complexity of their implementation in practice, as it requires large financial costs, an increase in the quantitative and qualitative characteristics of a qualified workforce, and considerable time for implementation. Just one collection of initial data will take more than one year, since much information is in paper form or is not available at all, and its quality is not always satisfactory, which entails the need to carry out a complex of field topographic and geodetic works to clarify the information. A prerequisite for the creation of a single information space is the requirement of spatial and temporal linking of information about all real estate objects and land in the city. Display of current information in the cadastre with high accuracy is possible provided that a single database of cadastral data is created. The data bank should cover all levels of administrative and territorial entities, from the village council to the district, region, and state.

In Ukraine, the scientific community pays insufficient attention to the topic of displaying the spatio-temporal properties of cadastral accounting objects, and the existing publications are mostly declarative in nature and mainly concern legal aspects (a detailed overview is given above). This confirms the need to study the technical and technological aspects of the raised issue.

The first scientific discussions at the international level regarding the 3D cadastre system took place in the 1990s. More intense development of 3D cadastre research began at the turn of the millennium, when the first international forums were organized, the purpose of which was to develop theoretical concepts of 3D cadastre. The FIG working group on 3D cadastre organized seven international thematic seminars. Research in the field of 3D cadastre was also carried out by various scientists. The methodological principles of the creation and functioning of three-dimensional cadastral systems are substantiated in the works of international scientists. In particular, several studies of international 3D cadastral developments were conducted (Oosterom et al., 2006; Thompson, 2007; Aien et al., 2011, 2013; Stoter et al., 2012, 2017; Lemmen et al., 2015; Mika et Jurkiewicz, 2018; Cemellini et al., 2020; Doner, 2021). These included detailed analyses of various complex three-dimensional configurations, focused on exploring the optimal legal, technical and cadastral basis for the 3D cadastre, in which several (theoretical) alternatives for the proper cadastral registration of multi-level property were proposed. The limited progress in the implementation of a full 3D cadastre worldwide can be explained by the fact that such implementation would require close cooperation between legal and technical experts in an empirical environment to understand the impact of each other's fields of activity. Achieving an international consensus on the legal, institutional and technical aspects of the 3D cadastral solution is a substantial challenge. Since the rights, restrictions and responsibilities with the 3D component are registered administratively, legal stakeholders are reluctant to implement the 3D cadastre. From a technical point of view, the technology required to use 3D digital data for registration has developed considerably over the past twenty years. However, further research is needed into a true 3D cadastral solution, creating a workflow that takes into account both the current legal and technical framework. In the context of the above, it is appropriate to study digital mapping technology and 3D laser scanner technology, which are already today a means of effective electronic planning, design, construction and life cycle of the building environment. These technologies can be used to improve productivity by facilitating the free flow of information between departments, divisions, offices and facilities, as well as between themselves, their contractors and partners, when the data obtained with the help of these technologies are processed and modeled in building information modeling (BIM) (Arayici, 2008).

In Ukraine, scientific research on the topic of 3D cadastre is mostly focused on legal aspects, and

somewhat less attention is paid to organizational and technical aspects. A wide group of Ukrainian scientists is engaged in solving issues related to the maintenance and formation of the cadastral system. In the studies by Popov (Popov et al., 2023), Dombrovska and Tyshkovets (Dombrovska and Tyshkovetz, 2019), the cadastral system is the basis for facilitating land administration. The studies by Martyn (2011) and Tsytsyura (2016) are focused on the current situation, advantages, disadvantages and opportunities to improve the functioning of the cadastral system. Scientists Perovych and Ludchak (2015) devote their research to foreign experience and comparative analysis for the development of the cadastral system in Ukraine. Yasynetska's research (Yasynetska et al., 2018) addresses geo-information technologies for the cadastral system. Regarding the study of the technical aspects of the functioning of the 3D cadastre, in 2020, Dubnytska defended her dissertation research, within which a conceptual model of the 3D cadastre was developed as a tool for monitoring water bodies in urban areas, and its validation was carried out (Petrakovska and Dubnytska, 2019; Dubnytska, 2020). At the same time, the organizational and technical issues of providing a 3D cadastre as a multi-purpose system for recording real estate and rights to it in Ukraine have not been studied in detail. As part of the possibilities of implementing international practices in Ukraine, it is necessary to take into account the fact that land relations are regulated by the current regulatory and legislative acts of Ukraine (Verkhovna Rada of Ukraine, 1996, 1998, 2001, 2003, 2004, 2011a, 2011b, 2019). Also, in connection with the introduction of changes to the Constitution of Ukraine (regarding the strategic course of the state to acquire full membership of Ukraine in the European Union and in the North Atlantic Treaty Organization) (Verkhovna Rada of Ukraine, 2019), it is advisable to take into account international standards: ISO 19106:2004; ISO 19132:2007; ISO 19152:2012 and other standards related to geospatial information (ISO 2004, 2007, 2012). At the international level, the issue of creating a three-dimensional spatial cadastre has been actively developed during the last decade. The leading institutions specializing in the study of this issue include the University of Melbourne in Australia, the Delft University of Technology in the Netherlands, as well as the International Federation of Surveyors (FIG), whose joint commissions No. 3 and No. 7 are actively working exclusively on the problems of 3D cadastres.

The analysis of the experience of foreign countries (monographic analysis, method of synthesis and analysis) regarding the management of cadastres revealed that the basis of the cadastral system is the operational modeling of real estate objects, the display of their technical, economic and legal status at the current moment.

Thus, the cadastre must contain information about the object, subject, rights and restrictions, geometric and technical parameters, estimated value of real estate. Despite the recognition of such horological and chronological properties of objects of cadastral accounting at the legislative level, Ukrainian cadastres (land, water, urban planning, etc.) still lack a spatial component – namely, the value of height-depth (coordinate z) (Verkhovna Rada of Ukraine, 1998, 2001, 2003, 2004, 2011a, 2011b, 2019). The two-dimensional (planar) cadastre is unable to adequately reflect the spatio-temporal properties of real estate objects, as well as the rights and restrictions associated with them. Currently, a land plot is considered as a limited part of the earth's surface with space above and below it (Verkhovna Rada of Ukraine, 2001). However, this approach is wrong for large cities – megalopolises, the space of which is a complex multi-layered structure with a multitude of diverse stakeholders' interests that intersect and overlap. In view of the rapid development of modern large cities in general and the acceleration of the dynamics of property relations in them in particular, there is an urgent need to form a multidimensional, multipurpose, and comprehensive cadastre of megacities to enable the display of the entire set of horological and chronological properties of spatial objects, which determines the relevance of the study.

