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DYNAMICS OF THE PROTECTED AREA SEMENIC-CHEILE CARAŞULUI NATIONAL PARK IN THE PERIOD 2015-2022 USING GIS TECHNOLOGY AND LANDSAT REMOTE SENSING IMAGES

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Abstract

This study aimed to analyze and characterize a protected area based on satellite imagery. Protected areas are terrestrial or aquatic areas specially designed to protect and maintain biodiversity, natural resources and related cultural resources. Remote sensing is the technology by which objects can be measured, identified and analyzed from a distance, without the need for direct contact. Thus, for the analysis of satellite images, we used the data obtained from Landsat 8. Semenic-Cheile Carasului National Park was studied under the aspect of the variation of NDVI, NDMI and NBR indices. It was considered a period of seven years, 2015-2022, for the study, and as the period of the year the summer season was taken into account. Satellite scenes, Landsat 8, were used, taken in August during the study period. Based on spectral information and established formulas, NDVI, NDMI and NBR indices were calculated. To better analyze the features in pictures, we use band combinations. We accomplish this by creatively rearranging the available channels. We can extract specific information from an image by employing band combinations. It can be seen how Semenic-Cheile Carasului changed its dynamics over the years.

Key words*: indices, Landsat 8, NDVI, protected area, satellite imagery.*

INTRODUCTION

Remote sensing is the acquisition of information about an object or phenomenon without physically coming into contact with the object, as opposed to in situ or on-site observation (Herbei and Sala, 2016). The term is especially applied to obtaining information about Earth and other planets. Remote sensing is used in many fields, including geography, topography, and most Earth science disciplines (e.g., hydrology, ecology, meteorology, oceanography, glaciology, geology); it also has military, intelligence, commercial, economic, planning and humanitarian applications, among others (Schowengerdt, 2007).

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth (https://www.usgs.gov).

The Semenic-Cheile Carașului National Park is a protected area of national interest that corresponds to IUCN category II (national park, special conservation area), located in the south-western part of Romania, on the territory of Caraș-Severin county (Grigore, 1990).

The Semenic Mountains and the Anine Mountains (comprising natural elements of value from a physical-geographical, floristic, hydrological, geological and speleological aspect) present a natural mountain area with a diverse range of flora and fauna, expressed both at the level of species and at the level of ecosystems terrestrial (Abran, 2012). The protected area is located in the central-western part of Caraș-Severin county (on the administrative territories of the cities of Anina and Reșita and those of the communes of Bozovici, Brebu Nou, Carașova, Goruia, Mehadica, Prigor, Teregova and Văliug) (www.protectedplanet.net).

Study of land areas based on satellite images (remote sensing techniques) and analysis imaging, is important as a result of the variable coverage area, in relation to the area of interest and the resolution of the images, the high level of details, the indexes that can be calculated for to evaluate, analyze and characterize a certain situation. The objectives of the work were to provide a package of useful data, through some indices and representative parameters in the characterization and management of land areas. The studied area was chosen because it presents a very high diversity, in relation to the different elements taken into consideration (natural or artificial), so that in relation to the proposed objectives it requires to appropriate methods and indices are used (Herbei, 2015).

The surface of the park is 36664.80 ha, its maximum altitude is 1400m, the minimum altitude is 230m, and the average altitude is 815m (Herbei and Sala, 2014).

