THE IMPORTANCE OF REMOTE SENSING IN MONITORING VEGETATION PARAMETERS IN AN AREA WITH A FRAGILE BALANCE

Abstract: The purpose of this study is to highlight the state of vegetation cover of a territory with fragile balance (sandy) and to present using the remote sensing techniques the correspondance degree between non-climatic parameters that can be underlined by remote sensing techniques and GIS. The present study is based on previous research in which there were obtained very accurate results.

Introduction

The remote sensing is one of the important data useful in monitoring vegetation coverage ussing the vegetation indices, that has been considered by numerous scientists (Tucker et al. 1982; Qi et. al, 1994; Liu and Huete, 1995; Amiri et al., 2009; Vuolo et. al, 2013; Gaitán et. al, 2013; Mahmoud et. al., 2016) as one of the important parameters for the mapping of agricultural fields, for estimating weather impacts, to calculating biomass and crop yield and to determined the vigor of the vegetation. Modification in the territory shown the impact of this, that can be positif (positive) or negativ(e). Changes in vegetation coverage in Southwestern Romanian Plain are negative and with the aim of remote sensing data we can highlight this.

According to the researches carried out for the period 1986-2015 in the Romanian Plain area (Jiu-Olt sector), the methods and techniques for detecting changes in land use based on satellite images, implicitly of satellite indices, show that the (write NDVI in full before the abbreviation) NDVI index is being occupied with lack of vegetation whereas the (write in full)MSAVI2 index is being occupied areas with moderate vegetation.

The results for two of the time periods from 1987 and 2015 showed changes in the way the area is covered with vegetation. From the analysis of the results of using the method of major classes of vegetation cover, the changes occurred on 53.0% of the analyzed area. Thus, on 47.0% of the area there were no changes. Of the moderate vegetation class, which underwent transformations in the absence of vegetation and changes from healthy vegetation to moderate vegetation, there were registered 31.9% of the total changes produced in the area.

Moreover, vegetation can be monitored, quantified, and evaluated using remote sensing technology as it provides spectral, temporal, and spatial information (Wachendorf M., et al., 2018). Normalized Difference Vegetation Index (NDVI) was computed to observe relation to as well as prediction accuracy in retrieving LAI values (Herrmann I., et al., 2011). The LAI describes the vegetation structures and is closely related to vegetative photosynthesis and energy balance (Running S.W., 1989, Sellers P.J., et al., 1997).

The MSAVI is shown to increase the dynamic range of the vegetation signal while further minimizing the soil background influences, resulting in greater vegetation sensitivity as defined by a “vegetation signal” to “soil noise” ratio (Qi J., et al., 1994). The normalised difference water index (NDWI) is used to monitor changes in the water content of leaves using NIR and short-wave infrared (SWIR) wavelengths (Gao, B.C., 1996, Otgonbayar et al., 2019).

Study Area

The Sadova-Corabia irrigation system was built between 1969-1973 and covers the Danube river basin area within Olt and Dolj counties, with a total net area of 71,775 ha, of which 52,725 ha belong only to Dolj county, the remaining 19,050 ha to Olt county (https://www.madr.ro/).

The blanket of sand dunes can be seen in Lunca Jiului, in Câmpurile Leu-Rotunda and Dăbuleni, as well as in Lunca Potelului. The largest surface covered by sandy textured soils at the level of relief unit is registered in Câmpul Dăbuleni. The terraces to the left of the Jiu, the southwestern part of the Leu-Rotunda Field and the terraces of the Danube are covered with sands and longitudinal dunes, elongated for several kilometers which generate a fading relief as it moves away from Jiu and the Danube.

Thus, on the terraces between Mârşani and Dăbuleni, in their sector of maximum extension, mobile dunes with heights of 15-20 m predominate. On the upper terraces of the Danube, the sand dunes are older, relatively consolidated, fixed by vegetation or agricultural crops.

The exit from the communist system and the transition to the form of democracy, in which agricultural lands changed their form of ownership, was the most important non-climatic factor of the analyzed area that led to the decommissioning of agricultural management.

