Land inventory on the basis of methods of GIS technologies use

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Abstract. *Taking into consideration that recently there has been a significant amount of interest in the improving and regulating the land relations, land inventory taking is an increasingly relevant and high-demand procedure. In this regard, there is a need to create a unified geographic information database that will combine information from various surveys, the environmental status assessment and cadastral information about land plots, territorial entities, agricultural enterprises etc. This aspect confirms the urgency of the research.*

The research objective is to develop a methodology for the agricultural land inventory based on the use of geographic information technologies (GIS technologies). The article analyzes the legal and methodological aspects of land inventory in Ukraine. The innovative methodology has been developed for inventory taking of agricultural lands through GIS technologies. The model of the Public Cadastral Map of Ukraine has been improved on the basis of a GIS-classifier, according to which data are entered into a single geographic information database of agricultural land inventory with the identification of base layers.

Keywords: *land, inventory, information technologies, database, GIS-technology.*

I. INTRODUCTION

The inventory of agricultural land is a matter of current interest in Ukraine as the process of redistribution and delimitation of productive land, used on various legal bases, continues to take place on these lands. The process of land redistribution has significantly complicated the determination of the inventory boundaries of the land management object. The dispersion of land plots of one owner, their impregnation in the land of state and collective ownership, the undifferentiated land of state and collective property indicate the advisability of conducting an inventory of agricultural land in the district. This approach allows to determine the exact number of land users in the district, their legal status, spatial and other characteristics of the land used. In this regard, the question of the methodological support of the agricultural land inventory arises.

II. MAIN ASPECTS OF THE ARTICLE

The primary objective of the research is to develop a methodology for conducting the agricultural land inventory through the Geographic Information Technologies (*GIS technologies*).

To achieve the research objective it is necessary to solve the following *tasks:*

- to study the legal and methodological support of land inventory taking;
- to develop a methodology for agricultural land inventory taking through *GIS technologies*;
- to develop the structure of a unified geographic information database for the cadastral interactive map of Ukraine, which will be based on operational and reliable information about

land resources.

The research object is the process of agricultural land inventory based on the application of the *GIS technology* methodology.

III. METHODOLOGY

Methodology in research is based on the development of domestic scientists and foreign experience of studying innovative forms use of information technology, as well as personal estimates of the authors.

Analytical, monographic, comparative, abstract and logical, system and analytical methods of research were used, particularly the use of analytical approach made it possible to build a model to work out methodology of *GIS technologies* to conduct an inventory of land.

IV. RESULTS

The modern period of land relations development in Ukraine is characterized, first of all, by the lack of a sound state policy in the field of land management. This is especially observed in relation to agricultural lands. There is an inefficient use of agricultural land, almost no land accounting and inventory, land management, land protection. Land inventory is the starting point of land use designing aimed at land development, defect correction of land plots and the transition to the efficient and economically sound land use. Therefore today, one of the important issues is the development of an effective methodology and technology for inventory taking of agricultural lands using GIS technologies that will lead to a fast, completely new way of carrying out work, reducing costs and shortening the time for their implementation.

Based on the foregoing, there is the need for the agricultural land inventory, but it is associated with a number of difficulties. Firstly, there is no methodological base and a poorly developed legal base for carrying out these works. In the *Land Management Act of Ukraine* dated 05.03.2009 No. 1066-VI [1], inventory is mentioned only as one of the types of land survey works. At the initial stage of land reform, land inventory was based on the legal principles of the *Land Code of Ukraine* [2], the *Law of Ukraine "On the State Land Cadastre"* [3]; the rules of the *State Register of Proprietary Rights to Immovable Property* [4], the *State Fund for Land Management Documentation* [5] and *Decree of the Cabinet of Ministers* No. 513 *"On the Procedure for Implementing the Land Inventory"* [6].

But at the moment most of these documents are no longer valid. On June 20, 2020, the *Decree of the Cabinet of Ministers* dated 05.06.2019 No. 476 entered into force and approved the new *Procedure for Land Inventory*, which defines the requirements for land inventory taking in land management, and the preparation of technical documentation based on its results.

Land inventory is carried out within the framework of administrative-territorial units, territories, the boundaries of which are determined by the projects for the territories formation and the demarcation for rural, village councils, agricultural land masses, individual land plots [7]. Taking the above into account, it should be noted that in Ukraine there is a regulatory framework that governs the general procedure for land inventory taking, but at the same time there is no single legislatively approved methodology that takes into account the specifics of work on agricultural lands.