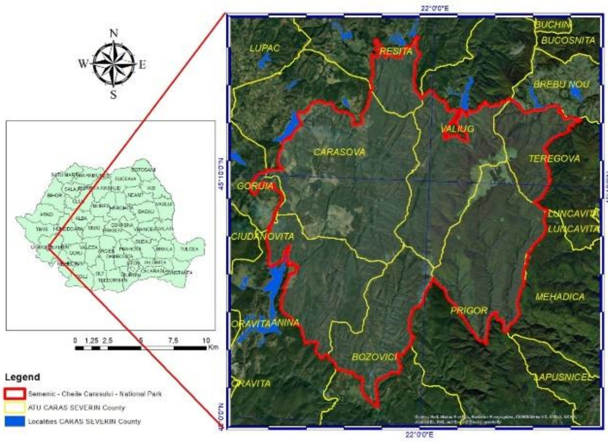


Figure 1. Location of the studied area

MATERIAL AND METHOD

The Landsat Data Continuity Mission has a successful launch February 11th 2013. It was officially renamed to Landsat 8 on May 30, 2013. The newest satellite in the Landsat series offers scientists a clearer view with better spatial resolution than most ocean-sensing instruments and greater sensitivity to brightness and color than previous Landsats.

Landsat 8 (formerly called the Landsat Data Continuity Mission, or LDCM) is NASA's eighth satellite in the Landsat series and continues the Landsat program's critical role in monitoring, understanding and managing the resources needed for human sustainment such as food, water and forests. As our population surpasses seven billion people, the impact of human society on the planet will increase, and Landsat monitors those impacts as well as environmental changes. Research of land area from airspace and outer space using remote sensing techniques delivers valuable information for many industries, among which: agriculture, forestry, geology, soil, hydrology, cartography, exploration and evaluation natural resources, environmental monitoring (soil, water and air) and others. Landsat images can be used successfully in a number of scientific applications and practical problems: global urbanization, wetland delineation, detecting changes.

The Landsat program offers the longest continuous global record of the Earth's surface; it continues to deliver visually stunning and scientifically valuable images of our planet. Since the early 1970s, Landsat has continuously and consistently archived images of Earth; this unparalleled data archive gives scientists the ability to assess changes in Earth's landscape.

For over 40 years, the Landsat program has collected spectral information from Earth's surface, creating a historical archive unmatched in quality, detail, coverage, and length.

This is an important spatial resolution because it is coarse enough for global coverage, yet detailed enough to characterize human-scale processes such as urban growth.

Operational Land Imager (OLI) contains nine spectral bands, including a pan band: band 1 Visible (0.43 - 0.45 µm) 30 m; band 2 Visible (0.450 - 0.51 µm) 30 m; band 3 Visible (0.53 - 0.59 µm) 30 m; band 4 Red (0.64 - 0.67 µm) 30 m; band 5 Near-Infrared (0.85 - 0.88 µm) 30 m; band 6 SWIR 1(1.57 - 1.65 µm) 30 m; band 7 SWIR 2 (2.11 - 2.29 µm) 30 m; band 8 Panchromatic (PAN) (0.50 - 0.68 µm) 15 m; band 9 Cirrus (1.36 - 1.38 µm) 30 m (https://landsat.gsfc.nasa.gov/satellites/landsat-8/).

To characterize the area under study, satellite images taken on summer season, in the Landsat 8 system, were used.

Table 1. Acquisition of satellite images

Satellite images	Acquisition date
Landsat 8	15.08.2015
Landsat 8	04.08.2017
Landsat 8	28.08.2020
Landsat 9	26.08.2022

NBR indices, equation (1), NDVI index, equation (2), and NDMI index, equation (3) were calculated.

$$NBR = (NIR - SWIR\,2)/(NIR + SWIR\,2) \quad (1)$$

(Kriegler et al., 1969)

$$NDVI = (NIR - RED)/(NIR + RED) \quad (2)$$

(Rouse et al., 1974)

$$NDMI = (NIR - SWIR)/(NIR + SWIR) \quad (3)$$

(Gates and David, 1980)

The NBR index (The Normalized Burn Ratio) is used to identify burned areas in fire areas. The formula is similar to that of NDVI; however, it uses both near-infrared (NIR) and short-wave infrared (SWIR) wavelengths. Thus, healthy vegetation has high NIR reflectance and low SWIR reflectance, which is the opposite of what is seen in fire-ravaged areas. A high NBR value suggests healthy vegetation, while a low value indicates barren land and regions that have been recently burned. Values close to 0 are usually attributes of unburnt areas (Herbei, 2015).

