АУЫЛ ШАРУАШЫЛЫҚ ҒЫЛЫМДАР / СЕЛЬСКОХОЗЯЙСТВЕННЫЕ НАУКИ / AGRICULTURAL SCIENCES

DOI 10.54596/2958-0048-2025-4-132-137
UDK 631/635:004.9
IRSTI 68.85.85

APPLICATION OF GEOINFORMATION TECHNOLOGIES IN PRECISION AGRICULTURE

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Abstract

Currently, one of the tools for assessing land resources is digital technology, which enables comprehensive monitoring and analysis of land using satellite data of various spatial resolutions and materials obtained from unmanned aerial vehicles. The digital technology market offers various online platforms for managing agricultural activities, each with its own set of functionalities.

Keywords: Digital technologies, land resources, remote sensing of the Earth, soil, genoinformation technologies.

ИСПОЛЬЗОВАНИЕ ГЕОИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ В ТОЧНОМ ЗЕМЛЕДЕЛИИ

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Аннотация

В настоящее время одними из инструментариев для оценки земельных ресурсов являются цифровые технологии, позволяющие проводит комплексный мониторинг и анализ земельных ресурсов с использованием спутниковых данных различного пространственного разрешения и материалы с беспилотных летательных аппаратов. На рынке цифровых технологий присутствуют различные интернет платформы для ведения хозяйственной деятельности с различным функционалом.

Ключевые слова: Цифровые технологии, земельные ресурсы, дистанционное зондирование земли**,** почва, геноинформационные технологии.

ДӘЛ ЕГІНШІЛІКТЕ ГЕОАҚПАРАТТЫҚ ТЕХНОЛОГИЯЛАРДЫ ПАЙДАЛАНУ

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Аңдатпа

Қазіргі уақытта жер ресурстарын бағалаудың құралдарының бірі – спутниктік түрлі кеңістіктік айырымдағы деректер мен ұшқышсыз ұшу аппараттарынан алынған материалдарды пайдалану арқылы жер ресурстарына кешенді мониторинг жүргізуге және талдау жасауға мүмкіндік беретін цифрлық технологиялар болып табылады. Цифрлық технологиялар нарығында әртүрлі функцияларға ие шаруашылық қызметті жүргізуге арналған интернет-платформалар кеңінен ұсынылған.

Кілт сөздер: цифрлық технологиялар, жер ресурстары, жерді қашықтықтан зондтау, топырақ, геноинформациялық технологиялар.

Introduction

The lack of accurate maps and aerial support, an underdeveloped network of operational and meteorological monitoring stations for ground stations, and many other factors complicate the control over agricultural lands. All these factors, as well as the absence of objective data necessary for determining the condition of land and forecasting future situations, negatively affect agricultural production, its optimization, the profitable use of land, and the minimization of incurred costs. Constant changes in the boundaries of sown areas, changing soil characteristics, various natural processes, and some other factors make it difficult to obtain accurate and objective data, which are essential for determining the condition of land and forecasting future situations. Remote sensing of the Earth (RSE) is actively used to solve problems of comprehensive and specialized management of agricultural territories [1].

With the help of RSE, monitoring of agricultural land is conducted over large areas, making it possible to simultaneously analyze territories of districts, regions, or even entire countries. Another feature of using RSE in agriculture is the ability to identify and predict such adverse phenomena as soil salinization, wind and water erosion, and soil trampling by animals, all of which play a significant role in planning agricultural activities [4].

Remote sensing is a method of obtaining information about an object or phenomenon without direct physical contact with that object. Multispectral platforms, such as Landsat, have been actively used since the 70s. Today, they are actively used in agriculture to determine land use boundaries, land use regimes, etc. Furthermore, they are used to create thematic maps by obtaining images in several wavelengths of the electromagnetic spectrum (multispectral) and are typically used on Earth observation satellites. Spectral imaging produces images in which each pixel contains full spectral information, displaying narrow spectral ranges within a continuous spectrum. Spectral imaging instruments are used to solve various tasks, including applications in mineralogy, biology, and environmental parameter measurements [1, 2, 7].

