Analysis of the Accuracy of Determining the Vegetation Edges according to the Landsat Remote Sensing Data over the Territory of the Sverdlovsk Region

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***Abstract*—The work is devoted to the study of the most commonly used vegetation indices in relation to the territory of the Sverdlovsk region according to Landsat-7 images. For the image fragments, vegetation maps were constructed using various indices. The accuracy was evaluated of the vegetation map according to digital topographic maps based on the criteria of false alarm errors and missing errors, as well as the total number. The indices having the smallest errors are found. Recommendations on the use of indices of vegetative regions covered by coniferous and mixed forests are given.**

Keywords— remote sensing data, vegetation indices, Landsat-7, accuracy estimation

I. INTRODUCTION

Monitoring agricultural and forest land is one of the most important spheres for using Earth remote sensing data. Assessment of vegetation cover is usually carried out using vegetation indices, which can be used for regional mapping and analysis of various types of landscapes, studying the dynamics of plant communities. The results of the calculation of vegetation indices are maps of forest and agricultural land productivity, maps of landscape types, vegetation and natural zones, and it is also possible to use them to obtain numerical data for use in estimating and forecasting yields and productivity, biological diversity, and damage from various natural and man-made disasters, accidents, etc. One of the most popular satellites used to solve the indicated problems is the Landsat spacecraft system [1]. Despite the fact that there is a huge springboard for research in this sphere, most of them relate to the territories of the satellite owner, that is, accordingly, in the United States, numerous vegetation indices adapted in the first category for subtropical and tropical climatic zones.

The territory of the Russian Federation is located mainly in the subarctic and temperate climatic zones, naturally, the problem arises of analyzing vegetation indices as applied to the designated territory. The features of the territory of the Sverdlovsk region, which must be taken into account when monitoring plant cover, are: a relatively short growing season (up to 130 days per year) with an average duration of snow cover of 170 days per year with the accumulation of large masses of snow; continental climate; the location is mainly in the taiga zone (83% of the territory is covered by forest vegetation, 40% of which are pine forests). From the point of view of the terrain, approximately half of the region's territory is located on the eastern slope of the Ural Mountains (the Middle and partially the Northern Urals) with a predominance of wooded ridges and ridges, the other half - in the adjacent territories of the West Siberian Plain [2].

Thus, when analyzing vegetation, it must be taken into account that sown and meadow areas make up no more than 15% of the territory while most of the vegetation indices are adapted specifically for such types of vegetation. Accordingly, it is necessary to establish which of the existing vegetation indices are optimal specifically for the designated region.

II. OVERVIEW OF EXISTING VEGETATION INDICES

There are several commonly used vegetation indices. The calculation of most of them is based on spectral brightness coefficients for the two most stable regions of the spectral reflection curve of vascular plants - red and infrared bands. The most common of them is NDVI [3]. NDVI values range from -1 to 1. Along with the NDVI index under conditions when vegetation occupies less than 30% of the image, the RVI index [4] is often used, which range takes values $[0, \infty]$. There are also perpendicular vegetation indices (PVI, WDVI, DVI [5,6,7]), transformed ones (TVI [8]) and other [8], a list of indices used in the work, as well as formulas for their calculation, are given in the table 1.

TABLE I. THE MAIN VEGETATION INDICES USED IN THE VEGETATION ANALYSIS

Vegetation index	Formula	Vegetation index	Formula
NDVI	$\frac{(NIR - RED)}{(NIR + RED)}$	DVI	$NIR - RED$
RVI	$\frac{NIR}{RED}$	PVI	$\sin\alpha \cdot NIR - \cos\alpha \cdot RED$
IPVI	$\frac{NIR}{(NIR + RED)}$	WDVI	$NIR - \alpha \cdot RED$
TVI	$\sqrt{\frac{(NIR - RED)}{(NIR + RED)} + \frac{1}{2}}$	SAVI	$\frac{NIR - RED}{NIR + RED + L}(1 + L)$

Vegetation maps on the territory of the Sverdlovsk Region (with a total area of 4300 sq. km), located within the boundaries of the city of Nizhny Tagil and Gornouralsky city district, are based on the Landsat-7 system data. [9]. The terrain is low-mountainous, the predominant type of vegetation is coniferous and mixed forests. Date: July 15, 2016. The image fragment is shown in Fig. 1. Ranges for various vegetation indices were limited according to previously indicated publications [10,11,12].

Fig. 1. The image fragment obtained by Landsat-7 system (true colors).