NDMI (The Normalized Difference Moisture Index) uses a combination of near infrared (NIR) and short wave infrared (SWIR) spectral bands to detect plant moisture levels. It is a solid indicator of water stress in agriculture. NDMI can only have values between -1 and +1. Negative numbers approaching -1 indicate water stress, while positive values suggest water binding (Richards, 1999).

NDVI (Normalized Difference Vegetation Index) measures the difference between near infrared and red light to quantify vegetation. The most used index in remote sensing is NDVI (Herbei et al., 2015).

Table 2. Description of NDVI intervals for vegetation cover

CLASS	CLASSIFICATION CRITERIA
Bare soil/water	NDVI ≤ 0
Very low	0< NDVI ≤ 0.2
Low	0.2< NDVI ≤ 0.4
Moderately low	0.4< NDVI ≤ 0.6
Moderately high	0.6< NDVI ≤ 0.8
High	0.8< NDVI ≤ 1

RESULTS AND DISCUSSIONS

The analysis of the dynamics of the Semenic-Cheile Carasului national park was done by calculating the NDVI, NDMI and NBR indices, as well as by comparing the combinations of spectral bands.

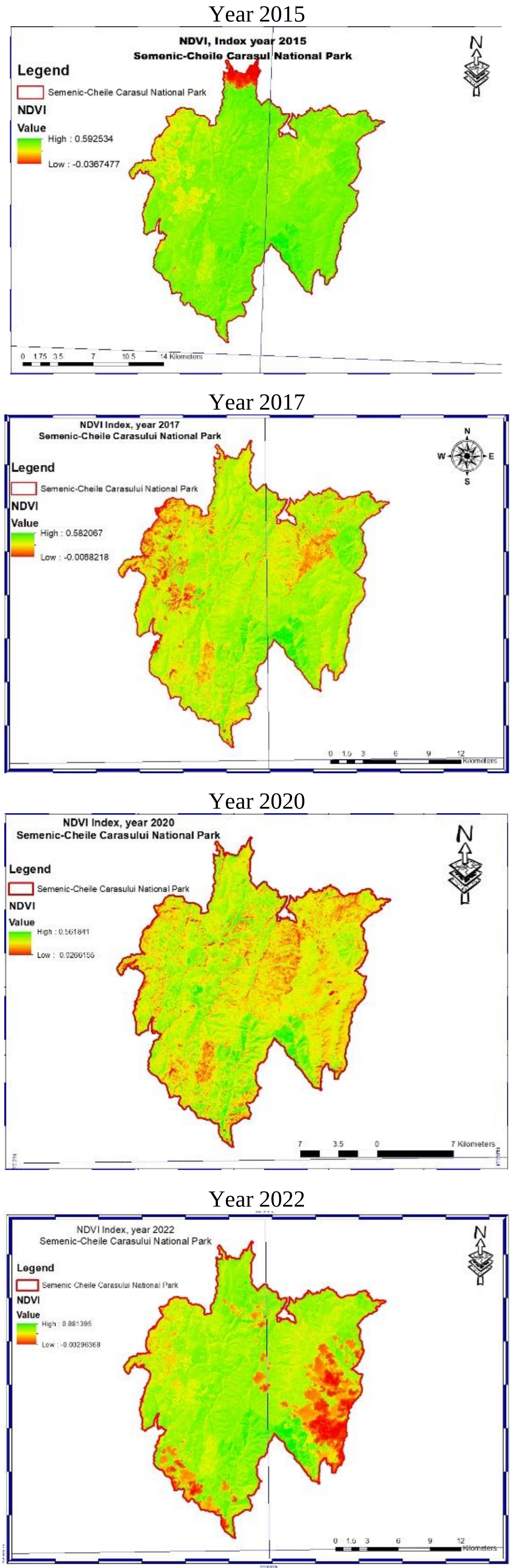
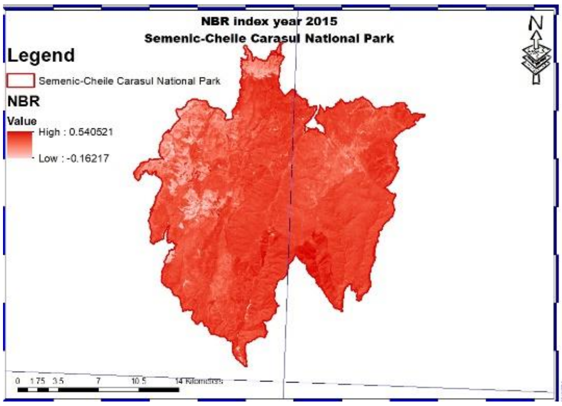


