Application of orthophotomaps in land cadastre

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Abstract. This article is devoted to obtaining and using orthophotomaps in the land cadastre. Efficient use and monitoring of land and water resources in Uzbekistan open up a wide range of opportunities with the use of orthophotomaps obtained from aerospace images. At the same time, the effective organization of state control over land use, the introduction of modern technologies in the field, and the accounting of land resources remain insufficiently organized. In particular, in cadastral plans, the boundary description for registered land plots is inconsistent with their real site location. Therefore, at present, special attention is paid to the geodetic and cartographic support of the cadastral system on the basis of modern geographical information systems, registration of objects, design, and creation of digital maps. The study discussed the issues is the development of orthophotomaps in the land cadastre and the improvement of methods for their regular renewal using modern technologies. As a result of this study, the orthophoto maps were obtained for the Karakul district of the Bukhara region, and a cadastral map was created by vectorization.

1 Introduction

The State Land Cadastre of Uzbekistan and its technological methods were substantially modified at every step of their development. On the 28th of August 1998, the Law of Uzbekistan "On the State Land Cadastre" was adopted, which defined the main directives of the development of the state land cadastre in Uzbekistan. On the basis of this Law, the State Land Cadastre was filled with new content and requirements, which must be fulfilled as a single state geoinformation system of information about lands within boundaries of the State Border of Uzbekistan, that are: their quantitative and qualitative characteristics, target purpose, restrictions in their use, evaluation and distribution of lands between owners and users.

Making a modern land cadastral survey requires the continuous improvement of measuring methods and mapping. In that connection, special attention is paid to geodetic and cartographic support of land cadastral works based on modern geographical information systems. The most pressing issues are the creation of orthophotomaps and improving the methods of regular updating of cartographic materials.

The State Land Registry Cadastre contains the data for land plots, the boundaries of which have been set in accordance with the law, as well as the data for earlier recorded land

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plots without descriptions of boundaries and their demarcation afield. In some cases, the boundary description for registered land plots is inconsistent with their real site location.

The relevance of this study is that a large volume of records for land plots accumulated in the Land Cadastre requires adjustment and correction errors and simultaneously specifies the location of all land plots within the boundaries of one or several closely-spaced cadastral units based on orthophotomaps.

On June 17, 2019, the Decree of the President of the Republic of Uzbekistan "On measures for the efficient use of land and water resources in agriculture" was issued. In accordance with this decree, in order to ensure accurate management and continuous updating of agricultural land records with the application of geographic information systems, an aerial survey of all territories was planned to be carried out, in order to form a database in the context of the contour of each field, as well as widely applied are remote sensing data to monitor the state of the use of land and water resources.

During 2019-2021, an aerial survey was performed in all regions of the country, in particular, in 2021 in the Republic of Karakalpakstan 26918.7 km2, Fergana region 6062.9 km2, Namangan region 4495.8 km2, Andijan region 3803.7 km2, Jizzakh region 5992.4 km2, Syrdarya region 3966.7 km2, Kashkadarya region 6733.0 km2, Surkhandarya region 12937.3 km2. Based on this data, work is ongoing on georeferencing aerospace images of recent years and were created digital orthophotomaps. As a result, by using aerial photogrammetrical methods 6,724 orthophotomaps were created at scale 1:2000, 6099 at scale 1: 10.000 for irrigated areas, and 3608 at scale 1: 25,000 for mountain, piedmont, and desert areas [1].

The purpose of this research is to establish the possibilities of using the digital aerial photogrammetry technique to collect geospatial data and digital image processing, in order to draw up maps for the land cadastre.

The main objective of this study is the development of large-scale cadastral maps and maps of agricultural land based on digital orthophotomaps.

2 Materials and methods

2.1 The study area

Considering the purpose and objectives of the paper, Karakul District was chosen as the study area. Karakul district is located in the southwestern part of the Bukhara Region of Uzbekistan at the latitude of 39°15'N - 40°42'N, a longitude of 62°10'E - 64°03'E, the absolute height of 195 m above sea level (Figure 1). The district is located in the lower reaches of the Zarafshan River, in the Karakul oasis in the south of the region. Its borders were formed in 1926 and the total area of Karakul district is 6954.09 km2, wherein the 5100.45 km2 is used in agriculture.

The eastern part of the region is occupied by ridges no higher than 200-300 m, the northern and northwestern parts are occupied by the Kyzylkum desert, Karakul, and Mokhonkul oases.

