THE USE OF REMOTE SENSING IMAGES IN THE ANALYSIS OF LAND SURFACES

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Abstract: *Remote sensing is the technology by which the characteristics of the analyzed objects can be identified, measured and analyzed without direct contact, but from a distance. Remote sensing technology to identify objects and understand environmental conditions is the uniqueness of reflection and emission. Landsat 8 is an American Earth observation satellite launched on February 11, 2013. It is the eighth satellite in the Landsat program and the seventh to successfully reach orbit. This satellite system provides medium resolution images from 15 meters to 100 meters of the land surface and polar regions. It works in the visible spectrum, near infrared, short wave infrared and thermal infrared. In the present study, the Landsat 8 method was used to collect spectral data. These data help us understand the evolution of many natural processes, the monitoring of agricultural and forest land, can allow the longest continuous data recording of the Earth's surface seen from space. Landsat data allow the monitoring of climate change, which leads to the improvement of human health and biodiversity. Satellite images have a very important role in the analysis of the earth's surface and important sources of extraction of stored geographical information. The study area is located in the west of Romania and is made up of the following administrative-territorial units: Ohaha Lungă, Mănăștiur, Dumbrava, Făget, Margina, Curtea, Fîrdea and Tomești. Based on the spectral information, four normalized differentiation indices for land surface analysis, namely NDMI, NDBR, NDWI and SAVI, were calculated for each study area.*

Keywords*: satellite images, land surface, remote sensing, normalized indices of differentiation*

INTRODUCTION

Remote sensing is the technology by which the characteristics of the analyzed objects can be identified, measured and analyzed without direct contact, but from a distance. Remote sensing technology to identify objects and understand environmental conditions is the uniqueness of reflection and emission (ROUSE ET AL., 1973).

Remote sensing data correlated with information from the ground (soil, water, air) (HORABLAGA ET AL., 2013; NITA ET AL., 2018; NITA ET AL., 2018), can provide very important information, in real time, regarding the vegetal carpet. Remote sensing systems together with GNSS systems can provide data, information and maps to support the decision-making process regarding a certain studied area (HERBEI ET AL., 2015; ŞMULEAC ET AL., 2016; ȚĂRĂU ET AL., 2013; BERTICI ET AL., 2012).

Satellite images are very important in the analysis of the geographic space and are important sources for extracting stored geographic information (BADEA ET AL., 2015; BADEA AND BADEA, 2016; SALA ET AL., 2020).

Regardless of the nature of the applications, passive or active, remote sensing uses electromagnetic radiation to obtain images of bodies, from altitude, from an airplane, satellite, balloon, helicopter, because in this way the image can be used to obtain maps and plans, and the interpretation objects is optimal (POPESCU ET AL., 2019; ŞMULEAC ET AL. 2019).

There are 4 types of phenomena that are of interest in remote sensing, namely:

1. refraction (from one medium to another and with another angle);
2. total reflection (the angle of incidence = with the angle of reflection);
3. diffraction (reflection in several angles simultaneously);
4. absorption (total or of certain wavelengths).

According to the energy source, the sensors can be:

PASSIVE – which use the object's energy (mainly from the sun) such as: radiometers, photographic systems, scanners, spectrometers.

ACTIVE – which emit energy that is reflected by the target object and captured by the sensor such as: radars and lidar systems (laser-based).

Analyzing the parts of the electromagnetic spectrum separately, digital color images are made up of three primary colors: red, green and blue.

The multispectral digital image can be rendered visually by choosing three spectral bands and assigning one conventional color from the three fundamental colors (red, green and blue). Thus, a false composite color combination and a multitude of combinations are obtained.

MATERIAL AND METHODS

To create these maps (BREBU ET AL., 2012; BEGOV UNGUR ET AL., 2019; ȘMULEAC ET AL., 2017), combinations of spectral bands were used, and with the help of the ArcMap program (figure 1.), normalized indices of differentiation were calculated for the study area.