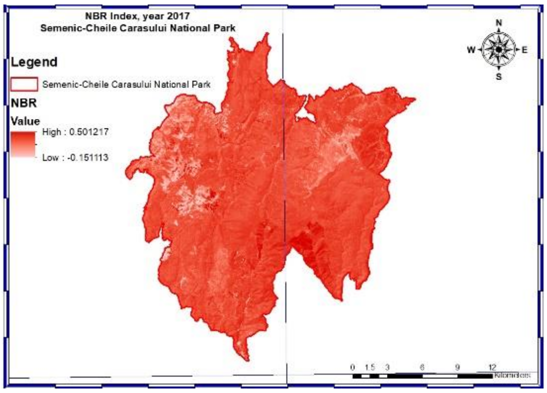
Figure 2. NDVI index

By calculating the NDVI index, it can be seen that the vegetation in 2015 is much healthier than the following years.

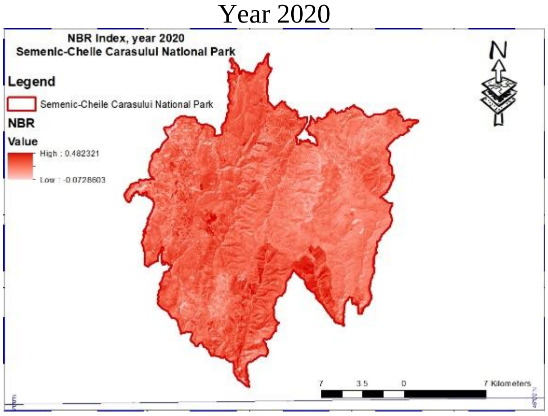
Year 2015



Year 2017



Year 2020



Year 2022

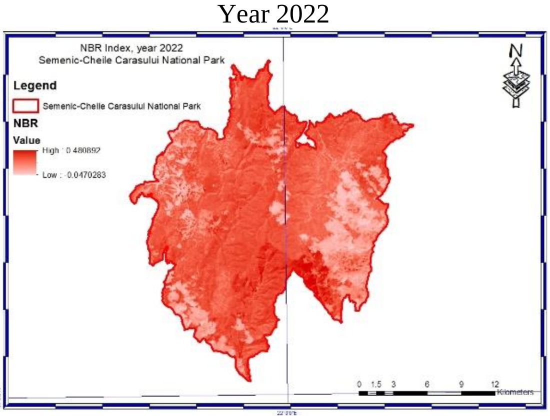
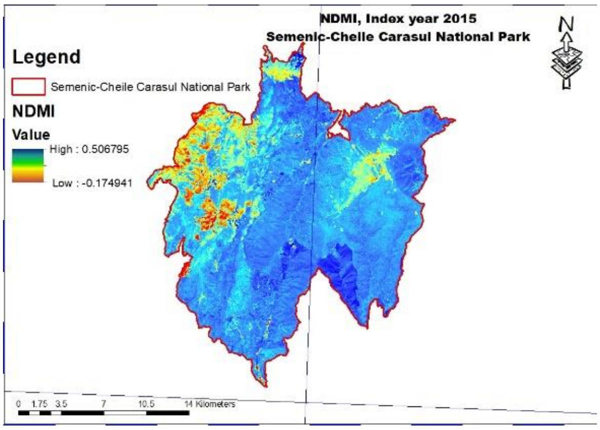
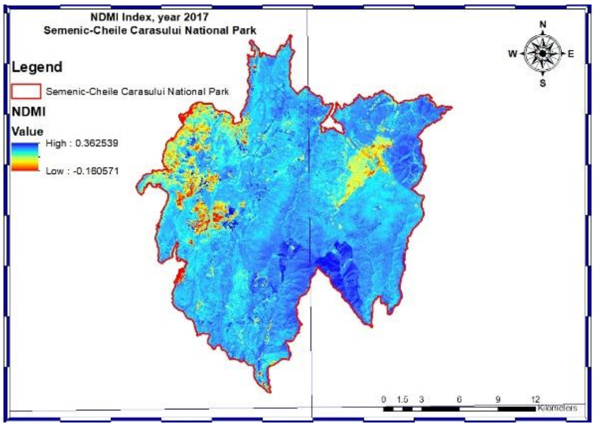


