

The use of satellite images in agriculture, forestry and horticulture. Reflective indices.

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Abstract The digitization of traditional fields and smart agriculture have become normality. The use of computer systems together with electronic sensors to monitor plants in order to streamline irrigation and fertilization processes is an important step in the implementation of intelligent agriculture. Given that the sectors "Food and agriculture" and "Water, forests and environment" are part of the critical infrastructure of the state, the training of the staff and the continuous professional training throughout the entire life is absolutely necessary for all those who work in these fields. Regardless of the level of development of organizations, the monitoring of crops, waters and vegetation is always appropriate and can contribute to the efficiency of the processes specific to these important fields of activity. For this study we used satellite images of the Copernicus space missions. This program belongs to the European Commission in collaboration with the European Space Agency. The program consists of launching constellations of satellites called Sentinel. There are 6 missions, each offering various services, from radar images, climate monitoring, various topographical instruments, to multispectral images for monitoring vegetation, atmosphere, water and soil. The images of the Sentinel 2A mission are taken at wavelengths 442.7; 492.4; 559.8; 664.6; 704.1; 740.5; 782.8; 832.8; 864.7; 945.1; 1373.5; 1613.7; 2202.4 nm. These resolutions are suitable for the analysis of large areas of vegetation.

Key words

sensor, monitoring, reflectance index, geographic information system, sentinel 2.

Sensor: is a device that can measure and transform a physical quantity into a signal that can be read or interpreted.

Monitoring: supervision of parameters, specific to plants in our case, which are to be analyzed and generate conclusions about plants.

Reflectance vegetation Indices: combinations of surface reflectance at two or more wavelengths designed to highlight a particular property of vegetation.

Geographic Information System: is a computer system that analyzes and displays geographically referenced information.

Sentinel 2: is a constellation of two polar orbiting satellites. It aims to monitor the conditions of the earth's surface. It provides free multi-visual images on 13 wavelengths from Blue-Purple to SWIR with resolution between 10 and 60 meters.

Material and Method

The main materials used in this project are presented below, along with a very brief description. In the study it was necessary to use well-established and well-documented algorithms for analyzing images.

List of materials

Hardware list:

1. A computer in which the images made available by the European Space Agency have been stored and on which the computer program for processing these images also runs.
2. Internet connection for downloading images and processing software.

Software list:

1. The QGIS image processing software presented below (Fig. 1)

This software has many image processing facilities and is free.

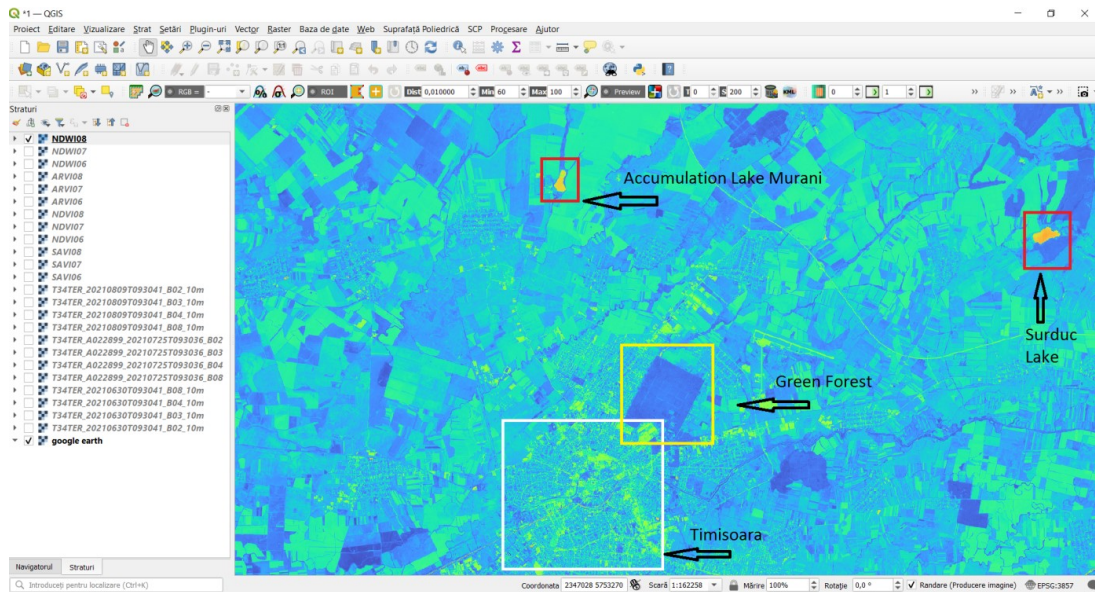


Fig. 1. QGIS software (original)

Material for the study: satellite images taken at different wavelengths and time intervals, representing agricultural fields located near our university.

Some examples in the pictures below (Fig.2 - Fig.4)



Fig. 2. Image 800nm 2021 iunie 30 from Sentinel 2(original)



Fig. 3. Image 800nm 2021 iulie 25 from Sentinel 2(original)



Fig. 4. Image 800nm 2021 august 09 from Sentinel 2 (original)

Necessary knowledge:

1. Average notions of computer equipment use.
2. Knowledge of using the image processing program (QGIS).
3. Getting into plant physiology to know the wavelengths reflected from the leaves of the chosen crops.
4. Knowledge about reflective indices used in the study of vegetation and their practical interpretation.