STATEMENT OF THE PROBLEM

Analysis of foreign experience and international standards in the field of 3D cadastre

In 2016, 3D legal norms for real estate objects to be registered in the land cadastre were introduced in the Netherlands. BIM (Building Information Models)

were used as a data source. Two cases were presented: at the railway station in Delft and the case of a complex of buildings in Amsterdam (Stoter et al., 2017). In fact, the need for three-dimensional display of cadastral information in large cities has existed for a long time, but former technologies did not allow it to be realised. In the modern world, such a need has become even more pressing, and in some cases, a 3D cadastre is nothing short of essential. An example can be any multi-level real estate object: apartment buildings, office centers or underground garages. In such cases, the owner must acquire the right to the volume. Some countries (Austria, Brazil, Croatia, Greece, Poland, Sweden) deal in depth with the issue of implementing the concept of 3D real estate, defining a 3D object at the legislative level, as well as the types of rights that can be registered in 3D. The solution to this problem in the Netherlands was based on the limitations and possibilities of the existing legal and cadastral structures, as well as on gaining experience in the field of 3D cadastre, where technical possibilities, on the one hand, and legal and cadastral needs, on the other hand, are closely interconnected. There are certain disadvantages linked to the fact that 2D and 2.5D objects are stored and structured separately in databases,. Therefore, the question arises of choosing a single space for working with 3D objects. Let us consider in detail the international standard CityGML, because other standards focus on accuracy or elements of geometry, attributes, and some semantic information, but less so on topology. CityGML is an open data model using the XML format based on the storage and exchange of virtual city models for the representation of 3D urban objects. Since photorealistic rendering alone is not sufficient for urban planning, navigation or disaster relief, additional information is needed. That is, the model of urban 3D objects should include geometry and semantics. Depending on the needs, 3D models require different levels of detail. CityGML distinguishes five levels of detail (LOD – Levels of Detail) (Fig. 1). The roughest LOD0 level is, in fact, a 2.5D digital terrain model. Buildings can be represented in LOD0 by polygons according to the height of the roof. LOD1 is known as a block model consisting of prismatic buildings with flat roof structures. In contrast, the building in LOD2 has differentiated roof structures and thematically differentiated surfaces. LOD3 includes architectural models with detailed structures for walls and roofs, potentially including doors and windows. LOD4 completes the LOD3 model by adding internal structures for buildings. For example, houses in LOD4 consist of rooms, interior doors, stairs and furniture. As a rule, in various software products, attention is focused on only one of the types of LOD. But if 3D

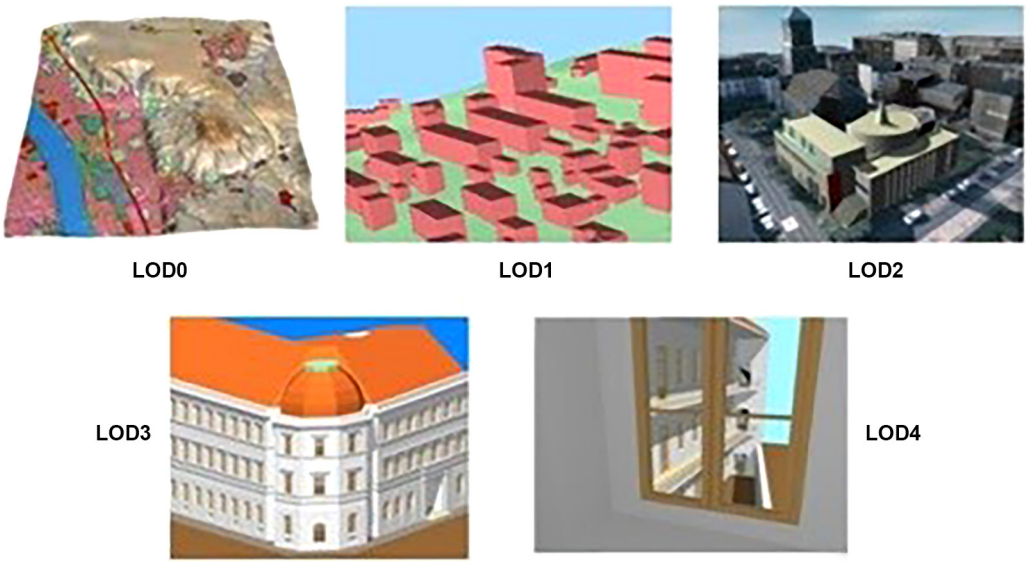

Fig. 1. Five levels detailing in CityGML (source: Arayici, 2008)

models of objects are represented by several LODs, this leads to a number of disadvantages, including: data redundancy, expensive storage, visualization limitations, and so on. Currently, scientific and research works show that there is a need for a single data model capable of supporting all aspects, attributes, semantics, and topology (Tekavec et al., 2018). In recent years, there has been a rapid growth in the integration, harmonization and implementation of support for standards related to 3D cadastre. In this context, the integration of 3D legal spaces with 3D physical objects becomes stronger, since legal boundaries do not always coincide with physical counterparts, which leads to unclear situations.

LADM is an international standard for land management, which currently most accurately represents 3D rights, restrictions and responsibilities. Legal boundaries in 3D are not always connected and coincide with physical boundaries, and only the synergy of 3D visualization together with a clear division of property interests can ensure legal certainty (Cemellini et al., 2020). Current discussions and research are focused on this integration, where the Land Management Model (LADM) domain mainly deals with the legal aspect of the models, while CityGML (using the development environment), BIM, InfraGML are generally used to describe the physical counterparts. Most of the developed countries of the world are currently trying to implement LADM in their cadastral systems and data infrastructures. For example, the Croatian 3D real estate cadastre is developed on the basis of the international standard (LADM), which has the designation ISO: 19152:2012 and is available since December 1, 2012.

INTERLIS is a Swiss standard (SN 612030) that regulates the processes of geo-information exchange, modeling, and integration of geo-data, which allow establishing connections between information systems in general, and geographic information systems in particular. In fact, INTERLIS is a language that has proven to be effective in creating tools and methodologies for data exchange and geospatial information transfer (Kalogianni et al., 2017). The connection of LADM-INTERLIS models is clearly illustrated in Fig. 2.

Cadastral system of Ukraine

Today, fairly extensive changes and improvements to the information base of the State Land cadastre are taking place in Ukraine. The development of the latest technologies in all fields requires spatial modeling of information. The main potential of the three-dimensional cadastral system consists of the registration, in space, of a separate object in the cadastral system. This is an invisible (above ground and underground) 3D property, which is reflected during the registration of a spatial 3D object using an official source of information – 3D cadastral surveying, as well as world standards in data modeling and structuring. In Ukraine, as in other countries of the world, registration of property above and below the surface of the earth is complicated. Despite this reality, Ukraine has not yet considered the introduction of a three-dimensional cadastral system, especially from a legal point of view. Regarding the display of cadastral information, on January 1, 2013, Ukraine took an important step towards the introduction of a clear and transparent land management system, namely opening access to cadastral informa-

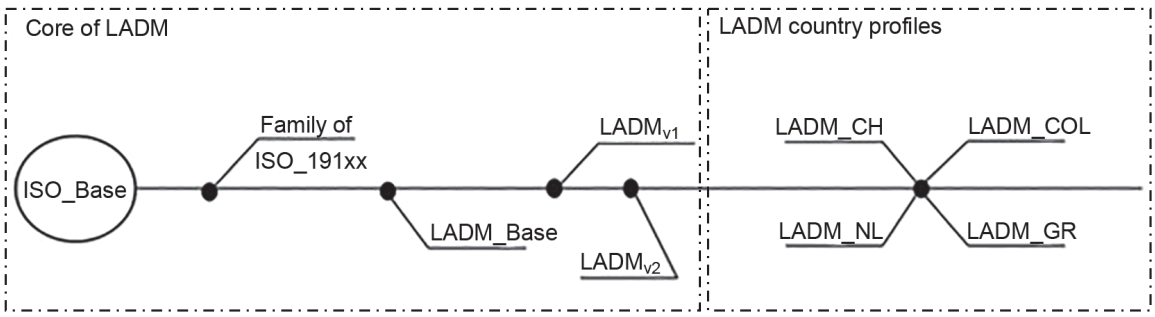

Fig. 2. Communication of LADM-INTERLIS models (source: Kalogianni et al., 2017)

tion through the Public cadastral map. It is a geoportal that displays official information of the State Land cadastre regarding the boundaries and purpose of land plots, restrictions on their use, forms of their ownership, boundaries of administrative-territorial formations, soil cover, etc. New layers are constantly being added to the Public Cadastral Map, however, since the introduction of martial law on the territory of Ukraine, the map has been closed for public viewing for security reasons, and access to it is granted only to officials of the State Geocadastre and certified engineers-land managers in a special order. An important drawback is the lack of information on buildings and structures on the Public Cadastral Map. Regarding the display of real estate objects in 3D-format, there is no such practice in Ukraine. The State Land cadastre in Ukraine is two-dimensional.