The soils are predominantly gray soil. The dry channel of the rivers Karakul and Mohondarya is composed of meadow-gray, sandy-gray soils, and alluvial deposits. The basins are covered with saline, and salt marshes, and the western part is occupied by beams, dunes, and barkhans. The climate is extremely continental with the average January temperature being -3°, and the average July temperature being 28.5°. The vegetation period is 213 days. The average annual rainfall is 100-150 mm, most of it falls in spring and winter time.

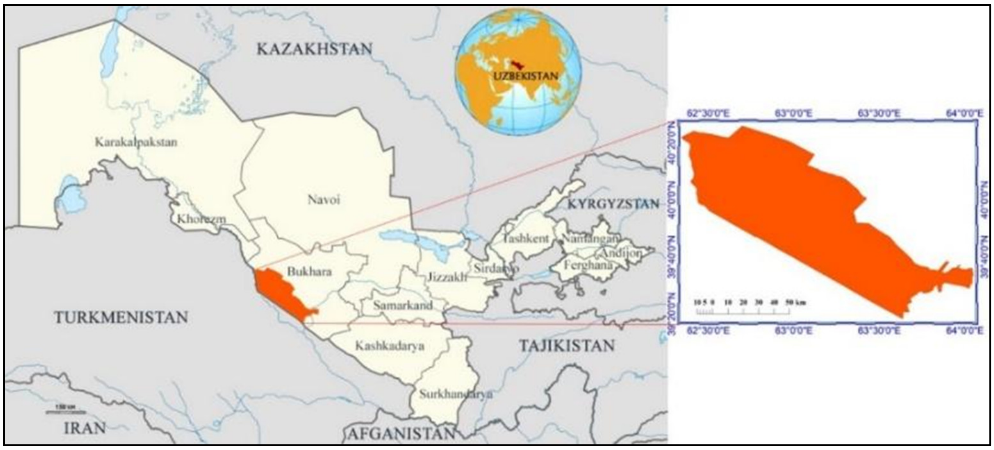

Fig. 1. Location map of the study area.

2.2 Methods

The following remote sensing, aerial survey and UAV data (imagery) and cartographic materials were applied in this study:

- The satellite images of the study area were provided by the Department of Remote Sensing, Geodesy and Cartography of the Cadastre Agency, viz. satellite images with the highest spatial resolution from Korean satellites KOMPSAT-3 and KOMPSAT-3A, which completely cover the territory of Uzbekistan. These images have five spectral channels (panchromatic, blue, green, red, and near-infrared) with a very high spatial resolution (2.8 m in multispectral mode and 0.7 m in panchromatic mode) [2].
- Aerial survey data, which was performed from the airplane AN-2 using the aerial camera UltraCamX from Vexcel Imaging GmbH, which can acquire images at large scale and at rather high stereoscopic overlaps. The advantages of UltraCam X are a large image format of 14430 pixels cross-track and 9420 pixels along the track, an excellent optical system with a 100 mm focal length for the panchromatic camera heads and 33 mm for the multispectral camera heads, the image storage capacity of 4700 frames for one single data storage unit, almost unlimited image harvest due to exchangeable data storage units, instant data download from the airplane by removable data storage units, fast data transfer to the post-processing system by the new docking station. This aerial camera has eight independent camera cones, 4 of them contributing to the large format panchromatic image, and 4 contributing to the multispectral image [3].
- Phantom 4 Pro UAV data, which can acquire images at large scale (1:100-1:1000) and are mainly used in large-scale cartography (creation and updating), monitoring (technical inspection of buildings and structures, control of monuments in the field of archeology, architecture, land management).

All data was obtained for the 2021 year and to achieve the goal we used the working methodology, which involves the use of the technology creation of orthophotomaps, which supposes the implementation of several stages presented in Figure 2.

For the processing of digital images and the elaboration of orthophotomaps, a Workstation DELL Precision 5820 with a very powerful processor was used, which allowed the processing of the large amount of information contained in the digital images. Obtaining the orthophotomap based on digital images was done with the PHOTOMOD Lite 7.2 program specialized in image processing to obtain three-dimensional models and orthorectified products.

The processing and transformation of the products obtained with the help of PHOTOMOD Lite 7.2 into other products easier to handle were done using the Data Management and Conversion tools ArcMap, and the vectorization and elaboration of the cadastral plans were done in ArcMap 10.8.

