THE RELATIONSHIP BETWEEN THE LAND SURFACE TEMPERATURE AND NORMALIZED DIFFERENCE VEGETATION INDEX

Codruta BADALUTA-MINDA [1], Andreea- Mihaela DUNCA [2]
[1]Politehnica University of Timisoara, Hydrotechnical Department, Spiru Haret Street, No. 1A, Romania
[2] Prof. Dr. - Școala gimnazială Ieud, Maramureș
Corresponding author: dunca.andreea.mihaela@gmail.com

Abstract. *In recent years, land cover / use has undergone major changes, and this aspect participate along with other factors in climate change both in our country and globally. Vegetation indices based on satellite images are increasingly used to characterize the response of vegetation to climate variability and change over large spatial scales. One of the parameters estimated based on remote sensing and used in the calculation of temperature interception is the LST index. This study proposes to evaluate the trend of the spatial-temporal relationship between land surface temperature (LST) and normalized difference vegetation index (NDVI) in different ranges of LST and NDVI values for Timis County. Vegetation is very sensitive to climate changes and various anthropogenic influences, and these variations of the NDVI index can cause changes in the temperature of the land surface. In the final part, the correlation between the spectral indices of land cover (NDVI and NDWI) with the soil surface temperature (LST) was made. The remote sensing images were processed using the Geographic Information System (GIS). This study highlights the association of the LST index with land cover indices, and from the obtained data it can be observed that the correlation between NDVI and LST is one negative.*

Keywords: *LST, surface temperature, land cover, NDVI, NDWI.*

INTRODUCERE

For this study was used the Landsat 8 imagery and obtained from the United State Geological Survey (USGS) (https://earthexplorer.usgs.gov/). These images were selected for the same month over a 3-year period with a spatial resolution of 30 meters. Remote sensing satellites at the various of the spatial, spectral and temporal resolutions provide a solution, regarding data base as a primary source, being used on a large scale in many fields. The Normalized Differential Vegetation Index (NDVI) is a standardized vegetation index that generates information about the relative biomass. Based on the absorption of chlorophyll in the red band and the reflectance of vegetation in the infrared band (NIR), using the ArcGIS Map program, the NDVI index is determined. Normalized Difference Vegetation Index (NDVI) has values ranging from -1 to +1, where values close to -1 highlight areas covered by soil, rock, built-up areas, and values that tend to approach the value 1 mean areas covered by vegetation (forests, parks, etc.).

The studies show that the land use change accentuated of the recent years can have an effect on the hydrological response from the catchment area regarding precipitation and not only (Huang et al. 2008). Monitoring of the land surface temperature (LST) through the remote sensing imagery is one of the most important contributions to climatology. LST (land surface temperature) results indicate the areas affected by the heat island effect and local thermal differences on different types of surfaces.

MATERIAL AND METHODS

THE STUDY AREA

This study was realized for Timis county, an area located in the western part of Romania, being the most extensive county in the country, with an area of 8,696.7 km². The

hydrographic network of this county includes two large catchment area: Bega–Timiș–Caraș and Mureș. In the northwest, it borders Hungary, in the southwest Serbia. The territory of the county is traversed from east to southwest by the Bega River and Timiș River, and in the north follows its course from east to west, the Aranca River, an old branch of the Mures River.