However, Ukraine has taken and continues to take certain steps in the direction of current trends. In particular, the "Pocket Country" project was launched, within which an AR-application was created, which became a platform for interactive acquaintance with 40 architectural monuments throughout the territory of Ukraine in the format of 3D models and augmented reality. The project seeks to popularize material cultural heritage for its preservation and rethinking its meaning by implementing 3D digitization of objects of material, cultural and architectural heritage of Ukraine. An interactive map of the objects of cultural heritage of Ukraine, filled with information about the current state of architectural monuments, has also been launched. It has put together hundreds of scans of buildings that can be used for reconstruction, restoration and promotion. The project is implemented by the SKEIRON team on the GEOPORTAL.UA resource.

In addition, within the framework of the Municipal target program for the use and protection of lands of the city of Kyiv for 2022–2025, digital aerial photography of the city territory is provided for the creation of Aerial True Orthophoto and 3D models of the city's buildings, and a high-precision digital model of the city's relief and ensuring their periodic updating (Kyiv City Council, 2021). It is expected that the received information will become the main source of data for the development of the management system of communal property and urban infrastructure, monitoring of land and other natural resources, control in the field of construction, etc. Nevertheless, at the moment, the implementation of the aforementioned aerial photography is impossible in practice, due to the prohibition of civil aviation flights due to the military situation in the country.

In Ukraine, the right to property belongs to the basic rights guaranteed by the Constitution. However, the state registration of the right, and the state registration of the object of civil legal relations are conducted separately. Property rights are registered in the State Register of Property Rights and their restrictions on land plots, as well as on real estate objects located on the land plot, the removal of which is impossible without their depreciation and change of purpose. Such real estate objects include residential and non-residential buildings, constructions, as well as their separate parts, apartments, residential and non-residential premises (Verkhovna Rada of Ukraine, 2001).

Land plots are registered in the State Land Cadastre as objects of property rights. State registration of a land plot is carried out during its formation with the opening of the Land Register for such a plot. Land Register is document of State Land Cadastre, which contains such data about land plot: cadastral number, area, location (administrative-territorial unit), composition of land, target designation, normative monetary assessment, information on restrictions on the use of the land plot, cadastral plan of the land plot, date of state registration of the land plot, information on land management documentation, data on credit rating and soils quality (Verkhovna Rada of Ukraine, 2011a).

Information on real estate objects (buildings and structures) is contained in the Unified State Electronic System in the field of construction. The system registers permits for construction or reconstruction, as well as technical parameters of real estate objects, including: area, volume, construction materials, drawings and schematics of real estate objects (Magvair et al., 2016). Note that drawings uploaded to the system are also created in 2D format. All three systems interact with each other in the order of automated information exchange. Therefore, in theory, it may be possible in Ukraine to register certain types of rights or their restrictions in a 3D format, similar to how they are currently registered in 2D.

Essential issues of 3D cadastre and multipurpose cadastre

By appointment, cadastres can be divided on three big categories:

– *fiscal cadastre*, aimed at serving the purposes of real estate taxation;
– *legal cadastre*, aimed at registration and protection of property rights in relation to real estate;
– *multipurpose cadastre*, which is the basis for geographical localization and for the determination of technical, legal, fiscal and economic information related to the earth. Multipurpose cadastre can be considered as a public, operational and administratively integrated land data system, which contains permanent and accessible land information at the level of "immovable unit" (Aien, 2013; Tekavec et al., 2018). The cadastral system is considered multipurpose when the available information allows solving specific problems in various spheres of social and economic life, such as: urbanization, planning, administration, environmental protection, fiscal, legal issues, etc. The formation of the multi-purpose cadastre is carried out on the basis of the determination of the relevant directions, which take into account each of the constituent parts of the State Land cadastre (Titova et al., 2022).

Although the Land Code of Ukraine formally enshrines the principle of unity of the land plot and the immovable property located on that plot, in fact, at the current stage of the existence of the real estate management system, there is a conscious separation of real estate objects from the land plots on which they are located (Verkhovna Rada of Ukraine, 2001). The internal division of the single nature of real estate leads to the division of systems for the registration of land plots and all other real estate objects. On the contrary, in international practice it is generally accepted that real estate is a single object: a land plot with improvements (real estate objects located on it, capital investments in land, etc.).

In almost all existing cadastres, the boundaries of accounting units are presented in the form of their projections on a conventional level surface. Accordingly, the cadastral metric is described in two dimensions (2D cadastre). The concept of 2.5D cadastre occupies an intermediate place between two- and three-dimensional cadastres. In this case, the projections of the accounting units may acquire a non-zero height value relative to the conventional level surface.

Methods of displaying 2.5-dimensional objects in GIS include triangulated irregular networks (TIN) and digital elevation models (DEM) (Magvair et al., 2016). 3D cadastre, operating with three-dimensional geodata, describes, on the one hand, three-dimensional physical objects (a mathematical model as close as possible to the real world), and on the other hand, legal 3D space. In the full 3D cadastre, the three-dimensional space is presented in the form of volumes (voxels), without overlays and gaps (Magvair et al., 2016). Traditionally, a plot of land is considered as property that is clearly delimited on the two-dimensional (2D) surface of the earth. In some countries, with a 2D plot of land, ownership of space is tied down to the center of the Earth and up to infinity. In this case, from a legal point of view, a 2D plot of land is actually three-dimensional in the sense that a 2D plot of land contains everything that is located above and below the surface of the plot of land. Nevertheless, the main problem of today's 2D land plots is that it is impossible to have separate property rights for the space above and below the surface of the earth belonging to third parties (Duma, 2014).

Most existing cadastral systems are two-dimensional and deal only with property on the surface of the earth. Because of this, such systems are unsuitable for displaying the multi-layered three-dimensional geometry of reality, which has developed in recent decades. In order to facilitate the further creation of engineering projects above and below the surface of the earth, and in particular, the possibility of registering property that is not located on the surface of the earth, it is necessary to amend the legislation and define a new multi-layered 3D cadastral model. The growing interest in cadastral 3D registration has been driven by several factors, including the significant increase in the cost of private property and the substantial rise in the number of tunnels, cables, pipelines, underground parking lots, shopping centers, and buildings above highways or railroads over the last fifty years. Additionally, the development of 3D approaches in various areas of informatization (such as 3D geographic information systems

and 3D planning) has made 3D cadastral registration technologically feasible, allowing it to register and provide an overview of rights and restrictions not only for land plots but also for 3D real estate objects. A 3D property unit is a limited amount of space to which the subject has the right of ownership. This approach to accounting is necessary in 3D property situations where different property objects, possibly with different land use types, are either located on top of each other or built in even more complex structures interconnected with each other. In 3D property situations, multiple users use different volumes of space, limited in three dimensions. These volumes can be located one above the other, within the limits of one basic plot of land, or they can cross its borders. There is a need to grant different property rights to different persons for different amounts. Digital 3D cadastres allow 3D visualization of property, i.e. legal objects and their physical counterparts (objects in the real world). Physical 3D objects are material objects in the surrounding environment (land plots, houses and structures, pipelines, communications, road and transport network, etc.). Legal 3D space is an intangible object of the environment that is formed around of physical 3D objects on the basis of standards, pertaining to construction, fire, sanitary, and security concerns, as well as based on restrictions and responsibilities (Fig. 3).

