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THE PROCEDURE OF USING AERIAL PHOTOGRAPHS TO CREATE THE GRAPHIC PART OF LAND MANAGEMENT DOCUMENTATION

Pilicheva Maryna[1], Anopriienko Tetiana[2], Fedorova Anna[2]
[1]O.M. Beketov National University of Urban Economy in Kharkiv,
[2]State Biotechnological University

Abstract
The article is devoted to the use of aerial surveying issue to create a graphic part of land management documentation. For each type of land management documentation, the scale of graphic materials of land management documentation is determined, as the scale depends on the task and the required accuracy of the work. It has been established that aerial surveying is the most effective method for creating (updating) basic graphic materials of land management documentation at the scales of 1:5 000, 1:2 000, 1:1 000, space imagery is used to create of maps on a scale of 1:5 000 in plains and 1:10 000 in mountainous areas. It was determined that the use of aerial photographs in solving land management problems is possible only after passing all stages of their preliminary processing: post-processing, rectification and an orthophoto plan creation. General recommendations have been developed regarding the use of aerial photography to create the graphic part of land management documentation: aerial photographs or space images should be used for a large area; aerial photographs – for displaying land management objects within the boundaries of settlements; space images – outside of populated areas, or at the stage of designing land management documentation or performing planning works.
Key words: scale, land management documentation, aerial photographs, photogrammetric processing, cartographic materials

Introduction

Land reform, which has been taking place in Ukraine for more than 30 years, is a set of measures and mechanisms aimed at regulating land relations on the basis of rational, efficient and sustainable land use. The priority direction is the development of rural areas, decentralization of power in the use of land resources, ensuring equality of all forms of land ownership [1].

During analysis of definitions, types and approaches of land reforms in foreign countries [2-4], it was determined that land reform is a necessary socio-political and economic process of any country. The priority direction is the development of rural areas, decentralization of power in the use of land resources, ensuring equality of all forms of land ownership. In Ukraine, the priority tasks of improving land relations, taking into account the best practices of foreign countries, are [1]:

1) definition of clear rules and criteria, instructions and methods of agricultural land circulation subject selection, optimization of the size of economic structures, legislative limitation of permissible land areas that can be owned;
2) land market opening in few stages: first, allow the purchase of agricultural land only by individual natural persons - citizens of Ukraine, then gradually supplement the list of juridical entities;
3) imrovement of the institutional structure improvement of the land relations regulation through the creation of a state body that would regulate the circulation of land;
4) transfer of state-owned lands to territorial communities;
5) introduction of two-level (state and local) control over the rational and efficient use of land;
6) transformation of the State Land Cadastre into the State Real Estate Cadastre.

During solving most of the listed tasks, land management documentation is developed, which includes textual and graphic materials elaborted and approved in accordance with the Law of Ukraine "On Land Management" [5].

During the development of land management documentation, topographic and geodetic and cartographic works, land inventory, soil, geobotanical and other land surveys, land evaluation works are carried out [6]. Based on the results of the work, we receive graphic materials on a certain scale, which are formed based on the data of cadastral surveys, existing cartographic materials and data of

aerospace surveying with the use of geoinformation systems. This determines the need for further research and specification of this direction.

Methodology of research and materials

The graphic part of land management documentation is performed using topographic maps and plans of various scales. At the same time, the scale of the cartographic material depends on the task and the required accuracy of the works. However, the law [5] does not specify the necessary accuracy of land management works. During the analysis of secondary legal acts of Ukraine (orders, methodological instructions and others) in the field of land management and urban planning, it was found that for most of the land management documentation no special rules and methodological instructions have been developed that would determine the accuracy of the work carried out.

The only document that regulates the accuracy of determining the boundaries of land plots is the Procedure for Conducting a Land Inventory [7], according to which the root mean square error of determining the coordinates of the turning points of the boundaries of land plots relative to the nearest points of the state geodetic network, geodetic networks of densification, urban geodetic networks should not exceed:

- in the city of Kyiv, Sevastopol and cities of regional subordination - 0.1 meters (corresponds to the scale accuracy of 1 : 500);
- in other cities and towns - 0.2 meters (corresponds to the scale accuracy 1 : 1 000);
- in villages - 0.3 meters (corresponds to the scale accuracy 1 : 2 000);
- outside the population centers - 0.5 meters (corresponds to the scale accuracy 1 : 5 000).