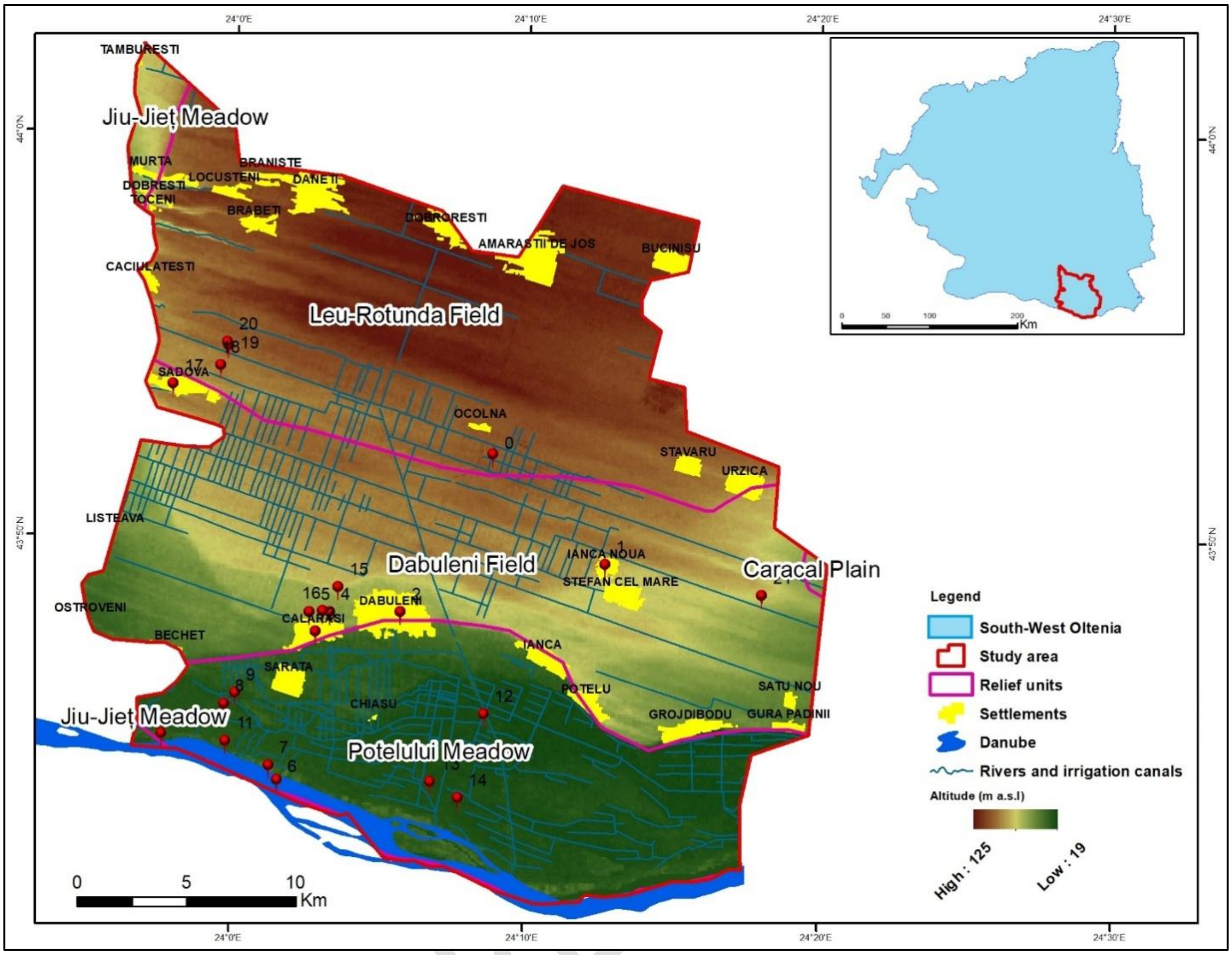

Fig. 1 Location of the study area

Data Sources and research methodology

The satellite data used in the study were provided and downloaded free of charge from the U.S. website Geological Survey, (http://glovis.usgs.gov/). Table 1 shows the details of the satellite data used in the study.

Tabelul 1. Tablel 1. Sentintel satellite images used in the study

Sensor	Date of purchase of satellite image	Image capture time	Image cloud coverage (%)
Sentinel-2A	2020-07-02	10:51:53	0.45
Sentinel-2B	2020-07-17	12:41:56	0.78
Sentinel-2A	2020-08-31	12:29:05	0.01

The satellite products used were Sentinel-type satellite imagery, on which pre-processing operations were performed using SNAP and the Sentinel Toolboxes and ArcMap 10.7.

The detection methodology used four indices: Normalized Difference Vegetation Index (NDVI), Modified Soil-Adjusted Vegetation Index (MSAVI2), because it uses in the calculation algorithm constant adjustment of the influence of soil reflectance, Leaf Area Index (LAI).

