

GEOSPATIAL TECHNOLOGIES IN REMOTE SENSING IMAGE PROCESSING

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Abstract

The main purpose of this paper is to study the dynamics of Timiș county based on spectral information obtained from Landsat 8 satellite imagery. The vegetation dynamic has been expressed differently from the normalized difference indices: NDVI, NDWI, NDSI, NDMI, NDBR and NDBI. With the help of the Arc Map software, one can create maps based on normalized difference indices. Each index has a certain representation: NDVI – vegetation, NDWI – water, NDSI – snow, NDMI – humidity, NDBR – potential of burning vegetation and NDBI – constructions. The presented results present a new, up-to-date method for monitoring the earth's surface based on geomatics technologies.

Key words: ArcGIS, Landsat 8, maps, NDVI, normalized indices

INTRODUCTION

In the past couple of years, remote sensing has witnessed impressive development considering that the first models of analysis and acquisition from a distance have appeared around four to five decades ago. This is based on the fact that the objects and the material processes send different corpuscular emanations and different types of radiation in the surrounding space; that, or the fact that they are joined by force fields with great spatial extension. Depending on the model or means applied, remote sensing may be passive – when reflected or radiated natural energy is used- and active – when remote sensing makes use of artificial radiation, which is being emitted in order to be make contact with certain objects and/or investigated phenomena.

The principles of passive remote sensing imply the acquisition of imagery related to phenomena or objects located on earth's surface, taken from a distance, using only the emission of electromagnetic radiation. The principles of active remote sensing utilize artificially generated electromagnetic radiation, to obtain imagery related to the aforementioned objects of interest. The most frequently used are radar

systems (with microwaves), lidar (with polarized light) and sonar (with sound waves). The principle of multispectral scanning is one of the more widely used ones since it can produce high quality imagery at the level of spectral and spatial resolution. The principle, perfected in the past three decades, relies on the fact that, in nature, every object or phenomena emits electromagnetic radiation, depending on its physical and chemical proprieties. These emissions allow further data acquisition, interpretation and analysis.

MATERIALS AND METHODS

Geographic information systems are computer systems capable of holding and using data describing places on the Earth's surface (Herbei, 2015).

The Landsat Mission was a National Aeronautics and Space Administration (NASA) initiated experimental and civil project, started in 1972 with launch of the ERTS satellite (also known as Landsat1). The LDCM (Landsat Continuity Mission) – Landsat 8 – debuted in 2013, overseen by National Aeronautics and Space Administration (NASA) and USGS, with the scope of acquiring imagery from earth's

surface. The LDCM Satellite has two instruments: OLI (Operational Land Imager) and TIRS (Thermal InfraRed Sensor), which allows for global coverage, at resolutions of 30m (visible spectre, NIR, SWIR), 100m (thermal bands) and 15m (panchromatic band) (Herbei et al., 2015).

The satellite carries the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) instruments. The OLI measures in the visible, near infrared, and shortwave infrared portions (VNIR, NIR, and SWIR) of the spectrum. The TIRS measures land surface temperature in two thermal bands with a new technology that applies quantum physics to detect heat. Landsat 8 images have 15-meter panchromatic and 30-meter multi-spectral spatial resolutions along a 185 km (115 mi). For the purpose of this paper, we used the ArcGis Desktop software, which also included the following extensions: ArcCatalog, ArcMap and ArcToolbox. Said tools were used in the following steps; we first inserted the map of Romania, and subsequently used the Timiș county as subject of representation for normalized difference indices (Figure 1 and Figure 2).