Secondly, the inventory taking of agricultural land is a problem due to the lack of the federal budget financing and weak or none financing from the regional budgets. Private owners are not interested and are not legally required to do the land inventory, since it is a state function.

It should be noted that at present not a single public authority, including the *Federal Service of State Registration, Land Register and Mapping*, has reliable information and does not possess the necessary amount of land information for making informed management decisions on the organization and planning of the agricultural land use. Reduced funding for land management led to the fact that in the period from 1998 to 2018 a comprehensive inventory of

agricultural land was not carried out, or was carried out only in certain territories or by individual agricultural enterprises. As of today, the land accounting system includes two forms: primary and current record. Current record is kept throughout the calendar year and records all changes occurring as of the 1st of January.

The basis of land accounting is the primary recording, while the current one only supplements, adjusts and updates previously obtained information [8, p. 58].

Current land registration, which is carried out in the form of state cadastral registration, cannot solve all problems, since not all the land plots passed the registration procedure and were registered declaratively, that is, work on establishing the location and demarcation was not carried out. Taking into consideration that recently there has been a significant amount of interest in the improving and regulating the land relations, land inventory taking is an increasingly relevant and high-demand procedure [9].

In this regard, there is a need to create a unified geographic information database that will combine information from various surveys, an assessment of the environmental status and cadastral information about land plots, territorial entities, agricultural enterprises etc.

The necessary information can be obtained by creating an interactive map with a single geographic information database, as well as a 3D-model of agricultural land inventory using *GIS technologies* , based on the *MapInfo Professional* program.

The process of creating an interactive map together with a single geographic information database and a 3D-model is shown in Fig. 1.

