# ANALYSIS OF LST-NDVI SPARSE/DENSE VEGETATION RELATIONSHIP: A CASE STUDY OF IASI COUNTY

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*Abstract*

*Although we often take the trees and plants around us for granted, almost every aspect of our lives depends upon them. They clothe us, feed us, provide us with oxygen, absorb carbon dioxide and give us building materials and medications. Vegetation, in Iasi County - the study area in this paper, is predominantly of forest-steppe. In this study is investigating correlation LST - sparse/dense vegetation extraction from NDVI, in three different moments of 2017. Landsat 8 images, which have undergone pre-processing, were used as based date. A lot of papers showed that the surface temperature of the work was confirmed from Landsat 5/7/8. Many researches indicated that between LST and NDVI is a linear relationship. It is noticeable that correlation coefficient has closer values to 1 for relationship LST - NDVI dense; R2 is about 0.9, while R2 is about 0.7 for relationship LST - NDVI sparse. In conclusion, this correlation can be used to study vegetation health, drought damage, and areas where Urban Heat Island can occur.*

*Key words*: NDVI, LST, sparse/dense vegetation, $R^2$.

## INTRODUCTION

Although we often take the trees and plants around us for granted, almost every aspect of our lives depends upon them. They clothe us, feed us, provide us with oxygen, absorb carbon dioxide and give us building materials and medications. If drastic changes occur to the vegetation around us, our economy, health and environment are all affected (USGS).

Vegetation, in Iasi County, is predominantly of forest-steppe. Due to the rugged relief and the appreciable difference in altitude between the lower valleys and the upper level of the dominant hills, the vegetation has a layered arrangement (steppe, silvosteap, forest), in close connection with the pedo-climatic levelling (PUG Iasi).

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and evaluate whether the aim being observed contains live green vegetation or not (Rousse J. et al., 1973).

Remote sensing, according to Orhan, is useful for comprehending the spatial-temporal LC (land cover change) in relation to the elementary physical properties as regards of the emissivity data and surface radiance (Orhan, 2016). Start the seventies of the twentieth century, satellite-derived (like Landsat-5 TM/ 7 ETM +/8 OLI) surface temperature data have been utilized for local and regional climate study on different scale (Carlson, 1977). Landsat data have medium-resolution in the only source of land surface temperature (LST) in worldwide since 1972. Consequently the Landsat-5/7/8 imaginary were used in research. A lot of papers showed that the surface temperature of the work was confirmed from Landsat 5/7/8 (Mallick et al., 2012; Macarof et al., 2017).

Nowadays LST is used to discover the temperature distribution at the change global, regional and local scale. Also, in particular, it is used in climate change model. LST, determined from remote sensing data can be use in a lot of sphere of science, like: agriculture, climate change, oceanography, hydrology, forestry, urban planning etc. (Orhan et al., 2014).

Many researches indicated that between LST and NDVI is a linear relationship. According to Carlson, this negative correlation between them is valuable for urban climate studies and another circle of science (Carlson et al., 1994).

In this paper is investigating correlation LST - sparse/dense vegetation extraction from NDVI,

in three different moments of 2017. As based date were used Landsat 8 images.

## MATERIALS AND METHODS

### Study area

Iasi County is considered as study area in this research. Study Area is geographically situated on latitude 46°48'N to 47°35'N and longitude 26°29'E to 28°07'E. Neigh borings Iasi County are Botosani to the north, Neamt to the west, Vaslui to the south and Republic of Moldova to the east.

### Landsat data

Landsat 8 measures different ranges of frequencies along the electromagnetic spectrum a colour, although not necessarily a colour visible to the human eye. Each range is called a band. Landsat 8 has 11 bands and the tenth and eleventh band are in the thermal infrared (TIR). These bands see heat. Instead of measuring the temperature of the air, such as weather stations do, it report on the ground itself, which is often hotter (NASA Landsat Science). Landsat data was offered free by USGS. Table 1 shows Landsat data that was used in this research.