The NDVI is computed as the difference between near-infrared (NIR) and red (RED) reflectance divided by their sum. The formula is (1):

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (1)$$

Through the complex calculation formula developed by Qi and others in 1994b, MSAVI2 better highlighted the areas occupied by vegetation. Initially, the above-mentioned authors developed MSAVI, where the correction factor L is found, which was calculated according to the formula (2):

$$L = 1 - (2 * S * NDVI * WDVI) \qquad (2)$$

where: S represents the slope of the ground line, compared to the proximity of the brightness values in the infrared zone. WDVI is the Weighted Difference Vegetation Index which has the following relation as the calculation formula (3):

$$WDVI = \rho nir - qred * \frac{\rho_s nir}{\rho_s red} \qquad (3)$$

where: $\frac{\rho_s\, nir}{\rho_s red}$ represents the linear relation between red and the reflectance of the soil exposed from near infrared (nir) (Baret et al., 1993; Clevers, 1988; Vuolo et al., 2013).

MSAVI2 uses the following mathematical calculation relation (4):

$$MSAVI2 = \frac{[2*NIR+1-\sqrt{(2*NIR+1)^2-8*(NIR-R)}]}{2} \qquad (4)$$

Mahmoud et al. (2016) showed that MSAVI is more suitable than NDVI when vegetation cover is very low, due to the increase in soil reflectance as vegetation cover decreases. Gaitán et al. (2013) showed that the MSAVI2 index is an index modified by NDVI values when they have a vegetation coverage of less than 40%. Thus, MSAVI2 is considered a particular index, indicated for our study area.

Normalized Difference Water Index (NDWI) is used to monitor changes in water content of leaves, using near-infrared (NIR) and short-wave infrared (SWIR) wavelengths, proposed by Gao in 1996 (5):

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR} \quad (5)$$

Leaf Area Index is developed by Wiliams (1946) and is calculated according to the formula (6):

$$LAI = \frac{Total\ leaf\ area\ of\ a\ plant}{Ground\ area\ occupied\ by\ the\ plant} \qquad (6)$$

Results

In the analyzed area, the Sadova-Corabia irrigation system changes caused by climate variability occur with great intensity. The effects of this variability combined with changes in land use could be observed from the analysis of the area using remote sensing techniques. Biophysical, biological or structural parameters of vegetation can be extracted from remote sensing data.

For the date 2.07.2020, the MSAVI2 index highlights much better the areas occupied by vegetation, so that the NDWI index indicates the areas where the humidity is more pronounced, following the last index, LAI to confirm the above with foliar surface density values (Fig. 2).

In order to make a quantitative and not only qualitative analysis, we made the correlation between the vegetation indices, the leaf surface index and the humidity index using 22 representative points for this studied area.

For 2.07.2021 the correlation between NDVI vs. LAI was statistically significant, with a value of 0.60, but the correlation between MSAVI2 and LAI was 0.77 (the explanation is that the MSAVI2 index highlights much better the vegetation being helped by the soil adjustment constant). The correlation between moisture and leaf surface density achieved between NDWI vs. LAI was 0.65 (Table 1).

Table 2. Correlation between vegetation indices, leaf surface index and humidity index

Tipul de corelație (r) The type of correlation	**NDVI vs LAI**			**MSAVI2 vs LAI**			**NDWI vs LAI**		
	2020-07-02	***2020-07-17***	***2020-08-31***	***2020-07-02***	***2020-07-17***	***2020-08-31***	***2020-07-02***	***2020-07-17***	***2020-08-31***
Linear (Pearson)	0.60	0.66	0.65	0.77	0.93	0.71	0.65	0.59	0.79

In Fig. 3 it is represented the graph formed by the 22 points illustratively chosen to highlight the relation between the dependence of the four satellite indices. This graph shows the maximum and minimum points of these locations, so that it can be seen that the LAI index has maximum values in the points where the area is covered by dense forest and wetland, while the minimum values are those with built-up areas (0.45), Danube river area (-0.06), but also in areas with agricultural crops (0.21).

In the absence of climate data, these biophysical, biological or structural parameters of vegetation provide conclusive data to observe the state of vegetation in this territory affected by climate variability.