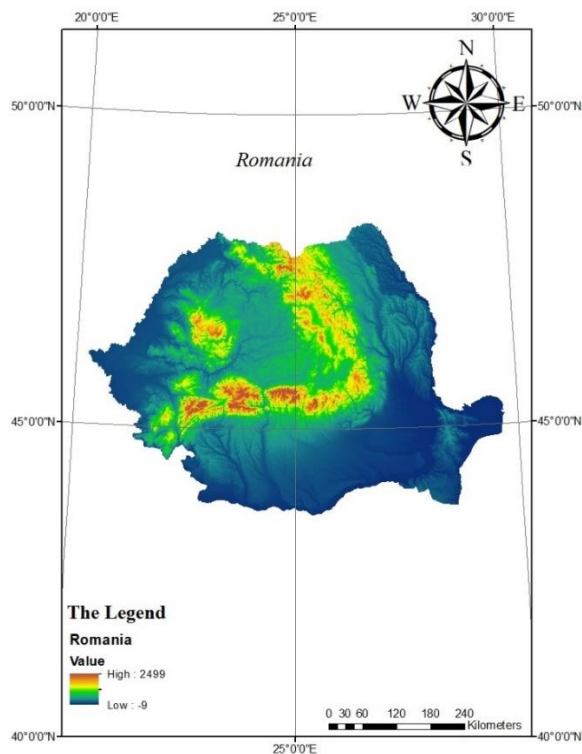


Figure 1. Digital elevation model of Romania

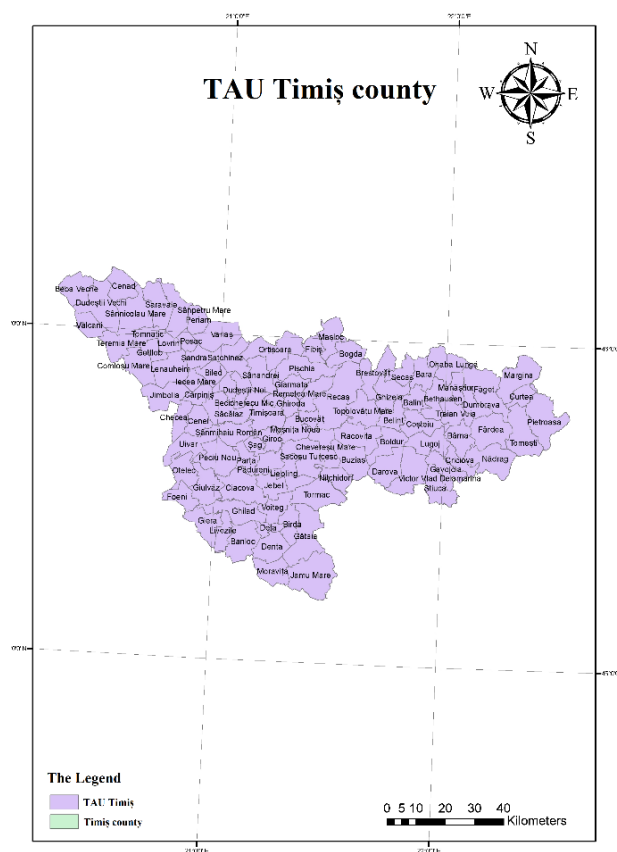


Figure 2. Map of TAU's from Timiș county

Timiș county is located in the western part of Romania, in the centre of the historical province of Banat. Its county seat is the municipality of Timișoara, capital of the western region, and largest city by size and importance in the Romanian southwestern macroregion of development. Timiș County was abolished by Law no. 5 of 8 Sept. 1950 (until then bearing the name Timiș-Torontal, with an area of 7,600 km², 13 towns, two cities – Timișoara and Lipova, and 243 villages) and the Timișoara region was established, with its headquarters. in Timișoara, which in 1956 was transformed into the Banat region (21,800 km², 12 districts, 16 cities and several hundred villages), and by Law no. 2 of February 17, 1968, it became a county again, with a supr. of 8,697 km² (the largest in the country), ten cities (two of which are municipalities), 89 communes and 313 villages. As previously mentioned, we created the maps with the help of ArcGIS Desktop, a software suite produced by Esri. It allows the user to make, workshop and integrate the analysis and display of geographical data at different levels of conceptualization.



Figure 3. Geographic information system

(https://www.google.com/search?q=gis+poze&sxsrf=APwXEdcSGqHncblbzmqjLQ1ThjcUnEUguzQ:1682507792363&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiwqa76tcf-AhWPgf0HHWPNAJEQ_AUoAXoECAEQAw&biw=1536&bih=722&dpr=1.25#imgrc=Ft0dm4EkKJWj9M)

ArcMap is the main component of Esri's ArcGIS suite of geospatial processing programs, and is used primarily to view, edit, create, and analyze geospatial data. ArcMap allows the user to explore data within a data set, symbolize features accordingly, and create maps. This is done through two distinct sections of the program, the table of contents and the data frame. In October 2020, it was announced that there are no plans to release 10.9 in 2021, [2] and that ArcMap would no longer be supported after March 1, 2026. Esri are encouraging their users to transition to ArcGIS Pro.

ArcMap users can create and manipulate data sets to include a variety of information. For example, the maps produced in ArcMap generally include features such as north arrows, scale bars, titles, legends, neat lines, etc. The software package includes a style-set of these features. As well as the ability to upload numerous other reference styles to apply to any mapping function.

RESULTS AND DISCUSSIONS

The normalized difference indices are expressed in the form of new images, in tones of grey, resulting from arithmetic operations taking place between certain spectral bands. In order to visually represent coloured images, red, green, and blue components have to be specified for

each pixel (presupposing a RGB colour scheme). This way, the “value” of the pixel is actually a vector made of three numbers.

The fact that satellite scenes are made up of different spectral bands, acquired in different areas of the electromagnetic spectrum, allow the representation of the components of the physical environment by means of remote sensing indices, respectively images that highlight different aspects related to: vegetation, water, built space, snow cover , etc.