The working inventory plan is drawn up on the basis of the regular cadastral plan or other planning and cartographic materials within cities and towns on a scale of at least 1:5,000, within villages and agricultural land massifs on a scale of at least 1:2,000, within territories defined by the projects of territory formation and establishment of village and settlement councils boundaries , on a scale of at least 1:10,000, within districts on a scale of 1:25,000. Boundaries of land plots entered into the State Land Cadastre, restrictions on their use, encumbrances of rights to land plots and lands are noted on the working inventory plan on a scale of at least 1:10,000.

Figure 1 shows various land management objects and the approximate scale of the image in the graphic part of the land management documentation.

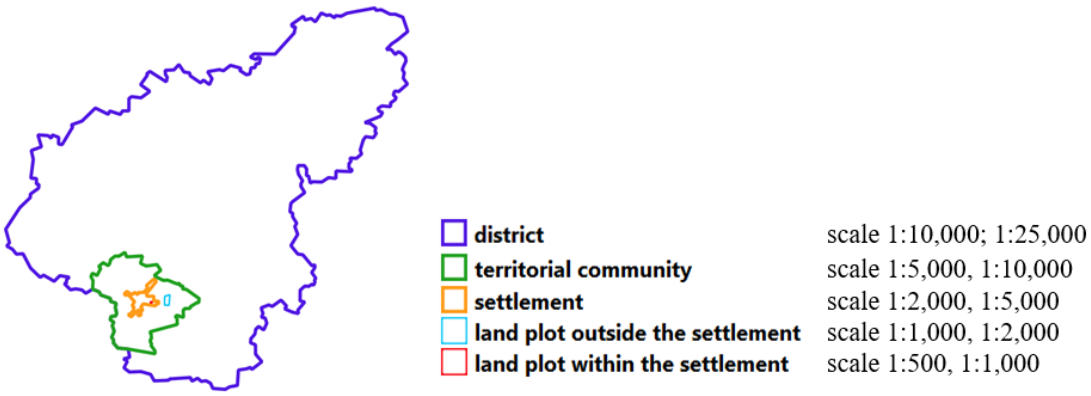

Fig 1. Land management objects and the approximate scale of the image in the graphic part of the land management documentation

Therefore, taking into account the requirements of the document [6], it can be determined that the graphic part of the land management documentation (main drawings) can be on a scale from 1: 500 to 1: 25,000 depending on the type of documentation, location and area of the territory (Table 1), and is compiled based on the results of cadastral surveys or available cartographic materials.

Table 1

The recommended scale of the land management documentation graphic part

No.	Land management documentation	Recommended scale of the map (plan)
1.	Land management schemes and technical and economic justifications for the use and protection of administrative-territorial units' lands	1:10 000, 1:25 000
2.	Land management projects regarding the territorial boundaries establishment of territorial communities	not less than 1 : 10 000
3.	Land management projects regarding the establishment (change) of the administrative and territorial units' borders	not less than 1 : 10 000
4.	Urban planning documentation, which is also land management documentation (complex plans for the spatial development of territories of territorial communities, general plans of settlements, detailed plans of territories)	from 1:500 to 1:5 000
5.	Land management projects regarding the organization and establishment of boundaries of the nature reserve fund and other nature conservation purposes, health, recreational, historical and cultural, forestry purposes, water fund lands and water protection zones, restrictions on the use of lands and their regime-forming objects	from 1:1 000 to 1:25 000
6.	Land management projects regarding land privatization of state and communal agricultural enterprises, institutions and organizations	from 1:500 to 1:10 000
7.	Land management projects regarding the allocation of land plots	from 1:500 to 1:5 000
8.	Land management projects regarding the arrangement of the territory for urban planning needs	from 1:500 to 1:5 000
9.	Land management projects that provide ecological and economic substantiation of crop rotation and land management	not less than 1:10 000
10.	Land management projects regarding the regulation of the settlements' territory	from 1:500 to 1:5 000
11.	Land management projects regarding the organization of the territory of land traces (shares)	from 1:5 000 to 1:10 000
12.	Land management working projects	from 1:2 000 to 1:25 000
13.	Technical documentation on land management regarding the establishment (restoration) of land plot boundaries naturally (on site)	from 1:500 to 1:5 000
14.	Technical documentation on land management regarding the establishment of the boundaries of the part of the land plot to which the rights of sublease, easement apply	from 1:500 to 1:5 000
15.	Technical documentation from the land surveying process and the association of land plots	from 1:500 to 1:5 000
16.	Technical documentation on land management regarding land inventory	from 1:1 000 to 1:25 000
17.	Technical documentation on land management regarding the reservation of territories and objects valuable for inheritance	from 1:1 000 to 1:25 000
18.	Technical documentation on land managemen regarding the establishment of regime-forming objects of cultural heritage boundaries	from 1:500 to 1:5 000
19.	Technical documentation on regulatory monetary assessment of land plots	from 1:500 to 1:10 000