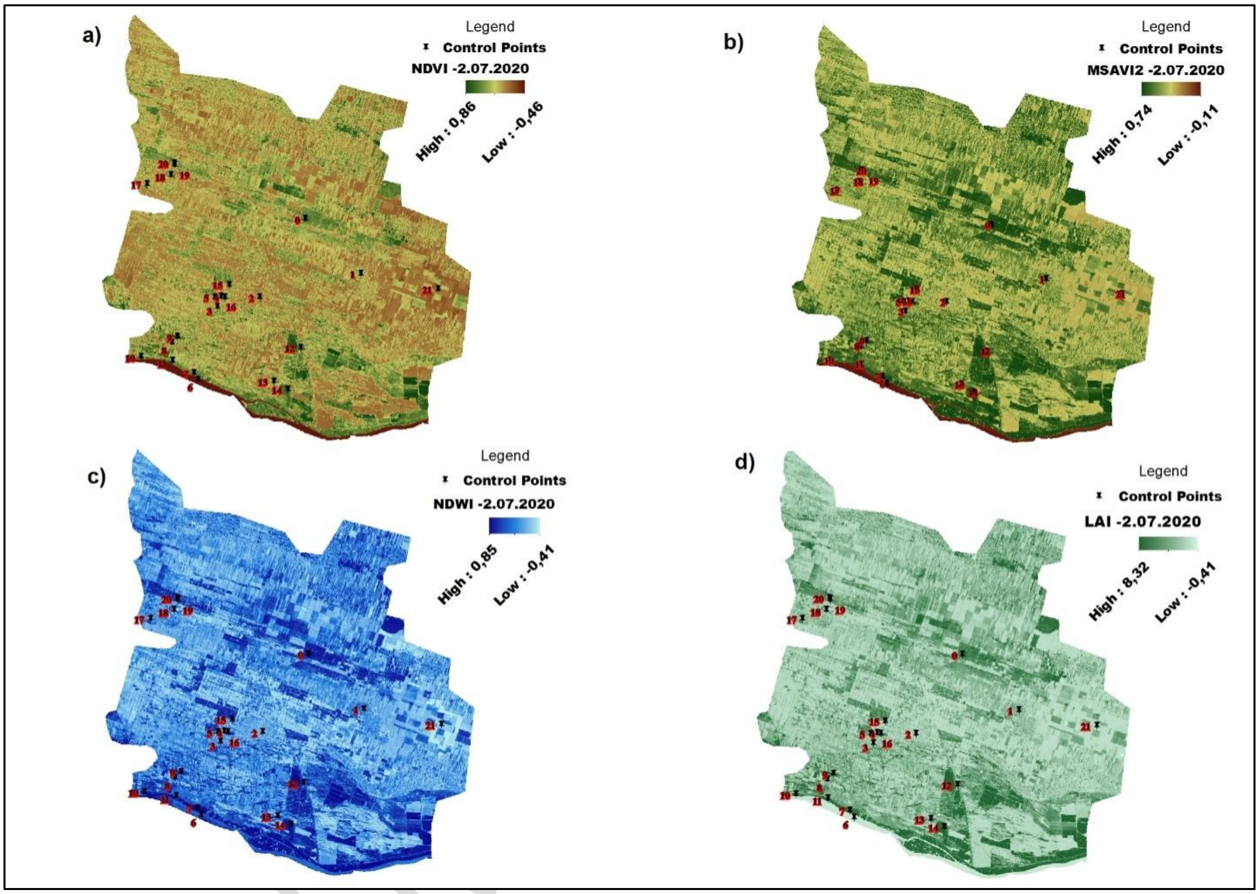

Fig. 2 NDVI, MSAVI2, NDWI, LAI on the 2th of July 2020 (a- NDVI; b- MSAVI2; c- NNDWI; d- LAI)