The normalized indices of differentiation of landscape elements, namely vegetation (NDVI), water (NDWI), snow (NDSI), soil moisture (NDMI), etc., have a wide applicability and are used in different aspects, both in theoretical as well as practical level (Kulkarni et al., 2002; Pettorelli et al., 2005; Gu et al., 2007; Loranty et al., 2018; Huang et al., 2021).

The Normalized Difference Vegetation Index - NDVI (Figure 4).

This index was first introduced in the literature by Dr. John Rouse in 1973.

Formula (1) :

$$NDVI = \frac{NIR - R}{NIR + R}$$

At the level of the study area, namely Timiș county, the NDVI values were maximum in the eastern part, in the Poiana Ruscă Mountains area.

The NDVI values may vary depending on the radiation absorbed by the chlorophyll in the red spectral zone and its reflectance in the near-infrared spectral zone. These values are noted between the values of -1 and +1, expressing the consistency of green vegetation. Values close to the +1 range (light tones) represent large-consistency vegetation and are specific for deciduous forests.

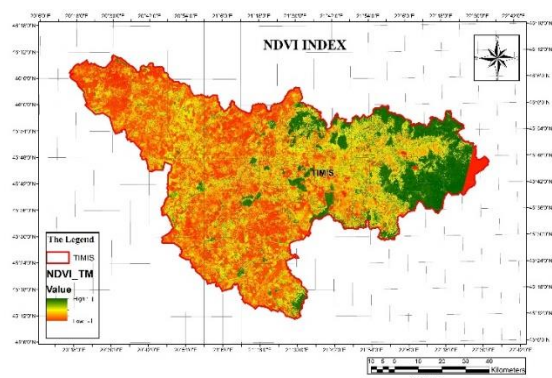


Figure 4. Timiș NDVI map

2. The Normalized Difference Water Index - NDWI (figure 5).

This index was proposed by McFeeters in 1996. Formula (2):

$$NDWI = \frac{NIR - GREEN}{NIR + GREEN}$$

Regarding the NDWI indices, the maximum values were also in the eastern part, being the mountainous area.

This index is used to map aquatic surfaces, as well as differentiate them in terms of turbidity (the content in sediments). When calculating the NDWI, green spectral bands are used (due to electromagnetic radiations piercing the water) as well as near-infrared (increasing the spectral response of the humidity in the soil, rocks and plants; the water begins to absorb the radiation from the uppermost surfaces).

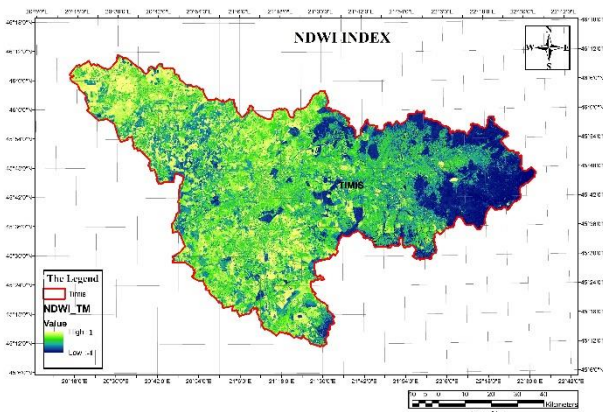


Figure 5. Timis NDWI map

3. The Normalized Difference Snow Index – NDSI (Figure 6). This index was introduced in the literature by Sidjak and Wheate in 1999.

Formula (3) :

$$NDSI = \frac{GREEN - SWIR1}{GREEN + SWIR1}$$

In calculating the formula, green spectral bands are used (in which the reflectance of snow is at its maximum) as well as medium infrared (in which humidity has its greatest reflectance). The values that make up the NDSI produced image range between -1 (dark tones displaying surfaces uncovered by snow) and +1 (light tones symbolizing snow-covered terrain). The white colour of snow is produced by the green band's high reflectance.

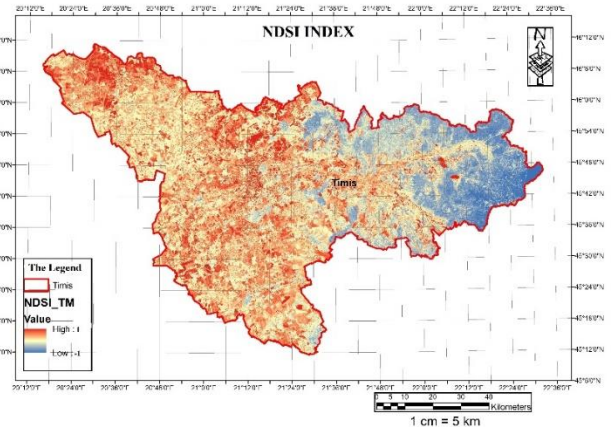


Figure 6. Timis NDSI map

4. Normalized humidity Differentiation Index – NDMI (Figure 7)

Formula (4) :

$$NDMI = \frac{NIR - SWIR1}{NIR + SWIR1}$$

Is reliable when looking at the differentiated highlight of certain objects' humidity content. Here we refer to components from the environment, especially soil, vegetation, or geological formations.

