THE USE OF GEOMATICS TECHNOLOGIES IN MONITORING THE EARTH'S SURFACE COVER

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Abstract. *Remote sensing is a technical field that deals with the process of detection, measurement, recording and visualization in the form of images, of electromagnetic radiation, emitted by objects and phenomena on Earth or in the Universe, from a distance, without having direct contact with them. The present research had as main objective the study of agricultural land based on the spectral information obtained from satellite images, the study area being within the Experimental Didactic Station of the BUASMV Timisoara. The purpose of this paper is to highlight the efficiency of remote sensing, satellite technologies, regarding the acquisition of data from the Earth`s surface and their interpretation, so that the obtained results serve as many fields of activity as possible. In order to reach the research objectives, the Sentinel 2 remote sensing system was used, the images being downloaded from the portal www.planet.com. The remote sensing mission – Sentinel 2 has: Multi-spectral data with 13 bands in the visible spectrum, near infrared and the one with the IR short wave of the electromagnetic spectrum; with global coverage of the land between the following coordinates: 56° S to 84° N, coastal and Mediterranean Sea; The review is every 5 days from the same viewing angles. In some parts, where the latitudes is high, Sentinel-2 overlaps, and some parts of the land will be observed twice or more every 5 days, with different viewing angles; the spatial resolution is 10 m, 20 m and 60 m and the field of view is 290 km The use of vegetation indices in the field of precision agriculture represents a new and of great interest for an adequate management of agricultural crops. In recent years, various studies have aimed at correlating vegetation, soil or water indices, calculated from remote sensing images, from drones or from the camera with data collected from the ground in order to increase agricultural productivity.*

Key words*: GIS, monitoring, Remote sensing soil agricultural crops*

INTRODUCTION

Remote sensing is the technical field that deals with the detection, measurement, recording and visualization (HERBEI et al., 2014 in the form of images (HALOIU et al., 2019), of electromagnetic radiation, emitted by objects and phenomena on Earth or in the Universe, from a distance, without having direct contact with them (HERBEI and SALA, 2014).

Remote sensing, regardless of the nature of the applications, passive or active (HERBEI and SALA, 2015), uses the electromagnetic radiation to obtain the images of the bodies from a certain altitude (plane, satellite, balloon, helicopter) because in this way, the image can be used in obtaining maps and planes (UNGUR et al., 2016), and object interpretation is optimal and easy.

The use of vegetation indices in the field of precision agriculture (HERBEI et al., 2015a, HERBEI et al., 2015b) represents a new and of great interest for an adequate management of agricultural crops. In recent years, various studies have aimed at correlating vegetation, soil or water indices, calculated from remote sensing images, from drones or from the camera with data collected from the ground in order to increase agricultural productivity (HERBEI et al., 2018).

This work had as main objective the study of agricultural parcels within the Experimental Teaching Station within BUASMV Timisoara based on the remote sensing images produced by the European Sentinel 2 system and based on vegetation, soil (RAWASHDEH and SALA, 2016) and water indices currently used in such studies (Sentinel 2 Handbook).

The satellite images were processed using specialized software, namely ArcGIS Pro. Image acquisition date is May 27, 2017 (HERBEI et al., 2018).

The purpose of this paper is to highlight the efficiency of remote sensing, satellite technologies, regarding the acquisition of data from the Earth`s surface and their interpretation, so that the obtained results serve as many fields of activity as possible (RAWASHDEH and SALA, 2014, RAWASHDEH and SALA, 2015).

MATERIAL AND METHODS

Sentinel 2 remote sensing system. The remote sensing mission – Sentinel 2 has: Multi-spectral data with 13 bands in the visible spectrum, near infrared and the one with the IR short wave of the electromagnetic spectrum; with global coverage of the land between the following coordinates: 56° S to 84° N, coastal and Mediterranean Sea; The review is every 5 days from the same viewing angles (DRUSCH et al., 2012).

Table 1.

