

## Using GIS technology in processing and analyzing satellite images – case study Cheile Nerei Beusnița National Park, Romania

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**Abstract** Satellite images, as objective representation of the earth's crust, represent the basis for analysis and classification of the reality from the field in real time or for storage of information in digital format. The purpose of this study is the analysis and classification of the land from National Park Cheile Nerei Beusnița, Romania, based on satellite images and GIS technology. Analysis and classification of the land corresponding to the reference area was based on satellite images Landsat 8. Processing and analysis of the images was performed using ArcGIS software, by means of two algorithms, ISO Data and K Means, with a variation in the number of iterations in order to evaluate the precision of the analysis process. In order to characterize the reference area we used the combination of spectral bands 432 (RED-GREEN-BLUE) and for analyzing and classifying the land, the band combination 543 (NIR-RED-GREEN) was chosen. By analyzing the satellite images based on the two algorithms, the results obtained were close regarding the size of the land surfaces according to the 7 user-defined classes. Under the conditions of a change in the number of classes, by defining a higher number, or by arbitrary classification without operator intervention, when achieving a complete classification based on digital information found in the base image, significant differences started to appear between results. At the same time by increasing the number of iterations, we recorded an increase in the analysis and classification accuracy while significantly increasing working time.

### Key words

GIS, Landsat 8, spectral bands, IsoData, K Means, classification

Research regarding the land surface from airspace and outer space with the help of remote sensing and imaging techniques enable the delivery of valuable information for many industries, including agriculture, archeology, mapping, prospecting and evaluating natural resources, environmental monitoring (soil, water and air) and others Wenb et al., 2008; Ungur 2010, Maican et al., 2011; Meliadis and Meliadis 2011; Sala et al., 2013, Herbei et al., 2014a, Sala et al., 2014.

The results obtained through the techniques of recording, transmission, processing and interpretation of remote sensing data are of particular value, and they are leading to new ways of investigation in the science of terrestrial measurements, as well as in other fields of activity Kumar 2004; Gitas et al., 2009, Herbei et al., 2014b.

Remote sensing images contain a large amount of information useful in various scientific and

practical domains, and to be able to benefit from this information correctly and completely, it is necessary to deepen the analysis and interpretation techniques, Borsan et al., 2013.

In order to overcome the difficulties of interpretation imposed by color tones, it is strongly recommended to use combinations of spectral bands, like the images in natural colors or false-colored images (conventional colors require reporting to a "color atlas"). Choosing the optimal combination is based on user needs, the requirements of the study, level of detail, moment of time, etc. If a multispectral image consists of a combination of the three additive colors, then the three bands can be combined in a natural color image. The colors of the color-compound image resulted are similar to those perceived by the human eye, but in the case of false-colored images, the color displayed by the objective has no resemblance to its actual color (17).

In 1972 NASA launched the first civilian program specialized in acquiring digital satellite remote sensing data, the first system being originally named ERTS (Earth Resources Technology Satellite) and then called Landsat (18).

Landsat satellite images signify perhaps the most important episode in the history of remote sensing and Earth observation. Between 26 July 1972 and 18 November 2011, the missions of the six satellites, have produced an impressive archive, considering that the registration of the same areas (satellite scene) was performed every 19 days (the first satellites) and 16 days (Landsat 5 and Landsat 7 satellites), Figure 1, (19).

The sensors used (optical, and from Landsat 5, optical and infrared thermal) have produced images of medium spatial resolution (eg. 30 m multispectral, 15

m in panchromatic and 60 m in infrared thermal, for the sensors on Landsat 7 ETM+). The main advantage of these images is the remarkable spectral resolution, allowing many combinations and especially, valuable digital analysis possibilities with the help of specialized software packages. After 2013 the project was initiated LDCM (Landsat Data Continuity Mission) by placing Landsat 8 in the orbit.