Table 1. Landsat data

| Nr. Crt. | Path | Row | Date |
|----------|------|-----|------|
| 1 | 182 | 27 | 2017-05-04 |
| 2 | 182 | 27 | 2017-06-05 |
| 3 | 182 | 27 | 2017-09-09 |

### Data processing

Image preprocessing
Preprocessing of Landsat-8 OLI images stage represent that operations that prepare images for subsequent analysis that attempts to compensate/correct for systematic errors. The images are subjected to several corrections like radiometric and atmospheric. In order to be used by some image processing application, the 90 m resolution TIR bands were resampled to "fit" to 30 m spatial. Resampling is used to "keep" the original pixel values in the resampled images nearest neighbour (miningeology.blogspot).
Radiometric correction is done to decrease/correct errors in the digital numbers (DN) of images. This process improves quality of remote sensed data. The process of eliminating the effects of the atmosphere to

obtain surface reflectance values represents the atmospheric correction. Atmospheric correction can significantly enhance the interpretability and usage of images. Perfectly for this process would be to have knowledge about the aerosol properties and the atmospheric conditions at the time the remote sensing data was acquired (miningeology.blogspot).

Normalized Difference Vegetation Index
NDVI, according to Rouse, is a numerical indicator that uses the visible (Vis) and near-infrared (NIR) bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and assess whether the aim being observed contains live green vegetation or not (John Rouse, 1973). The NDVI algorithm subtracts the red reflectance values from the near-infrared (NIR) and divides it by the sum of them.

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

Generally, healthy vegetation will absorb most of the visible (Vis) light that falls on it, and reflects a large portion of the NIR light. Unhealthy / sparse vegetation reflects more visible light and less near-infrared (NIR light) (Holme et al., 1987).

Land surface temperature (LST)
To estimate the LST from thermal infrared (TIR) band data of Landsat-8 OLI, digital numbers (DN) of sensors were transformed to spectral radiance using equation (Barsi et al., 2014).

$$L_l = M_L \times Qcal + A_L - Q_i \qquad (2)$$
where:
• $ML$ = rescaling factor
• $Q$cal = the Band 10/11 image
• $AL$ = the band-specific additive rescaling factor
• $Qi$ = the correction for Band 10/11
Spectral radiance is converted to brightness temperature by assuming the earth of surface is a black body (Chander et al., 2009; Coll et al., 2010):

$$Tb = \frac{K_2}{\ln((\frac{K_1}{L\lambda})+1)} - 273.15 \qquad (3)$$

where:
- Tb = the brightness temperature
- Lλ = the cell value as radiance
- $K_1$, $K_2$ = Calibration constant of Landsat 8 calibration

There are algorithms applied to transfer Brightness Temperature (BT) for LST:

$$LST = BT/[1+(\lambda xE/\rho)x\ln(LSE)] \qquad (4)$$

where:
- $\rho = 14380$;
- LSE is Land Surface Emissivity.

NDVI was used to extract Land Surface Emissivity (LSE), which is an adjustable parameter in correcting Land Surface Temperature in the next step. Values of LSE were calculated based on the proportion of vegetation (Jiménez-Muñoz et al., 2014).

$$LSE = 0.004PV + 0.986 \qquad (5)$$

where:
Pv is the proportion of vegetation, based on a normalized NDVI value of each pixel.

$$PV = (\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}})2$$

## RESULTS AND DISCUSSIONS

Figure 1 and tables 2 and 3 shows NDVI, LST maps and data statistics.

Analyzing the statistical data of NDVI and LST, the maximum temperature is 40.1°C and the minimum temperature is 1.76°C. The mean NDVI parameter indicates the high vegetation level in June.

NDVI values range from +1.0 to -1.0. Areas of barren rock, sand, or snow usually show very low NDVI values (for example, 0.1 or less). Sparse vegetation such as shrubs and grasslands or senescing crops may result in moderate NDVI values (approximately 0.2 to

0.5). High NDVI values (over 0.6) correspond to dense vegetation such as that found in temperate forests or crops at their peak growth stage (Ferri et al., 2016).

For generated sparse/dense vegetation map (Figure 2) was applied a filter. Sparse vegetation map was extracted from NDVI map, putting condition to extracted areas with values which ranged between 0.2-0.5, respectively over 0.6 for dense vegetation. For areas resulted was extracted and LST maps area.

