THE USE OF REMOTE SENSING IMAGES IN LAND MONITORING

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Abstract. *Remote sensing is defined as the technical field that deals with the detection, measurement, recording and visualization in the form of images, of electromagnetic radiation, which are emitted by objects, but also phenomena, from the surface of the Earth or from the Universe, from certain distances, without the existence of real or direct contact with them. As its name implies, remote sensing involves "the acquisition of information from a distance, without having direct contact with the detected object", through a "set of means that allow the recording of information on the earth's surface". This paper presents the spectral behaviour of some components of the environment, such as: spectral reflectance and spectral signature. Next, are presented a series of satellites, the most important of which is Landsat 8, which is the eighth satellite in the Landsat program and the seventh that successfully reaches orbit. The satellite has two instruments: OLI (Operational Land Imager) and TIRS (Thermal InfraRed Sensor), which provides global coverage at resolutions of 30m (visible spectrum, NIR, SWIR), 100m (thermal bands) and 15m (panchromatic band). We will conduct a study on the most important vegetation indices. The formulas for the calculation of the indices start from the hypothesis that the spectral variation of the soils without vegetation is linear. The function which described this variation is called the straight of the soils. This line can be most easily determined in a two-dimensional histogram of radiometric values, having as x-axis red band and z-axis, near infrared band. The radiometric values corresponding to the lack of vegetation are identified in the histogram. The straight for best approximating is the straight of the soils. Vegetation indices are very useful in monitoring of large areas, as they represent a very effective means of monitoring and evaluating drought phenomena at the scale of images, due to the possibilities of precise discrimination of vegetation, as well as correlations with biophysical parameters that determine the vegetation status and turgidity such as: plant height, leaf index, biomass, etc.*

Key words: *Remote Sensing, Vegetation indices, NDVI, NDWI, Landsat*

INTRODUCTION

Remote sensing is defined as the technical domain that operate with the detection, measurement, recording and visualization as images, of electromagnetic radiation, which are emitted by objects, but also phenomena, from the surface (Bertici et al., 2012) of the Earth or from the Universe, from certain distances (Ienciu et al., 2013), without the existence of real or direct contact with them (Herbei et al., 2015).

As per name, remote sensing involves "the acquisition of information from a distance, without having direct contact with the detected object" (Herbei and Sala, 2015), through a "set of means to record information on the earth's surface" (Herbei and Sala, 2014).

- Remote sensing applications (Herbei et al., 2016)

The fields of applicability of remote sensing are multiple (Herbei et al., 2017), but the largest applicability is in the field of the study of the Earth's natural resources (Smuleac et al., 2013). Optical instruments provide multispectral images, at high resolutions and containing a lot of information that can be interpreted for various purposes (Herbei et al., 2014, Herbei et al., 2011).

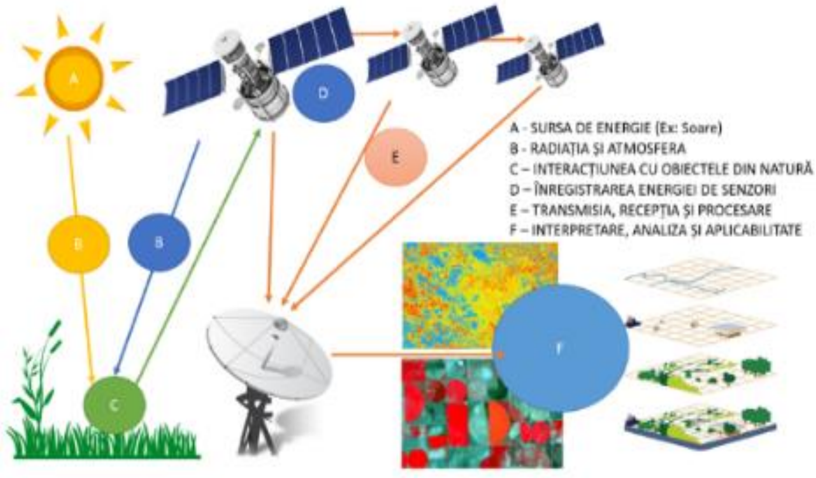

Figure 1 The remote sensing methodology

Reflectance represents the characteristic of the component of the terrestrial environment to reflect a part of the incident solar radiation in the direction of the remote sensing sensor, depending on their physical and chemical properties (Gaf et al., 2015).