Based on the facilities offered by Landsat 8 system, supported by specialized software and information technology which has an increasing capacity of data processing, and in the context of the need for land areas analysis by providing real-time data and information on categories of use, condition or vegetation dynamics, the present research has studied the area of Nera Beusnita National Park, Romania based on satellite images Landsat 8.

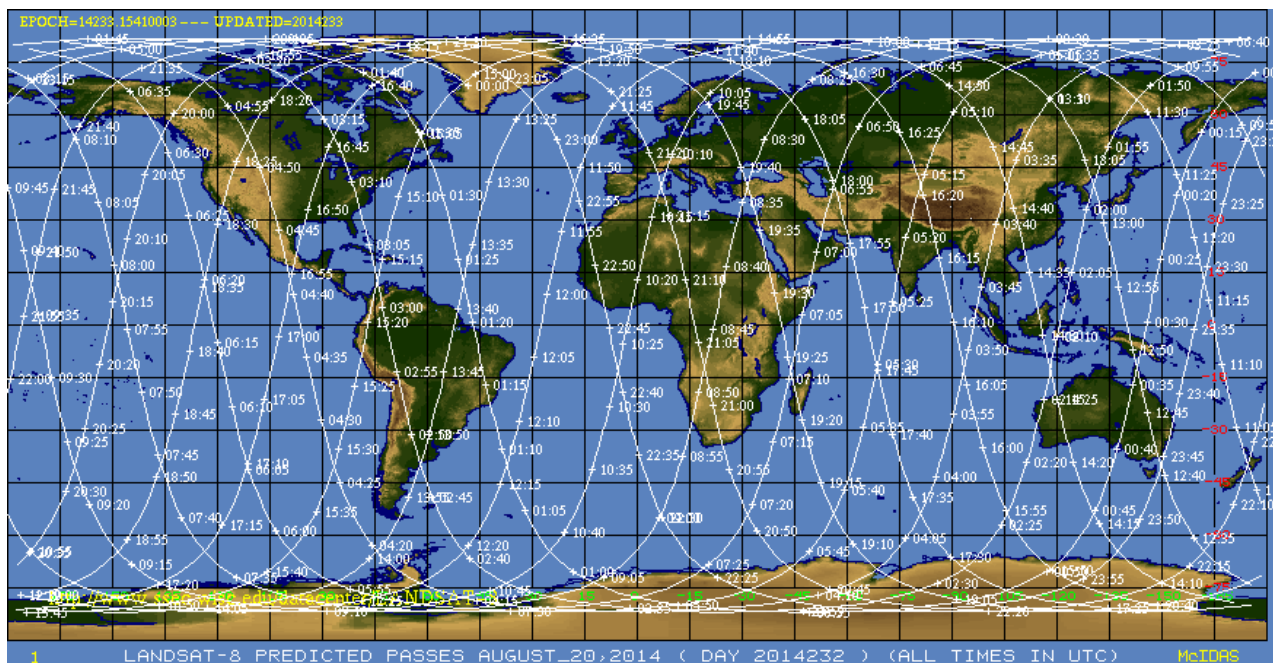


Fig. 1. The orbits of Landsat satellites (16).

## Material and Method

The research aimed to achieve a classification of the land based on the analysis of the Landsat 8 satellite image covering the Nera Beusnita National Park, Romania.

### Location of the studied area

This study, based on GIS technology for processing and analysis of satellite images, aimed Cheile Nerei National Park, having an area of 36.758 hectares, and declared as protected area by Law No.5 of 6 March 2000 (regarding the approval of the Arrangement Plan for national territory - Section III –

protected areas), and since 2003 the limits and surface of the national park have been reestablished. Cheile Nerei Beusnita National Park lies in the south-west side of Caras-Severin county, on the administrative territories of cities Anina and Oravița, and also reaching localities: Bozovici, Cărbunari, Ciclova Română, Lăpușnicu Mare, Sasca Montană and Șopotu Nou, and it is crossed by national road DN57B which links the city Oravița to the village Bozovici, Figure 2.