In the view to the above, there is an urgent need to introduce a 3D cadastre, which would display a land plot in three spatial aspects, taking into account all objects under and above the surface of a specific plot,

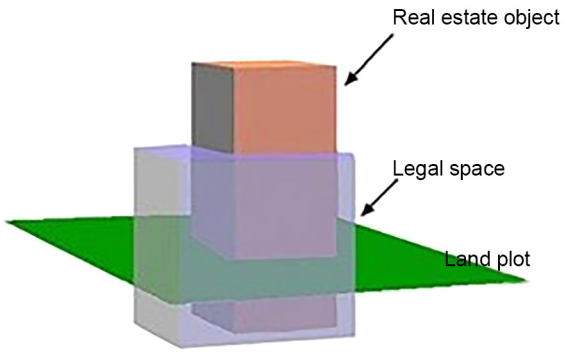

Fig. 3. Objects registered in the three-dimensional cadastre (source: Gif, 2011)

and the ownership rights of each part of such plots and objects, as is common in other countries. Such system would contribute to the prevention of ambiguity in the definition of property rights. The multi-purpose cadastre system should ensure the following main functions, including: regulatory, fiscal, legal, accounting, and economic (Titova et al., 2022).

The following fundamental concepts for registering 3D situations can be noted in the multipurpose cadastre:

– 3D signs in the existing system of cadastral registration (the solution provides for the preservation of the 2D cadastre with external links to the digital presentation of 3D situations);
– hybrid solution (mandatory registration of two-dimensional plots and additional registration of 3D legal space in the case of 3D property units; mandatory registration of two-dimensional plots and additional registration of physical 3D objects in the case of 3D property units);
– full 3D cadastre registration (combined 2D/3D alternative; full 3D cadastre).

Therefore, the problem of providing any land management projects with high-quality topographical and geodetic materials is acute and requires specific and consistent actions to create the basis for further development.

The cadastre plays the role of a trigger for the development and growth of most countries, as it is a tool for regulating land use and is the basis for carrying out improvements. Some countries have already created a multipurpose cadastre for different jurisdictions. However, the country of the world does not have a complete three-dimensional cadastral information system, which includes all aspects (3D legislation, 3D geodetic methods, registration of 3D rights, restrictions and responsibilities, management, etc.).

The question of the urgent need to introduce a 3D cadastre is especially acute in settlements, where there is a need to display land plots in three spatial aspects, taking into account all objects under and above the surface of the earth, and their ownership rights. Such solution would contribute to the prevention of ambiguity in the determination of ownership rights to real estate, and would stimulate the filling of budgets due to more effective taxation of property. At the same time, for agricultural territories, the transition to

a full-fledged 3D cadastre is not as important, whereas a more urgent issue is the introduction of a 2.5D cadastre that would contain a fairly accurate digital terrain model. Terrain data are necessary for the rational use and protection of agricultural land, erosion control, determination of slope areas where specific tillage is necessary, etc.

The most developed countries of the world already have the experience of a partial transition to 3D cadastres, therefore, in further studies, it would be appropriate to consider the features of the accounting and registration system of land resources of foreign countries in order to identify positive trends and consequences that Ukraine should also strive for (Doner, 2021).

The results of a scientific study on the effectiveness of operating various property interests in space rather than on a plane

In contemporary Ukrainian legislation (Verkhovna Rada of Ukraine, 1998, 2001, 2003, 2004, 2011a, 2011b, 2019), a land plot as an object of property rights is a part of the earth's surface with established boundaries, with a specific location, and with defined rights in relation to it. At the same time, ownership of a land plot extends to the space above and below the surface of the plot to the height and depth necessary for the construction of residential, industrial and other buildings and structures (Verkhovna Rada of Ukraine, 2001). This definition of a land plot as an object of civil rights is relevant in those cases when land acts as a means of production, i.e. in agrarian areas, but it „does not work" in megacities, in conditions of active urbanization processes, when the intensity of use of above-ground and underground space increases in proportion to the growth of the city's population.

In large cities around the world, a phenomenon has arisen when real estate objects of different owners and users are placed one above the other, and the boundaries of the distribution of rights to these objects acquire a vertical dimension. Clear examples of that include underground communications and objects of engineering infrastructure, high-rise buildings and underground shopping centers, subway tunnels and road junctions, bridges and viaducts (Verkhovna Rada of Ukraine, 2011a). All these objects need not only proper registration in the land and urban cadastre, but also the determination of access routes and procedures for their operation and maintenance.

Today, in Ukraine, this problem is partially solved by the establishment of land servitudes and protection zones around engineering communications, power system and communication facilities, as well as pipelines. However, quite often the indicated restrictions of rights are either not established or ignored, which is related to both the low awareness of land users and the shortcomings of land legislation (there are no clear explanations as to which types of activities are prohibited within the protection zones). In addition, both easements and protective zones reduce the value of the land plot, which generally contradicts the basic principles of land management (Verkhovna Rada of Ukraine, 2004, 2011b).

In our opinion, the establishment of protection zones around engineering communications in the modern form, with their subsequent registration as polygons in the State Land cadastre, has a dubious effect. Engineering networks and communications lie at different depths, and the projections of their protection zones often intersect, therefore the interested party cannot draw a conclusion about the useful area of the land plot based on the data of the State Land cadastre about the area of protection zones (Fig. 4, 5). In addition, local networks are often moved during construction; they may be expanded or shortened, whereas the protection zones in the cadastre do not change. Finally, in the legislation there is no division between inactive networks and those currently in use – in both cases, protective zones of the same size are established. At the same time, it would be expedient to consider the spread of different interests in space not in a categorical way, prohibiting or limiting land use, but leaving room for a compromise (Fig. 6).

Considering the necessity and expediency of displaying communications and engineering networks in 3D format, it is impossible to avoid the following problem: modern symbols do not allow displaying all aspects of such objects, in particular: status (used or not), material (cast iron, concrete, plastic, metal etc.), possible connection points, condition (good, satisfactory, in need of repair / reconstruction).