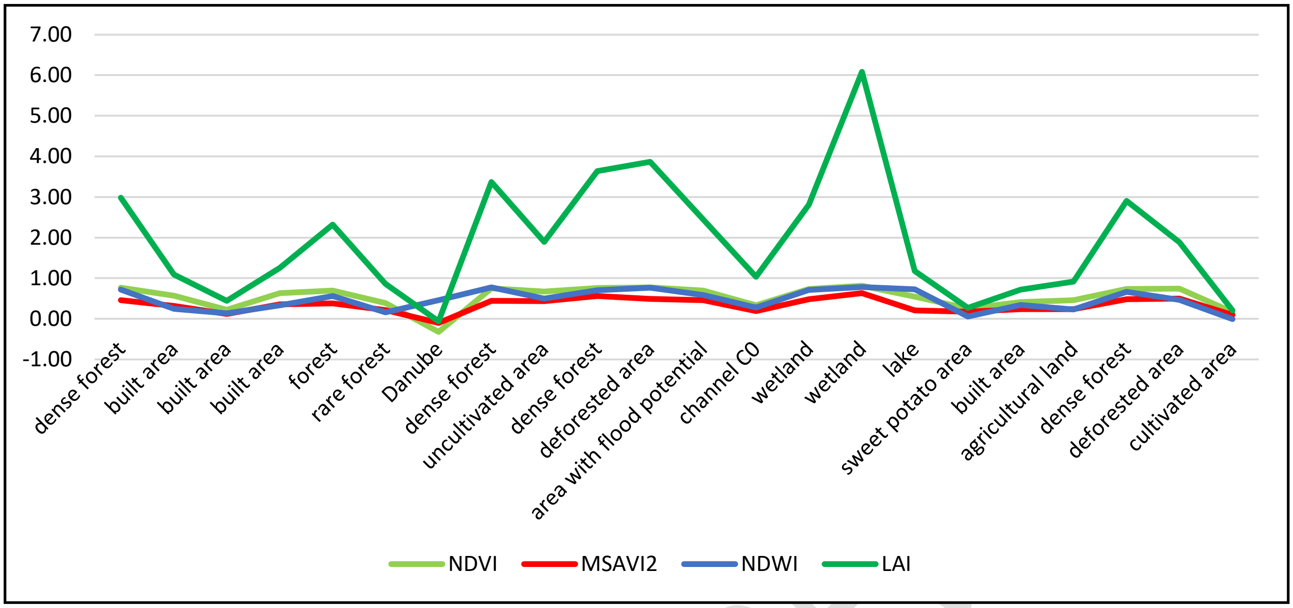

Fig. 3 NDVI, MSAVI2, NDWI, LAI on the 2th of July 2020 graph (a- NDVI; b- MSAVI2; c- NNDWI; d- LAI)

For the next time period studied, 17.07.2020, the correlation between the indices had different values, so that the MSAVI2 index registered a statistically significant correlation of 0.93, while the NDVI vs. LAI index registered a correlation of 0.60. In this case, the humidity given by the NDWI index correlated with the values of the LAI index was 0.59 (Table 1).

The maximum pixel values in the case of the NDVI index were 0.95, and those of the MSAVI2 index were 0.90, the difference being made by the minimum values of the indices (NDVI of - 0.81, and MSAVI2 of - 0.08). In this case, the values of the MSAVI2 index reflected the areas covered with vegetation much better.

The validation of these results was performed in the field and is confirmed by the well-defined areas of the forest (Fig. 5).