Figure 1. ArcMap program

The territorial administrative units in the study area are within the Timis county, Banat, Romania.

Timiș is a county located in the western part of Romania, in the center of the historical province of Banat. His residence is the city of Timișoara, the capital of the West region and the largest and most important city of the South-West development macroregion of Romania.

Geographically, it is the westernmost county of the country. It borders the counties of Arad, Caraș-Severin and Hunedoara, as well as the South Banat, Central Banat and North Banat districts of Serbia and the Csongrád-Csanád county of Hungary, with which they form state borders.

Timișoara (figure 2.) is the largest county in Romania, occupying 8,696.7 km², respectively 3.65% of the country's surface. It is intersected by the parallel of 46° lat. N, of the meridian of 21° long. It is also 22° long.

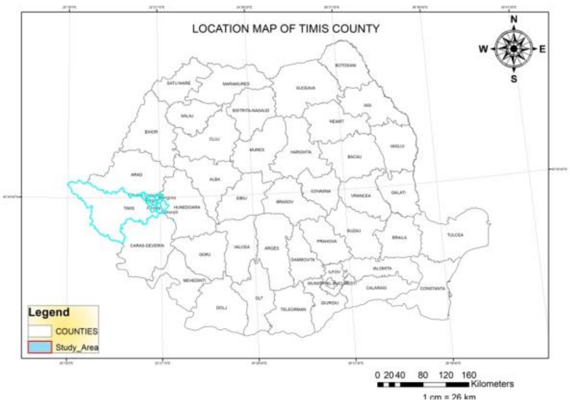

Figure 2. Timis county

For the study area, a mosaic of color images was used that were recorded in the visible or invisible parts of the electromagnetic spectrum to form a combination of false colors (figure 3.) and a combination of natural colors (figure 4.)