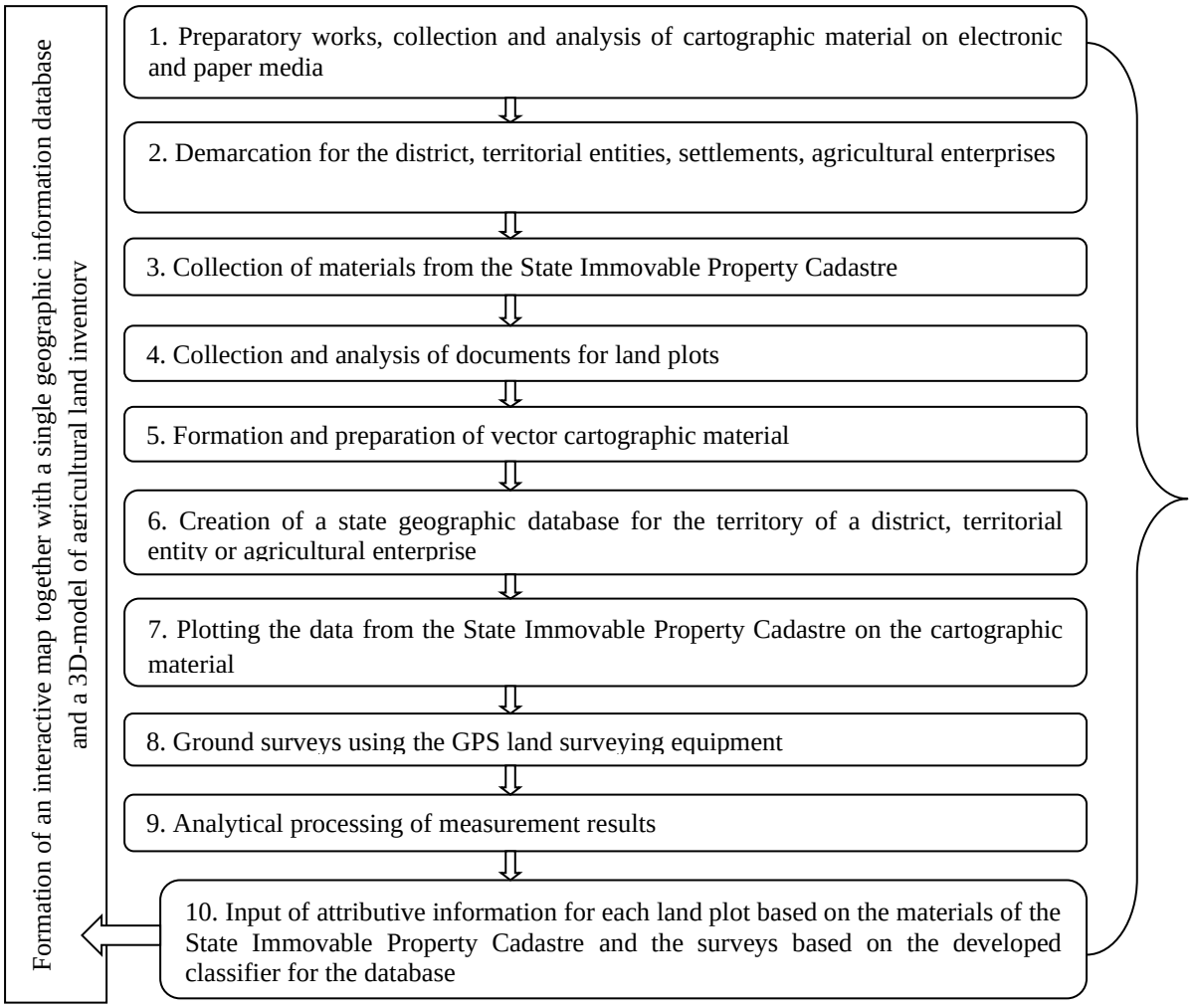

Figure 1. Scheme for creating an interactive map in accordance with a single GIS database and 3D-modeling *

**Source: compiled by the authors in course of the research.*

At the first stage preparatory work, collection and analysis of archival cartographic material on the territory of works on the agricultural land inventory is carried out. Sources of information, as a rule, are the bodies of the *Federal Service of State Registration, Land Register and Mapping, administrations* of rural settlements and municipal districts, agricultural producers and other organizations.

The requested information can be both graphic and textual material on the inventory object.

The next stage is the demarcation for the district, territorial entities, settlements on the basis of the *Territorial Entities Demarcation Act*, as well as the demarcation for agricultural enterprises.

After the borders are established, materials are collected from the *State Immovable Property Cadastre (GKN)*, such as a cadastral statement for each land plot and *Cadastral Plan of the territory (KPT).*

When the list of all the necessary cadastral units is formed, an order is made for cadastral plans of the territory for each unit as well as the cadastral excerpts for land plots on the *Federal Service of State Registration, Land Register and Mapping* website. This information is necessary to identify those land plots that have passed state registration of rights, in which the requested information about the property is displayed in text and graphic form, as well as to obtain information about their owners and users.

Next, the collection and analysis of land documents is made. It is necessary to collect entitling and supporting documents for land.

The next stage after collecting and analyzing the received documents is the formation and preparation of vector cartographic material based on geological maps. Using the *RosreestrXML* converter and the *MapInfo Professional* geographic information system, it is necessary to import the xml files and save them as *MapInfo* tables in the tab format, thereby creating a vector base in the geodetic coordinate system for the interactive map and geographic information database.

The basis for creating an interactive map is topographic maps, satellite images, agrochemical surveys materials, soil maps, site plans and the territorial planning scheme of the district.

Maps distributed in the public domain and obtained as a result of downloading in the *SAS*. Planet program are also used for land inventories.

Then the creation of a state soil-geographical database and a register of soils on the territory of the district, territorial formation or agricultural enterprise follow. *MapInfo Professional* conducts vectorization in the *GIS*, based on soil survey data from the state fund of land surveying documentation, which was carried out in the regions of Ukraine in the 1990s.

Further work is carried out on the ground. At this stage a new planning and cartographic material is selected, adjusted or created. In this connection, the aerial surveys are performed or the orthophotomaps, prepared using the results of satellite imagery aerial photographs or drone filming, are corrected.

The ground-based geodetic work is carried out to find the control points and attach photo plans to them to obtain the necessary horizontal and vertical survey. In this case, numerous errors of determining coordinates, calculating areas, etc., which have to be eliminated, are often revealed.

Also, during this stage, a land survey is carried out with the preparation of acts for each land plot or mass of territory. The land surveying act contains the following information:

1. Land category: agricultural land.
2. Name of the land plot use according to the documents.
3. Land use patterns in the past and present.
4. Cultural and technical condition of land.
5. Predominant vegetation.
6. Description of the land boundaries.
7. Security interest in the land use.

8. Distance to the nearest settlements, the economic center, livestock breeding complexes and hard-surface roads.

9. Reasons for the disposal of land from active turnover.

10. Special conditions under which it is possible to use the land mass.

To determine the exact location on the ground, graphical data of cadastral plans of the territory with a coordinate referencing are used [10, p.253].