Spectral bands - SENTINEL 2

SENTINEL 2- bands	Wavelength (nm)	Resolution (m / pixel)	Bandwidth (nm)
Band 1 Coastal spray	0.443	60	20
Band 2 Blue	0.490	10	65
Band 3 Green	0.560	10	35
Band 4 Red	0.665	10	30
Band 5 Red margin of vegetation	0.705	20	15
Band 6 Red edge of vegetation	0.740	20	15
Band 7 Red margin of vegetation	0.783	20	20
Band 8 NIR	0.842	10	115
Band 8A Near Infrared (Narrow NIR)	0.865	20	20
Band 9 Water vapor	0.943	60	20
Band 10 SWIR - Cirrus	1.375	60	20
Band 11 SWIR	1.610	20	90
Band 12 SWIR	2.190	20	180

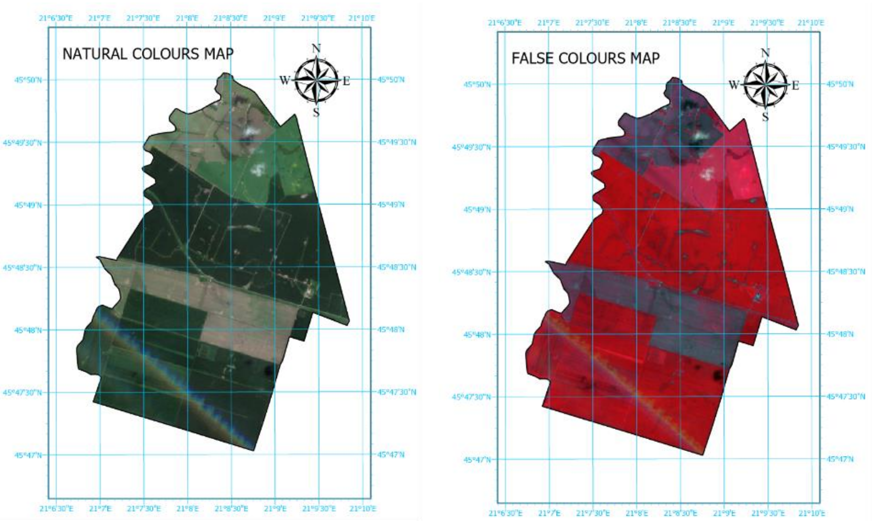

Figure 1. The Natural and False Colour Maps of study area

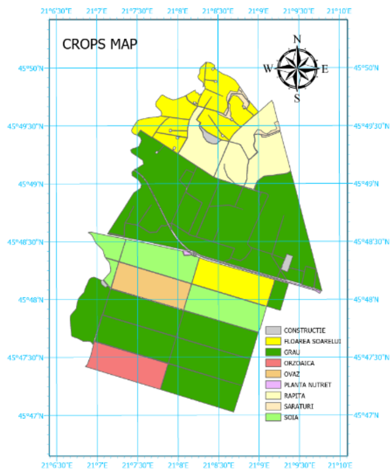

Figure 2. The CROPS Maps of study area

Vegetation indices. In this research, the following vegetation, soil and water indices were calculated using ArcGIS Pro software.

NDVI. The NDVI index - normalized difference vegetation index – represent a standardized index that allows the generation of an image that presents greenness, in other words the relative biomass (ROUSE et al., 1973, D’ODORICO et al., 2013).

$$NDVI = \frac{NIR-RED}{NIR+RED} \tag{1}$$

GNDVI. The GNDVI index - Green Normalized Difference Vegetation Index - it is a vegetation index that estimate a photo-synthetic activity and is used in order to determine the absorption of the water and the nitrogen in the canopy of plants (BUSCHMANN and NAGEL, 1993).

$$GNDVI = \frac{NIR-GREEN}{NIR+GREEN} \tag{2}$$

SAVI. The SAVI index - Soil-Adjusted Vegetation Index - [9] is a vegetation index which is used in order to minimize the influences of soil brightness and is using a factor of correction for soil brightness. The correction factor - L varies depending on the amount of green vegetation cover (HUETE 1988).

$$SAVI = \frac{NIR-RED}{NIR+RED+L}(1+L) \tag{3}$$

CI Green. The CIgreen index - Chlorophyll Index – Green - is a vegetation index that is used in order to estimate chlorophyll content from leaves by using a ratio of reflectivity in = NIR and green bands (GITELSON et al., 1996).

$$CI\ Green = \frac{NIR}{GREEN} - 1 \tag{4}$$

VARI. The VARI index - Visible Atmospherically Resistant Index - it is used to monitor the vegetation in the visible portion of the electromagnetic spectrum. This index is using all 3 visible R-G-B spectral bands. This index greatly reduces lighting differences and atmospheric effects, while reducing lighting differences and atmospheric effects (GITELSON et al., 2002, GITELSON et al., 2003).