Each object from nature has a spectral reflectance curve. The behaviour of surfaces, objects or phenomena against the radiation they come into contact is not identical. They absorb specific wavelengths and reflect others. The percentage of the electromagnetic spectrum that a surface (Nistor, 2011) reflects is defined as spectral signature of that surface.

The concept spectral signature represents the most commonly used method of identifying and separating different materials and objects, using multispectral data. For any material, the amount of solar reflected radiation (absorbed or transmitted) depending on the wavelength. This make possible to identify the different objects according to their spectral signatures.

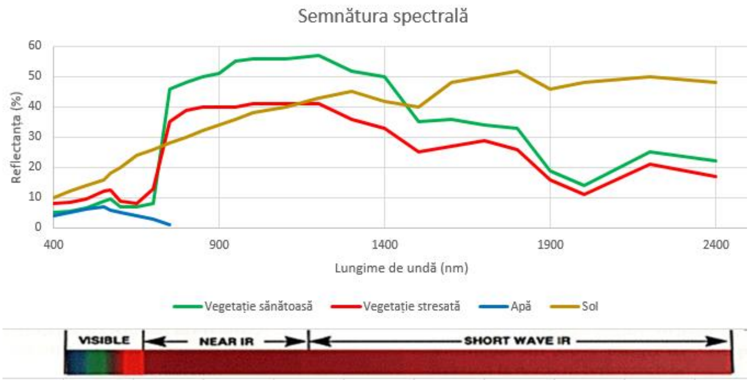

Figure 2. Spectral signature

MATERIAL AND METHOD

In 1972, the first satellite in the Landsat series was launched by NASA. The great success in using of obtained data from this mission (Oncia et al., 2013) has led to a continuous development of the field of remote sensing.

Other remote sensing satellites, which are still performing, were launched by both NASA and other agencies. Thus, France launches the SPOT satellite series, India launches the IRS satellite series, the European Agency launches the ERS satellites, and Russia the COSMOS spy satellites.

Thus, over 4000 satellites have been launched so far, of which approx. 400 are still in function.

Annually, approx. 20 satellites are launched. ¾ of these total are for remote sensing. At the moment, there are a large number of satellite platforms in the extra-atmospheric space around the Earth (Popescu et al., 2016), which carry remote sensing sensors.

Landsat 8 is an American Earth observation satellite launched on February 11, 2013. It is the 8th satellite in the Landsat program and the 7thwich successfully reach theorbit.

The satellite has two instruments: OLI (Operational Land Imager) and TIRS (Thermal InfraRed Sensor), which provides global coverage at resolutions of 30 m (visible spectrum, NIR, SWIR), 100m (thermal bands) and 15 m (panchromatic band).

Technical characteristics	
Release date	11.02.2013
Statute	Operational
Sensors	OLI, TIRS
Inclination	98.2
Altitude	705 km
Orbit	heliosincron
Re-visiting time	16 days

Figure 3.Technical characteristics of Landsat 8

The OLI instrument has two new spectral bands, one for the recognition of cirrus clouds, the other for observations on the coastal areas. TIRS acquires images with two new thermal spectral bands. The LDCM scenes have the dimensions of 185 km on the perpendicular direction of the route and 180 km on the direction of the route. Compared to Landsat 7, the number of registered scenes increases, from 250 to 400 scenes / day.

Landsat products are made in 11 preprocessing levels, the most commonly used being the following:

- Level 0: the scanning distortions are corrected, taking into account the geometry of the detector and the type of sampling (Smuleac et al., 2014)
- Level 1: the image is radiometrically corrected
- Level 8: corresponds to SPOT level 2 (without landmarks)
- Level 9 and 10: correspond to levels 2B, Ortho respectively.