Figure 3. NBR index

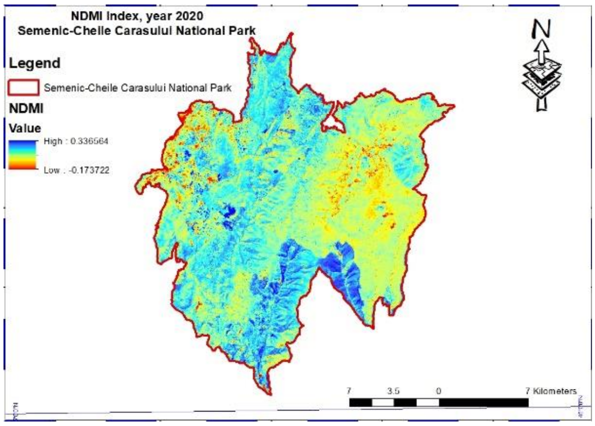
Year 2015



Year 2017



Year 2020



Year 2022

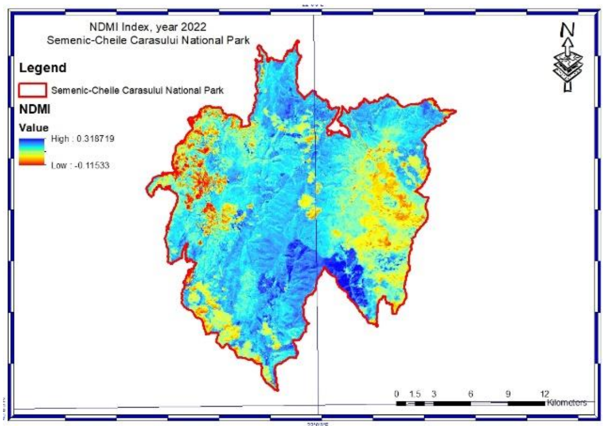
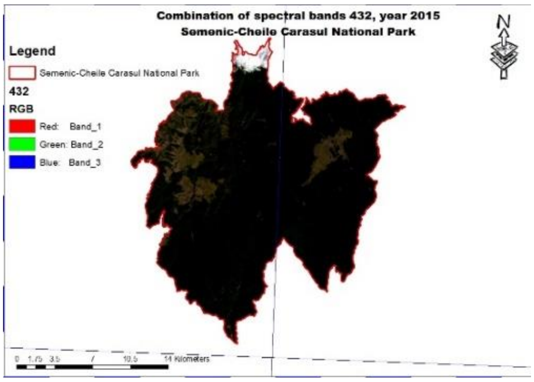


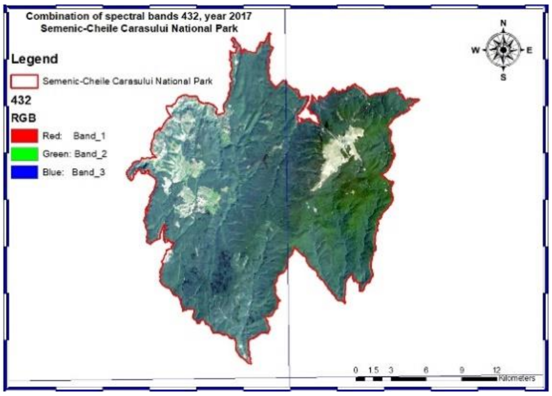
Figure 4. NDMI index

Considering the rainfall recorded in 2022 (76-125mm), it can be seen that there is no water stress on the studied area.