$$VARI = \frac{GREEN-RED}{GREEN+RED+BLUE} \tag{5}$$

SR. The SR index - Simple Ratio - is a vegetation index used for estimating the amount of vegetation. This index is the ratio between NIR and absorbed in the red band, which reduces the effects of the atmosphere and the topography (BIRTH and MCVEY, 1968).

$$SR = \frac{NIR}{RED} \tag{6}$$

NDMI. The NDMI index - Normalized Difference Moisture Index - it is sensitive to the humidity levels in the vegetation. The NDMI index is used to monitor droughts as well as to monitor fuel levels in areas prone to fire. It uses NIR and SWIR bands when creating a report designed to mitigate lighting and atmospheric effects (WILSON and SADER, 2002).

$$NDMI = \frac{NIR-SWIR1}{NIR+SWIR1} \tag{7}$$

RESULTS AND DISCUTIONS

Following are the maps resulting from the calculation of the indices presented above.

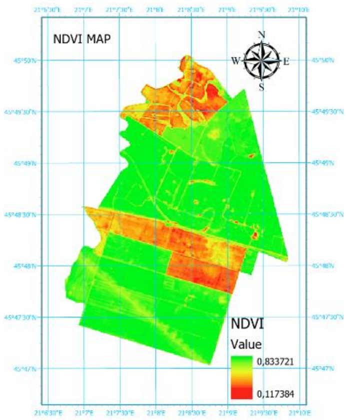

Figure 3. The NDVI Map of study area

Table 2.

NDVI interpretation

(https://wiki.landscapetoolbox.org/doku.php/remote_sensing_methods:normalized_difference_vegetation_index, https://wiki.landscapetoolbox.org/doku.php/remote_sensing_methods:normalized_difference_vegetation_index, Shoko and Mutanga, 2017, Denton et al., 2017)

0 – 0,1	Bare soil
0,1 – 0,2	Almost absent canopy cover
0,2 – 0,3	Very low canopy cover
0,3 – 0,4	Low canopy cover, low vigour or very low canopy cover, high vigour
0,4 – 0,5	Mid-low canopy cover, low vigour or low canopy cover, high vigour
0,5 – 0,6	Average canopy cover, low vigour or mid-low canopy cover, high vigour
0,6 – 0,7	Mid-high canopy cover, low vigour or average canopy cover, high vigour
0,7 – 0,8	High canopy cover, high vigour
0,8 – 0,9	Very high canopy cover, very high vigour
0,9 – 1	Total canopy cover, very high vigour