Therefore, each soil contour that has passed the vectorization procedure has its own referencing in the geodetic coordinate system.

The use of a digital cartographic basis will make it possible to display the land plot boundaries together with a cadastral division layer and the soil contours boundaries, which, in turn, will help determine the quality condition and accurately calculate the cost characteristics of a particular land plot.

If necessary, the ground surveys are carried out using the *GPS* equipment, total stations, as well as subsequent cameral processing of measurement results in a *GIS environment*, while bypassing the production of materials on paper media.

Then the attribute information is entered for each land plot. To create an interactive map with a single geographic information database, it is necessary to carry out a lot of work to collect materials and add them to specialized software – *MapInfo Professional GIS.*

Information is collected through the comprehensive inventory of agricultural land.

The inventory of agricultural land allows to establish the quantitative and qualitative state of agricultural land, to identify the land that is not used, used inefficiently and not for its intended purpose.

The work on creating a unified geographic information database is carried out in *MapInfo Professional GIS* and has the structure shown in Fig. 2.

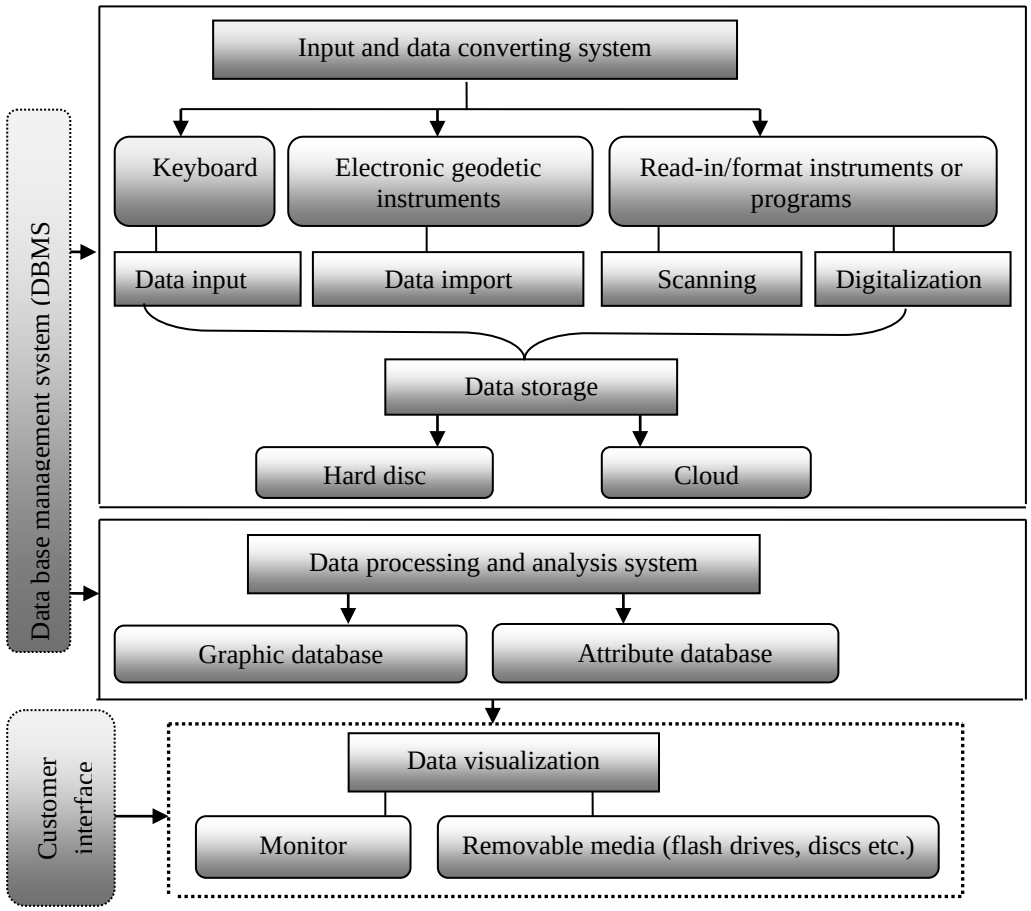

Figure 2. Structure of a single geographic information database implemented in GIS MapInfo Professional*

**Source: compiled by the authors in course of the research.*

In the process of the research, the authors improved the model of the *Public Cadastral Map of Ukraine* based on the GIS-classifier, according to which the data are entered into a single geographic information database of agricultural land inventory with the identification of so-called base layers (straits) (Table 1).