To construct the vegetation indices according to table 1, two Landsat-7 channels were used: № 3 (wavelength is 0.63–0.68 μm) and № 4 (wavelength is 0.84–0.88 μm). The calculations were carried out using MATLAB 2018,b.

III. Results

To assess the accuracy of the obtained vegetation maps, digital topographic maps of scale 1: 200 000 were used, taking into account the fact that half of the territory is located on a hilly area, the average error in the contours of areal objects is equal to 30 m. In general, three types of errors were calculated: δ1 is the relative missing error (in relation to the standard) when according to the standard there should be vegetation, but there is nothing on the vegetation map, and δ2 is the relative false error when vegetation is present on the vegetation map, and on the standard it is absent, as well as the total error δ1 + δ2. The results are shown in table 2.

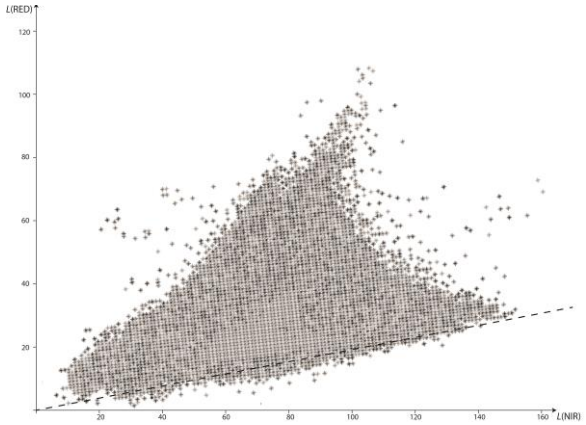

Fig. 2. Red and near-infrared scatter chart («the tasseled cap»). The line of soils is shown as dotted line

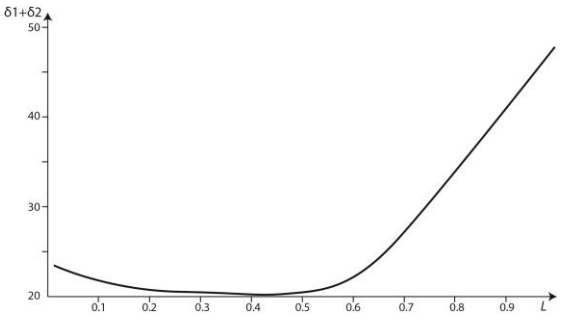

Fig. 3. Dependence of the total classification error on a parameter L for SAVI vegetation map.

It should be noted that for the PVI and WDVI indices when constructing vegetation maps, knowledge of the position of the line of soils was required, which was calculated according to the "tasseled cap" graph (Fig. 2). The angle of the line of soils is 9.7°. It should also be noted that for the SAVI vegetation index, according to the articles, there is uncertainty in the indication of the parameter L, therefore, the need arose to consider it. The results are presented in Fig. 3 and Fig.4. It was found that the right parameter value for the selected area should be equal to 0.43.

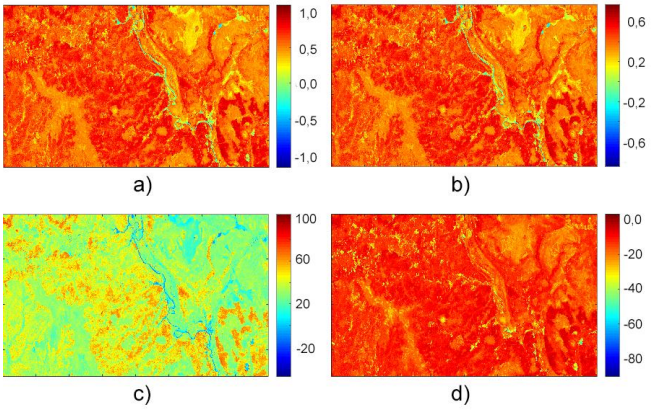

Fig. 4. Vegetation maps a) SAVI; b) NDVI; c) DVI; d) PVI.

IV. Conclusion

The most widely used vegetation indices were studied in relation to the territory of the Sverdlovsk region In the course of the work. It has been found that the most suitable index for the studied fragment of the territory of the Sverdlovsk region is IPVI the total classification error of 19,2 %. Vegetation maps based on indices NDVI (20,2 %), RVI (20.2 %) and SAVI (20,3 %) show slightly worse results. In general, the errors turned out to be quite large, which is due to the systematic deforestation and generally high dynamics of the terrain. In the future, it is planned to carry out a more detailed study of the range boundaries for the space systems of Landsat-7, Landsat-8 and Sentinel-2, corresponding to different types of vegetation, to identify the best vegetation indices in order to adapt them to the specifics of the Sverdlovsk region territory.

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