Updating cartographic materials using traditional geodetic methods requires significant time, labor, material and financial costs. To reduce the listed costs, orthophoto plans of scales 1 : 2,000 and 1 : 5,000 were made, covering the entire territory of Ukraine according to the Project of Issuing State Acts on Land Ownership in Rural Areas and Creating a Cadastre System, which was financed by the

World Bank and implemented since 2004 until 2013 [8]. At the same time, the following difficulties arise:

1. The obtained materials are not available for most state and private geodetic and land management firms and enterprises.
2. Orthophoto plans become obsolete, which also leads to the need to update them (aerial photography was performed in 2007-2014).Therefore, a promising direction of research is the combined use of cadastral survey data, existing cartographic materials and aerospace survey data with the use of geoinformation systems at the stage of designing land management documentation.

Aerospace survey data are widely used to solve land management problems both in Ukraine and abroad. This is due to:

- relevance of data while shooting;
- ease of obtaining data (there is no need to obtain permission);
- high efficiency of data acquisition;
- significance of area coverage (starting with several square meters);
- high informativeness;
- lowering the cost of works compared to ground geodetic measurements.

Aerospace imaging data can be divided into three groups according to the way of shooting:

- aerial photographs from digital cameras mounted on aircraft or helicopters;
- aerial photographs from digital cameras installed on unmanned aerial vehicles (UAVs);
- space pictures obtained from artificial satellites of the Earth.

In Ukraine, aerial photographs obtained from the metric digital camera 3DAS of the scientific and production enterprise "Geosystem" are widely used [9].

To obtain images for end users (index block when using a stereo model or orthophotoplan), the original image necessarily undergoes photogrammetric processing using specialized software (Fig. 2).