Table 1. Base layers of the Public Cadastral Map of Ukraine based on the GIS-Classifier*

№	Base layer name
1.	Orthophotomap of Ukraine in digital format (satellite)
2.	Borders of Ukraine, its regions and districts
3.	Index cadastral maps
4.	Information about the land plots: area, cadastral number, intended use
5.	Type of ownership
6.	Soil map
7.	Land use restrictions
8.	Land plots with geometric errors
9.	Archive land plots (These are all plots that were put in the so-called archive, and others appeared in their place). Generally it happens by:
9.1.	– the division of the land plot into several new ones;
9.2.	– inventory taking (clarifying the configuration and area of the plot) on the basis of which the appropriate changes are made to the cadastral register
10.	Disposal of agricultural land (Displays the areas for which the "Orders for the permission to develop project documentation" or "Orders for ownership" were issued)
10.1.	Data on crops on the registered agricultural land
10.2.	Data on crops on the unregistered agricultural land
11.	ATU – administrative-territorial structure of Ukraine (The boundaries of settlements and the united territorial communities formed in accordance with the reform on decentralization, which has been operating in Ukraine since 2014, are displayed)
12.	Regional centers – the corresponding city names are displayed
13.	Location of the Administrative Services Center – on a cadastral map all centers will be displayed with an indication of their type – district or city

*Source: compiled by the authors in course of the research.

Information is entered into the agricultural land inventory database on the basis of archived cartographic material and explanatory notes thereto, information from the unified state register of rights, agrochemical, soil and other surveys, scientific research, as well as the results of geodetic work and monitoring of agricultural lands.

At the last stage, an interactive map is formed together with a unified geographic information database and a 3D-model of agricultural land inventory, and it becomes possible to view information for each land plot.

To develop a 3D-model, the topographic maps are used as well as the data of the horizontal and vertical survey obtained as a result of geodetic work with *GPS equipment*.

The *MapInfo* geographic information system, taking into account the real size of the object, allows to create a truth model that helps to clearly and thoroughly present the inventory project and without leaving your office to see the situation on the ground and the state of land resources.

As a result of creating a single geographic information database for agricultural land inventory using *GIS*, filled out on the basis of all the surveys and surveys, the information presented in the classifier will be displayed on the interactive cadastral map (Fig. 3).