Another type of real estate objects, which are associated with specific "multi-layered" legal relations, are

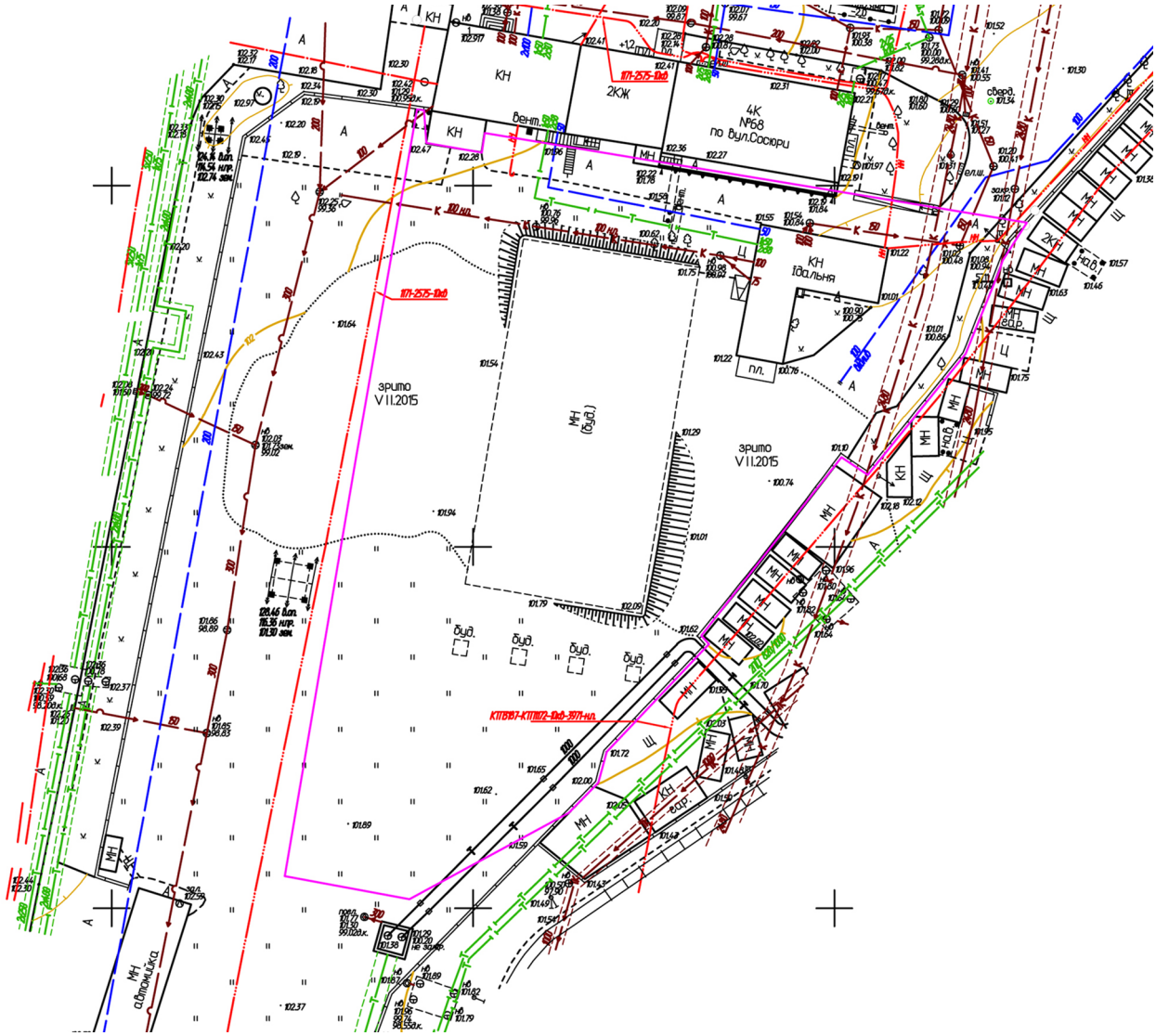

Fig. 4. Topographical plan of the land plot (boundaries marked in purple) scale 1 : 500 (source: Authors' own elaboration)

multilevel above-ground and underground buildings and structures. For the further development of the cadastral accounting tools of such objects, it is advisable to divide them into classes:

– buildings with parts removed (balconies or transitions hanging above the ground, basements or other rooms protruding beyond the main part of the building);
– planar underground structures (parking lots, shopping and entertainment centers connected to the earth's surface only through entrances or exits);
– linear underground or above-ground constructions (transport tunnels, engineering communications, pipelines);
– multi-level infrastructure objects (transport junctions);
– point objects, the general configuration of which does not coincide with the base (power line supports, poles with overhanging elements, lanterns, billboards).

Often such real estate has an uncertain status due to its indirect connection with the earth's surface.

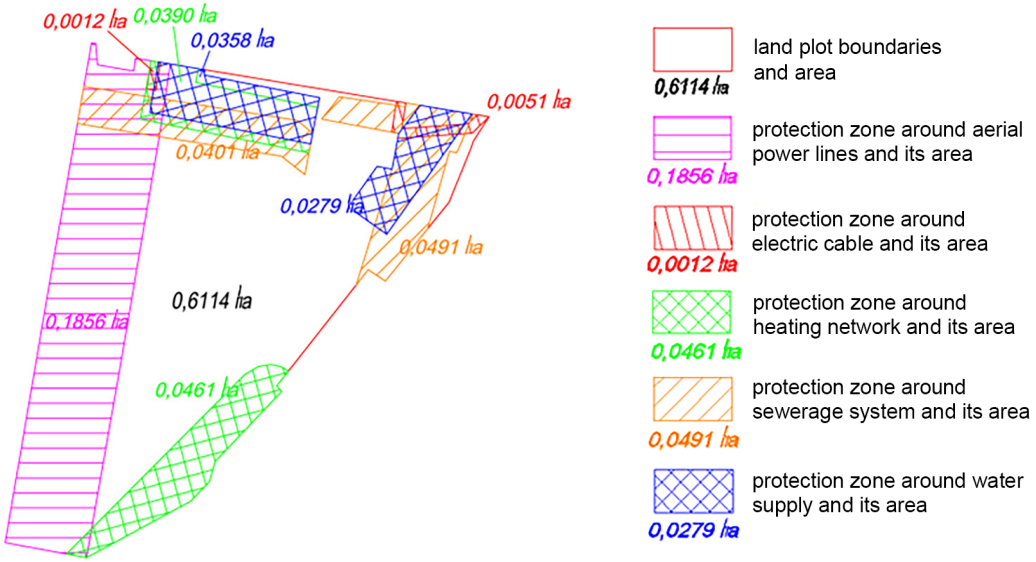

Fig. 5. Protective zones of engineering networks and communications, defined in accordance with current legislation (source: Authors' own elaboration)

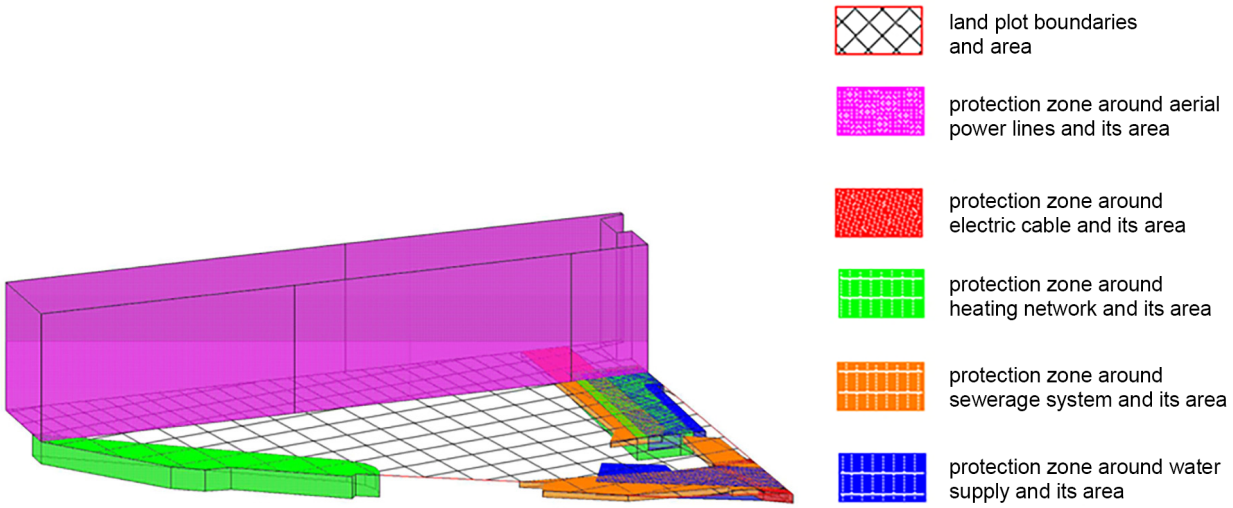

Fig. 6. Vertical distribution of interests in space (source: Authors' own elaboration)

This problem is exacerbated for the objects of underground public buildings located within the red lines of streets and roads, which is expressly prohibited by the current legislation (Duma, 2014), that does not take into account the existence of the height coordinate.