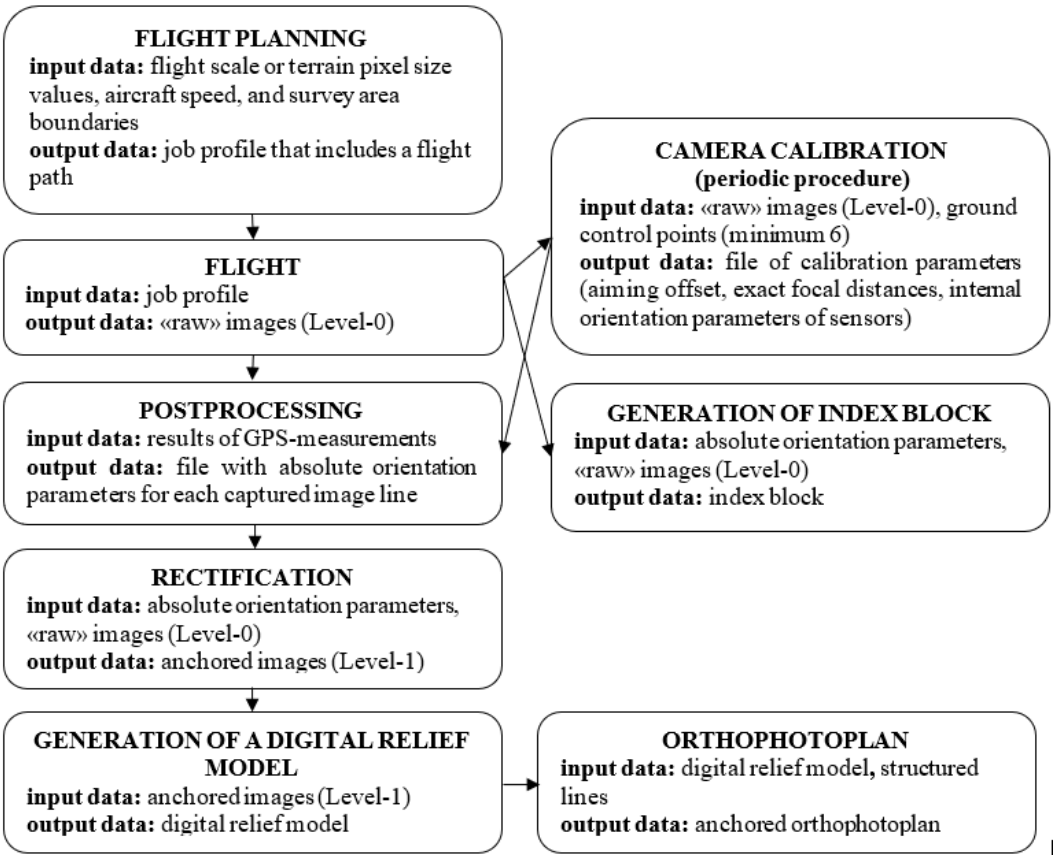

Fig. 2. Technological scheme of aerial photographs acquisition and photogrammetric processing

At the first stage of processing, flight GPS measurements are aligned together with measurements of base stations, at the second stage - automatic rectification of the original images using the data obtained at the first stage [10]. The image obtained in this way is corrected for the angles of inclination and the trajectory of the aircraft and has a geodesic reference. At the third stage, stereo drawing of the situation (creation of a digital map) or creation of a digital relief model (DRM), orthophoto transformation and composition of mosaic orthophoto plans in a geodetic layout is performed.

According to [11], aerial photographs obtained from a 3DAS digital camera are used:

- for the purposes of inventorying urban settlements (survey scale is 1:8,000-1:12,000, resolution on the ground is 0.07-0.10 m, accuracy tolerance is ±0.2 m);
- for the purposes of inventorying rural settlements (survey scale is 1:14,000-1:16,000, resolution on the ground is 0,12-0,15 m, accuracy tolerance is ±0,4m);
- for the purposes of forest taxation and forest inventory (survey scale is 1:25,000, resolution on the ground is 0,23 m, accuracy tolerance is ±1,0 m).

To control the accuracy of the obtained results, an independent selective accuracy control is performed by determining the coordinates of clear contour points using GPS measurements. The detected deviations for shooting scales of 1:10,000-1:12,000 are within tolerance and did not exceed the average error of ±0.15 m.

During shooting from unmanned aerial vehicles (UAVs), non-metric compact digital cameras are mainly used. The focal length of cameras is usually about 50 mm, which corresponds to a pixel size on the ground from 7 to 35 cm. The result of aerial photography is visible spectrum images (color images) or multispectral images – a synthesis of color images and near-infrared images. The possibility of using UAVs for aerial photography processes is considered in works [12-13]. In order to obtain the maximum accuracy of the results - about one pixel, which corresponds to the accuracy of orthophoto plans of scales from 1: 500 to 1: 2,000 depending on the shooting height - the shooting and processing of its results must be carried out based on strict photogrammetric data processing, i.e. perform phototriangulation.

The processing of aerial photography from UAVs at digital photogrammetric stations (DPS) is generally similar to the processing of aerial photography from "large aircraft" (Fig. 2). However, the peculiarities of the data from the UAV board often do not allow the use of automatic procedures of photogrammetric software. After strict photogrammetric processing of aerial photographs from a UAV, it is possible to obtain the accuracy of the planned position of the points of about 0.3-0.5 cm and the height - 1 m. The low results are explained by the following factors:

1. Image blurring during exposure.
2. Unsatisfactory tilt angles (more than 12°).
3. Longitudinal overlapping of images is not always satisfactory: unstable ground speed of the aircraft.

In addition, UAVs have an increased accident rate, so there is a high risk of losing the device and equipment. This is due to the fact that UAVs are not equipped with an obstacle detection and collision avoidance system, in addition, many models are equipped with less than perfect autopilots.

Currently, UAV data is not widely used due to the above-mentioned disadvantages. However, aerial photographs from UAVs, when eliminating the latter, can be used to solve problems:

- inventory of settlements lands and agricultural lands;
- monitoring the condition of forest areas, agricultural crops, monitoring the quality and timeliness of various activities in these territories;
- planning of agricultural and industrial land use;
- examination of the storage area of harmful and poisonous substances, to which human access is limited or dangerous;
- creation of large-scale plans of rural settlements for land registration and establishment of land plots boundaries.

To create large-scale plans (scale 1:5,000), space photographs with a spatial resolution of 0.61 m at nadir and 0.66 m at 15° deviation from nadir are also used. Space images are in color and multispectral. Multispectrality is provided by a panchromatic channel and a multispectral image,

which consists of four channels − blue (0.45−0.520 μm), green (0.52−0.60 μm), red (0.63−0.69 μm), and infrared (0.76−0.90 μm) spectral range.

