

THE RELEVANCE OF DEVELOPING AN INNOVATIVE SYSTEM FOR REMOTE MONITORING AND MAPPING OF AGRICULTURAL LANDS

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Abstract:

This study emphasizes that creating maps of agricultural lands through remote sensing and innovative methods is not merely a visual tool, but also a powerful instrument for complex data analysis, forecasting, and decision-making, and may serve as a foundation for sustainable development. The study substantiates proposals for solving land-use planning problems through the preparation of various maps based on satellite imagery. It also examines the main objectives of agriculture, including restoring an effective agricultural land management system, reviving land-use planning as a core management function, establishing an efficient monitoring system for assessing land conditions and qualitative changes in the land fund, financially supporting agricultural producers, ensuring the rational use of designated land parcels, and increasing the investment attractiveness of agriculture.

Keywords: Land Cadastre, Land Resource Management, Land Fund, Rational Land Use, Agricultural Lands, Organization of Agricultural Land Use, Agricultural Producers

Introduction

Agriculture is one of the key sectors of the national economy of Uzbekistan. In this context, the creation and visualization of electronic, interactive, and web-based maps using modern geoinformation systems and technologies are of great importance for representing socio-economic processes taking place globally and across different regions [1].

In recent years, agricultural registration activities in Uzbekistan have been carried out with

reference to international recommendations and the experience of European countries such as Poland, Italy, Spain, and France, as well as CIS countries including Belarus, Azerbaijan, Kazakhstan, Kyrgyzstan, Armenia, and Moldova. During this process, a number of land-use problems were identified, including the following:

- Unauthorized occupation of land plots and inefficient land use;
- violations of legal requirements by authorized officials and land users;
- failure to comply with environmental requirements in land use;
- incomplete legal documentation related to land use;
- insufficient implementation of land management, land cadastre, and monitoring activities in the regions, as well as
- inaccuracies in land accounting data;
- declining soil fertility;
- different degrees of land degradation and deterioration of
- meliorative conditions, among others[2].

In Uzbekistan, considerable attention is being paid to targeted scientific research aimed at developing effective methods for data visualization and the preparation of electronic maps of agricultural lands using modern geoinformation systems, technologies, and remote sensing data[3]. These studies focus on data collection, storage, analysis, processing, evaluation, and the creation of geospatial databases. Therefore, improving the methodology for preparing electronic agricultural maps based on GIS and remote sensing data has become one of the urgent tasks of socio-economic cartography. The implementation of these tasks requires the development of theoretical and methodological foundations for agricultural mapping, as well as the creation of agro-geospatial databases related to agricultural sectors and infrastructure facilities, taking into account the socio-economic conditions necessary for agricultural development [4].



Figure 1. Real-time agricultural land monitoring technology

Algorithms can analyze satellite images, drone imagery, LiDAR data, and even data from social media sources in order to automatically generate and continuously update maps. This reduces human labor and improves the timeliness and relevance of cartographic products [5].

Materials and Methods

An analysis of the methods used to develop an innovative system for the remote monitoring and mapping of agricultural lands makes it possible to highlight the following. Agricultural lands can be monitored, mapped, and analyzed in real time using satellite imagery, drones, and IoT sensors. Such a system enables farmers, agricultural enterprises, and government agencies to manage land resources more efficiently [6].

Agricultural land monitoring and mapping are essential processes for the efficient use of land resources, increased productivity, environmental monitoring, and the formulation of agricultural policy. Traditional methods are often resource-intensive and time-consuming. For this reason, innovative systems for remote monitoring and mapping offer an effective solution. This paper examines the methods for developing such innovative systems [7].