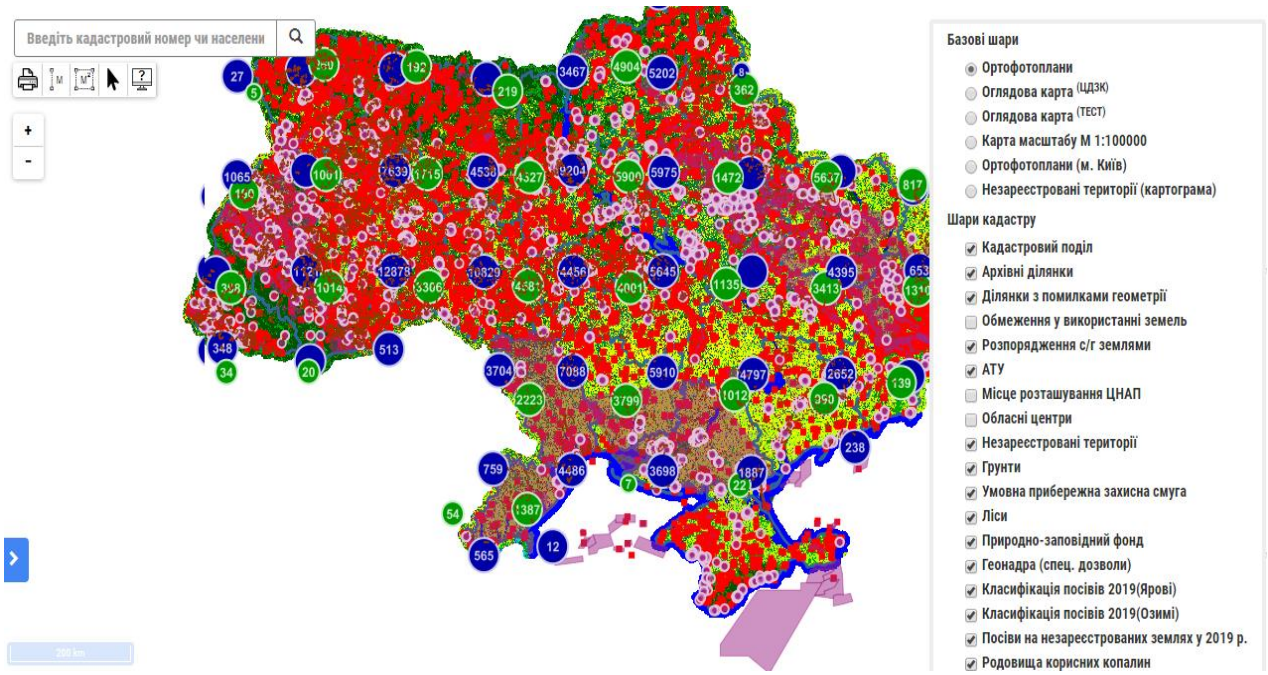

Figure 3. Public cadastral map of Ukraine indicating the base layers of the GIS-classifier*

**Source: compiled by the authors in course of the research.*

Application of the results of land inventory, carried out by means of *GIS technologies* using *MapInfo Professional* software, will allow:

– to create a regularly updated single geographic information database, an interactive map and a 3D-model;

– to display attributive information for each land plot on the interactive map and the 3D-model, as well as to improve the quality of the materials provided;

– to form a high-quality land management system, which will lead to the improved cadastral registration;

– to collect and update data on the qualitative condition and quantitative composition of lands used for different legal reasons;

– to generate relevant data for monitoring compliance with the intended use of land;

– to improve accuracy and significantly reduce the time of work due to the use of satellite geodetic equipment.

V. CONCLUSIONS

Intensification of land use in Ukraine requires a large-scale inventory with improved methods for identifying the vacant, unreasonably used land plots or land plots used not for intended purpose with modern, quick *GIS methods*, which does not involve excessive financial and labor costs.

Therefore, the inventory of agricultural land is the starting point of land management planning aimed at land development, defect correction of land and the transition to efficient and economically sound land use.

Information obtained as a result of land inventory, taking into account all of the above indices, is especially important for local authorities, as it determines the cadastral value of land plots, that is, it is the tax base, and budget revenues from the land tax are the basis of social and economic territory development.

REFERENCES

1. “About of land management”. Law of Ukraine. The Verkhovna Rada of Ukraine, No.858-IV, (2020) January 16, https://zakon.rada.gov.ua/laws/show/858-15

2. “Land Code of Ukraine”. Law of Ukraine. The Verkhovna Rada of Ukraine, No.440-IX, (2020) January 14, https://zakon.rada.gov.ua/laws/show/2768-14

3. “On State Land Cadastre”. Law of Ukraine. The Verkhovna Rada of Ukraine, No.8, (2012) October 16, https://zakon.rada.gov.ua/laws/show/3613-17

4. “On State Registration of Rights to Real Estate and Their Encumbrances”. Cabinet of Ministers of Ukraine, No.1127, (2015) December 25, https://zakon.rada.gov.ua/laws/show/1127-2015-%D0%BF

5. State fund documentation of Land Management. *Official Website*, (2020), https://land.gov.ua/info/derzhavnyi-fond-dokumentatsii-iz-zemleustroiu/

6. “On approval of the Procedure for Land Inventory”. Cabinet of Ministers of Ukraine, No.513, (2012) May 23, https://zakon.rada.gov.ua/laws/show/513-2012-%D0%BF

7. “The procedure for conducting land inventories, which defines the requirements for conducting land inventories during land management, and for the preparation, based on its results, of technical documentation”. Cabinet of Ministers of Ukraine, No.476, (2019) June 5, https://zakon.rada.gov.ua/laws/show/476-2019-%D0%BF

8. A.M. Tretyak and O.S. Dorosh, Editor, “Management of land resources”, New Book, Vinnitsa, (2006).

9. “Organization of land use. Land composition and their use”, (2020), http://agroua.net/economics/documents/category-127/doc-219

10. R. Kozhukhivska, M. Shemyakin, I. Udovenko and N. Verniuk, “The innovation principles of economic model of the cadastral land valuation for business activity”. *Problems and Perspectives in Management*, 15(3), (2017), 253-265. doi:10.21511/ppm.15(3-1).2017.09

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