GEOINFORMATICS IN GEOGRAPHY

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THE USE OF REMOTE SENSING OF THE EARTH IN THE ASSESSMENT OF SECONDARY SWAMPING OF DRAINED WESTERN SIBERIAN BOGS PROCESS

SUMMARY. The possibility of using remote sensing of the Earth data in the evaluation process of the secondary swamping of West Siberian drained bogs in terms of Tarmanskiy geosystem.

KEY WORDS. Remote sensing of the Earth, secondary bogging, normalized difference vegetation index, normalized difference water index.

Along with forest, swampy and marsh landscapes are essential components of the natural environment of Western Siberia and the sources of resources. In the conditions of industrial development, wetland landscapes undergo anthropogenic impacts related primarily to the operation of oil and gas, agriculture and forestry. Because of this, the areas of anthropogenically disturbed lands are growing. Negative processes and phenomena in such disturbed areas are identified not only in terrestrial studies, but in the analysis of remote sensing data. So, in geoenvironmental studies the technologies based on the interpretation of space images of different spatial and temporal resolution are being increasingly used [1], [2]. Remote sensing data provides reliability, efficiency and regularity of measuring the characteristics of the natural environment. They also form the basis for the organization of monitoring in remote and inaccessible (due to high quantity of bogs) areas of West Siberia.

One of the most acute problems of Land Reclamation in Western Siberia is secondary swamping of drained swamps, followed by degradation processes in ecosystems, the emergence of gley and accumulation of decomposed remains on the surface. Secondary swamping affects agronomic properties of the soil and reduces their productivity. According to the data, annually 20-30 thousand hectares become waterlogged additionally in the West Siberian Plain.

It is necessary to find out the causes of secondary swamping: whether there were some natural premises for it or the ill human actions caused the adverse situation.

Experimental part. The examples of secondary swamping of Western Siberia drained swamps are considered in terms of Tyumen suburban area within the reclamation system of Tarmanskiy forest-lake-marsh geosystems.

Tarmanskiy forest-lake-marsh geosystem is located on the border of northern steppe and Subtaiga on the second terrace of the Tura floodplain in the major orographic elements — Transural plateau. The ground-pressure type of water supply (15 to 87%) is predominant in Tarmanskiy geosystem [3]. The details of its natural characteristics are presented in a special study [4].

Since 1990 the return process of secondary irrigation of the area and secondary waterlogging of soil (according to the data of regime observations on water wells) on the territory of Tarmanskiy forest-lake-marsh geosystem began (Fig. 1) [5].

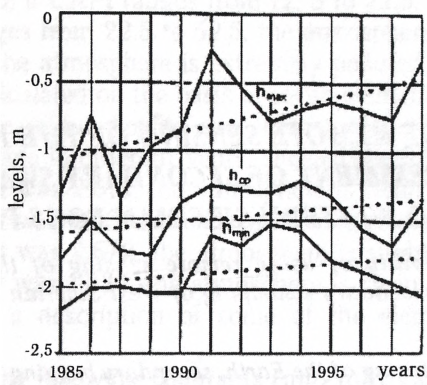

Fig. 1. The process of annual groundwater levels.
The object is "Reshetnikovo" wells. 15g

To conduct this study, the following materials of remote sensing have been widely used:

1. Satellite imagery of 1990-2011. Obtained from spacecraft series Landsat (scanners MSS, TM and ETM +) and QuickBird;

2. Aerial photographs of scale 1:10 000.

The work consisted of several stages:

1. Pre-processing of satellite images Landsat:

During the pre-processing of images, the operation called "The merger of several layers" (Layer Stacking) was performed. This operation was performed in the software package ENVI, where there is a tool for creation a file from georeferenced images on the same territory, but with a different resolution and tied in different projections. When using this tool, all the channels of the original image were collected in a single file, reduced to one resolution and one projection.

2. The conversion of images:

At the stage the conversion of images, a relative vegetation index and a differential moisture index were calculated.

NDVI (Normalized Difference Vegetation Index) — a normalized vegetation index — a simple quantitative measure of the number of photosynthetically active biomass. NDVI is one of the most common indexes to solve problems using quantitative estimates of vegetation.