### Satellite system used

Landsat 8 shows significant differences regarding the wavelengths of spectral bands compared to its predecessor, Landsat 7, thus resulting different

combinations of spectral bands having additional facilities. LANDSAT spectral bands and their

properties, specifically the wavelength and resolution, are shown in Table 1.

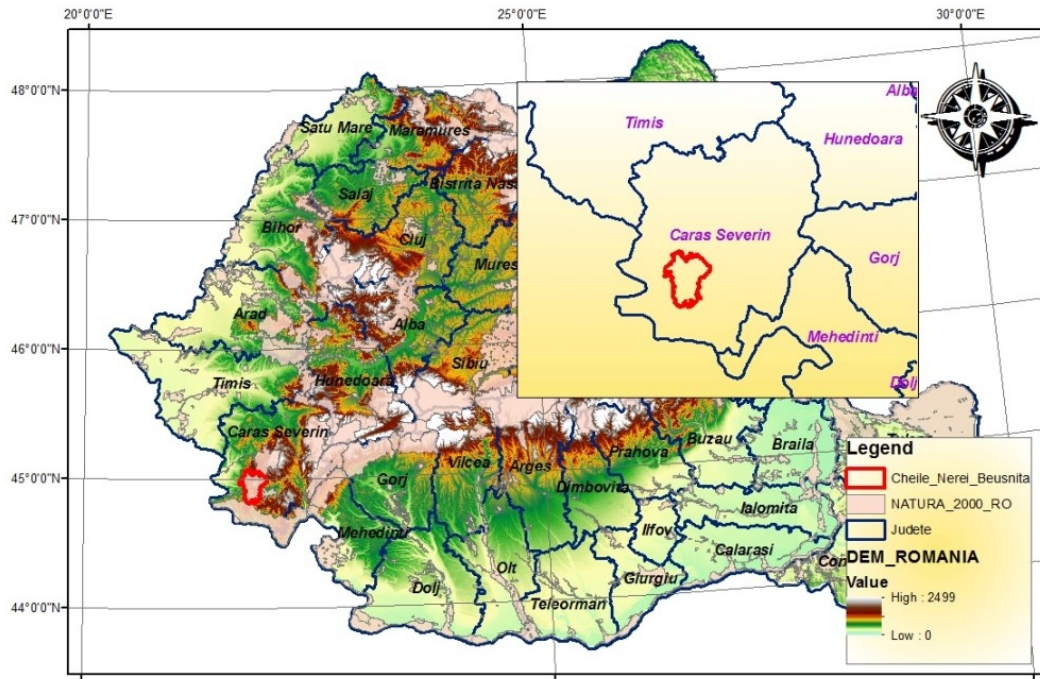


Fig. 2 Location of Cheile Nerei National Park – Beusnita, Romania.

Table 1

Spectral bands description – Landsat 8

No.	Band	Wavelengths ( mm)	Pixel resolution
Band 1	Coastal	0.43-0.45	30
Band 2	Blue	0.45-0.51	30
Band 3	Green	0.53-0.59	30
Band 4	Red	0.64-0.67	30
Band 5	NIR	0.85-0.88	30
Band 6	SWIR 1	1.57-1.65	30
Band 7	SWIR 2	2.11-2.29	30
Band 8	Pan	0.50-0.68	15
Band 9	Cirrus	1.36-1.38	30
Band 10	TIRS 1	10.6-11.19	100
Band 11	TIRS 2	11.5-12.51	100

### Characteristics of satellite images used

For this application we used a Landsat 8 satellite image from 2014 which covers the entire surface of the National Park Cheile Nerei-Beusnita, Romania, Fig.3.

The satellite image together with the spectral bands was downloaded from the database Earth Explorer (20) and it was subjected to complex mathematical operations in the digital environment, in order to extract geographic information.