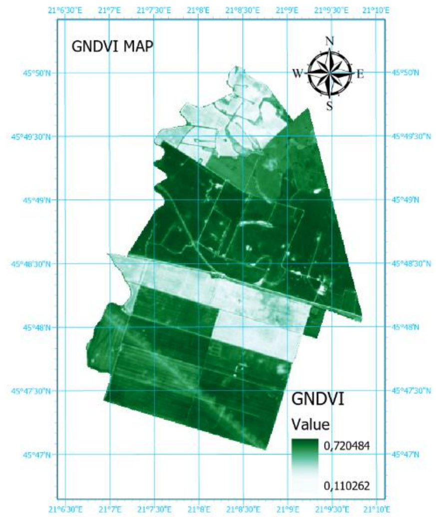

Figure 4. GNDVI Index Map

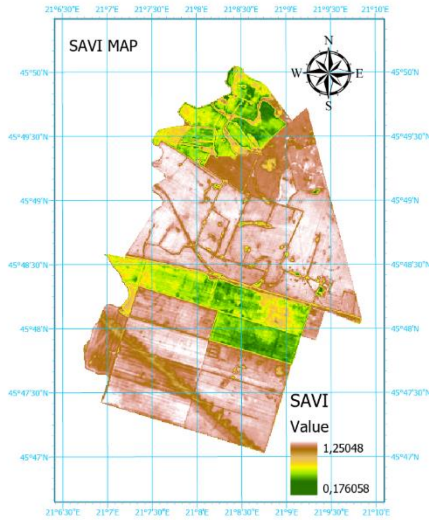

Figure 5. SAVI Index Map

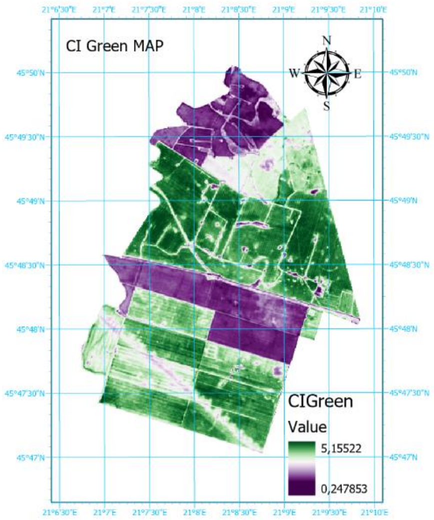

Figure 6. CI Green Index Map

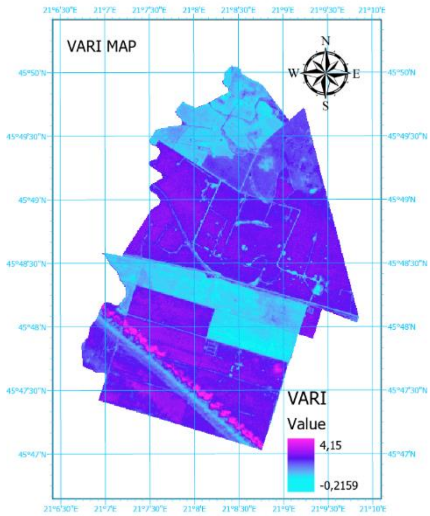

Figure 7. VARI Index Map

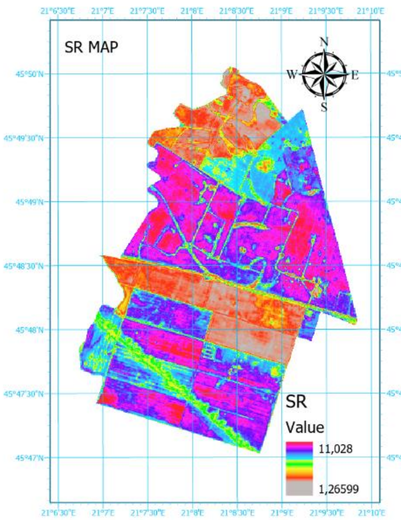

Figure 8. SR Map Index

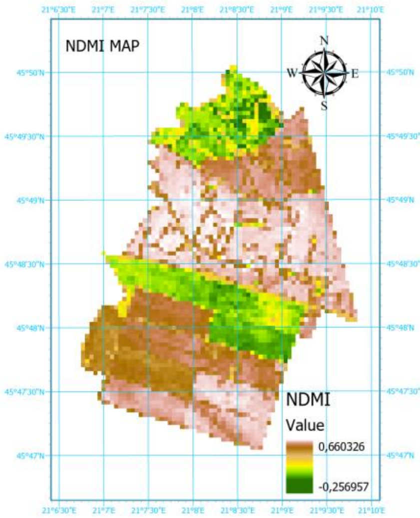

Figure 9. NDMI Index Map

The minimum, maximum and average values of the calculated indices are shown in table 3.

Table 3.

Statistical parameters describing the values of indices

No.	Index	Min	Max	Average
1	NDVI	0,117384000	0,833721000	0,677332082
2	GNDVI	0,110262000	0,720484000	0,580680391
3	CI Green	0,247853000	5,155220000	3,155811646
4	SAVI	0,176058000	1,250480000	1,015881533
5	SR	1,265990000	11,028000000	6,347534050
6	VARI	-0,215900000	4,150000000	0,649656958
7	NDMI	-0,256957000	0,660326000	0,419650472

The resulting data of the indices were subjected to a correlation analysis, presented in table 4.

Table 4.

Matrix correlation table (Kendall) between calculated indices

	NDVI	GNDVI	CI Green	SAVI	SR	VARI	NDMI
NDVI	1						
GNDVI	0,988563	1					
CI Green	0,949596	0,979120022	1				
SAVI	1	0,988565152	0,949599892	1			
SR	0,963945	0,975403787	0,987898012	0,963948252	1		
VARI	0,899576	0,881174442	0,876085449	0,899570011	0,917763	1	
NDMI	-0,04724	-0,063850185	-0,059229003	-0,04724228	-0,04556	-0,00814	1

Based on the correlation matrix, it was found that the best correlations exist between the index NDVI - SAVI, NDVI - GNDVI, GNDVI - SAVI, CI Green - SR, SAVI - SR and SR - VARI. Subsequently, a series of regression analyzes were performed that facilitated the prediction of one index according to another index.