Finally, two-dimensional cadastral systems do not convey the real geometry of space, which requires the construction of a high-quality digital terrain model.

In a nutshell, we note that in the conditions of modern development of cities with the emergence of specific three-dimensional property relations in the field of land and real estate, it is absolutely necessary to create an effective tool to protect the interests of all interested parties – a three-dimensional (3D) real estate cadastre. Foreign experience shows the effectiveness of such a system in complex management of resources at the

level of municipalities, with positive impact on increasing the investment attractiveness of the territories due to the guaranteed realization by the owners of all rights to any three-dimensional real estate object, and on the reduction of property disputes, since the height coordinate is a control and 98% protects the cadastral system from overlays and false registration of object boundaries.

The issue of restoration of Ukraine in the context of the introduction of 3D cadastre

Restoration, reconstruction, modernization and economic growth of Ukraine are the main priorities of state policy for the coming years. These tasks will require the implementation of reforms and investments in all sectors. The construction of a unified architecture of planning documents in a multi-level system of state administration, focused on wartime priorities, as well as well-defined frameworks for the post-war recovery and development of Ukraine, can become the basis for the effective implementation of these priorities. The state regional development strategy will cover the needs for restoration, reconstruction and modernization, including the specific needs of regions and territorial communities. At the local level this includes community development strategies, comprehensive plans for the spatial development of the territories of territorial communities, programs for the comprehensive restoration of the territories of territorial communities, and plans for the restoration and development of communities.

Global experience confirms the effectiveness of implementing a 3D cadastre system in the comprehensive management of resources at the municipal level. It enhances the investment attractiveness of areas by ensuring that owners can fully exercise their rights to any three-dimensional real estate object, and it reduces the number of property disputes. In our opinion, the 3D cadastre technology in the context of the presented material should help to satisfy the growing social demand for accurate management of immovable property (land and housing). The information contained in 3D cadastre databases is important and necessary for land registrars, surveyors, architects, developers, designers, real estate agents, local governments, and corporate owners. The issue of introducing a 3D cadastre in populated areas is especially relevant in light of the need to restore real estate damaged or destroyed as a result of military operations.

CONCLUSIONS

1. Foreign experience has proven that the three-dimensional cadastre must be created through the parallel development of three main directions: legislative (integration of the concept of "3D object of immovable property" and "3D rights" into the legal field; definition of the procedure for registration of 3D real estate objects), institutional (establishment of mutual relations arising between interested parties), and technical (developing a platform for the implementation of 3D cadastre). Ukraine has the opportunity to take into account the attempts and mistakes of other countries when developing its own three-dimensional cadastre system.
2. Modern State Land Cadastre of Ukraine is characterized by a number of problems related to the uncertainty of the legal status of the height component of land cadastral information, the insufficient volume of registration data regarding land use restrictions, the lack of documentary status in electronic cadastral data, etc.
3. The Public Cadastral Map of Ukraine is an important step towards modern systems of automated and public cadastral accounting, which corresponds to the latest global norms regarding the democratic disclosure of property rights of Ukrainian citizens. At the same time, all the positive gains from the introduction of the Public Cadastral Map are now nullified due to the restriction of access to it driven by the military situation.
4. The Public Cadastral Map of Ukraine has several shortcomings, including numerous errors and inaccuracies. The completeness of information for all land plots is not sufficiently ensured, and there are no images or data on real estate objects located on the land plots. Additionally, different spatial coordinate systems are used, further complicating the map's accuracy and usability.
5. The creation of a 3D cadastre in Ukraine (in particular, on the territory of populated areas) will make it possible to solve the problems that arise regarding the registration of ownership rights to real estate objects located above and below the ground.
6. Ukrainian legislation to some extent provides for the presentation of real estate objects in 3D format,

but there are no on how to do this. A great deal of work is needed on errors in the State Land Cadastre, integration of registers of various components of the cadastre, primarily this concerns the register of land plots, their estimated value, and the register of rights in combination with other registers.

7. Solving the problem of building a multi-purpose cadastre includes three interrelated and interdependent aspects: legal, cadastral, and technical. All of the above examples of the application of different types of systems for implementation in the multipurpose cadastre are relevant and useful to Ukraine, taking into account the existing land legal system and the state's strategic course towards full membership of Ukraine in the European Union.

REFERENCES

Aien, A. (2013). 3D cadastral data modeling: PhD thesis. The University of Melbourne. Victoria. https://eng.unimelb.edu.au/__data/assets/pdf_file/0005/3928784/ali-aien-phd-thesis.pdf (accessed: July 06, 2024).

Aien, A., Kalantari, M., Rajabifard, A., Bennett, R. (2011). Advanced principles of 3D cadastral data modeling. 2nd International Workshop on 3D cadastres (Delft, 16–18 November 2011). https://www.researchgate.net/publication/258209232_Advanced_principles_of_3D_cadastral_data_modelling_powerpoint (accessed: July 06, 2024).

Arayici, Y. (2008). Towards building information modeling for existing structures. July 2008. Structural Survey, 26(3), 210–222. DOI: 10.1108/02630800810887108

Cemellini, B., van Oosterom, P., Thompson, R., deVries, M (2020). Design, development and usability testing of an LADM compliant 3D cadastral prototype system. Land Use Policy, 98, 104418. DOI: 10.1016/j.landusepol.2019.104418

Dombrovska, O., Tyshkovets, V. (2019). The value of land cadastral data in the system of land resources administration. Eastern Europe: Economics, Business and Management, 2, 242–249. https://www.easterneurope-ebm.in.ua/journal/19_2019/38.pdf (accessed: July 06, 2024).

Doner, F. (2021). Analysis of literature on 3D-cadastre. International Journal of Engineering and Geosciences, 6(2), 90–97. DOI: 10.26833/ijeg.703244

Dubnytska, M. (2020). Improvement of the urban water objects use monitoring based on a three-dimensional cadastre: PhD thesis. Kyiv National University of Construction and Architecture. Kyiv, 2020. 243. https://docs.google.com/document/d/1V0lv7LC_lX7azIXngaSxoum_qUqeLjZ7/edit?usp=sharing&ouid=106423560094432616533&rtpof=true&sd=true (accessed: July 06, 2024).

Duma, Yu. (2014). The need to introduce a 3D cadastre in Ukraine. Bulletin of Lviv National Agrarian University. Series: Economics of Agriculture, 21 (2), 108–112.

GIF (2011). Objects of three-dimensional (3D) cadastre. https://uk.wikipedia.org/wiki.jpg (accessed: July 19, 2024).

ISO (2004). ISO 19106:2004 Geographic information – Profiles. https://www.iso.org/standard/26011.html (accessed: July 06, 2024).