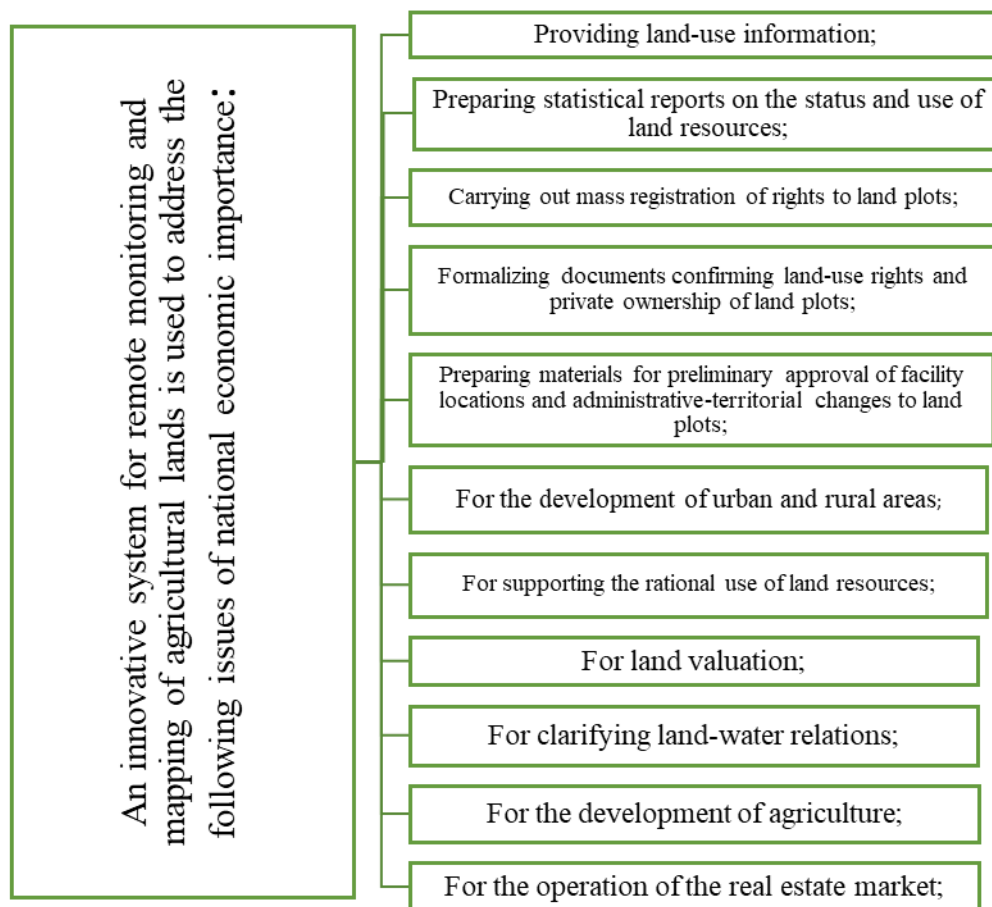


Figure 2. Key areas addressed by an innovative system for remote monitoring and mapping of agricultural lands

The development of an innovative system for the remote monitoring and mapping of agricultural lands is based on the integration of modern technologies, including satellites, drones, GIS, artificial intelligence, and the Internet of Things. These systems are important tools for increasing productivity, reducing costs, and promoting sustainable agriculture. The proper selection, design, and implementation of these technologies open new opportunities for the agricultural sector and can generate significant benefits for the national economy [8].

Table 1. Main system components and technologies

Component	Technology
Satellite data	Google Earth Engine
AI/ML	TensorFlow / PyTorch
Mapping	QGIS / Leaflet.js
Big data	Apache Spark

Results

The practical results of developing an innovative system for the remote monitoring and mapping of agricultural lands can be summarized in several important areas:

1. Efficient use of land resources:

Accurate information: Data obtained from satellite and drone imagery and GIS technologies

provide accurate information on crop conditions, soil moisture, the spread of pests, and plant diseases. This helps farmers determine how much water, fertilizer, or chemical treatment is needed in each field.

Optimized irrigation and fertilization: By determining irrigation and fertilization regimes for each area based on data, the waste of water and fertilizers can be reduced and their efficiency can be increased. This lowers farm costs and reduces negative environmental impacts.

Proper land use: Information on the productivity of each plot, soil type, and landscape characteristics makes it possible to select the most suitable crops and allocate them properly. This increases yields and protects land from erosion and degradation[9].

2. Increasing productivity and economic efficiency:

Early detection and prevention: The early signs of plant diseases and pests can be detected quickly, allowing timely intervention and reducing damage to crops.

"Smart" agriculture: The analysis of data and the use of automated systems for managing operations, such as automatic irrigation and spraying, significantly increase productivity.

Saving material and labor resources: Targeted measures, such as spraying only affected areas, save both material and labor resources.

Market forecasting: The ability to estimate and forecast crop yields supports market planning and price forecasting.

3. Risk reduction and sustainability:

Assessment of natural disaster impacts: After natural disasters such as floods, droughts, or fog, the damage caused to agricultural lands can be assessed quickly and accurately. This helps organize compensation and recovery measures effectively.

Environmental protection: The targeted use of chemicals and water reduces the contamination of soil and water bodies and helps preserve biodiversity.

Adaptation to climate change: Monitoring and analyzing crop growth under different climatic conditions helps develop strategies for adapting to future climate change[10].

4. Improving governance and policy:

Government oversight and planning: Government agencies can accurately monitor the use of agricultural lands, assess their efficiency, and develop future development strategies[11].

Improvement of agricultural policy: Based on the data obtained, legislation and regulations in the agricultural sector can be improved, and subsidies and support programs can be targeted more effectively.

Food security: Increasing overall productivity and ensuring the stability of agricultural production strengthen national food security.

In summary, an innovative system for the remote monitoring and mapping of agricultural lands benefits not only farmers, but also plays an important role in modernizing the sector, developing the economy, protecting the environment, and ensuring food security. Such a system makes it possible to build a more sustainable and efficient agricultural sector for future generations.