The methods for calculating the vegetation indices (including index NDVI) are to allocate green vegetation with a simple arithmetic transformation. These methods are referred to fully automated methods in which user participation is limited to just one last step — the identification of the selected objects.

The index is calculated by the following formula:

$$NDVI = \frac{NIR-RED}{NIR+RED}, \qquad (1)$$

where: NIR — the reflection in the near infrared region of the spectrum;
RED — reflected in the red region of the spectrum.

According to this formula, the density of vegetation at a certain point of the image is equal to the difference between the intensities of the reflected light in the red and infrared range, divided by the sum of their intensities.

NDVI calculation is based on the two most stable (independent of other factors) sections of the spectral reflectance curve of vascular plants. There is a maximum amount of solar radiation absorption by chlorophyll of higher vascular plants in the red part of the spectrum (0.6-0.7 mm). The region of maximum reflection of cellular leaf structures is in the infrared region (0.7-1.0 mm). That is, the high photosynthetic activity (associated generally with dense vegetation) leads to less reflection in the red part of the spectrum and more in the infrared. The ratio of these indices to each other allows distinguishing and analyzing plant objects from other natural objects. The use of not a simple relationship, but a normalized difference between the minimum and the maximum reflection increases the accuracy of images, allows reducing such phenomena as differences in image brightness, clouds, haze, the absorption of radiation by the atmosphere.

NDWI (Normalized Difference Water Index) — a normalized differential moisture index — the indicator of the relative water content in plants.

NDVI was calculated by standard tools of software package vegetation ENVI analysis, and NDWI was calculated using the tool "Band Match according to the following formula:

$$NDWI = \frac{NIR-SWIR}{NIR+SWIR}, \qquad (2)$$

where: NIR — the reflection in the near infrared region of the spectrum;
SWIR — the reflection in the short-wave infrared.

To see more subtle color variations, both scenes were painted with a tool "ENV I Color Table" (color scale ENV I). The choice of expressive coloring for both indexes allowed distinguishing more minor differences in the intensity of the growing season (Fig. 2) and moisture content (Fig. 3).

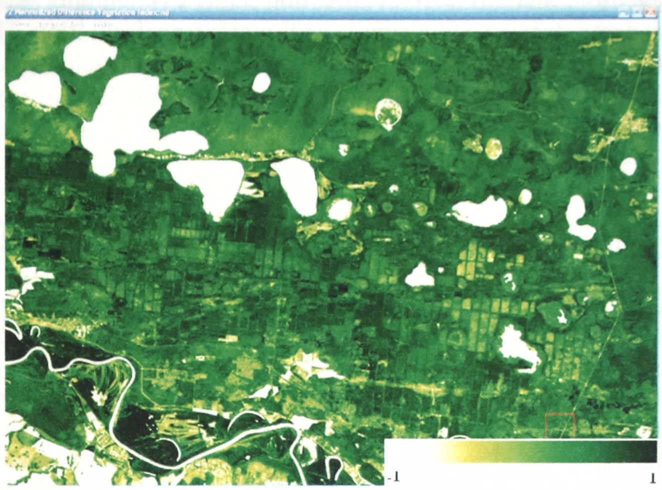

Fig. 2. The mask of a normalized relative vegetation index

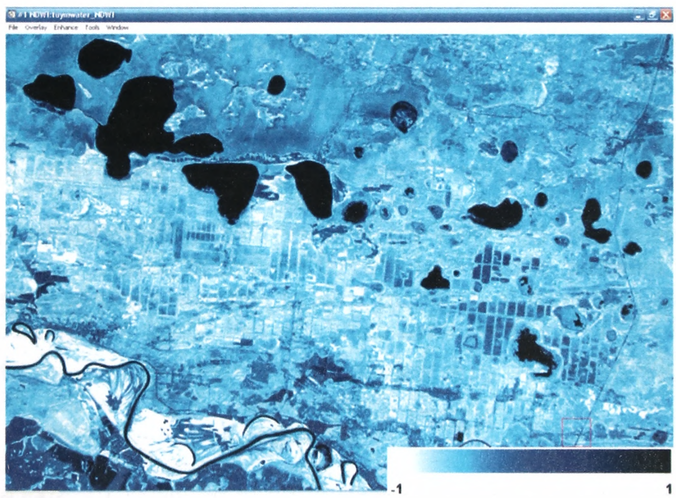

Fig. 3. The mask of a normalized differential moisture index

Lighter areas on the mask of a relative normalized vegetation index mean the least of its value (-0,5-0,025) and dark areas, respectively, the highest values (0-0.75). White areas mean vegetation free surface (water, concrete, etc.).