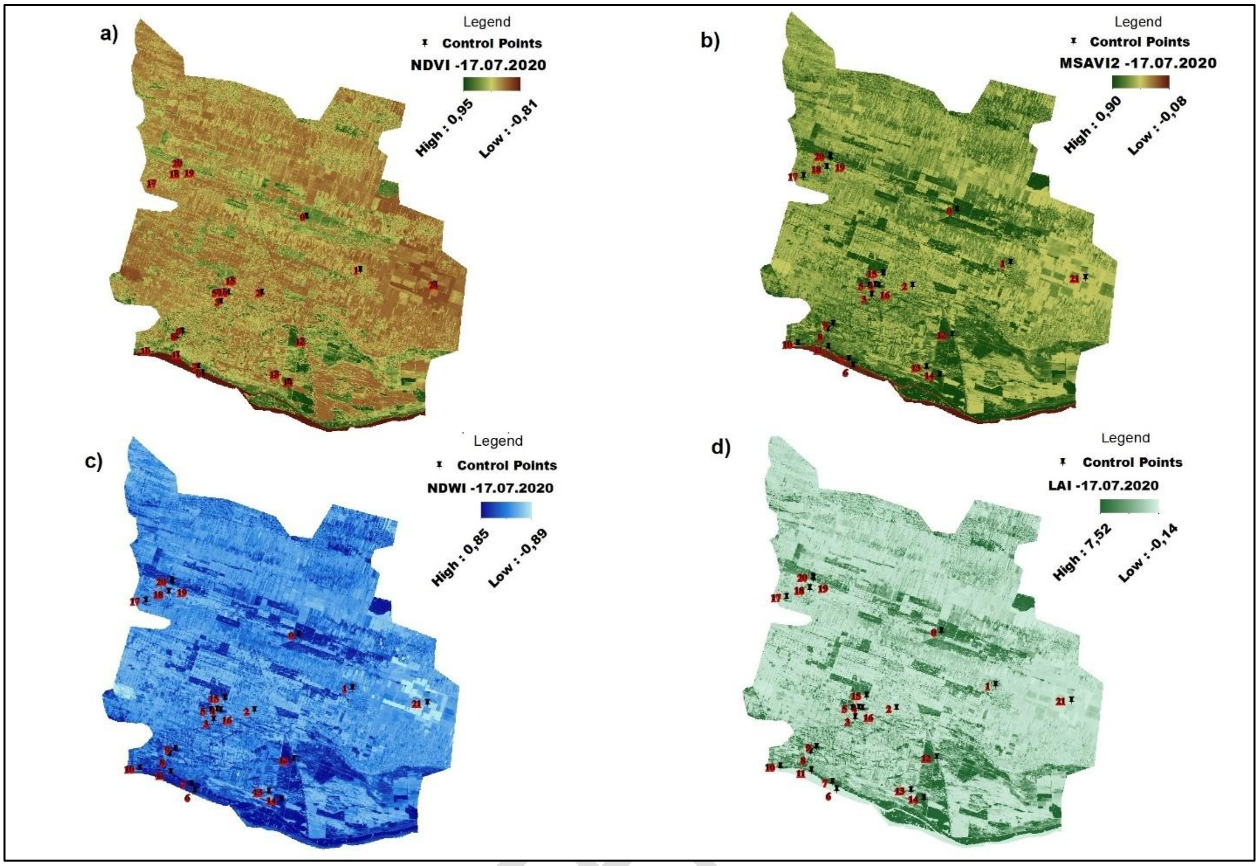

Fig. 4 NDVI, MSAVI2, NDWI, LAI on the 17th of July 2020 (a- NDVI; b- MSAVI2; c- NNDWI; d- LAI)

Fig. 5 Forest area (Source: Google Earth imagery)

The graph of the control points highlights the aspects notified for the image from 2.07.2020, the values being different, keeping the same trend (the LAI values are maximum in the points with high humidity).