Each Landsat 8 satellite image which is taken from the international database Earth Explorer contains

a set of standard parameters showing the properties of the image acquired, useful in the analysis: type and format of the image (Level 1T -terrain corrected, GeoTIFF), rezolutia (15 meters /30 meters /100 meters, panchromatic/ multispectral/ thermal), map projection (UTM - Polar Stereographic for Antarctica), geodetic datum (WGS 84, North-up map; Cubic convolution), precision (OLI OLI: 12 meters circular error, 90-percent confidence; TIRS: 41 meters circular error, 90-percent confidence) etc.

Landsat 8 satellite image acquired for the studied area, in addition to standard parameters



presented above also includes some specific features, namely: filename LC81850292014233LGN00; LC8 (Landsat 8 satellite and sensor); 185 (orbit), 029 (string) from the International reference system WRS-2; 2014 Year of acquiry; 233 number of the day when

the image was taken in 2014 (2014-21-08); LGN00 ground station ID from which the signal was captured becoming the image and version of the product (00 signifies basic image).

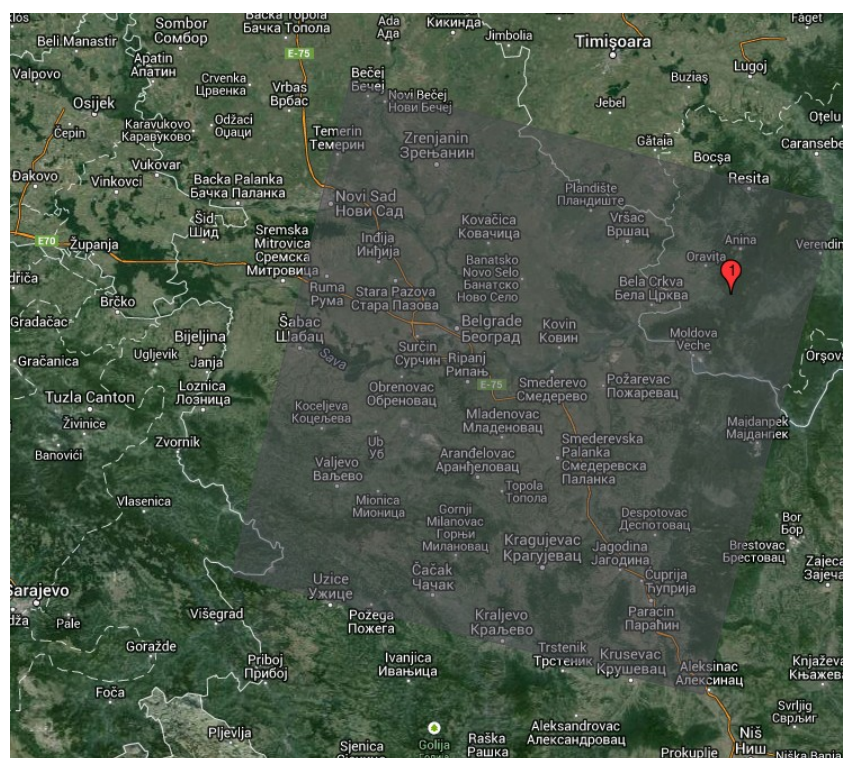


Fig. 3 Acquired satellite image Landsat 8 (21.08.2014)

### ***The classification of satellite images***

Image classification represents the grouping of pixels which build the digital image, depending on the spectral response, under the form of classes of the land based on geographic information contained in each pixel constituting the image, in this studio being used K-Means and ISO DATA algorithms.

Both algorithms allow digital image analysis and classification of land in a number of user-defined classes, or can perform independent analysis until the exhaustion of the information from the database of images by generating a random number of classes. For each algorithm, the number of iterations was varied in order to check the accuracy and working time.

### **Results**

In the case of Landsat 8 images, some of the most used remote sensing images, many combinations of spectral bands can be made, Table 2, but much fewer combinations have a practical use. In the present research the following combinations were studied: 432 - Natural colour, 764 - False Colour, 543 - Colour IR, 652 - Agriculture (Basic Farming), 765 - Atmospheric Penetration, 562 - Vegetation Health, 564 - Land and

water, 753 - Land (Athmospheric Removal), 754 - SWIR Bands useful in various fields.