ISO (2007) ISO 19132:2007 Geographic information – Location-based services – Reference model. https://www.iso.org/standard/40601.html (accessed: July 06, 2024).

ISO (2012). ISO 19152:2012 Geographic information – Land Administration Domain Model (LADM). https://www.idep.gob.pe/normas/ISO_19152.pdf (accessed: July 06, 2024).

Kalogianni, E., Dimopoulou. E., Quak, W., Oosterom, van P. (2017). LADM and INTERLIS as a perfect match for 3D cadastre. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-4/W7, 23–26. DOI: 10.5194/isprs-archives-XLII-4-W7-23-2017

Kyiv City Council (2021). On Approval of the City Target Program for the Use and Protection of Land in Kyiv for 2022–2025. Decision No. 2727/2768. https://kmr.gov.ua/uk/content/proekt-rishennya-kyyivskoyi-miskoyi-rady-21739 (accessed: July 06, 2024).

Lemmen, Ch., Oosterom, van P., Bennett, R. (2015). The land administration domain model. Land Use Policy, 49, 2015, 535–545. DOI: 10.1016/j.landusepol.2015.01.014

Magvair, B., Pashynska, N., Datsenko, L., Govorov M., Putrenko V. (2016). Geoinformation technologies and spatial data infrastructure: in 6 volumes. Volume 1: Introduction to geographic information systems for spatial data infrastructure. Study guide. Kharkiv: Planeta-Print.

Martyn, A.G. (2011). Problems of the State Land Cadastre in Ukraine. Land Management and Cadastre, 3, 33–50.

Mika, M., Jurkiewicz, M. (2018). Legal and technological obstacles on the road to creating the 3D cadastre in Poland. Acta Scientiarum Polonorum. Formatio Circumiectus, 17 (2), 135–143. DOI: 10.15576/ASP.FC/2018.17.2.135

Oosterom, van P., Ploeger, H.D., Stoter, J.E., Thompson, R., Lemmen, C. (2006). Aspects of 4D cadastre: A first

study. In FIG 2006: Conference Proceedings: Shaping Change, XXXIII FIG Congress, Munich, Germany, 8–13 October 2006. Frederiksberg: International Federation of Surveyors (FIG). http://www.fig.net/pub/fig2006/papers/ts14/ts14_06_oosterom_etal_0576.pdf (accessed: July 06, 2024).

Perovych, L., Ludchak, O. (2015). Cadastral system of Ukraine in the context of global development. Modern Achievements of Geodetic Science and Production, 1 (29), 15–19. http://nbuv.gov.ua/UJRN/sdgn_2015_1_5 (accessed: July 06, 2024).

Petrakovska, O., Dubnytska, M. (2019). 3D cadastre as the Instrument for Water Objects Monitoring. KELM (Knowledge, Education, Law, Management): Czasopismo Naukowe, 2 (26), 160–170. http://kelmczasopisma.com/ua/downloadfile/237 (accessed: July 06, 2024).

Popov, A., Kolodiy, P., Zadorogniy, Y. (2023). An evaluation framework of the current cadastral system in Ukraine – A case study. Acta Scientiarum Polonorum. Administratio Locorum, 22 (4), 537–560. DOI: 10.31648/aspal.9044 (accessed: July 06, 2024).

Stoter, J.E., Ploeger, H., Oosterom van, P. (2012). 3D cadastre in the Netherlands: Developments and international applicability. Computers, Environment and Urban Systems. DOI: 10.1016/j.compenvurbsys.2012.08.008

Stoter, J., Ploeger, H., Roes, R., Riet, van der E., Biljecki, F., Ledoux, H., Kok, D., Kim, S. (2017). Registration of multi-level property rights in 3D in the Netherlands: Two cases and next steps in further implementation. ISPRS International Journal of Geo-Information, 6(6), 158. URL: https://doi.org/10.3390/ijgi6060158

Tekavec, J., Ferlan, M., Lisec, A. (2018). A review of research on 3D-real property cadastre. Geodetski Vestnik, 62(2), 249–278. DOI: 10.15292/geodetski-vestnik.2018.02.249-278

Thompson, R.J. (2007). Towards a rigorous logic for spatial data representation: PhD thesis. Delft University of Technology. Delft, Netherlands Geodetic Commission. https://www.researchgate.net/publication/27346885_Towards_a_rigorous_logic_for_spatial_data_representation (accessed: July 06, 2024).

Titova, S., Datsenko, L., Dubnytska, M., Bodnar, S. (2022). Cadastre. Taras Shevchenko National University of Kyiv. https://drive.google.com/file/d/1NXpbkJ9tMFy-OT9r6C5QrtwNSVNZddbtF/view (accessed: July 06, 2024).

Tsytsyura, Y.G. (2016). Public cadastral map of Ukraine: Adaptability assessment and improvement strategy. Agriculture and Forestry, 3, 6–14. http://nbuv.gov.ua/UJRN/agf_2016_3_3 (accessed: July 06, 2024).

Verkhovna Rada of Ukraine (1996). The Constitution of Ukraine. Law of Ukraine No. 254 k /96- VR. https://zakon.rada.gov.ua/laws/card/254%D0%BA/96-%D0%B2%D1%80 (accessed: July 06, 2024).

Verkhovna Rada of Ukraine (1998). About Land Lease. Law of Ukraine No. 161-XIV. https://zakon.rada.gov.ua/laws/show/161-14#Text (accessed: July 06, 2024).

Verkhovna Rada of Ukraine (2001). Land Code of Ukraine. Law of Ukraine No. 2768-III. http://zakon0.rada.gov.ua/laws/show/2768-14 (accessed: July 06, 2024).

Verkhovna Rada of Ukraine (2003). About Land Management. Law of Ukraine No. 858-IV. https://zakon.rada.gov.ua/laws/show/858-15#Text (accessed: July 06, 2024).

Verkhovna Rada of Ukraine (2004). On State Registration of Real Rights to Real Estate and their Encumbrances. Law of Ukraine No. 1952-IV. https://zakon.rada.gov.ua/laws/show/1952-15#Text (accessed: July 06, 2024).

Verkhovna Rada of Ukraine (2011a). About the State Land Cadastre. Law of Ukraine No. 3613-VI. https://zakon.rada.gov.ua/laws/show/3613-17#Text (accessed: July 06, 2024).

Verkhovna Rada of Ukraine (2011b). On the Regulation of Urban Development Activities. Law of Ukraine No. 3038-VI. https://zakon.rada.gov.ua/laws/show/3038-17#Text (accessed: July 06, 2024).

Verkhovna Rada of Ukraine (2019). On Amendments to the Constitution of Ukraine (regarding the strategic course of the state for Ukraine's full membership in the European Union and the North Atlantic Treaty Organization). Law of Ukraine No. No. 2680-VIII. https://zakon.rada.gov.ua/laws/show/2680-19#Text (accessed: July 06, 2024).

Yasynetska, I.A., Petryshche, O.I., Kovtynyak, I.P. (2018). State Land Cadastre as an information base. Economy and Society, 14, 680–685. https://economyandsociety.in.ua/journals/14_ukr/96.pdf (accessed: July 06, 2024).