In the strategically important agricultural sector, especially in the use of land resources, the implementation of economic and legal reforms is considered fundamental to carrying out reforms across all sectors of the national economy[12].

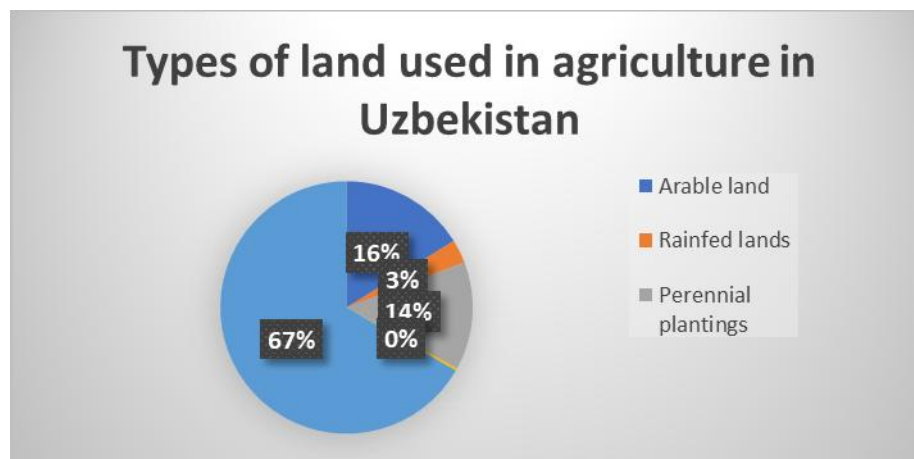


Figure 3. Distribution of agricultural land use in Uzbekistan. (Source: Kun.uz)<https://kun.uz/07458776>

Modern solutions for monitoring and mapping agricultural lands are largely based on advanced technologies and must ensure both high accuracy and ease of use for end users.

Discussion

No matter how advanced modern solutions have become, a number of pressing problems still remain in the monitoring and mapping of agricultural lands:

1. **Data integration and standardization:**

- It is difficult to integrate data from different sources, such as satellites, drones, sensors, and GIS platforms, and to convert them into mutually compatible formats. The lack of standardization complicates the analytical process.

2. **Limited access to advanced technologies and shortage of qualified specialists:**

- Modern technologies, including drones, GIS software, and AI platforms, are expensive and are not always affordable for small and medium-sized farms[13].
- In addition, there is a shortage of specialists with the knowledge and skills required to use these technologies effectively. Therefore, it is necessary to improve the digital literacy of agricultural professionals and farmers.

3. **Data quality and reliability:**

- Satellite imagery may be affected by atmospheric conditions such as clouds and dust.
- Sensor data may contain errors due to incorrect calibration or technical malfunctions[14].
- The accuracy of soil samples and laboratory analyses is also important.

4. **Storage, processing, and analysis of large data volumes:**

- Modern monitoring systems generate very large volumes of data (big data). Storing, rapidly processing, and extracting valuable insights from these data require powerful server infrastructure and complex software.

5. **Economic efficiency and ROI (Return on Investment):**

- For many farmers, it remains an important question how quickly investments in modern technologies will pay off and how effective they will be. The relationship between the cost of technology and the benefits obtained is crucial.

6. **Internet connectivity and infrastructure:**

- In many rural areas of Uzbekistan, the lack of stable and high-speed Internet access creates barriers to the implementation of digital technologies and the real-time transmission of data.

7. **Legal and regulatory framework:**

- A clear and practical legal framework for issues such as the use of drones, data privacy and ownership, and the exchange of remote sensing data has not yet been fully established.

8. **Climate change:**

- Unexpected weather events, droughts, or floods complicate monitoring and forecasting models and make decision-making more difficult[15].

Conclusion

The analytical and monographic studies conducted show that land is state property and a national asset, and its rational and efficient use plays an important role in raising the national economy to meet the requirements of modern market relations and in improving the social standard of living of the population. Therefore, comprehensive and rational land management is essential for ensuring a stable supply of food products to the population, raw materials to industry, and the rapid development of the economy as a whole in Uzbekistan [1,10].

By using GIS software in the preparation of agricultural maps, it is possible to organize territory proportionally in accordance with natural and socio-economic conditions, improve the productivity of existing irrigated lands, enhance the meliorative condition of regional soils, maintain land records, prepare plans and maps, and achieve results through the application of advanced scientific achievements. In this field, the preparation of thematic and agricultural maps plays an important role in carrying out land accounting tasks. They make it possible to represent events and phenomena spatially and temporally, compare the specific characteristics of land masses, and provide opportunities for scientific analysis [12].

In conclusion, remote monitoring and map generation technologies are developing continuously. Although some limitations and problems remain, technological advances, especially in artificial intelligence and big data analytics, are enabling this field to be applied more effectively and on a broader scale.

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