The theoretical basis for evaluating the suitability of space-based imaging systems for territory mapping is the resolution and radiometric characteristics. To improve the visual and geometric characteristics of the image, the following types of processing are carried out: sensory correction, radiometric correction, geometric correction.

However, the above data are valid only for perfect conditions. Under normal conditions, due to the influence of atmospheric turbulence, spacecraft and receiver tilt, image shift, residual defocusing, diffraction, and receiver discreteness, the accuracy can be 1.5–2 times lower [14]. Also, the scale of orthophoto plans, which can be created from space photographs, depends on many factors, among them: the quality and quantity of reference points, the quality of digital models of the terrain and the terrain, the characteristics of the software, and the qualifications of the performers. Moreover, all these factors must be considered together.

Despite all the advantages of using special software for working with data from aerial photography, there is also a significant drawback - its high cost. According to the authors, the problem can be solved by using special settings of modern multipurpose geoinformation systems that allow working with space images. However, in this case, it is necessary to buy a picture that has already been subjected to additional geometric processing, which, in our opinion, leads to an increase in costs of work.

The problem of using space survey data for large-scale mapping was also considered by the authors [15-18]. They developed a technological scheme for the creation of topographic materials with the involvement of space images, which includes the following stages:

1. Outline of the work area. Choosing the optimal type of pictures. Preparation of the nomenclature list and ordering of pictures.
2. Compilation, preparation, scanning and spatial reference of relevant large-scale cartographic materials.
3. Construction of a digital terrain model.
4. Radiometric correction of space shooting materials.
5. Geometric correction of space images using a digital terrain model.
6. Creating a mosaic covering the work area.
7. Spectral correction. Improvement of pictures visual perception.
8. Camera decoding and creation of necessary vector layers (vectorization of contours).
9. Selection of coordinate system and topographic projection. Compilation of the received materials into a single information system.
10. Generalization. Preparation of additional data to ensure fast and high-quality visualization of the vector and raster base at different scale levels.
11. Choosing the optimal data format. Transferring the resulting data into the required format for further inclusion in the geoinformation system.

While solving specific land management problems, orthoimages are used that have undergone preliminary processing and are an analogue of a plan or map.

Space images are successfully used to solve land management problems related to the use of agricultural land [19]. Using images with even a medium (2.5 m) spatial resolution, it is possible to decipher the boundaries of land (arable fields, meadows, gardens, etc.) and their condition (land disturbance, tree vegetation, types of crops, soil moisture, damage by pests or weeds, etc.). Agricultural land boundaries are determined by visual or automatic decoding.

Thus, at this stage the remote sensing methods, aerial surveying according to technical, economic and multifunctional characteristics development is still the most effective method of creating (updating) basic cartographic materials at the scales of 1:5,000, 1:2,000, 1:1,000 for solving problems cadastre and accounting of land resources, while ensuring a comprehensive approach to planning and functional organization of territories. Space images of high spatial capacity can be used to update only the contour part of maps at a scale of 1:5,000 in plains and 1:10,000 in mountainous terrain.

Discussions and results

So, let's assume that when using aerial photos, we receive graphic materials on a scale of 1:2,000, 1:1,000, and space photos on a scale of 1:5,000 and smaller, so the general recommendations for using data from aerospace photography are following:

1. aerial photos or space images are advisable to use when solving land management problems of a large territory;
2. aerial photographs are used to solve land management problems within settlements;
3. space images are used to solve land management problems outside settlements or at the stage of planning and designing land management documentation.

Recommendations for the use of aerial survey data during the development of the graphic part of specific land management documentation according to the Law [5] are given in the table 2.

Table 2

Recommendations on the use of aerial survey data for the development of the land management documentation graphic part