Datsenko, L., Titova, S., Dubnytska, M. (2024). 3D cadastre as a tool for regulating property relations and a spatial information base for multipurpose cadastral system. Acta Sci. Pol., Formatio Circumiectus, 23 (4), 19–35. DOI: http://dx.doi.org/10.15576/ASP.FC/194269

KATASTER 3D JAKO NARZĘDZIE DO REGULACJI STOSUNKÓW WŁASNOŚCIOWYCH I BAZA INFORMACJI PRZESTRZENNEJ DLA WIELOZADANIOWEGO SYSTEMU KATASTRALNEGO

ABSTRAKT

Cel pracy

Celem prezentowanej pracy jest udowodnienie, jak istotne i konieczne są transformacja krajowego systemu katastralnego Ukrainy i wprowadzenie technologii katastru 3D do pomiaru nieruchomości w czasie rzeczywistym. Przeanalizowano wyniki dotychczasowych krajowych i zagranicznych badań naukowych w dziedzinie trójwymiarowego modelowania obiektów, porównano wiodące systemy modelowania 3D, określono prawa stron w zakresie tworzenia i prowadzenia trójwymiarowego katastru nieruchomości, a także opracowano zalecenia dotyczące potrzeby ich wykorzystania w Ukrainie. Przeprowadzono analizę istniejących standardów i stosowanych podejść metodologicznych do konstruowania trójwymiarowych modeli obiektów nieruchomości, a także analizę możliwości wprowadzenia trójwymiarowych obiektów do wielozadaniowego systemu katastralnego, opartego na międzynarodowych standardach w ramach systemu administracyjno-prawnego Ukrainy. Na przykładzie konkretnej działki gruntowej wykazano skuteczność działań podejmowanych z różnych powodów w odniesieniu do badanego obiektu – w trójwymiarowej przestrzeni, a nie tylko na dwuwymiarowej płaszczyźnie.

Materiał i metody

Podstawę teoretyczną stanowią prace naukowe krajowych i zagranicznych naukowców w dziedzinie modelowania 3D obiektów (nieruchomości) oraz materiały metodyczne i instruktażowe do wdrażania technologii katastru 3D, które umożliwią wprowadzenie pomiaru obiektów nieruchomości w czasie rzeczywistym, a także rejestrację praw własności do obiektów i elementów nieruchomości znajdujących się nad i pod powierzchnią ziemi. Przy doborze materiałów do niniejszego opracowania zastosowano podejście systematyczne, aby zapewnić trafność i wiarygodność źródeł. Najpierw przeprowadziliśmy kompleksową kwerendę (w drodze wyszukiwania) recenzowanych artykułów, książek i raportów opublikowanych w ciągu ostatnich 20 lat, skupiając się na tematach bezpośrednio związanych z systemami katastralnymi 3D, modelowaniem obiektów nieruchomości i odnośnymi ramami prawnymi. Najważniejsze bazy danych, które przeszukano, to: Scopus, Web of Science i Google Scholar, co pozwoliło uwzględnić wyniki z szerokiego zakresu badań, o globalnym zasięgu. Zaprezentowane badania wybrano na podstawie wkładu, jaki wniosły w postęp teoretyczny, metodologiczny i praktyczny w omawianej dziedzinie, ze szczególnym uwzględnieniem ostatnich osiągnięć w technologii katastru 3D. Ponadto priorytet przyznano pracom o wysokim wskaźniku cytowań i publikacjom wiodących ekspertów w przedmiotowej dziedzinie. Ostateczny wybór materiałów odzwierciedla zarówno podstawowe teorie, jak i nowatorskie rozwiązania i innowacje, które wspierają cele i zawartość merytoryczną naszej pracy.

Biorąc pod uwagę specyfikę Ukrainy i realia powojennej odbudowy państwa, przeprowadziliśmy analizę najlepszych praktyk (w zakresie badań naukowych), skupiając się szczególnie na najbardziej praktycznych, które mogą stać się podstawą nowych, lokalnych badań na terenie naszego kraju, ze względu na obowiązujące tu specyficzne ramy regulacyjne i ustawodawcze. Interesujące z naszego punktu widzenia są doświadczenia zagraniczne, które potwierdzają skuteczność takiego systemu w kompleksowym zarządzaniu zasobami na poziomie gmin. Mianowicie: wielozadaniowy system katastralny pozwala na zwiększenie atrakcyjności inwestycyjnej terytoriów dzięki temu, że właściciele mają zagwarantowaną realizację wszystkich praw do dowolnego trójwymiarowego obiektu (nieruchomości), a jednocześnie na zmniejszenie liczby sporów majątkowych, ponieważ kontrolowana jest współrzędna wysokości, co w 98% chroni system katastralny przed nakładkami i fałszywą rejestracją granic obiektów.

Do badania i uogólnienia istniejących podejść naukowych do problemu trójwymiarowego modelowania obiektów (nieruchomości) oraz możliwości wprowadzania trójwymiarowych obiektów do wielozadaniowego systemu katastralnego wykorzystano analizę monograficzną, uwzględniającą dzisiejsze realia panujące na Ukrainie oraz biorąc pod uwagę perspektywy przyśpieszonego rozwoju społecznie zorientowanej gospodarki rynkowej po wojnie.

Metoda syntezy przejawia się w kompleksowym pogłębieniu teoretycznych, metodologicznych i metodycznych podstaw krajowego systemu katastralnego i jego transformacji. Kataster jest zawsze związany z ziemią, która jest przestrzenną podstawą życia ludzi. Jednakże informacje katastralne są nie tylko podstawą racjonalnego użytkowania i ochrony gruntów, ale również stanowią podstawę rozliczania oraz księgowania obiektów (nieruchomości) i innych ulepszeń gruntów. To właśnie dzięki zastosowaniu metody syntezy udowodniono rolę wielozadaniowego katastru 3D jako skutecznego narzędzia do rozliczania działek gruntowych, nieruchomości, a także praw do nich i obciążeń z nimi związanych.

Podejście systematyczne oznacza, że bazy danych katastru 3D mogą być wykorzystywane przez osoby zaangażowane w procesy zagospodarowania gruntów, w tym przez geodetów, architektów, deweloperów, projektantów, pośredników nieruchomości, władze lokalne, struktury zarządcze i właścicieli korporacyjnych. System katastru 3D może dostarczyć ważnych informacji dla różnych aspektów zarządzania gruntami i nieruchomościami.

Metodologia badań opiera się na następujących zasadach głównych: ogólnej zasadzie dialektycznej łączenia i interakcji; zasadzie przyczynowości, która jest związana z zasadami komunikacji i rozwoju; zasadach systematyczności poznawczej.

Wyniki i wnioski

Intensywny rozwój miast w Ukrainie, w połączeniu ze złożonymi przypadkami demarkacji przestrzennej, w odniesieniu do praw własności wymaga nowego podejścia do zarządzania gruntami, które umożliwiłoby rejestrowanie obiektów nieruchomości i praw do nich w formacie 3D – czyli prowadzenie rejestrów katastralnych z trójwymiarową prezentacją informacji. W tym celu niezbędne jest stworzenie systemu katastru 3D, który będzie w stanie rozwiązać problemy niejednoznaczności występujące w prowadzeniu katastru 2D. Aby skutecznie utworzyć kataster 3D w Ukrainie, konieczne jest udoskonalenie krajowego systemu katastralnego, w szczególności wypełnienie go informacjami o budynkach i budowlach, a także powiązanie rejestrów zawierających informacje o działkach gruntowych i znajdujących się na nich obiektach nieruchomości z informacjami o prawach własności.

Słowa kluczowe: kataster 3D, kataster wielofunkcyjny, pionowy rozkład interesów, strefy ochronne, łączność inżynieryjna, modelowanie 3D (przestrzenne, trójwymiarowe)