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Prospects For The Development And Significance Of Remote Sensing Methods In Maintaining State Cadastres

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Abstract: This article examines key trends and development prospects of remote sensing technologies in maintaining state cadastres. The work highlights the global and national status of the field and discusses the historical and economic foundations underpinning these developments.

Keywords: Cadastre, remote sensing, space research, development prospects, global trends, aerospace images, maps, GIS, topographic bases, cartographic basis.

Introduction

Efficient and rational use of agricultural lands requires accurate and reliable information on their current condition, quality, and quantitative characteristics. From this perspective, the creation of precise, detailed, and regularly updated digital maps and models based on geospatial technologies is of great importance in maintaining state cadastres. In this regard, developing remote sensing methods and improving the quality of up-to-date cartographic data in state cadastres remains a priority.

Research worldwide emphasizes acquiring, processing, and analyzing remote sensing data, applying geographic information systems (GIS), modeling, and producing digital maps and models. High-resolution satellite imagery, photogrammetric processing, digital elevation models, orthophoto maps, and GIS-based analyses play a critical role in improving the technological basis of cadastre management.

Significant reforms have been implemented in Uzbekistan to enhance the creation and maintenance of state cadastres. The Presidential Decree on the "Uzbekistan–2030 Strategy" outlines major directions for establishing the National Spatial Data Infrastructure. The strategy prioritizes regulating, developing, and improving the use of spatial data within government agencies. Advanced geospatial technologies—especially remote sensing and GIS—are becoming essential in creating large-scale digital maps and improving cadastral processes.

Furthermore, in accordance with the Presidential Decree PF-16 (January 30, 2025), technical documentation for the project "Creation of the National Spatial Data Infrastructure" will be developed in 2025. This study supports the tasks defined in the Law of the Republic of Uzbekistan "On Spatial Data" (2021) and related regulations.

Analysis Of The Current State Of The Problem

The state cadastre system, a fundamental element of the market economy, aligns with the principles and development trajectory of Uzbekistan. A total of 20 state cadastres are maintained and integrated into the Unified State Cadastre System. The goal is to create an automated cadastral information system for the entire country.

In recent years, remote sensing data have been widely used in maintaining and updating state cadastres. Remote sensing now plays an essential role in geodesy, cartography, and cadastre. According to the open data of the Cadastral Agency, 61,513 square meters have been covered by aerial imagery, and orthophoto maps have been produced for 26,000 square meters.

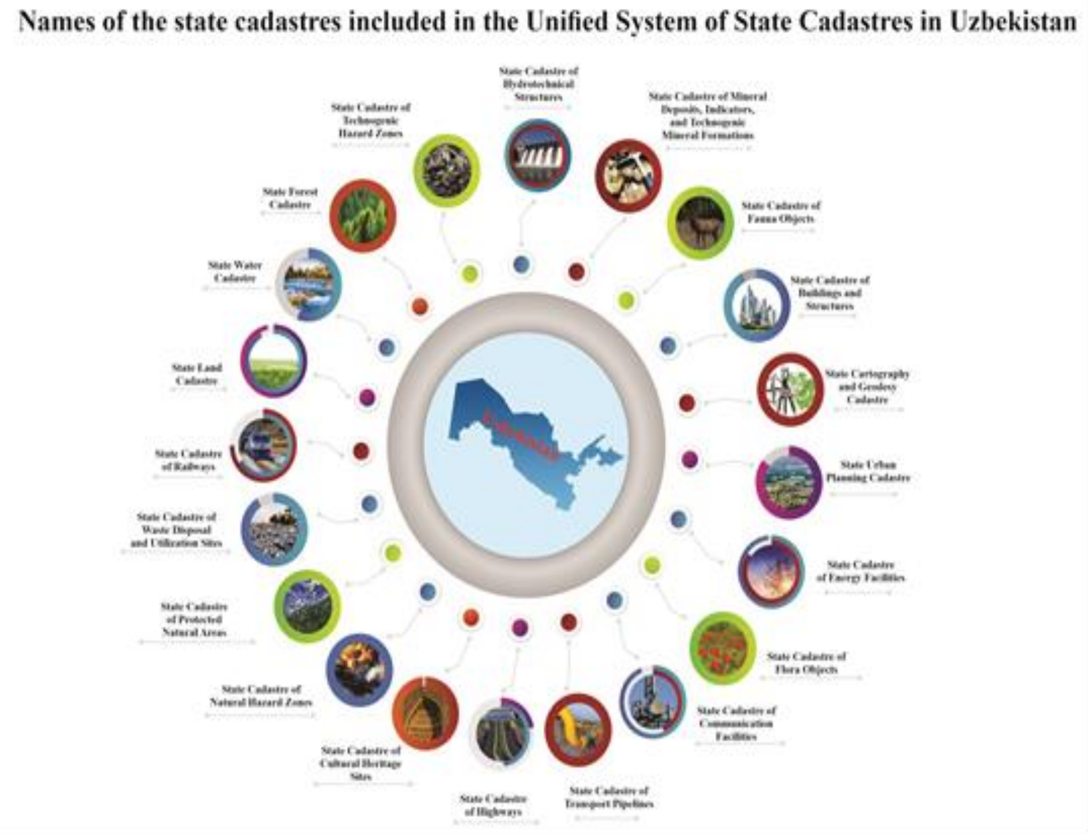

Fig. 1. Names of the state cadastres result of the survey.