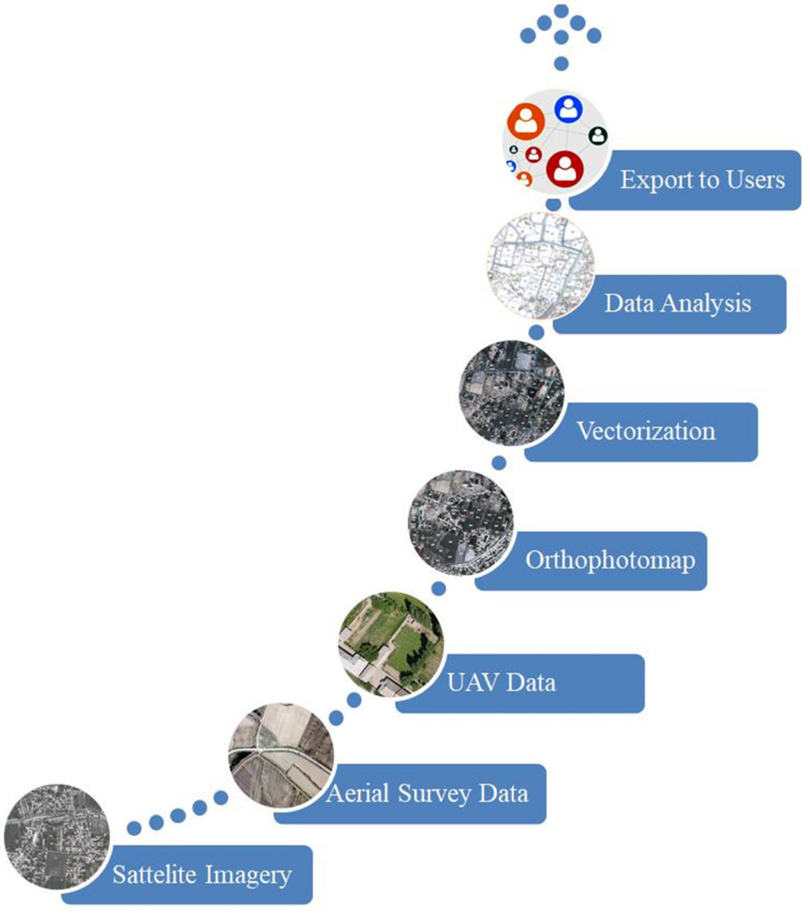

Fig. 2. Research methodology.

3 Results

In this study, a new trend in the acquisition of geospatial data in cadastre for the preparation of orthophotomaps, regardless of land types and category of land use was applied, which is the use of aerial images obtained using airplanes and drones, and satellite imagery. Using drone images with terrestrial measurements allows for getting more accurate georeferencing results. Based on the orthophotomap, which was created using this methodology, it is possible to establish cadastral boundaries with an accuracy of up to 3 cm.

Obtaining an orthophotomap based on the downloaded digital images goes through two stages: pre-processing and post-processing. The first stage is the correction and georeferencing with the transformation in order to transfer the data into a unified coordinate system (Figure 3).

Fig. 3. Fragment of the Orthophotomap.

The second stage is to obtain the orthophotomap using the PHOTOMOD Lite 7.2 program. As a result of this process, we obtained an orthophtomap with a spatial resolution of 10 cm/pixel for the entire area of the Karakul district in GeoTiff format. Due to the difficulty of handling the obtained result (the file was very large) and for optimal use in terms of the loading time of the orthophotomap for processing in GIS, built pyramids, which are a reduced-resolution version of the data at different scales. The accuracy of the obtained orthophotomap was evaluated by comparing the coordinates of some details determined in the field using GNSS technology (corner fences, channel holes, road markings, etc.). Obtaining such centimeter-level accuracy is an indisputable argument when using UAV images together with aerial and space images to collect geospatial data for the preparation of orthophotomaps, which are used in turn as a basis for obtaining the cadastral plan.

The implementation of the cadastral map in digital format according to the proposed working methodology is the operation of vectorizing the details identified on the orthophotomap (fences, structures, roads, razors, etc.) with the subsequent assignment of the descriptive data accompanying them (categories of use, destinations of construction, etc., see (Figure 4). By comparing the result of vectorization with the descriptive data collected from the field and from the supporting documents relating to the building, the digital cadastral map can be generated in different formats (Figure 5). And also, by confronting different data sets, one can express an objective point of view on the quality of previously obtained results.

Fig.4. Vectorization process of the Orthophotomap.