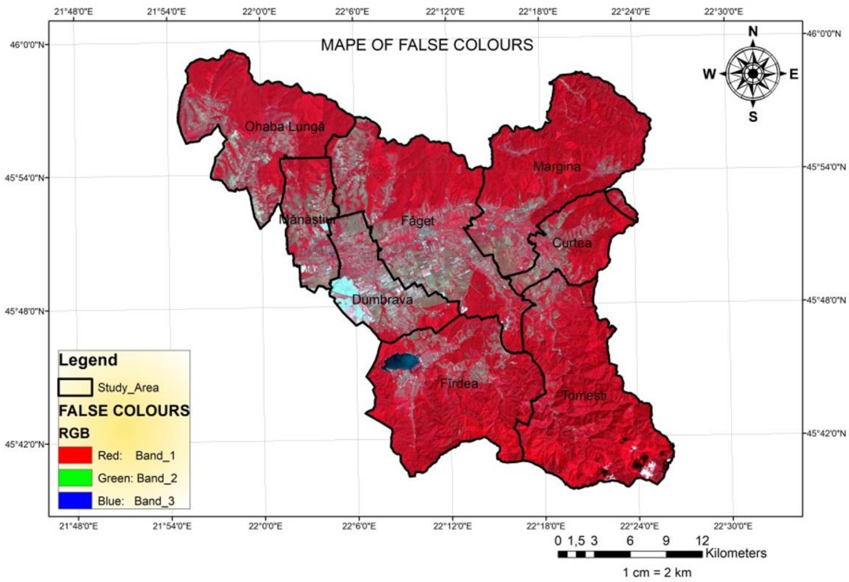

Figure 3. Combination Near Infrared-Red-Green

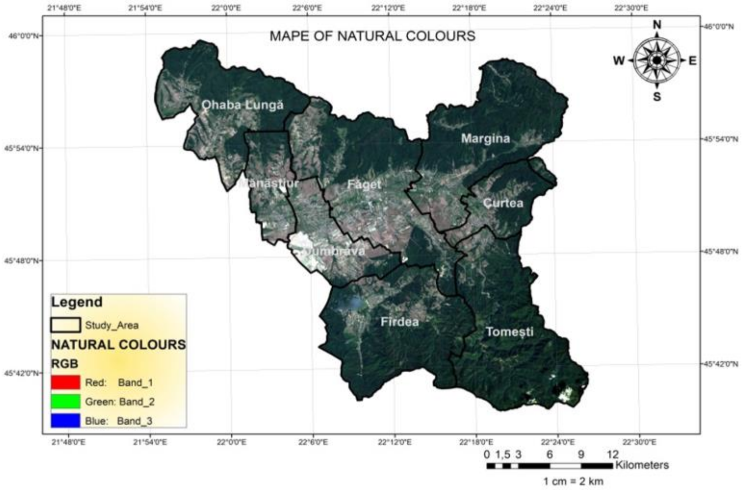

Figure 4. Combination of natural colors

- ***Landsat 8 satellite system***

Landsat 8 is an American Earth observation satellite launched on February 11, 2013. It is the eighth satellite in the Landsat program and the seventh to successfully reach orbit.

This satellite system provides medium resolution images from 15 meters to 100 meters of the land surface and polar regions. It works in the visible spectrum, near infrared, short wave infrared and thermal infrared.

Of its 11 bands (table 1), only those in the very shortest wavelengths (bands 1–4 and 8) sense visible light – all the others are in parts of the spectrum that we can't see. The true-color view from Landsat is less than half of what it sees.

Table 1.

The spectral bands of the Landsat 8 satellite

Band Number	µm	Resolution
1	0.433–0.453	30 m
2	0.450–0.515	30 m
3	0.525–0.600	30 m
4	0.630–0.680	30 m
5	0.845–0.885	30 m
6	1.560–1.660	30 m
7	2.100–2.300	30 m
8	0.500–0.680	15 m
9	1.360–1.390	30 m
10	10.6-11.2	100 m
11	11.5-12.5	100 m

RESULTS AND DISCUSSIONS

Based on the spectral information, four normalized differentiation indices were calculated for land surface analysis, respectively NDVI (figure 5), NDBR (figure 6), NDWI (figure 7) and SAVI (figure 8) (ROUSE ET AL., 1973); KEY AND BENSON, 1999; COCKE ET AL., 2005; ESCUIN ET AL., 2008; HUANG ET AL., 2013).

➢ *Normalized vegetation differentiation index NDVI*

The values of this differentiation index differ depending on the absorption of radiation by chlorophyll in the red spectral zone and its reflectance in the near infrared spectral zone. They are between -1 and +1, expressing the consistency of the green vegetation.

Light tones have values close to +1, which are represented by a high consistency of vegetation that is characteristic of dense deciduous forests.

Dark tones have values close to -1, and these values mean the land is devoid of vegetation, with fresh soil or rock.Intermediate tones have values close to 0 and are represented by grasslands.

The calculation formula (1) for the NDVI index is:

$$NDVI=\frac{NIR - R}{NIR + R}, \text{ where:} \qquad (1)$$

NDVI - normalized vegetation differentiation index
NIR - near infrared spectral band
R - red spectral band

In the study area that is represented in figure 5, we have values between -0.049816 and 0.853915 for the vegetation differentiation index, and the purchase date of the images is July 26, 2022.