Methods

The research uses field measurements, aerial and space imagery, geodetic and photogrammetric methods, statistical analysis, GIS tools, rational function models, geospatial analysis, and object-based image analysis (GEOBIA). The findings highlight the need for further scientific research to improve processes such as analysing high-resolution satellite imagery, performing photogrammetric correction, orthotransformation using various DEMs, interpreting cadastral objects, producing digital cadastral maps at scales 1: 10 000 and 1:25 000, and assessing accuracy.

The first stage of preparing state cadastre maps involves identifying the types of materials used in map creation, the dates on which the work was carried out, and the results of aerial photographs and field surveys.

Today, along with traditional cartographic materials, aerospace imagery is also used as a primary source for compiling and updating cadastral maps. The aerospace method of creating and updating digital electronic cadastre maps includes map revision, detection of existing changes, and automation of photogrammetric processes. Foreign software is widely utilized in processing the optical decoding features of acquired or collected images. Analyses show that organizations in the republic predominantly use PHOTOMOD, MapInfo, and Panorama GIS software for processing optical decoding signals [5].

These software packages operate based on satellite and aerial imagery available in the Google system, as well as images obtained by satellites such as Landsat 7 and Ikonos in the red, green, blue, and near-infrared spectral ranges. It has been determined that the Panorama GIS software provides the highest efficiency in creating cadastral maps. Before decoding satellite images, the coordinate data of the area are analyzed, systematized, and evaluated.

Additionally, experts collect satellite data according to the purpose and objectives of the study. Particular attention is paid to the scale, spectral ranges, season, and time at which remotely sensed materials were acquired.

Prior to decoding the images, they are enlarged multiple times, and the objects depicted in the images are compared with geographic and topographic maps. If significant changes are found in the area's features, the images are reprocessed using special software tools.

Some scientific sources qualitatively describe discrepancies between remote sensing materials and geographic or topographic bases using various terms that are rarely applied in current practice.

At the preparatory stage of decoding, a photodiagram of the study area is created. For this purpose, images are resized, enhanced in graphic software, and saved in JPG format. Then, depending on the scale of the topographic base, classifiers are selected in Panorama GIS, remote sensing data are transformed by linking them to the topographic trapezoid, and an orthophotoplan of the area is generated.

In the process of updating cadastral maps, image decoding is considered the most complex stage. In this process, quantitative and qualitative indicators of changes that must be included in the map are evaluated. The most effective method for assessing changes is the use of remote sensing data. By analyzing the volumetric (3D) representation of stereophotogrammetric images, changes in the area are identified and classified according to the newly developed evaluation scale.

Thus, remotely sensed images are integrated based on the area nomenclature and the required scale orthophotoplan. New objects identified from orthophotoplans and stereo pairs are added to cadastral maps according to their degree of change, and information for each object is stored in separate layers.

Results And Discussions

Currently, some scientific and practical work is being carried out on the use of GIS technologies and remote sensing data in maintaining state cadastres, and on the basis of which large-scale digital maps are created. In particular, as a result of the interpretation of aerospace images in field and camera conditions, orthophotos and digital contour maps of land cadastral data at scales of 1:10,000 and 1:25,000 are being created, depending on the purpose of use. At the same time, it should be noted that the technology for creating these orthophotos and digital maps is based on instructions or manuals intended for traditional methods. The history and stages of technological development of remote sensing of the earth were analyzed (Table 1). The results of the analysis showed that not only high-resolution aerial photographs, but also space images can be used to create large-scale cadastral maps. As Doctor of Philosophy in Geographical Sciences G. Yakubov said, in order to ensure the necessary accuracy in drawing up large-scale plans and maps, it is advisable to use space images with high spatial resolution (1-10 m) and very high (<1 m) for drawing up agricultural maps [7]. For drawing up cadastral maps from these space images with high spatial resolution (1-10 m) and very high (<1 m), the spectral characteristics of the images are also important.

In this regard, in particular, small satellite constellations - hyperspectral imaging - artificial intelligence (AI) and machine learning / data fusion - cloud-native data distribution systems for real-time or rapid monitoring - the use of multisensor and multimodal data integration methods allows for reliable interpretation of cadastral objects

Table 1. History and technological development of remote sensing of the Earth.