Lighter areas on the mask of a normalized differential moisture index is the least of its value (-1-0,3) and dark areas, respectively, the highest values (0.3-1).

3. The expert interpretation of secondary swamping reclamation system of Tarmanskoe lake-bog:

At this stage, the masks of indices NDVI and NDWI were visually assessed and analyzed, and then by the "digitization on raster substrate" in the software product MapInfo, a map of secondary swamping of Tarmanskiy geosystem reclamation system was created (Fig. 4).

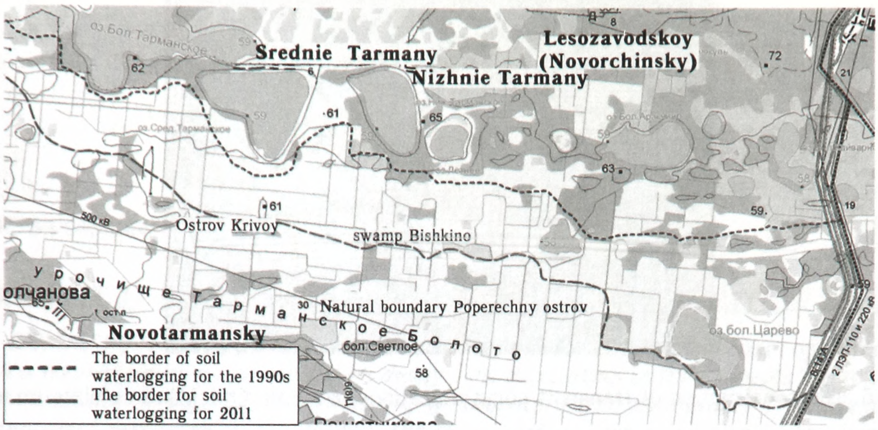

Fig. 4. A map fragment of secondary swamping reclamation system of Tarmanskiy geosystem 1:200 000

4. The analysis of aerial photographs (APS) and the images from spacecraft QuickBird:

At this stage, a visual interpretation of remote sensing data was carried out. It aimed to detect adverse events that can lead to a secondary water-logging in the study of reclamation system. The observed adverse events were subject to mapping.

Results and discussion. According to the analysis of aerial photographs and images from spacecraft QuickBird, a number of possible causes of secondary swamping of the study area was established:

1. The destruction and obliteration of drainage network channels.
2. Overlapping of drainage network channels by earthen dams and embankments (Fig. 5).
3. The construction of transport communications (probably with violations of the SNIP) (Fig. 6).

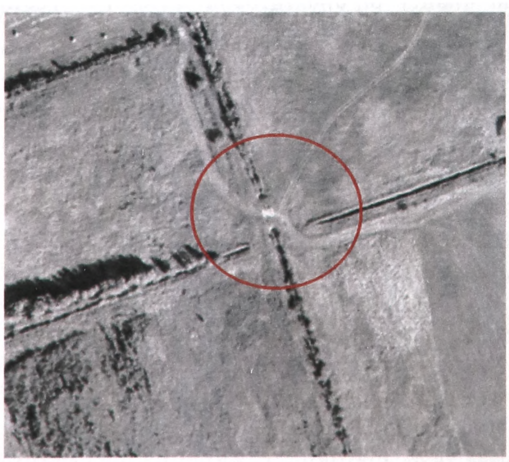

Fig. 5. Overlapping of drainage network channels by earthen dams APS

Fig. 6. The construction of transport communications based on QuickBird satellite imagery

By analyzing the images taken from spacecraft series Landsat, it was established that the area of secondary water logging in the reclamation system of Tarmanskiy forest-lake-marsh geosystems for this period increased by an average of 4.248 km^2 per year, and as of carrying out the study it was 84.96 km^2.

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