Materials and Methods

When applying RSE methods, there are a number of features that must be considered. Typically, the best time to obtain data by remote sensing methods is the summer (specifically, these months have the highest sun angle above the horizon and the longest day length).

The main advantages of RSE data for solving agricultural tasks are: operational efficiency. Current satellite images can be obtained within 24 hours after placing an order for imaging;

- objectivity. Information obtained from satellite images is a priori reliable and reflects the actual picture of the state of agricultural lands and vegetation;
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- solving a wide range of applied agricultural problem.

Detecting changes in land surface condition is necessary for updating vegetation cover maps and rationalizing the use of natural resources. Changes are typically detected by co paring several images containing multiple levels of data, as well as, in some cases, by comparing old maps and updated remote sensing images:

- seasonal changes: Agricultural land and deciduous forests change seasonally;
- annual changes: Changes in land surface or land use territory, for example, areas of deforestation or overgrowth of agricultural land with woody-shrub vegetation, salinization, and waterlogging of arable land.

Unmanned aerial vehicles (UAVs) - drones and quadcopters - seem promising for digital agriculture and remote sensing purposes. These devices fly under the clouds, meaning the accuracy of their measurements is less dependent on weather. They combine measurement quality and data acquisition repeatability while being quite affordable. Another significant advantage of drones is their ability to account for the sun's position and changes in solar radiation intensity that affect measurement accuracy. Moreover, their operation is fully automated.

In light of the above, studying the technology of using multi-temporal RSE data to identify and predict processes of changing conditions of agricultural lands in the context of various natural zones of the Omsk region is relevant.

To achieve the fastest and most accurate solutions for controlling and monitoring the state of agricultural lands, modern agricultural enterprises use IT tools, including geographic information systems for information processing.

Modern hardware and instrumental aids for agriculturists include: satellite images, weather data, aerial photography, GPS and GIS technology data, field measurement (operating principle, equipment, application, cost).

Research Results

Based on RSE data, it is possible to obtain vegetation index maps - calculations based on the spectral reflectivity values of various surface objects (soil, biomass and the chlorophyll it contains, water bodies, etc.)

The most popular vegetation indices among agriculturists are:

- -NDVI (Normalized Difference Vegetation Index) - reflects the amount of biomass, the level of plant cover development. Infrared range imaging is used. Ranges from 0 to 1;
- -VCI (Vegetation Condition Index) - an index of vegetation conditions, derived from NDVI. Reflects the state of vegetation on a selected date relative to the long-term average;
- -Other indices - EVI, GNDVI, CIG, LAI, FPAR.

Along with crop vegetation indices, the modern agronomist uses indices of moisture content in leaves (NDMI), soil water (SWI), surface soil moisture (SSM), and others.

Research results and discussion

The Normalized Difference Moisture Index (NDMI) is sensitive to the level of moisture in vegetation (Figure 1). It is used to track droughts and also indicates the level of combustible materials in fire hazard zones. It uses NIR and SWIR channels to create a coefficient designed to mitigate illumination and atmospheric effects (Formula 1). Purpose: assessment of the heterogeneity of the degree of moisture in vegetation and soils.

$$NDMI = (NIR - SWIR) / (NIR + SWIR) \quad (1)$$

where: NIR - intensity of light reflection in the near-infrared channel;

SWIR - intensity of light reflection in the short-wave infrared channel.