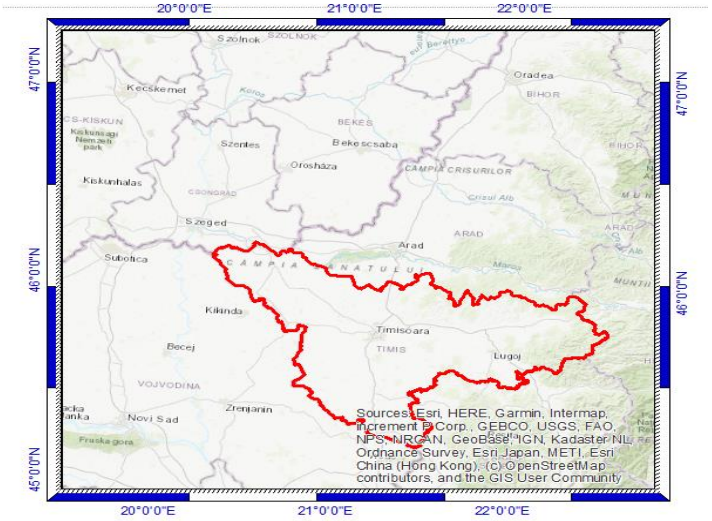

Figure 1 The study area - Timis County

SATELLITE SYSTEM AND INDICES USED

Landsat 8 is one of the Landsat series of NASA (National Aeronautics and Space Administration) and it is available in USGS (United States Geological Survey) Earth Explorer website for research purpose. In the present study, the TIR bands 4 and 5 were used to generate NDVI of the study area from the Landsat 8 image. Satellite data over the study region of April of 2018 and 2019 and May 2023 have been used in this study. The NDVI is the most used index for vegetation monitoring and is based on the combination of red band and near infra-red (NIR) band wavelengths and can be computed by the well-known formula (Eq. 1) of Rouse et al. (1974).

$$NDVI=(NIR–RED)/(NIR+RED) \quad (1)$$

Where: NDVI is the Normalized Difference Vegetation Index;
NIR is the near infra-red band (841–876 nm);
RED is the red band (620–670 nm).

Another index used is NDWI, a parameter used to monitor water body changes based on the wavelength of the green band and the NIR band. It can be calculated by the formula (Equation 2) of McFeeters (1996):

$$NDWI=(GREEN–NIR)/(GREEN+NIR) \quad (2)$$

Where: NDWI is the Normalized Difference Water Index;
GREEN is the green band (525–600 nm).

Then is determined LST from the satellite infrared band, which is a key parameter for land cover analysis and for many fields of study, such as agriculture, desertification studies, etc.

RESULTS AND DISCUSSIONS

Figure 3 shows the spatial-temporal distribution of NDVI index of the study area for the months of April 2018, 2019, and May 2023 processed in ArcGIS based on Landsat collection 2 -Level 2 satellite images. The vegetation cover had a spatial variability especially for the year 2019, respectively 2023 (figure 3). The negative NDVI values reflect the bodies of water or saturated soil throughout the time of analysis of the area. In areas with higher values of NDVI index, it was observed the lower value for LST index , as seen in Figure 3, and statistical indices for NDVI are shown in Table 1.

Table 1

Statistics of NDVI

Date	Minimun	Maximum	Mean	Standard deviation
April 2018	-0.0826127	0.765158	0.00	0.03
April 2019	-0.21624	0.886986	0.25	0.11
May 2023	-0.164328	0.848492	0.30	0.16