Research methods

1. From the beginning I started from the idea of trying to validate the solution of using free platforms and multispectral satellite images in field research. The aim is not to replace fieldwork, but to provide reasonable and documented guidance on geographic areas with potential crop problems and to guide field teams in those areas for a real investigation of the existing situation.
2. After the documentation phase on the chosen topic and the technical documentation in order to achieve the image processing, I have a geographical location for its analysis and to draw some conclusions.
3. Multispectral images of the chosen area were used. Images with a resolution of 10 meters and wavelengths of 832nm (band 8 NIR), 670nm (band 4 RED), 559.8nm (band 3 GREEN), 492nm (band 2 BLUE) were used.
4. Images of the same area were analyzed in June, July and August respectively 30 June, 25 July and 09 August of the current year, between 09:30-09:40 UTC.
5. The following reflection indices have been chosen:

- Normalized Difference Vegetation Index (NDVI)

The index measures the health of green vegetation, based on how plants reflect light at different wavelengths. The range of values is from -1 to 1. Negative values close to -1 correspond to water. Values close to 0 (-0.1 to +0.1) correspond to areas of rock, sand and snow in winter. The values between 0.2 and 0.4

correspond to pastures and shrubs and the high values represent forests. In our pictures -1 is represented by white and 1 by dark green.

Implementation formula $NDVI = \frac{NIR-RED}{NIR+RED}$

- Soil Adjusted Vegetation Index (SAVI)

The index was designed to minimize the influences of soil brightness (given by soil color, soil moisture, soil variability throughout the region) by adding an L adjustment factor to the NDVI formula. In the case of regions with large green vegetation L=0. In the case of areas with low vegetation L=1 such as young crops with exposed soil surfaces. For general situations, L=0.5 is used.

Implementation formula $SAVI = \frac{NIR-RED}{NIR+RED+L} (1+L)$,
unde L = 0.5

- Atmospherically Resistant Vegetation Index (ARVI)

The index corrects NDVI against the influence of atmospheric factors such as pollution, fog, smoke, rain, soot. It is also more robust to the topographic effects. Use infrared, red and blue wavelengths. In the images in project 1 it is represented by dark green and -1 is represented by white.

Implementation formula $ARVI = \frac{NIR-(2*RED)+BLUE}{NIR+(2*RED)+BLUE}$

- Normalized Difference Water Index (NDWI green-red)

It is used to monitor changes in the amount of water in water bodies. Uses green and infrared tape. The vegetation has values less than 0.5 and the water bodies more than 0.5. In the images contained in the project 1 it is represented by red and -1 is represented by dark blue. The index was proposed by McFeeters, 1996.

Implementation formula $NDWI = \frac{GREEN-RED}{GREEN+RED}$

6. In the program of image analysis, the algorithms corresponding to the studied indices have been implemented.

7. The generated images are displayed in discrete values for a better perception of the differences.
 8. The images resulted from the processing according to the chosen indexes were generated and conclusions were drawn.
 The area chosen for the study is represented by the coordinates:

21.175288 N, 45.803734 E;
 21.227197 N, 45.803787 E;
 21.227081 N, 45.781953 E;
 21.175249 N, 45.781926 E;
 The aerial overview of the area is shown in the image below (Fig.5).

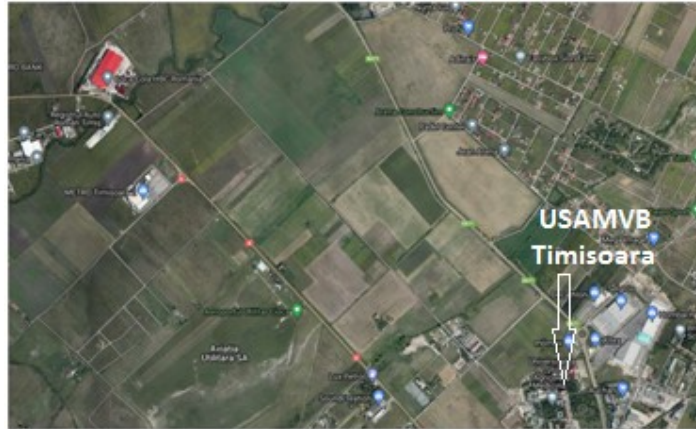


Fig. 5. Selected area (source Google Earth)

Results and Discussions

Reflectance measurements

I believe that the use of this method can be extremely useful to all those involved in monitoring crops and vegetation in general, in forestry but also horticulture on large areas. The facilities made available free of charge by the European Space Agency and the

possibility to use software at no cost make the method extremely approachable. After processing the satellite images by applying the specific processing formulas to each chosen index, we obtained the following results, presented in the images below (Fig. 6 - Fig.18)

1. For Normalized Difference Vegetation Index (NDVI)



NDVI

Interpretation:

Values close to -1 correspond to water.
 The values close between -0.1 and 0.1 correspond to the areas of rock, sand.
 Values between 0.2 and 0.4 correspond to pastures and shrubs.
 Values higher than 0.5 represent forests or high vegetation density.