Development Periods	Main Events / Technologies
Late 19th century – early 20th century	Photographing the Earth's surface from a balloon, then from an airplane by aerial photography – early forms of the RS concept..
1960s Remote	sensing began to operate on a global scale through the first civil Earth observation satellites..
1970–1980s Kona and new sensors;	multispectral scanners, thermal and infrared sensors, as well as radar technologies expanded..
Since the 1990s,	increasingly complex sensors with a wide range of capabilities, high spatial resolution, multispectral and spectroscopic sensors, radar (e.g. SAR) and other active/passive sensors have been developed..
Recent 2020s	trends in small satellite constellations – hyperspectral imaging – and machine learning/data fusion – cloud native data distribution systems for real-time or rapid monitoring – multisensory and multimodal data integration methods In the future, artificial intelligence (AI) has great potential for simultaneous analysis of Earth remote sensing data.
In the future	Artificial intelligence (AI) has great potential for simultaneous analysis of remote sensing data.

The prospects for the development of remote sensing methods of the Earth in the table were studied. We see that these main events and technologies can be performed three times more accurately and in a shorter time in the coming years.

Based on the above methods, it is possible to use not only space images, but also other geospatial data as initial data for analysis in the GEOBIA method, and analyze them together. In the research work, based on a complex analysis of a high-resolution space image of the site and a digital model of the surface of the site, the main agricultural objects on the site were automatically interpreted, and a map of land use and land types was created.

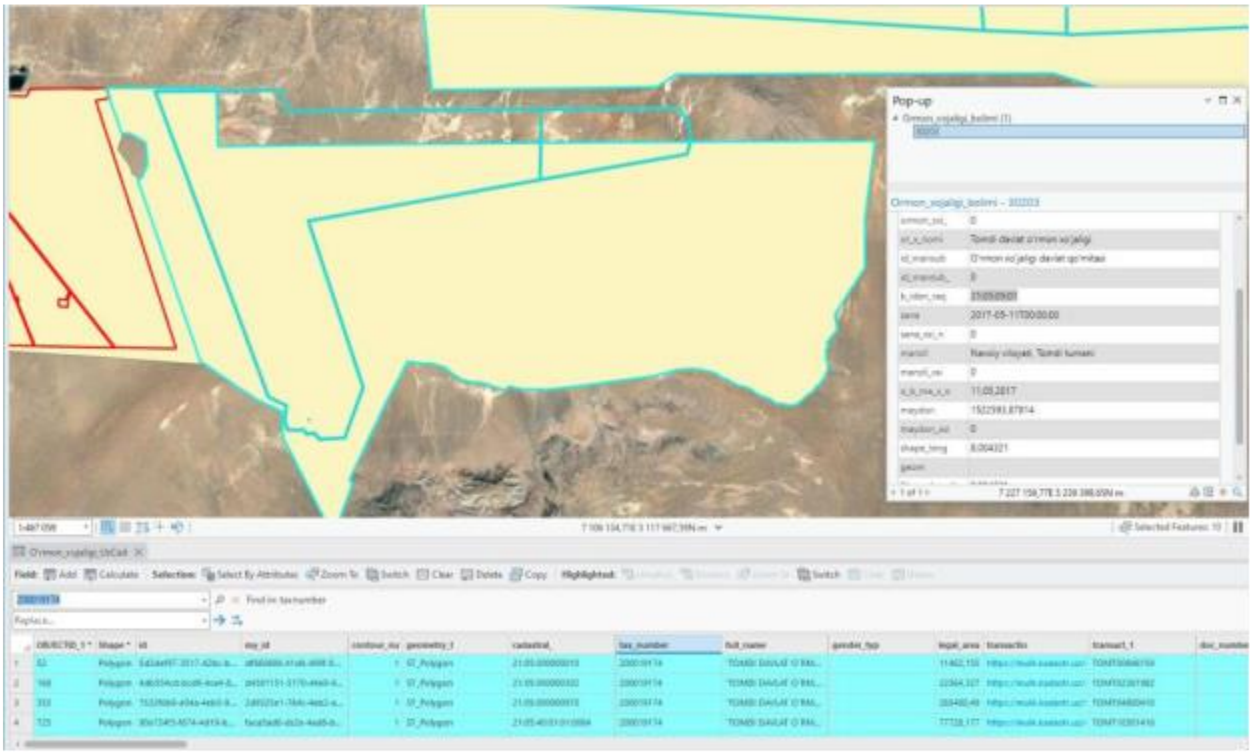

Fig. 2. Names state Land cadastres result of the survey.

Conclusion

The article made it possible to develop the following conclusions, proposals and recommendations on the prospects for the development and importance of remote sensing methods in maintaining state cadastres:

In order to fully provide the state cadastre with up-to-date cartographic bases, introduce a system of continuous updating of cartographic bases and provide ministries and departments with unified cartographic bases;

Organize the provision of spatial data together with metadata. In this regard, conduct seminars, trainings on the creation of metadata and their formation in accordance with current standards, and provide practical assistance;

Widely use of remote sensing materials in maintaining state cadastres.

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