Typically for the remote sensing analyzes, there are used standard combinations of spectral bands adapted to the themes pursued. Based on the spectral information which build Landsat 8 satellite image corresponding to the studied area, several combinations of spectral bands were made using ArcGIS software (432, 764, 543, 652, 765, 562, 564, 753 and 754), particular interest in this study showing combinations 432 and 543.

Therefore, in this study we used combinations of spectral bands 4-3-2 (REED - GREEN - BLUE) and 5-4-3 (NIR - REED - GREEN) which facilitated useful information on land classification based on the analysis of satellite images through GIS technology.

In Figure 4 is shown the combination of spectral bands 4-3-2 (RGB) of the studied area, in this model each color is represented using primary spectral components red, green and blue.

The combination of spectral bands useful in the study of vegetation, remote sensing analysis and delineation of the built space from the one covered with vegetation used in classification of the study area was the combination 543, the resulting image (Figure

4) can be interpreted as follows: deep red - deciduous forests; Light red - green meadows and grassy farmland; dark green-black - conifer forests; blue-green

light - land with soil up to date; green - excessively humid lands; blue - minor beds of rivers and lakes.

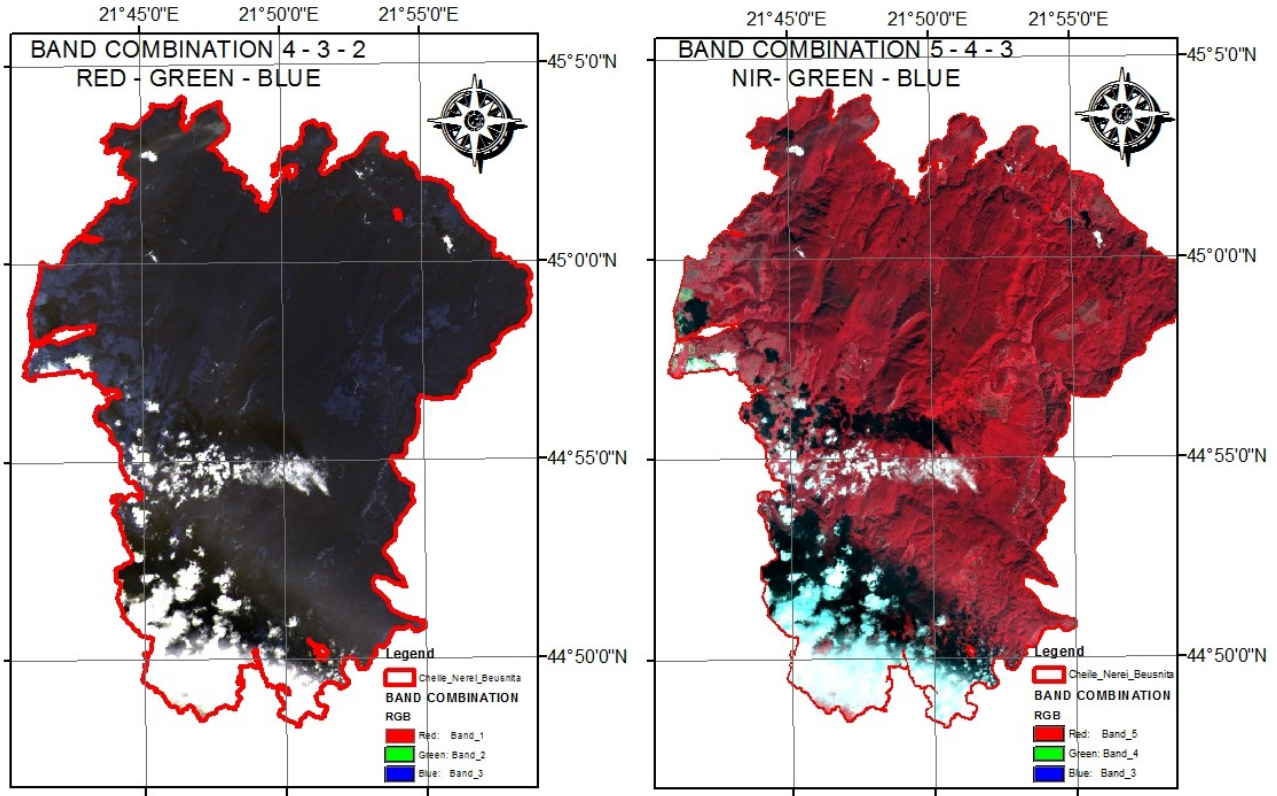


Fig. 4 Combinations of spectral bands

The image obtained according to the combinations of spectral bands 543 (NIR - RED - GREEN), useful in the study of vegetation, remote sensing analysis and delineation of the built space of the one covered with vegetation, was subjected to unsupervised classification process based on two algorithms, algorithm ISODATA – 1 iteration and algorithm K-Means - 3 iterations, results are presented in Table 1, the graphical representation in Figure 5.