Year 2015



Year 2017



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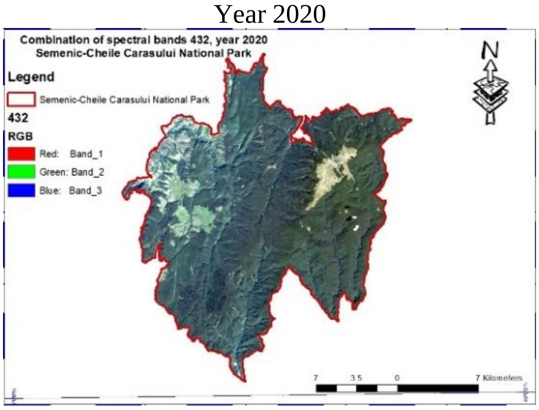

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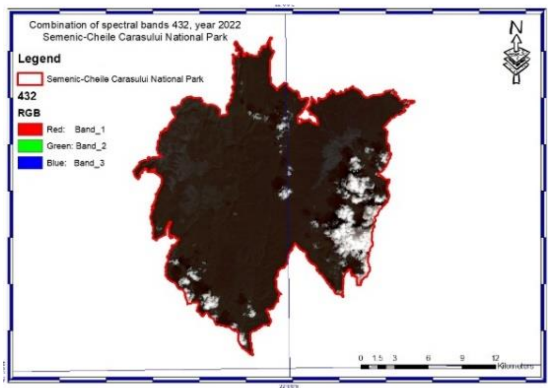
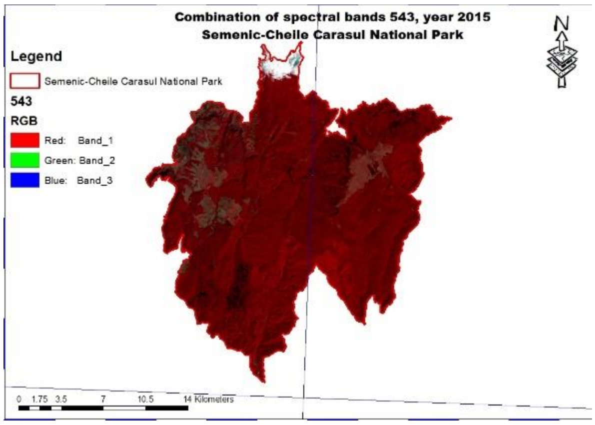


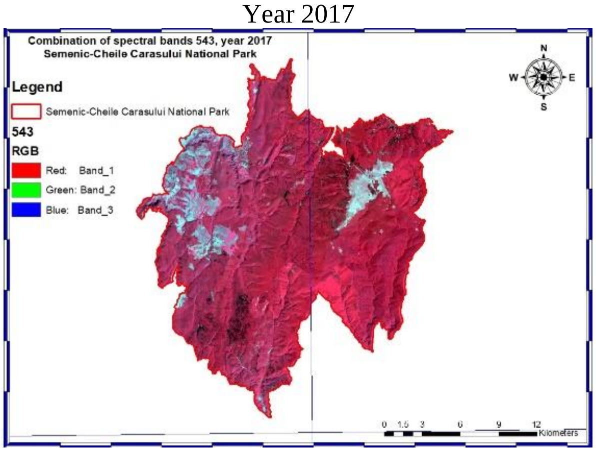
Figure 5. Combination of spectral bands 432