Regression analysis facilitated prediction of SAVI based on NDVI, under conditions of R2 = 1, if GNDVI based on NDVI, under conditions of R2 = 0.9779, prediction of SAVI based on GNDVI, under conditions of R2 = 0.9773, prediction of SR based on CI Green, under conditions of R2 = 0.9759, prediction of SR based on SAVI, under conditions of R2 = 0.9897, prediction of VARI based on SR, under conditions of R2 = 0.8363.

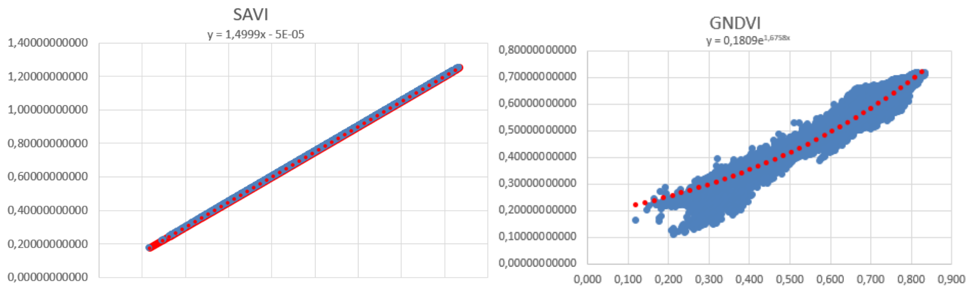

Figure 10. The SAVI and GNDVI prediction based on NDVI

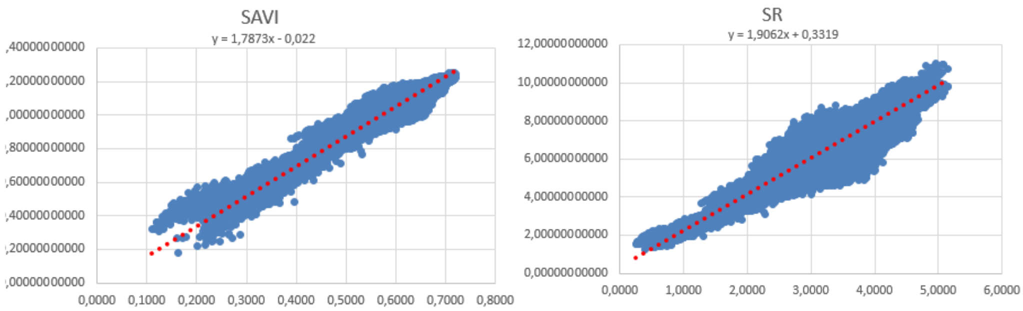

Figure 11. The SAVI and SR prediction based on GNDVI and CI Green

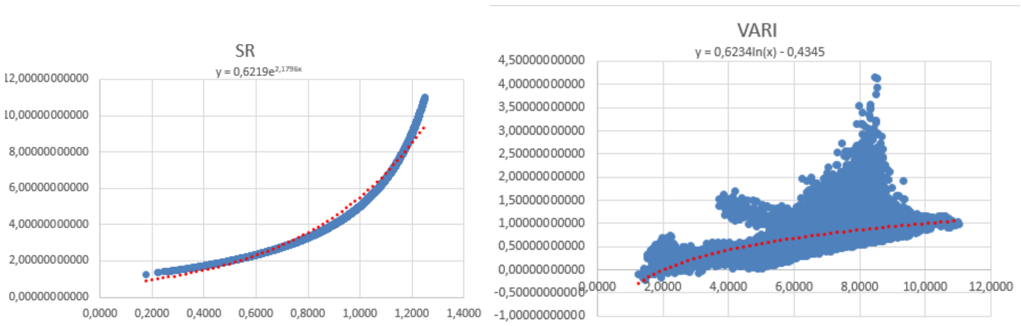

Figure 12. The SR and VARI prediction based on SAVI and SR

CONCLUSIONS

Remote sensing techniques are modern tools that are increasingly used in the field of precision agriculture. Satellite images cover large areas of land and this can help farmers to increase agricultural productivity.

In this paper, an analysis of the terrestrial surface was attempted based on the satellite images offered by the remote sensing system Sentinel 2. Also, on the basis of the spectral bands, a series of indices were calculated that characterize the agricultural crops in particular and a correlation was attempted in order to predict one index against another.

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