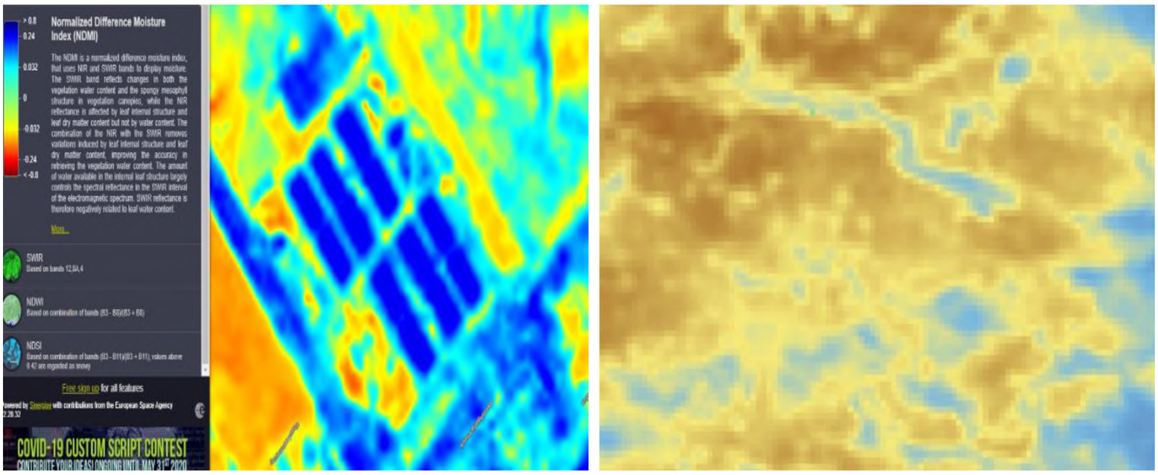

Figure 1. Example of NDMI and NDVI index display

The Soil Water Index (SWI) quantifies the moisture condition at various depths in the soil. The measurement step is 12x12 km for global data; data is available daily and as 10-day averages. SWI is calculated based on a combination of surface soil moisture (SSM) observations from Sentinel-1 C-band SAR sensors and Metop ASCAT [1, 2, 6].

Modern professional software for GIS specialists used in the agro-industrial complex includes QGIS (a free and open-source geographic information system), ArcGIS (a suite of geoinformation software products by the American company ESRI), GIS Panorama AGRO and other products by KB Panorama, AgroGIS, and others [3, 4].

To create an electronic map in geographic information systems, three methods of field measurement are used:

- Digital measurement based on aerial photographs (UAV);
- Remote digital measurement based on satellite images and machinery monitoring data;
- Driving around by car using high-precision GPS equipment.

Remote monitoring systems for agricultural land are information systems (IS) for PCs, mobile applications that contain all information about the farm (electronic field maps, machinery registers, crop rotation data, space and aerial imagery) (Figure 2). The most well-known and promising ones are: Soft.Farm Eye, Dnevnik Agronoma (Agronomist's Diary), Agrodozor, GPS Izmerenie Ploshchadi Poley (GPS Field Area Measurement), Agromon, Cropio, Navigator Poley (Field Navigator), Farm Manager, ExactFarming, TsPS: Agroupravlenie (CPS: Agro Management), Geoanalitika Agro, OneSoil, Agrosignal, etc. [5].

Figure 2. Visualization of data from remote monitoring systems for agricultural land

Conclusion

Currently, there is rapid development of geoinformation systems; nano-satellites with great potential in various spheres of human activity, from agriculture to methods of analyzing climate warming and climatically active gases, are being launched into orbit. There is rapid development of unmanned aviation.

Thus, modern information processing technologies allow for the prompt and competent solution of tasks related to the control and monitoring of the state of agricultural lands. Modern agricultural enterprises have a wide choice of IT tools and technologies, including geoinformation systems, for remote control of agricultural land and remote expert assistance to agronomists. However, there is a lack of technologies and IT tools for processing retrospective and current information to identify and determine the intensity of degradation processes on agricultural lands, as well as to build predictive models of degradation development for making optimal decisions regarding the use regime of these lands, the feasibility of putting them into circulation if they are not used for their intended purpose, and technological operations for carrying out reclamation measures on them.

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