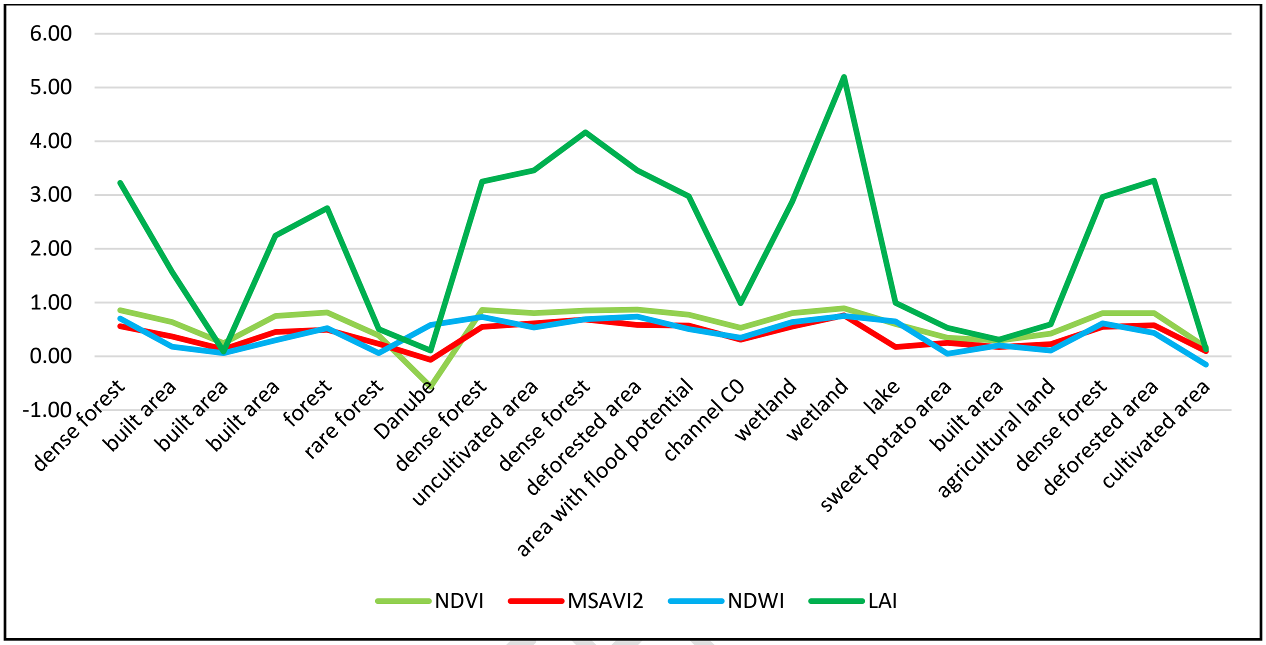

Fig. 6 NDVI, MSAVI2, NDWI, LAI on the 17th of July 2020 graph

For the last period in this data set 31.08.2020, the data obtained from the correlation of the indices indicated values of 0.65 for NDVI vs,. LAI. In the case of the correlation between MSAVI2 and LAI, the correlation value was 0.71 and that between NDWI and LAI was 0.79 (Table 1).

The degree of humidity of a territory greatly influences the degree of vegetation cover of the soil, and in the case of a sandy soil the problems are more and more complicated and diverse. Due to the high permeability of sandy soils, in the western part of the territory were observed the areas occupied by lack of moisture, unlike the situation encountered in the eastern part, that which is occupied by the class of chernozems and brown soils.

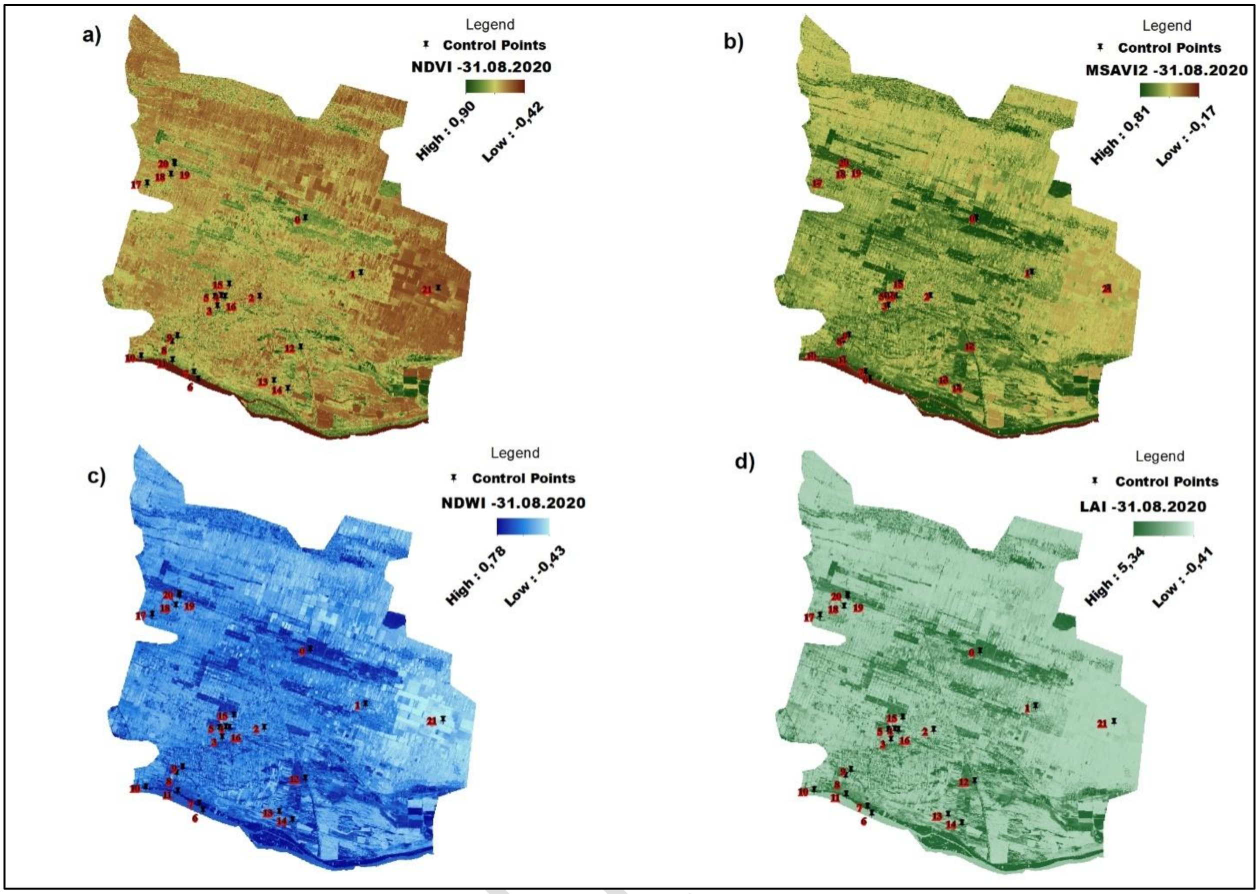

Fig. 7 NDVI, MSAVI2, NDWI LAI on the 31th of August 2020 (a- NDVI; b- MSAVI2; c- NNDWI; d- LAI)