Landsat satellite images are digitized and transformed into electrons fluxes that are transmitted to the ground by telemetry, in real time, at reception stations, arranged throughout the Globe, at the satellite's passage above them, or stored for transmission at the next passage.

BANDĂ SPECTRALĂ	LUNGIME DE UNDĂ	APLICABILITATE
Banda 1 – aerosoli de coastă	0.43-0.45	Studii de coastă şi aerosoli
Banda 2 – albastru	0.45-0.51	Cartografiere batimetrică, distinge solul de vegetaţie şi vegetaţia de tip foioase de cea de tip conifere
Banda 3 - verde	0.53-0.59	Evidenţiază vegetaţia de vârf,ceea ce este util pentru evaluarea vigorii plantelor
Banda 4 - roşu	0.64-0.67	Diferenţiază pantele în vegetaţie
Banda 5- infraroşu apropiat (NIR)	085.-0.88	Evidenţiază conţinutul de biomasă şi linia ţărmurilor
Banda 6-unde-scurte infraroşu (SWIR) 1	1.57-1.65	Diferenţiază umiditatea solului şi a vegetaţiei; penetrează norii subţiri
Banda 7 -unde scurte(SWIR) 2	2.11-2.29	Detectare îmbunătăţită a umidităţii solului şi a vegetaţiei, cât şi a penetrării norilor subţiri
Banda 8 - Pancromatic	.50-.68	Rezoluţie de 15 metri, definire mai clară a imaginii
Banda 9 – Cirrus	1.36 -1.38	Detectare îmbunătăţită a contaminării norilor cirrus
Banda 10 – TIRS 1	10.60 – 11.19	Rezoluţie de 100 metri, cartografiere termală şi estimare a umidităţii solului
Banda 11 – TIRS 2	11.5-12.51	Rezolutie de 100 metri, cartografiere termală şi estimare îmbunătăţită a umidităţii solului

Figure 4.Spectral bands of Landsat 8

All the spectral bands of the Landsat 8 sensor have a resolution of 30 m, only the band 8 has a resolution of 15 m. In the case of images collected with Landsat 8 (with 11 spectral bands), compared to Landsat 7 (with 8 spectral bands), additional bands appear:

• OLI sensor includes a new band for the investigation of the coastal areas and the analysis of the aerosol concentration in the atmosphere (band 1) and a band for the recognition of new cirrus (band 9).

• TIRS sensor acquires images with two new thermal spectral bands (band 10 and band 11).

Combinations with spectral bands on different satellites:

Imagine	Landsat 5, Landsat 7	Landsat 8
Fals-color	432	543
Culori naturale	321	432
Fals-color	543	654
Fals-color	753	764
Fals-color	742	753

Figure 5. Combination with spectral bands and differentsatellites

RESULTS AND DISCUSSIONS

- **Normalized indices of differentiation**

Normalized indices of differentiation result from spectral band operations, which means that they are obtained on the basis of multispectral images (with more spectral bands).

Through the specific operations, the aim is to amplify the spectral signatures in the band in which a particular object has the highest reflectance and to diminish the signature of the object, respectively in the band in which it has the smallest reflectance.

As a result of these transformations, the normalized indices shown in the gray scale images result, in which the pixels have new numerical values. The data obtained are no longer byte type (levels between 0-255, in the case of 8-bit images), but floating point type, between -1 and 1.

1. **The Normalized Difference Vegetation Index** (NDVI) is particularly useful in mapping the areas covered with vegetation, in establishing the vegetation typology and health status.

In order to determine the density of vegetation, the wavelengths of the visible and near infrared fields are taken into account.

The calculation formula expresses the differentiation of the spectral signatures at the limit of the visible area, the red band, the infrared zone, the near IR band, having the following elements:

$$NDVI=\frac{\mathbf{NIR-R}}{\mathbf{NIR+R}} \qquad (1)$$

In which: NDVI - Normalized Difference Vegetation Index; NIR - near infrared spectral band; R - the red spectral band

In Landsat 8:

$$NDVI=\frac{\mathbf{BAND\ 5-BAND\ 4}}{\mathbf{BAND\ 5+BAND\ 4}} \qquad (2)$$

The NDVI values dependwith the absorption of the radiation by the chlorophyll in the red spectral area and its reflectance in the near infrared spectral area.