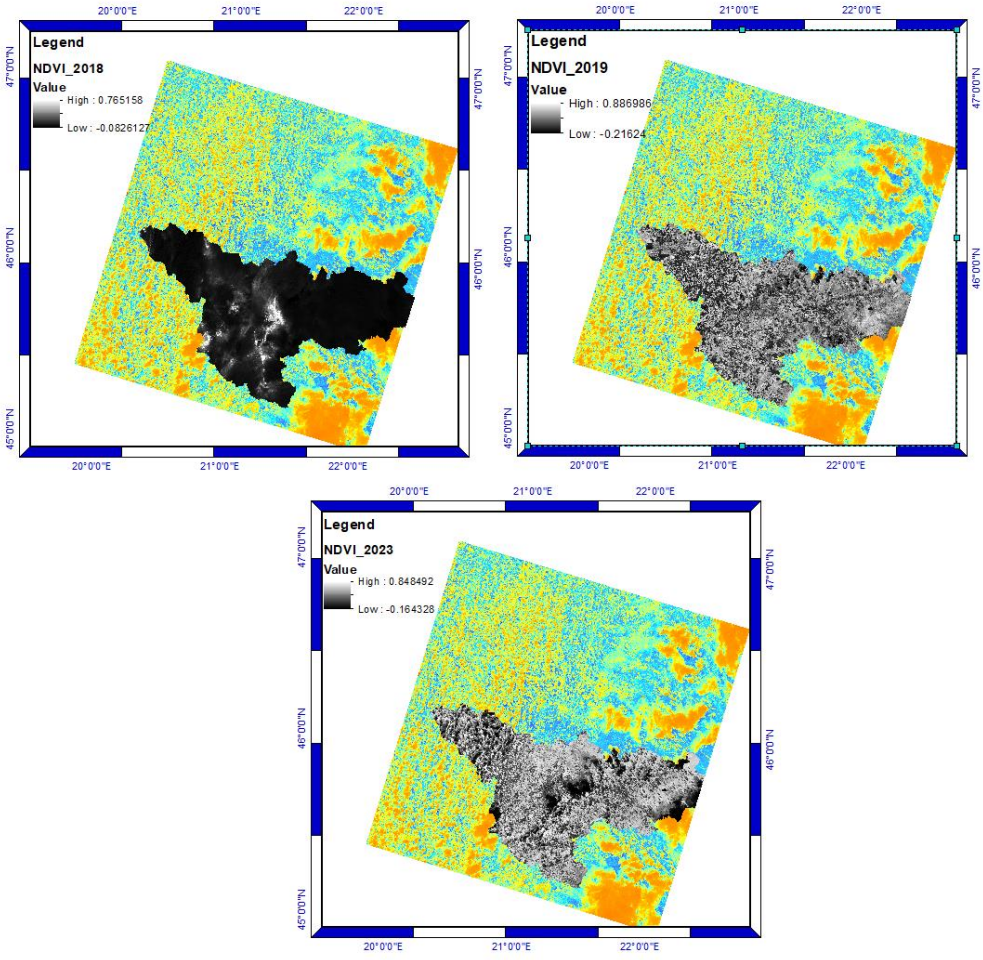

Figure 3. NDVI maps of the study area of April 2018 and 2019 , May 2023

NDVI is an important factor in the LST (Land Surface Temperature) Index derivation processes, therefore NDVI is used directly in the determination of land surface emissivity, being a significant factor for LST estimation. The relationship of Land Surface Temperature (LST) with Normalized Difference Vegetation Index (NDVI) is quite interesting and attracts remote sensing scientists from many directions (Goward SN, Xue YK, Czajkowski KP , 2002). To determine the LST Index from the thermal bands of the Landsat-8 satellite images that captured an image for Timis county, April 2018 and 2019, respectively 2023, May; high LST peaks indicate urban areas, while low LST peaks indicate hills and valleys.