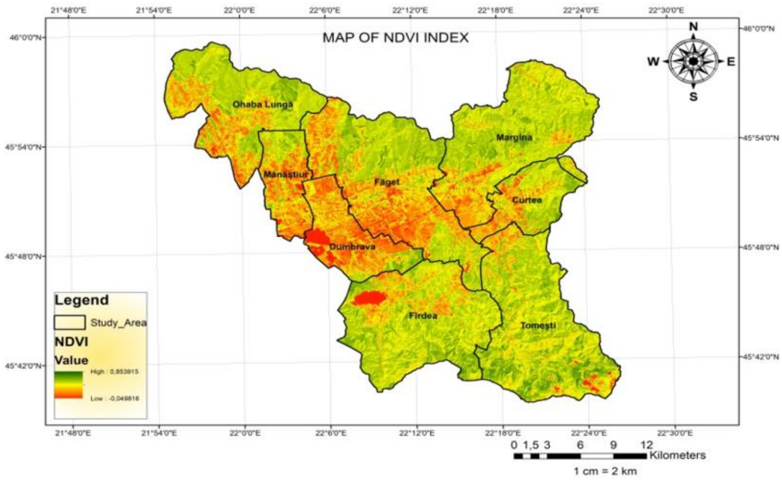

Figure 5. Normalized vegetation differentiation index NDVI

- ***Normalized Differentiation Index of Vegetation Burning Potential NDBR***

This index is useful in representing the unburnt vegetation (near infrared) and the burned ones being the strongest (mid infrared), NDVI values are between -1 and +1.

Lands with a high risk of catching fire, i.e. forests, dry scrubs, are symbolized by values above 0.1 and these represent the light tones.

Dark tones are signified by non-flammable areas such as stone or concrete buildings, highways and roads, railways, etc.

The mathematical relationship (2) of this index of differentiation of the differentiation of the burning potential of the vegetation is the following:

$$NDBR=\frac{NIR-MIR}{NIR+MIR}, \text{ where:} \quad (2)$$

NDBR - the normalized differentiation index of the combustion potential of the vegetation

NIR - near infrared spectral band

MIR - mid-infrared spectral band

In the study area that is represented in figure 6, we have values between -0.0734559 and 0.164592, for the differentiation index of the combustion potential of the vegetation, the acquisition date of the images is July 26, 2022.

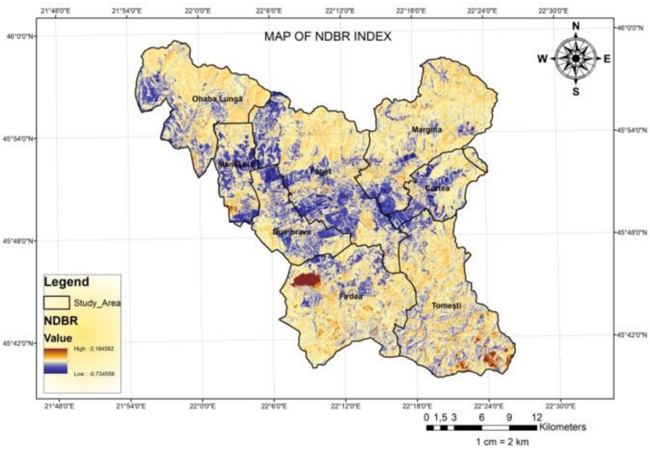

Figure 6. Normalized Differentiation Index of Vegetation Burning Potential NDBR

- ***NDWI Normalized Water Differentiation Index***

It uses green spectral bands when electromagnetic radiation penetrates water and near infrared when the spectral response of moisture in soils, rocks and plants increases, and water begins to absorb radiation in the surface layers.

Values less than 0 express the sheen of water, and these are dark tones, and light tones have values greater than 0, which leads to a dry land.

This index is useful in the case of visualizing the differences in turbidity and plant content of the water, but it also has an important role in the mapping of water bodies.

Calculation formula (3) for the NDWI index is:

$$NDWI=\frac{NIR-G}{NIR+G}, \text{ where:} \quad (3)$$

NDWI - normalized water differentiation index
NIR - near infrared spectral band
G - green spectral band

This normalized water differentiation index is represented in the study area by values between -0.0911884 and 0.753804 (figure 7.), and the acquisition date of the images is July 26, 2022.