These values are between -1 and +1, expressing the consistency of green vegetation. Those close to **+1 (light tones) represent a great consistency of vegetation** and are specific to dense deciduous forests.

Values close to **-1 (dark tones) represent land without vegetation**. The value 0 (**intermediate tones**) is associated with lands with meadows. It is useful in mapping the areas with vegetation the typology of the vegetation, the health status of the vegetation, the use of the land, etc.

2. The Normalized Difference Water Index (NDWI) is useful in mapping aquatic surfaces, as well as in differentiating them based on turbidity (sediment content).

The NDWI calculation uses green spectral bands (due to the fact that electromagnetic radiation penetrates the water) and near infrared (increases the spectral response of humidity in soils, rocks and plants, and the water begins to absorb the radiation in the surface layers).

The formula for calculating this index is as follows:

$$NDWI = \frac{NIR-GREEN}{NIR+GREEN} = \frac{BAND\ 5 - BAND\ 3}{BAND\ 5+BAND\ 3} \quad (3)$$

In which: NDWI - Normalized Difference Water Index; NIR - near infrared spectral band; G - green spectral band.

Dark tones (values close to -1) express the gloss of the water. Open tones (values close to +1), dry land. Intermediate tones (values close to 0), lands with intermediate moisture content.

3. The Normalized Difference Snow Index (NDSI) highlights the snow-covered areas in contrast to the unpaved surfaces.

In the calculation formula are used the green spectral bands - the band in which the snow reflectance is maximum - and the average infrared - in which the humidity has the highest reflectance, thus:

$$NDSI = \frac{G-IR}{G+IR} = \frac{BAND\ 3 - BAND\ 6}{BAND\ 3+ BAND\ 6} \quad (4)$$

In which: NDSI - the Normalized Difference Snow Index; G - green spectral band; IR - medium infrared spectral band

Interpretation: light tones (snowy terrain), dark tones (snowy terrain).

4. Normalized Difference Moisture Index (NDMI) is useful in the differentiation of the content of unimidity of environmental components, especially of soils, vegetation or geological formations.

For the calculation of the humidity index, the following formula is used:

$$NDMI = \frac{NIR-IR}{NIR+IR} \quad (5)$$

In which: NDMI - Normalized Difference Moisture Index; NIR - near infrared spectral band; IR - medium infrared spectral band.

The images are represented by grey tones, with floating point values, from -1 (closed tones specific to low humidity fields) to 1 (open tones that render the lands with high humidity).

5. The Normalized Difference Burning Ratio (NDBR) is useful, especially in areas with high fire potential (mountainous areas with large forested areas where the effect of phoen is manifested, which may fire, savanna areas, high temperatures, etc.)

To obtain this index, the bands in which the spectral response of the non-ignited (near infrared) and arson (medium infrared) vegetation are used are the strongest. The differences in reflectance mean the presence of chlorophyll, before the fire, respectively its absence after the fire, the following relation being applied:

$$NDBR = \frac{NIR-MIR}{NIR+MIR} = \frac{BAND\ 4 - BAND\ 7}{BAND\ 4 + BAND\ 7} \quad (6)$$

In which: NDBR - The Normalized Difference Burning Ratio of the burning potential of the vegetation; NIR - near infrared band; MIR - medium infrared band.

The open tones (values above 0.1) symbolize the lands with a high risk of fire (forests, dry bushes). The dark tones symbolize the lands without risk of catching fire (stone or concrete buildings, highways and roads, railways, etc.).

6. Normalized Difference Building Index (NDBI) is useful in territorial analysis, by highlighting the built environment: human settlements, road networks, bridges, dams.

The NDBI calculation relationship involves spectral signatures of objects in the middle infrared bands (with high humidity reflectance, including building materials) and near infrared (with maximum vegetation reflectance) - so the spectral differentiation between vegetation and construction materials is used .

