Real-time monitoring of agricultural land using GIS technology

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Abstract. The scientific article presents the results of the real-time monitoring of agricultural lands with the use of GIS-technologies. The aim of the research was to assess the efficiency of agricultural land use in the Russko-Kameshkirsky village council on the basis of remote sensing data with the use of GIS-technologies for effective resource management. The result of the conducted work is vectorization of land plots, obtaining actual cartographic material with specification of arable area in cultivation. The stages of overgrowing of arable land with tree and bush vegetation were determined, allowing to develop a plan of putting fallow lands into turnover.

1. Introduction

Rational use of agricultural land plays an important role in ensuring food security of the state. This natural resource provides the population with foodstuffs.

During the transition to a market economy, problems of a legal nature have arisen in the area of land use, requiring radical measures to resolve them.

These problems include, first and foremost, the acquisition of agricultural land without direct use and subsequent sale. Such land plots are often overgrown with grass and shrubbery and are not used for their intended purpose.

Another legitimate problem is the lack of interest on the part of agricultural producers in land plots with low soil quality. This category of land plots, for the most part, does not have clarified borders and is not registered in the state cadastr.

On lands, which are included into the agriculture, elements of crop cultivation technologies are violated, which is expressed in non-compliance with scientifically based crop rotations, application of large volume of chemical means of plant protection, and, as a result, deterioration of ecological situation.

The emergence of a large amount of fallow lands is a natural result of the imperfection of the mechanism of legal regulation of the use of these lands and insufficient state control over the efficiency of their use. The inventory of agricultural lands, which is necessary to clarify the availability and condition of agricultural lands, to identify unused and inefficiently used lands, to determine the qualitative characteristics of lands, has not been carried out recently [1, 2, 3, 4].

Under the existing conditions, it is most reasonable to apply modern methods of remote sensing and GIS-technologies, allowing to reveal the dynamics and features of agricultural land overgrowth, caused by zonal-climatic and technogenic-landscape characteristics of different territories. Currently, there is
no complete understanding of the specific influence of various factors on the processes of overgrowing of agricultural land and the mechanism for identifying and assessing the current state of unused agricultural land overgrown with shrubs and small forests. There are no mechanisms to identify options for alternative use of these lands, taking into account the degree of their degradation on the basis of environmental and economic justification of their economic use [2, 5, 6, 7, 8].

The object of the research was agricultural land of the Russko-Kameshkirsky village council of the Kameshkirsky District.

The subject of the research was the study of processes of degradation of agricultural land (arable land) due to the development of overgrowth processes of wood and shrub vegetation on the territory of Russko-Kameshkirsky village council, identified through an analysis and assessment of spatial data using GIS-technology.

The aim of the research was to assess the effectiveness of agricultural land use in Russko-Kameshkirsky village council on the basis of remote sensing data with the application of GIS-technologies for effective resource management.

2. Materials and methods

The village and district centre of Russky Kameshkir is located 110 km south-east of Penza, 40 km from the Chaadaevka railway station on the Penza-Kuznetsk line, on both banks of the Kameshkir river, the left tributary of the Kadada, in a lowland area formed by the river valley.

Of the total area of the village council (17839 ha), 67% are farmland, 5.5% - land for human settlements, 26.8% - forest land, 0.1% - water resources, 0.4% - industrial land.

The following research methods were used: statistical method, analysis, photogrammetric method. The study of agricultural land (arable land) overgrowing with herbaceous and tree and shrub vegetation was conducted by cameral method with the use of GIS-systems. As a result, the stages of agricultural land overgrowth were established.

3. Results

One of the fastest and most effective sources of obtaining semantic information on land plots is remote sensing data both within the atmosphere and from outer space.

The main advantages of aerial and space imagery are speed, relevance and objectivity of the information obtained. Modern satellite systems of remote sensing allow for high resolution imagery with specified periodicity during the whole vegetation period.

The scientific paper presents the mechanism of remote sensing data use for real-time monitoring of agricultural land (arable land) efficiency.

At the first stage of the work an orthophotographic plan of the territory of the village council was prepared. The archived space images of high (1-10 m) spatial resolution, uploaded through SAS Planet, were used. The space images were transformed in the CREDO TRANSFORM program using the catalogue of coordinates of absolute reference points. Such points can be coordinate grid crosses, ground control points, coordinated building corners, etc. If the coordinate system used is based on a map projection, the reference points are automatically recalculated and the image is transformed when the coordinate system is changed. At that, the program monitors distortions in the central part of the image and if they do not exceed half a pixel, affine transformation is performed, in other cases - piecewise linear transformation. In the GIS Panorama environment the vectorization of land parcels contours was done by visual interpretation (figure 1).