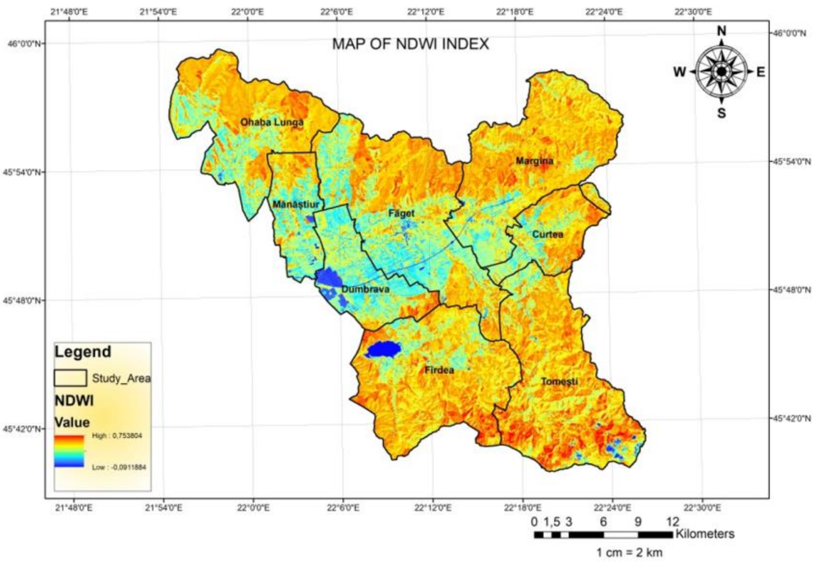

Figure 7. Normalized Water Differentiation Index NDWI

➢ ***The Soil Adjusted Vegetation Index (SAVI)***

Method is a vegetation index that uses a soil brightness correction factor and tries to minimize the influences of soil brightness. This is often used in arid regions where vegetation cover is low and generates values between -1.0 and 1.0.

The empirical calculation formula (4) is:

$$SAVI = \left(\frac{NIR-RED}{NIR+RED+L}\right) x\ (1 + L), \text{ where:} \quad (4)$$

SAVI - the Soil Adjusted Vegetation Index
NIR - pixel values in the near infrared band
Red - pixel values in the near red band
L - amount of green vegetation cover

In the study area, this SAVI index has values between -0.049816 and 0.853915, (figure 8.) and the best data for the images is July 26, 2022.

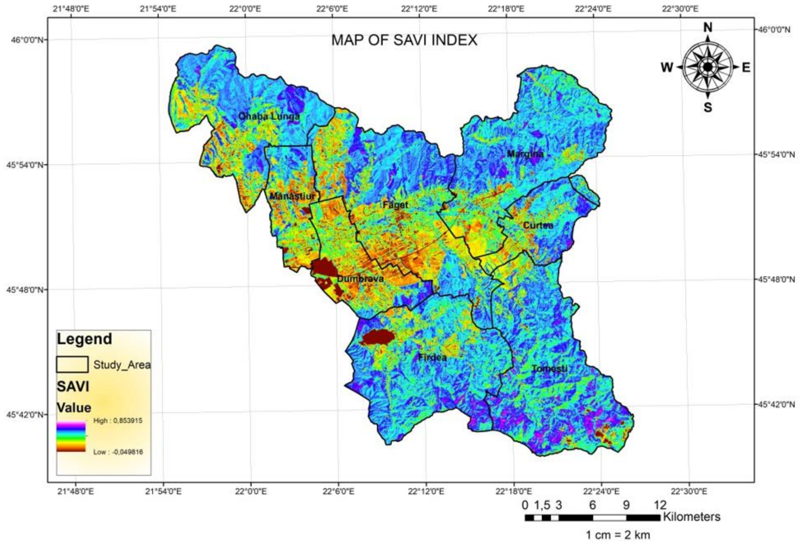

Figure 8. Soil adjustment index of the vegetation SAVI

CONCLUSIONS

This study aims to analyze the earth's crust by obtaining geospatial information, detecting, measuring and recording the emitted or reflected electromagnetic radiation by the bodies on the surface of the earth's crust.

This paper presents the way of using the information obtained from the remote sensing systems, the combinations of spectral bands and the way of calculating some indicators that can characterize and provide useful information for the management of the vegetation cover.

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