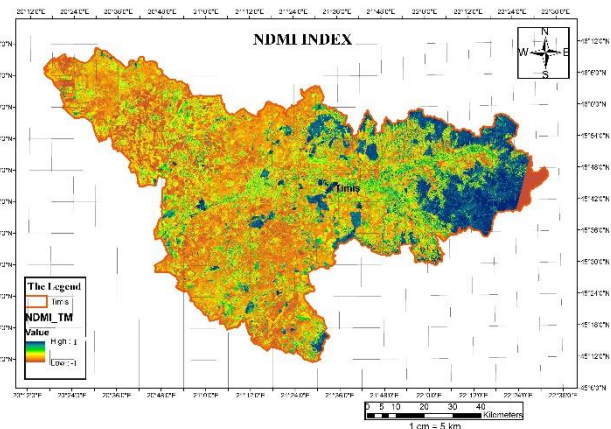


Figure 7. Timis NDMI map

5. The Normalized Difference Burn Ratio – NDBR (Figure 8)

Formula (5) :

$$NDBR = \frac{NIR - SWIR2}{NIR + SWIR2}$$

This index is useful, especially when charting zones with a high potential for ignition (mountainous areas with large forest-covered surfaces where the foehn effect may jump start fires, savannahs, high temperature areas, etc.). To obtain this index, the software used bands in

which the spectral responses of unlit vegetation (near-infrared), as well as as lit vegetation (medium infrared) are the most potent.

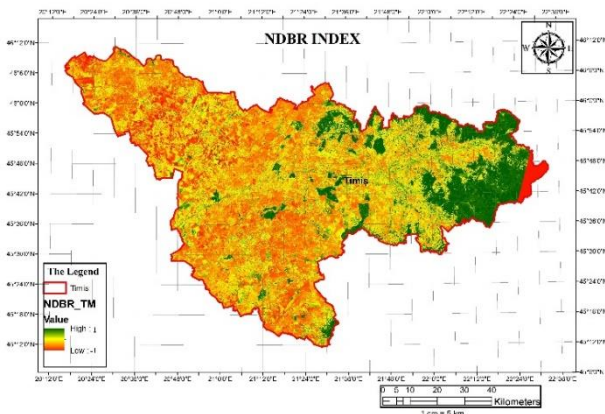


Figure 8. Timis NDBR map

6. The Normalized Difference Built-up Index - NDBI (figure 9) was introduced fairly recently in the literature by Y. Zha in 2003.

Formula (6) :

$$NDBI = \frac{IR - NIR}{IR + NIR}$$

NDBI proves to be useful in territorial analysis, through highlighting the built-up environment (human settlements, road networks, bridges, dams, etc). The NDBI formula includes the spectral signatures of objects from the mid-infrared bands (with great reflectance of humidity, including construction materials) and near-infrared (with maximum reflectance of vegetation).

In other words, it is used for the spectral differentiation of vegetation and construction materials.

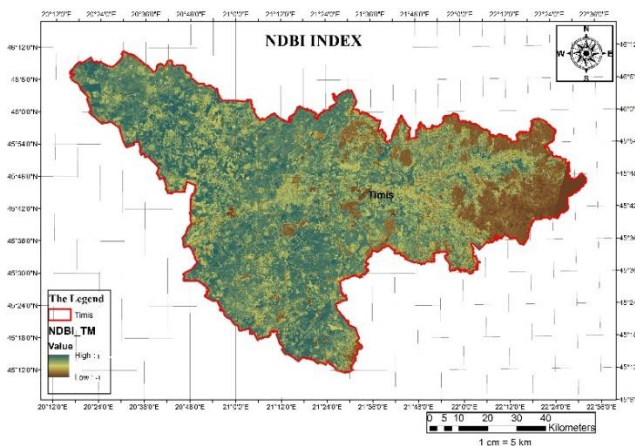


Figure 9. Timis NDBI map

CONCLUSIONS

Landsat 8 spectral bands help us in coastal and aerosol studies, distinguishing soil from vegetation, plant differentiation, soil moisture detection and thermal mapping. Each band can be viewed as a distinct image. The principles used to classify satellite images are based on the analysis and placement of pixels with similar characteristics in the same group. And with the help of the ArcGIS program and the ArcMap application we can explore, edit, analyze and symbolize the data.

The purpose of the research included in this study was to apply different remote sensing indices to highlight, on the one hand, the variability of environmental factors in the territory considered as a case study (Timiș county), and on the other hand, the possibility of analyzing " from a distance" of a vast territory, under different aspects: vegetation, water surfaces, built space, etc.

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