Table 4a and 4b shows LST data statistics for sparse/dense area vegetation and figure 3 LST and NDVI maps for sparse/dense area vegetation and correlation between NDVI and LST for that area.

Next step was studied correlation between LST and NDVI sparse/dense vegetation for three moments of year. Figure 3 shows scatter plot and correlation coefficient between LST and NDVI sparse/dense vegetation.

It is noticeable that correlation coefficient has closer values to 1 for relationship LST-NDVI dense; $R^2$ is about 0.9, while $R^2$ is about 0.7 for relationship LST-NDVI sparse.

Table 2. NDVI data statistics

| Date | min | max | mean | Variation |
|---|---|---|---|---|
| 2017-05-04 | -0.33 | 0.84 | 0.51 | 1.17 |
| 2017-06-05 | -0.82 | 0.92 | 0.60 | 1.74 |
| 2017-09-09 | -0.36 | 0.77 | 0.40 | 1.13 |

Table 3. LST data statistics

| Date | min | max | mean | Variation |
|---|---|---|---|---|
| 2017-05-04 | 5.34 | 35.33 | 24.47 | 29.99 |
| 2017-06-05 | 18.28 | 40.10 | 26.60 | 21.82 |
| 2017-09-09 | 1.76 | 25.05 | 16.84 | 23.29 |

Table 4a. LST data statistics for sparse areas vegetation

| Date | min | max | mean | Variation |
|---|---|---|---|---|
| 2017-05-04 | 7.40 | 34.88 | 26.77 | 27.48 |
| 2017-06-05 | 19.43 | 37.54 | 29.98 | 18.11 |
| 2017-09-09 | 1.81 | 24.86 | 17.56 | 23.05 |

Table 4b. LST data statistics-for dense areas vegetation

| Date | min | max | mean | Variation |
|---|---|---|---|---|
| 2017-05-04 | 11.50 | 32.15 | 22.22 | 20.65 |
| 2017-06-05 | 19.21 | 34.75 | 24.67 | 15.54 |
| 2017-09-09 | 3.18 | 24.17 | 14.23 | 20.99 |

LST-04.05.2017

NDVI-04.05.2017

LST-05.06.2017

NDVI-05.06.2017

LST-09.09.2017

NDVI-09.09.2017
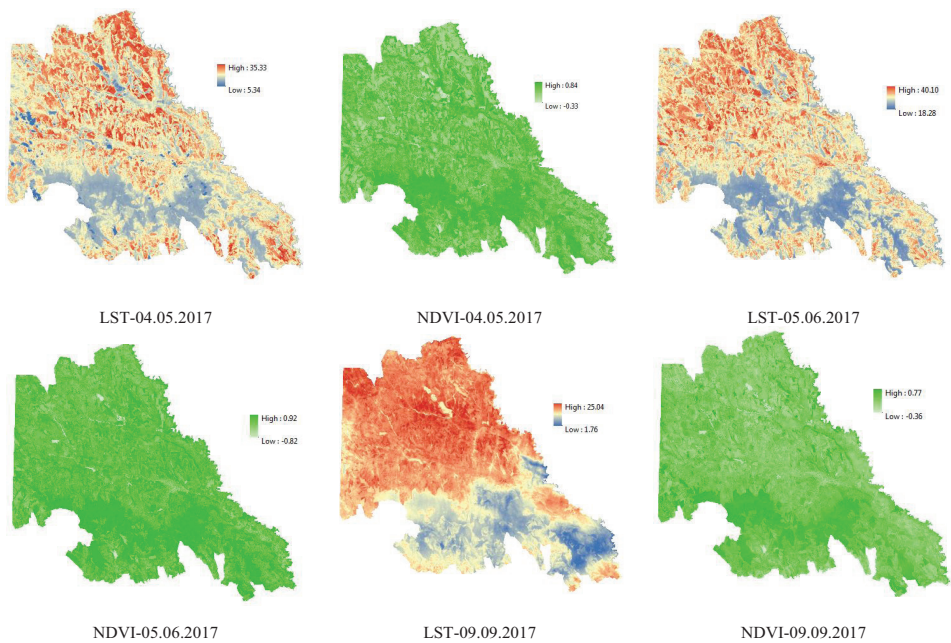
Figure 1. NDVI and LST maps