Red (4), green (3), and blue (2) make up the band combination used in the natural color composite. It closely resembles what our eyes can see. Green denotes healthy vegetation, whereas brown denotes unhealthy flora. Water is either dark blue or black, and urban characteristics are white and grey. Natural Color is used to represent an image in natural colour and therefore best approaches the appearance of the landscape in reality. Band 3 detects chlorophyll absorption in vegetation (thus low reflection). Band 2 detects the green reflectance from vegetation. Band 1 is more suited for penetration in water, in clear water this can be some 25 meters. On the other hand one can also derive information about sediment transportation in water from this band. Band 1 also differentiates between soil and vegetation and distinguishes forest types. These bands, which have a vivid green appearance, are helpful for monitoring agricultural crops. Uncultivated vegetation appears as more muted tones of green and bare dirt appears as a magenta colour.

Year 2015



Year 2017



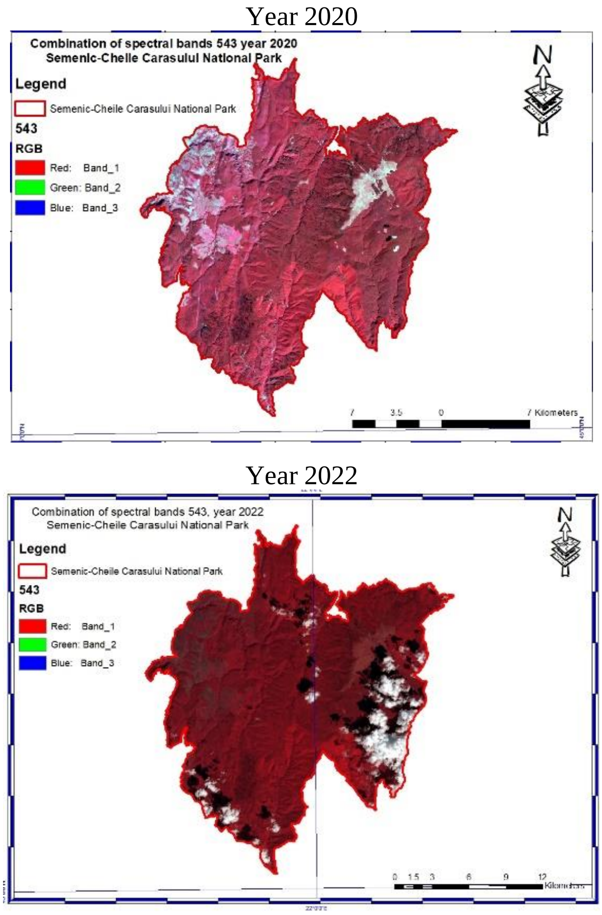


Figure 6. Combination of spectral bands 543

The term "near-infrared (NIR) composite" is also used to refer to this band combination. It employs red (4), green (5), and near-infrared (3). While near-infrared light is reflected by chlorophyll, this band composition is helpful for examining plants. Particularly, the reddish regions have healthier vegetation. Water is in the dark, and cities are white.

Bands 5, 4, and 3 are falsely colored crimson, green, and blue, respectively, while band 5 is blue. Coniferous forests are depicted in darker red or even brown than deciduous forests, whereas plantations are indicated by the color red. Urban areas are indicated by the color green-blue, while water bodies are near to the color black.

The outcomes of this band combination are comparable to those of conventional color infrared aerial photography. This band combination is helpful for crop growth stages, drainage and soil pattern monitoring, and vegetation studies.