The NDBI is calculated with the formula:

$$NDBI = \frac{IR - NIR}{IR + NIR} \quad (7)$$

In which: NDBI - Normalized Difference Building Index; NIR - near infrared spectral band; IR - medium infrared spectral band.

In NDBI images the open tones (positive values) express the land covered with constructions, and the closed tones (negative values) represent lands on which no constructions are located.

Next, we used the SNAP program was used to make a combination of spectral bands

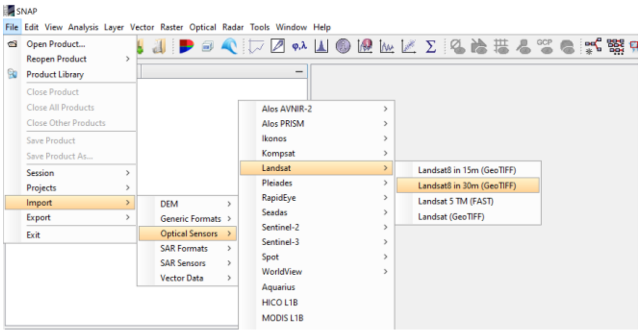

Figure 6. Choosing of sensor type

Combination of RGB spectral bands:

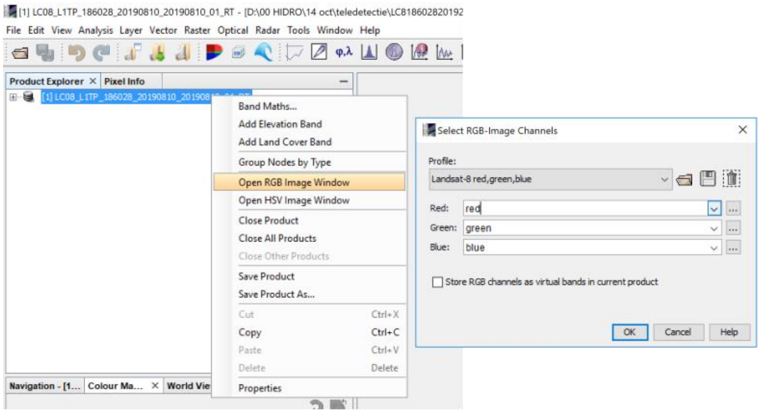

Figure 7. Combination of spectral bands

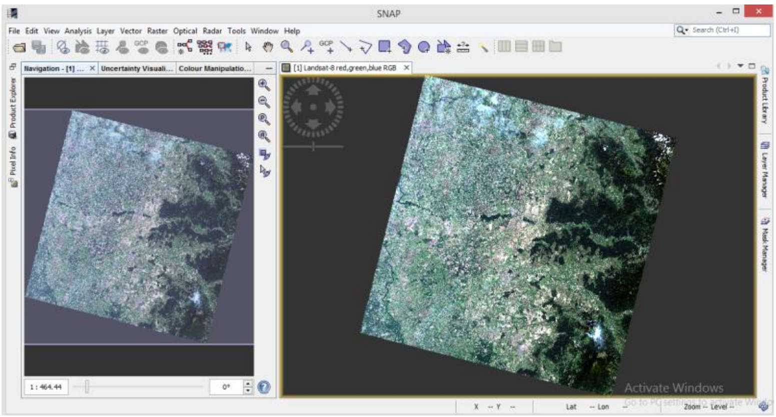

Figure 8. Combination of spectral bands

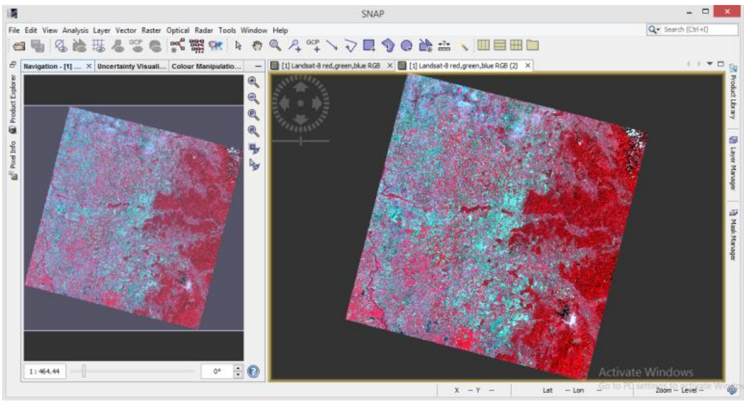

Figure 9. Combination 543 – Nir-Red-Green

SNAP program was also used for the calculation of the standardized indices of differentiation: NDVI, NDWI, NDSI. To carry out this case study, was used an image from Faget locality, Timis county, located in the southwest of the country.