Fig. 6. NDVI processing result 2021 June 30 (original)



Fig.7. NDVI processing result 2021 July 25 (original)



Fig.8. NDVI processing result 2021 August 09 (original)

For Soil Adjusted Vegetation Index (SAVI)



SAVI

Interpretation:

The dark areas represent harvested, uncultivated land and in a few places arid land. In the urban area of the image, the dark shade represents buildings. Light-colored areas represent dense vegetation.



Fig. 9. SAVI processing result 2021 June 30 (original)



Fig. 10. SAVI processing result 2021 July 25 (original)



Fig. 11. SAVI processing result 2021 August 09 (original)

For Atmospherically Resistant Vegetation Index (ARVI)



ARVI

Interpretation:
 There is a greater difference between the shades of the image compared to NDVI, due to the index's resistentness to atmospheric factors.



Fig. 12, ARVI processing result 2021 June 30 (original)



Fig. 13. ARVI processing result 2021 July 25 (original)



Fig. 14. ARVI processing result 2021 August 09 (original)

For Normalized Difference Water Index (NDWI)



NDWI

Interpretation:

The various shades of dark blue represent dense vegetation or trees. Shades of light blue represent harvested, uncultivated or arid land.

Shades of yellow represent buildings or concrete areas.

In the last picture, the reddish areas represent lakes or water accumulations.



Fig. 15. NDWI processing result 2021 June 30 (original)



Fig. 16. NDWI processing result 2021 July 25 (original)



Fig. 17. NDWI processing result 2021 August 09 (original)

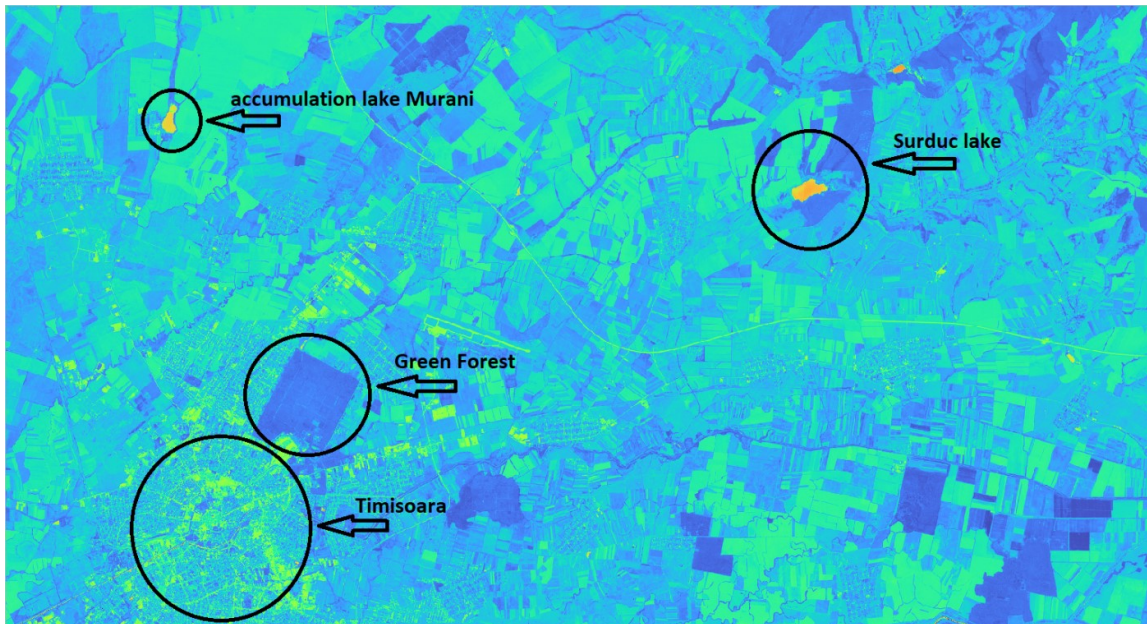


Fig. 18. NDWI representation of water accumulation(orange-red), forest(blue) and city buildings(yellow) (original)

Conclusions

Following the study, we came to the conclusion that the use of multispectral satellite images is especially useful in the case of combining images belonging to different spectra. The method is easily applicable to large areas of land, forests, large orchards and vegetable growing on large areas. For small areas of land the method is usable by using high resolution satellite images. They can be accessed for a fee from specialized operators. Analysis using reflective indices contributes to the improvement of the performance in plant growth and the study of vegetation, is feasible and easily accessible in practice regardless of the size of the economic operator. The necessary knowledge, at least for the image processing part, are of medium level, the method being able to be approached by most companies. For the practical interpretation of the vegetation reflection indices, a volume of study is required that cannot be ignored. As a measure of improvement I believe that it is necessary to correlate and validate the data obtained by processing satellite images with measurements and field verifications, in this way the method can be greatly improved. In the case of working with very large areas such as those found in forestry, the classification of image elements according to certain criteria and subsequent recognition cannot be ignored as a practical utility.

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