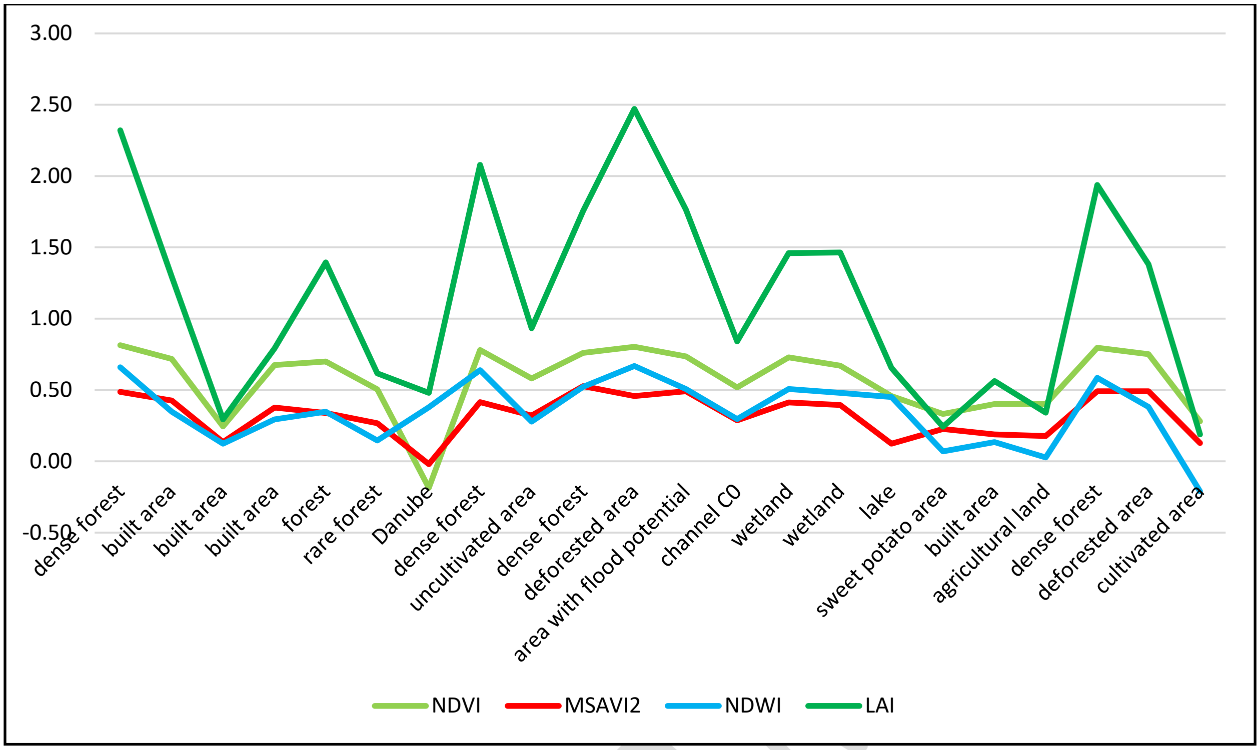

Fig. 8 NDVI, MSAVI2, NDWI, LAI on the 31th of August 2020 graph

Conclusions

Changing the structure of land ownership after the exit from the communist system played a decisive role in creating facilities for anthropogenic intervention on land and its use. The changes were due to the climatic factors to which were added those of non-climatic nature materialized by the phenomenon of abandonment, deforestation, legislative changes, the uncertain situation on land properties, poverty and people’s unconsciousness. The appearance of the imbalance between the plants water needs and the useful reserves of the soil was reproduced by analyzing the complex parameters of remote sensing.

In prezent(present) the use of satellite imagery data has become more common in precision agriculture and usefull. The tehnique of remote sensing provide data in different range of spatial and temporal scales, that obtained very difficult/hard by traditional methods.

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