Figure 10. Satellite location of city Faget

1. **Normalized Difference Vegetation Index (NDVI)**

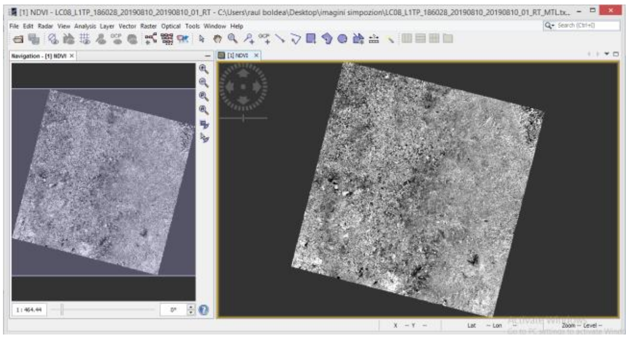

Figure 11.Normalized differentiation vegetation index (NDVI)

2. **Normalized differentiation water index** (NDWI)

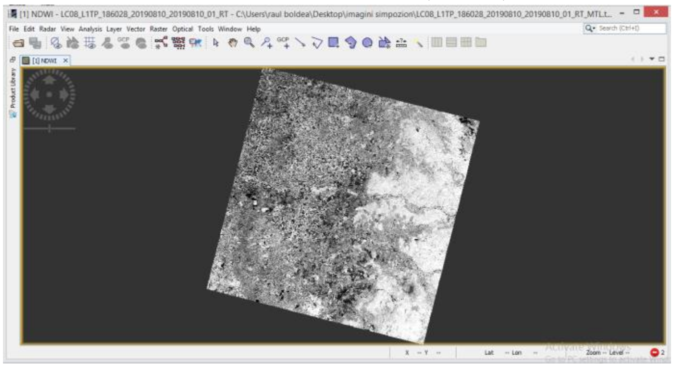

Figure 12. Normalized differentiation water index (NDWI)

3. **Normalized Difference Snow Index** (NDSI)

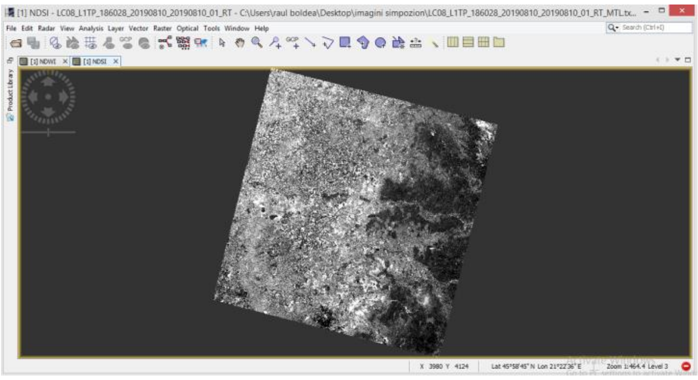

Figure 13.Normalized Difference Snow Index (NDSI)

CONCLUSIONS

Vegetation indices are very useful in monitoring of large areas, as they represent a very effective tool of monitoring and evaluating drought phenomena at the scale of images, due to the possibilities of precise discrimination of vegetation, as well as correlations with biophysical parameters that determine the vegetation status and turgidity such as: plant height, leaf index, biomass, etc.

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