No.	Land management documentation	Recommended scale of the map (plan)	Aerospace survey data
1	2	3	4
1.	Land management schemes and technical and economic justifications for the use and protection of administrative-territorial units lands	1:10 000, 1:25 000	space images
2.	Land management projects regarding the establishment of territorial boundaries of territorial communities	not less than 1:10 000	space images / aerial photos
3.	Land management projects regarding the establishment (change) of administrative and territorial units borders	not less than 1:10 000	space images / aerial photos
4.	Urban planning documentation, which is also land management documentation (complex plans for the spatial development of territories of territorial communities, general plans of settlements, detailed plans of territories)	from 1:1 000 to 1:5 000	space images / aerial photos
5.	Land management projects regarding the organization and establishment of boundaries of the territories of the nature reserve fund and other nature conservation purposes, health, recreational, historical and cultural, forestry purposes, water fund lands and water protection zones, restrictions on the use of lands and their regime-forming objects	from 1:1 000 to 1:25 000	space images / aerial photos
6.	Land management projects regarding land privatization of state and communal agricultural enterprises, institutions and organizations	from 1:500 to 1:1 000	aerial photos
7.	Land management projects regarding the allocation of land plots	from 1:500 to 1:5 000	aerial photos
8.	Land management projects regarding the arrangement of the territory for urban planning needs	від 1:500 to 1:5 000	aerial photos
9.	Land management projects that provide ecological and economic substantiation of crop rotation and land management	not less than 1:10 000	space images
10.	Land management projects regarding the regulation of the settlements territory	from 1:500 to 1:5 000	space images / aerial photos
11.	Land management projects regarding the organization of the territory of land traces (shares)	from 1:5 000 to 1:10 000	space images / aerial photos
12.	Land management working projects	from 1:2000 to 1:25000	space images / aerial photos
13.	Technical documentation on land management regarding the establishment (restoration) of land plot boundaries naturally (on site)	from 1:500 to 1:5 000	aerial photos

Table 2 continuation

1	2	3	4
15.	Technical documentation from the land surveying process and the association of land plots	from 1:500 to 1:5 000	aerial photos
16.	Technical documentation on land management regarding land inventory	from 1:1 000 to 1:25 000	space images / aerial photos
17.	Technical documentation on land management regarding the reservation of territories and objects valuable for inheritance	from 1:1 000 to 1:25 000	space images / aerial photos
18.	Technical documentation on regulatory monetary assessment of land plots	from 1:500 to 1:5 000	aerial photos

The specified list is not exclusive and can be supplemented taking into account the development of modern information systems and the legal field.

Conclusions and proposals:

1. The successful solution of land management problems in the modern conditions of Ukraine requires constant updating and actualization of cartographic materials along with a reduction in the cost and labor intensity of works. The solution to the given problem requires the improvement of joint use areas at the stage of designing land management documentation of cadastral survey data, existing cartographic materials and aerospace survey data with the use of geoinformation systems.
2. The analysis of existing approaches to the use of aerospace survey data made it possible to establish that at this stage of the development of remote sensing methods, aerial surveying is the most effective method for creating (updating) basic cartographic materials at scales of 1 : 5,000, 1 : 2,000, 1 : 1,000 to solve cadastre problems and accounting for land resources while providing an integrated approach to planning and functional organization of territories. Space images can be used to update only the contour part of the 1 : 5,000 scale maps in plains and 1 : 10,000 in mountainous terrain.
3. The use of aerial photographs when creating the graphic part of land management documentation is possible only after passing all stages of preliminary processing: post-processing, rectification and creation of an orthophoto plan.
4. The approach of using aerial photographs during the formation of land management documentation graphic materials is based on general recommendations:

− it is advisable to use aerial photographs or space photographs during the formation of graphic materials of land management documentation of a large territory;

− aerial photographs are used during the formation of land management documentation graphic materials within settlements;

− space images are used during the formation of land management documentation graphic materials outside of settlements, or at the stage of designing land management documentation or performing planned works.

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Information about authors:
Maryna, Pilicheva, candidate of technical sciences, associate professor, associate professor of the department of land administration and geoinformation systems, O.M. Beketov National University of Urban Economy in Kharkiv. 17 Marshal Bazhanov str., Kharkiv, 61002, Ukraine, +380992125804, maryna.pilicheva@gmail.com. Photogrammetry and remote sensing, land cadastre, land management, territory planning.
Tetiana, Anopriienko, candidate of economic sciences, associate professor, associate professor of the department of land management, geodesy and cadastre, State Biotechnological University. 44 Alchevskyh str., Kharkiv, 61002, Ukraine, +380956888377, atatyanav2017@gmail.com. Management of land resources, territory planning, land cadastre, real estate evaluation
Anna, Fedorova, assistant of the department of land management, geodesy and cadastre, State Biotechnological University. 44 Alchevskyh str., Kharkiv, 61002, Ukraine, +380679575400, anna.shtykh@gmail.com. Geodesy, photogrammetry and remote sensing, territory planning, real estate evaluation.