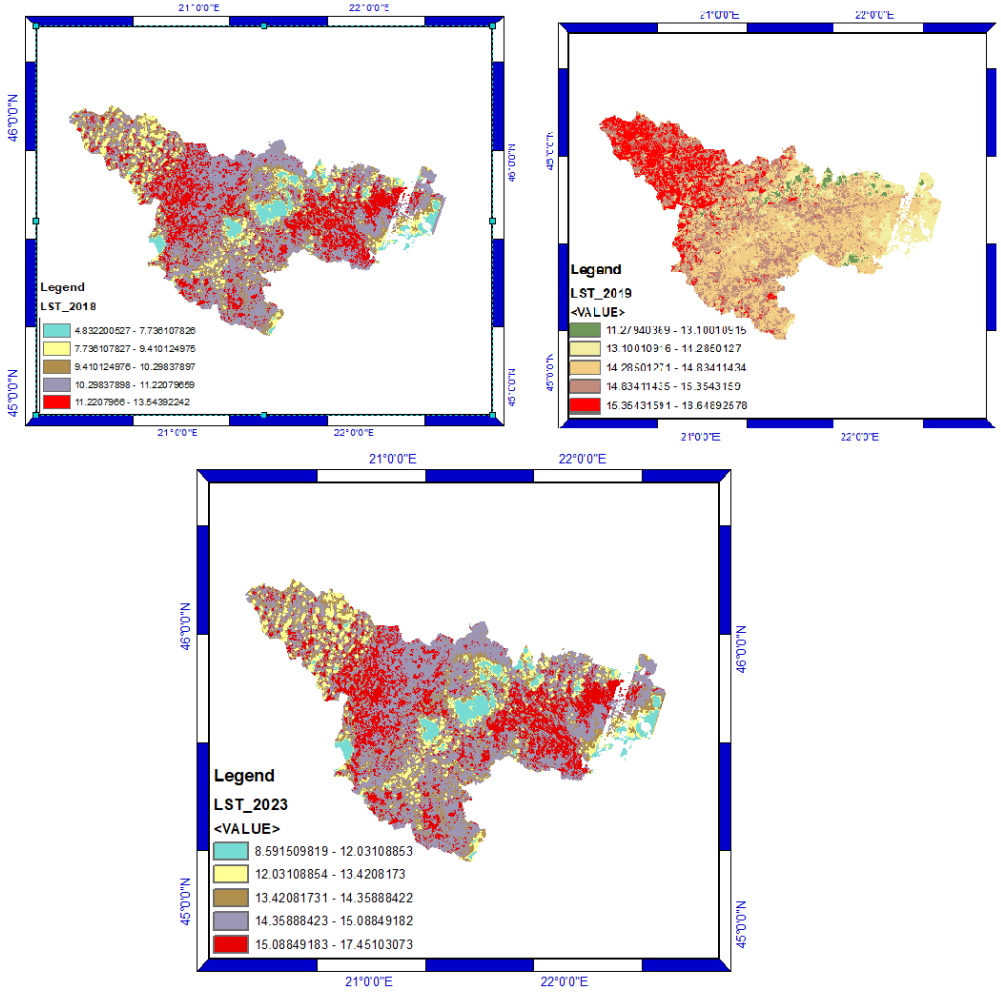

Figure 4. LST maps of the study area of April 2018 and 2019 , May 2023

The NDWI - Normalized Difference Water Index is an index that shows the water presence from satellite images. The equations for NDWI are as follows:

$$NDWI = (Green - NIR)/(Green + NIR) \quad (3)$$

$$NDWI = (Band3-Band5)/(Band3+ Band5) \quad (4)$$

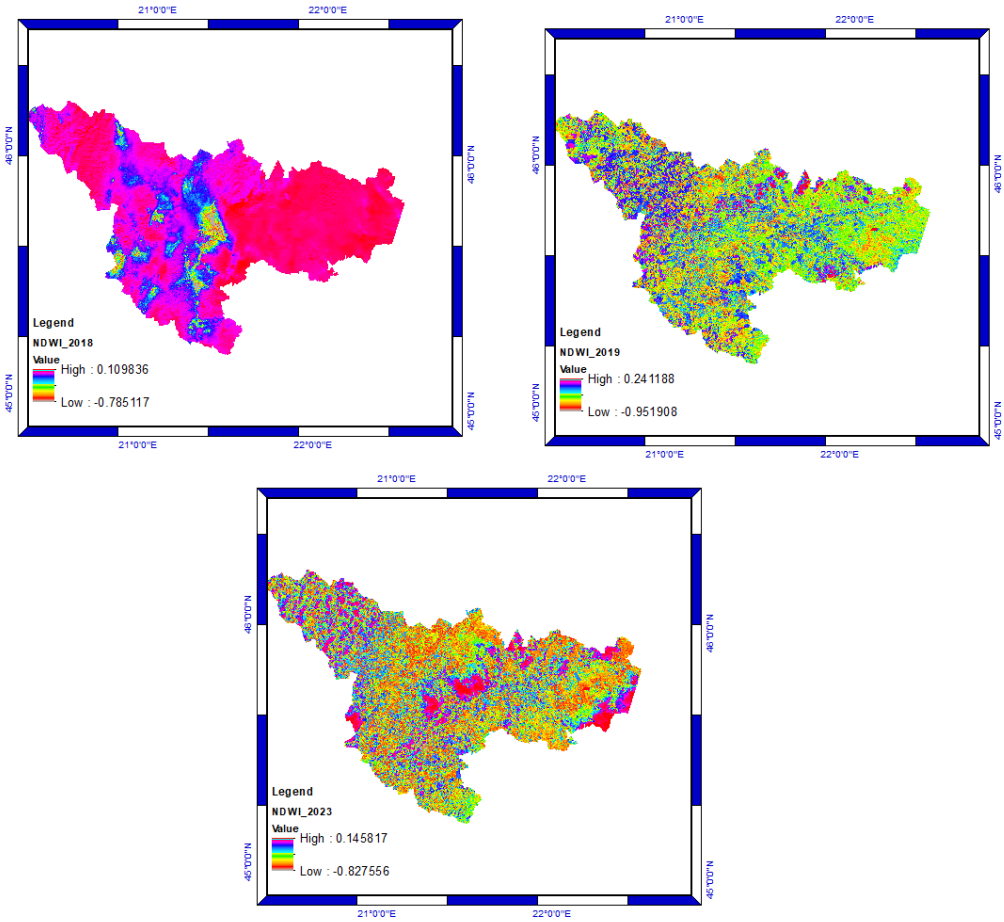

Figure 5. NDWI maps of the study area of April 2018 and 2019 , May 2023

The statistical indices for NDWI are shown in Table 1.

Table 2

Statistics of NDWI

Date	Minimun	Maximum	Mean	Standard deviation
April 2018	-0.785	0.109	0.00	0.04
April 2019	-0.951	0.241	- 0.25	0.09
May 2023	-0.827	0.145	- 0.28	0.14

Gao, 1996 calculates the NDWI index from NIR - Near Infrared band – which reflects the content of dry matter and SWIR- Short Wave Near Infrared band - reflects the water content of the vegetation. NDWI value ranges from -1 to + 1, McFeeter's (1996), suggested a threshold of zero for extracting water bodies, where all positive NDWI values are categorized as water and values less than or equal to zero (i.e. ≤0) are classified as non-water. The relationship between the land cover indices and LST is shown in Figure 6.

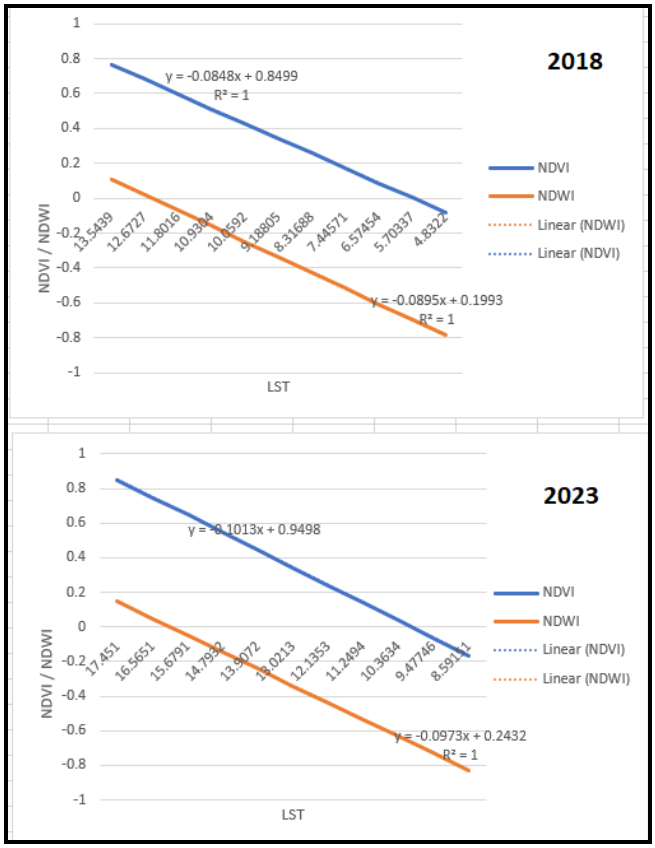

Figure 6. Relationship between LST and land cover Indices for April 2018

CONCLUSIONS

The LST maps were prepared from the satellite data, and the analysis represents the spatial distribution of surface temperature for Timis County. The analysis of LST index showed of the higher surface temperature in the built-up area and lower in areas with healthy vegetation. The maximum value of LST observed in each month was 17.45ºC for 2023 year, 13.54 ºC for 2018 and 18.64 ºC for 2019 year. This study highlights the association of the LST index with land cover indices, and from the obtained data it can be observed that the correlation between NDVI and LST is one negative. The relationship between land surface temperatures derived from Landsat satellites and land cover indicators can give an indication of the possibility of monitoring the phenomenon of desertification, urban development and expansion, drought and wetlands.

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