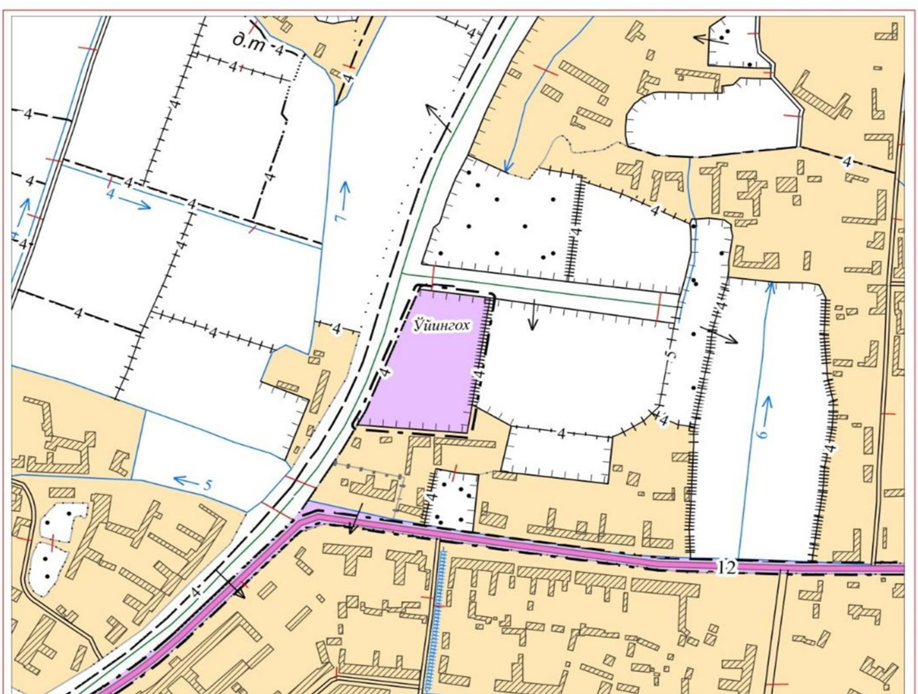

Fig. 5. Fragment of the Cadastral map.

4 Discussion

In this study based on orthophotomaps, a digital map of the entire agricultural land of Karakul district covering the administrative limits of territorial units and those of the physical blocks necessary for agriculture land owners was compiled, aiming at identification and registering the land plots.

One of the main components of spatial information systems is the image layer, which includes satellite images, and aerial photographs obtained using satellites, airplanes, and UAVs [4, 5, 6]. According to the results of the research, it was revealed that aerial photographs are the faster and more reliable source for establishing image basis than satellite images [7]. In addition, the cost of their production is lower than satellite data and aerial photography provides more accurate, up-to-date, and cloudless information [8, 9, 6].

On the basis of orthophotomaps and digital maps, work was carried out to update the calculation sheets for the contours of land types that are directly related to land users, as well as the inventory of land plots. In addition, these data were widely used as an important source for updating the database of the “Geoportal” open system, which is designed to maintain state land cadastral reporting in electronic form, as well as to place and agricultural crops.

Orthophotopmaps are an indispensable source for maintaining the land cadastre. One of the main advantages of using them is the ability to obtain more detailed data with high resolution. When using orthophotomaps, fieldwork can be reduced by up to 80%, and the time and cost of updating existing maps have been reduced by 60% due to the revision of details, land categories, and the introduction of modified data into orthophotomaps in the prescribed manner, furthermore, the quality of cartographic materials has been increased by 30%.

For a consistent continuation of this type of work, we consider it necessary to carry out research in the following areas [10,11]:

- scientific substantiation of the application and significance of modern methods and technologies in the creation of an orthophotomap of the cadastral system;
- further improvement through the creation of a transparent and efficient land acquisition system;
- ensuring the correct accounting of lands and continuously updating land cadastre data;
- performing a large-scale aerial survey of all areas in order to form a geospatial database;
- ensuring the reliability and completeness of the data of the state cadastre;
- development of orthophotomaps and monitoring of natural resources using data from aerospace and unmanned aerial vehicles.

5 Conclusions

Obtaining and using orthophotopmaps as a basis for cadastral maps involves some stages of fieldwork, as well as performing cameral work that requires specialized equipment and programs.

Using orthophotomaps for renovation can be a useful way due to their accuracy, applicability, reliability, and cost. Therefore, studies on the way to modernize the “fast cadastre” or “mobile cadastre” are relevant support. Orthophotomaps will save time and cost for field surveying and can be produced for cadastral applications, especially to update and maintain cadastral GIS databases, as reliable cadastral data, serving as the basis of the land management policies and sustainable development.

Digital cadastral maps, as the end products of such a methodology, performed on large scale with increasing accuracy, can provide both a metric product and the possibility of use in various applications. Moreover, this technology allows quick and efficient control of the status of a certain area and records the changes that have taken place in order to continuously update the cadastral maps.

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