The latest information on the state of the land was obtained from the Sentinel hub EO Browse resource as of 16 June 2020. Sentinel Hub services currently support data sources including freely available and commercial satellites, a digital elevation model and the ability to provide your own data.

Fallow lands have a set of specific properties, which complicates their identification from satellite observation materials. Identification of fallow lands using satellite images is based on the analysis of spectral response and peculiarities of their textural characteristics. Image texture is the main interpretation feature. For land type interpretation it is reasonable to use multi-temporal satellite data or
spectral vegetation indices, combinations of images from different sensors, or different combinations of multi-zonal space imagery channels or their texture features. The uneven age of fallow lands can also be significantly reflected in the composition of the phytocenosis. The composition of vegetation and its projective cover may also vary considerably. Significant problems in identifying fallows are caused by traces of ploughing, making them look like ploughed areas. Fields being fallow lands are, in most cases, relatively small in size, which complicates the interpretation of vegetation cover even at high resolution of the images. The vegetation of fallow lands may have a spectral response very similar to the reflection spectrum of the vegetation of gullies, ravines and some types of cultivated fields and even garden plots [9].

Figure 1. The map of agricultural overgrowth stages.

The degradation processes of agricultural land overgrowth with herbaceous and woody shrub vegetation were investigated using the False color index desktop method. False color maps the near-infrared spectral bands B8 with the red and green bands B4 and B3 directly onto the sRGB components. It is most often used to assess plant density as plants reflect the near-infrared and green light while absorbing the red light. Because they reflect more near-infrared than green, a plant-covered Earth appears dark red. Denser plant growth has a darker red colour. Cities and open soil are grey or brown, and water is blue or black.

During visual interpretation, the stages of overgrowing of agricultural land (arable land) were distinguished:

- zero stage: no overgrowth processes. The land is used for its intended purpose;
- first stage: shrubs and small growth of tree species appear with projective cover of not more than 10 %. These are still commensurate with the herbaceous layer and compete for space.
• second stage: small groups of undergrowth of woody species and shrub thickets are formed. In most cases trees and shrubs do not yet compete with each other, as their density is low, up to 20%.
• third stage: the number of trees and shrubs increases, and a tree and shrub layer of varying heights begins to form. At this time, the density of trees and shrubs increases to such an extent that trees and shrubs compete actively with each other and light-loving species are suppressed.
• fourth stage: young closed forest with residual shrubs. The undergrowth begins to form, forest grass species appear, but meadow species can still be found in the herbaceous layer [2].

In the process of visual interpretation and updating of land information, a map of the stages of agricultural land overgrowth (arable land) was drawn up. The application of the calculation module in the GIS Panorama environment made it possible to update the areas of arable land in cultivation and fallow land. There are 6790 ha in the zero overgrowing stage, 404 ha in the first stage, 1434 ha in the second stage, 445 ha in the third stage and 231 ha in the fourth one. The information obtained through GIS-technologies can be used by the land resources control authorities and the administration of the municipality.

In order to reduce the area of unused agricultural land and increase the productivity of agricultural land, the Penza Region Ministry of Agriculture has developed a priority project "Putting unused agricultural land into turnover in the Penza Region". Within the framework of the project, it is planned to put 181,000 ha of unused agricultural land into agricultural turnover within a four-year period through consolidation and strengthening of management actions of all project participants.

Based on the assessment of the qualitative condition of agricultural lands (overgrowth with tree and shrub vegetation), natural-climatic conditions of the territory and technological indicators of the fields, a plan of economic use of fallow lands was made, including restoration of arable land on the area of 2283 ha (first, second and third stages of overgrowth). Land plots with the fourth stage of overgrowth (213 ha) are recommended for reforestation.

Such an approach allows for the most effective resolution of land management problems in relation to regional perspectives on land use and the current qualitative state of agricultural land.

4. Conclusion
In modern conditions of agricultural production in such municipal formations as village councils, there is a lack of up-to-date information on the land fund. The application of GIS technologies in land resources monitoring makes it possible to obtain relevant information at a certain periodicity, which is of great importance for efficient resource management. The calculations carried out show that not all arable land is used as intended. Determining the stages of overgrowth is necessary to develop plans for putting fallow land into use. The results of the study can be used to improve remote monitoring of agricultural land subjected to overgrowth processes by tree and shrub vegetation. The proposed methodology for assessing the economic use of agricultural lands makes it possible to identify areas for improving the efficiency of land use by agricultural enterprises. The obtained materials and recommendations are intended for various organizations for development of land management projects, organization of measures for rational use of agricultural lands.

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