In the present paper unsupervised classification method was used, based on the 2 different algorithms, K-MEANS and ISO DATA, with a high degree of safety in the analysis of satellite images, Akgün et al., 2004. ISO DATA algorithm developed by Geoffrey and Hall (1965) uses the minimum spectral distance formula for cluster formation and grouping, based on the equation for the Euclidean distance (Swain and Davis, 1978; Melesse and Jordan, 2002), equation (1).

$$SD_{xyc} = \sqrt{\sum_{i=1}^n (\mu_{ci} - X_{xyi})^2} \quad (1)$$

where:  $n$  - number of bands

$i$  - band number;

$c$  - particular class

$X_{xyi}$  - data file value of pixel  $x, y$  in band  $i$ ;

$\mu_{ci}$  - mean of data file values (digital numbers) in and  $i$  for the sample the class  $c$ ;

$SD_{xyc}$  - spectral distance from pixels  $x, y$  to the mean of class  $c$ .

Following the classification process K-Means and ISO DATA algorithms show similar results if the user has set the same number of classes in which pixels were grouped according to their characteristics. If the number of classes change, then the results start to be distinct.

The case study in this paper has chosen for a number of 7 classes for the beginning, where the 543 satellite image was classified and the results were similar. The difference between the images obtained after applying the two algorithms appeared when for K-Means algorithm were chosen 3 iterations, thus noticing significant changes (Table 1, Figure 5) even if the number of classes remained the same, their shares being different, confirmation of safety by working with



multiple iterations being confirmed by Fayyad et al, 1998.

Table 2

**Classification of area National Park Cheile Nerei Beusnita based on the combination of spectral bands 543 by unsupervised classification analysis**

ISO DATA ALGORITHM			K MEANS ALGORITHM		
CLASS	TYPE	PERCENT	CLASS	TYPE	PERCENT
1	deciduous forests	43.52	1	deciduous forests	46.43
2	green meadows and grassy farmland	26.33	2	green meadows and grassy farmland	27.11
3	peak	11.15	3	peak	8.84
4	land with soil up to date	6.35	4	land with soil up to date	6.47
5,6	cloud	12.1	5,6	cloud	9.07
7	conifer forests	0.56	7	conifer forests	2.08