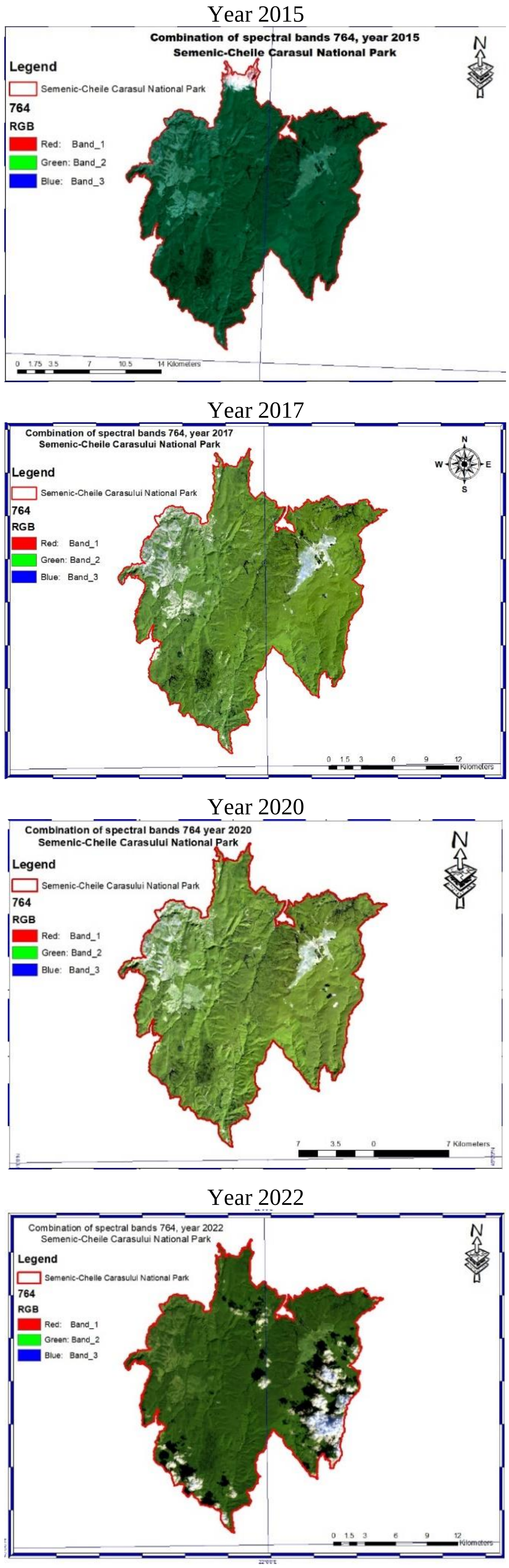


Figure 7. Combination of spectral bands 764

Red, SWIR-1, and SWIR-2 are the components of the short-wave infrared band combination (4). Green hues can be seen throughout the plants in this composite. Denser vegetation is represented by darker shades of green, whilst sparse vegetation is represented by lighter hues. While soils have varying tones of brown, urban areas are blue.
For this band, vegetation appears in shades of dark and light during the growing season, and urban features are white, grey, cyan or purple. Snow and ice appear as dark blue.
This band combination on Landsat 8 uses both of the SWIR bands, which results in a sharper image than band combinations that use shorter wavelength bands, which are more prone to haze.

CONCLUSIONS

Remote sensing data is very valuable in mountain environments due to the ability to a extrapolate the information gathered from detailed surveys into accessible areas in large regions inaccessible, thus allowing us to fill the substantial knowledge gaps we have about the pattern and rate of vegetation change in such areas. regions. Classification of images by remote sensing commonly uses data from pixel values where the ecological situation on terrain is well known to establish a rule or a set of rules to extrapolate pixels which appear spectrally similar.
The method provides useful information for the general management of the area, works specific, warnings, or the development of objectives of interest, such as the ski area.
The information obtained can be corroborated with data and weather information to make some methods and models of information and forecasting for the studied area, regarding certain moments risk (floods, avalanches, etc.), monitoring, or development.
Remote sensing monitoring can provide essential information for the efficient, transparent, repeatable and defensible decision making in ecological systems. Remote sensing has unique advantages in monitoring the landscape dynamics in the world.
To investigate the studied area in more detail, several combinations of spectral bands can be analyzed, as well as an analysis of land cover classes (Corine Land Cover).
Thus, GIS has an important role in improving the digital processing of images in areas mountains.

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