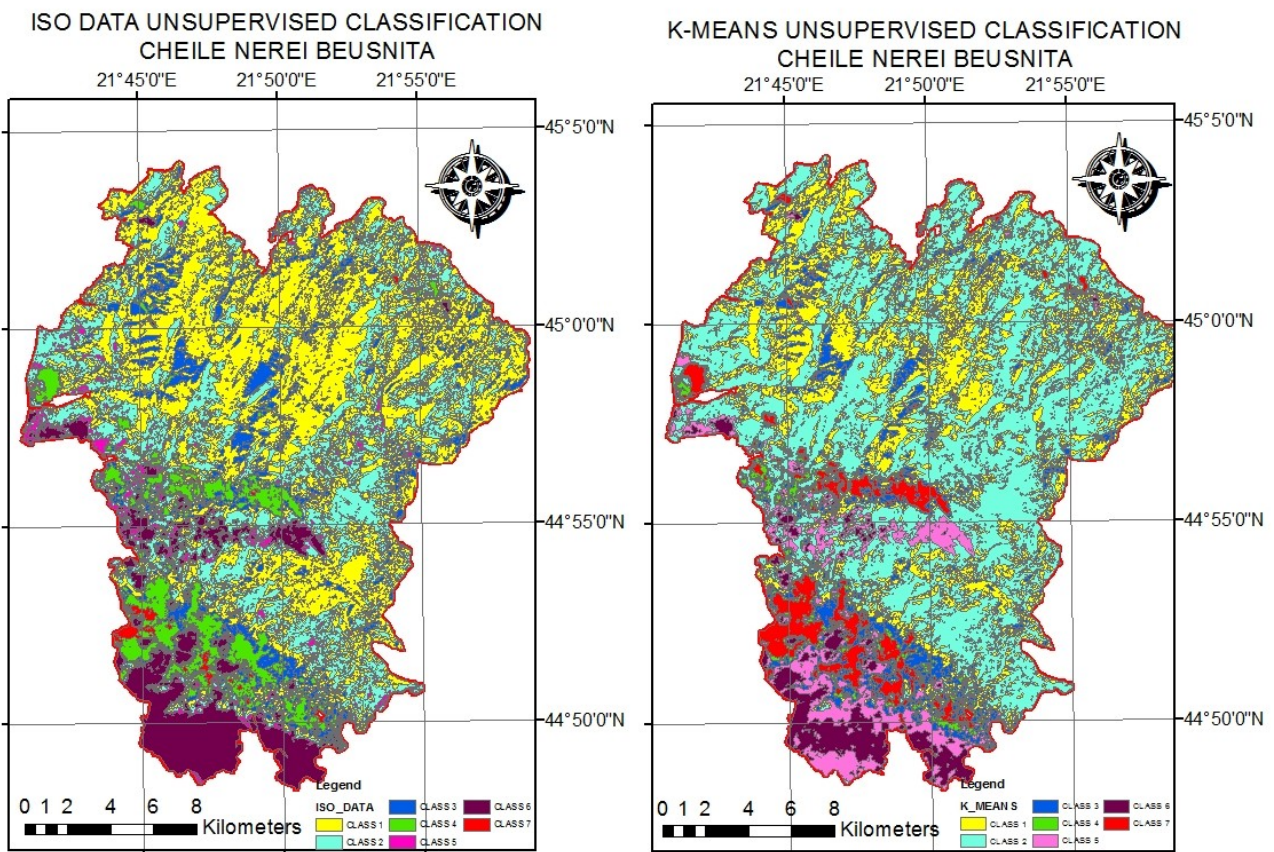


Fig. 5 Unsupervised classification

## Conclusions

GIS technology has facilitated the analysis and classification of land in the area Cheile Nerei Beusnita National Park, Romania based on LandSat 8 satellite images.

K-Means algorithms and ISO Data generated similar results in the analysis on the satellite image, also registering a higher accuracy in classification of land according to the number of iterations used. As a

result of significantly longer time in data processing when using a larger number of iterations, for general purpose, informative, there may be used 1-3 iterations without significant loss of information.

Based on the initial data, the combination of spectral bands 4.3.2. enabled the acquiry of RGB images and the combination 5.4.3 facilitated the study of vegetation and land classification.

Both ISO DATA algorithm and K-MEANS have close values for the share of land categories

within the 7 user-defined classes, with a slight variation in the share of territory within the generated classes. If the number of classes change, the results are beginning to be distinct.

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