NDVIsparse-04.05.2017

NDVIdense-04.05.2017

LSTsparse-04.05.2017

LSTdense-04.05.2017

NDVIsparse-05.06.2017

NDVIdense-05.06.2017
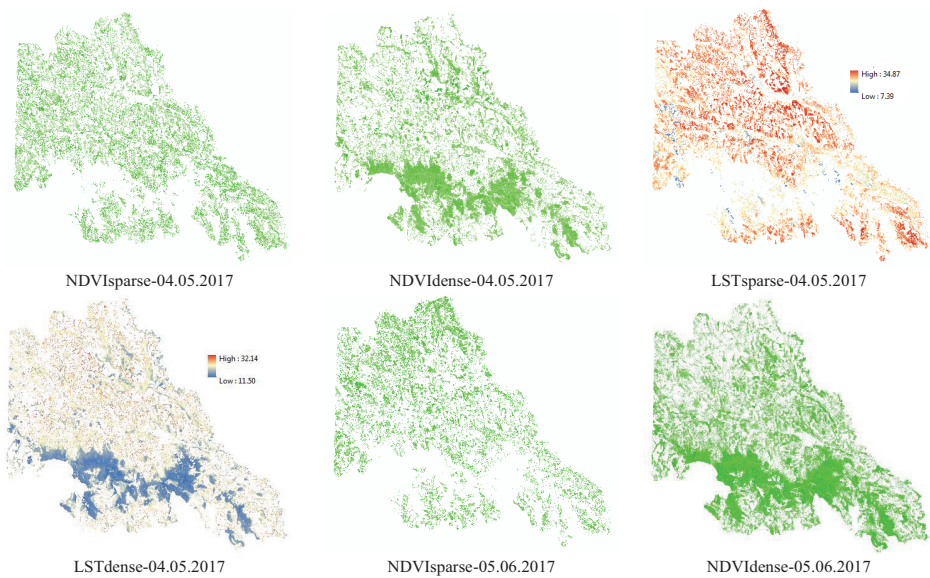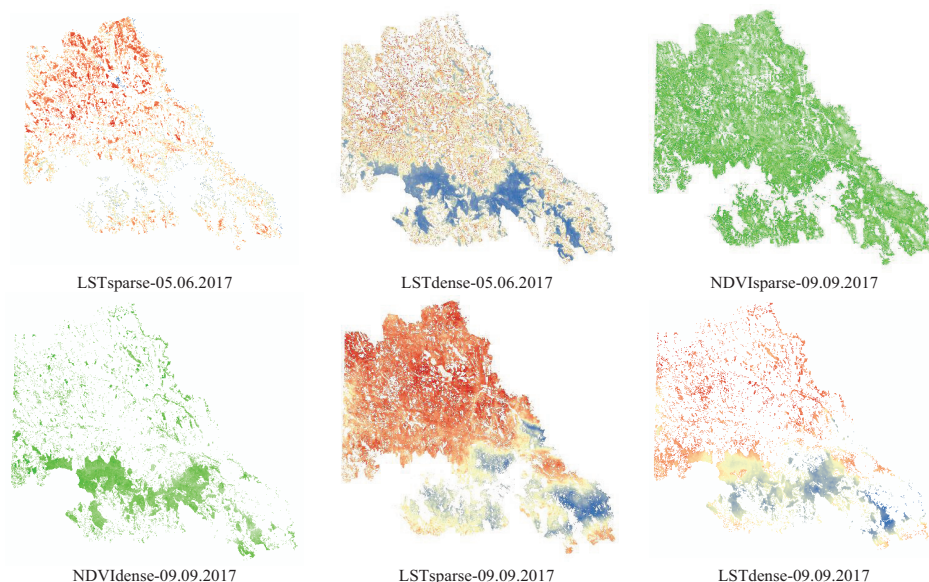
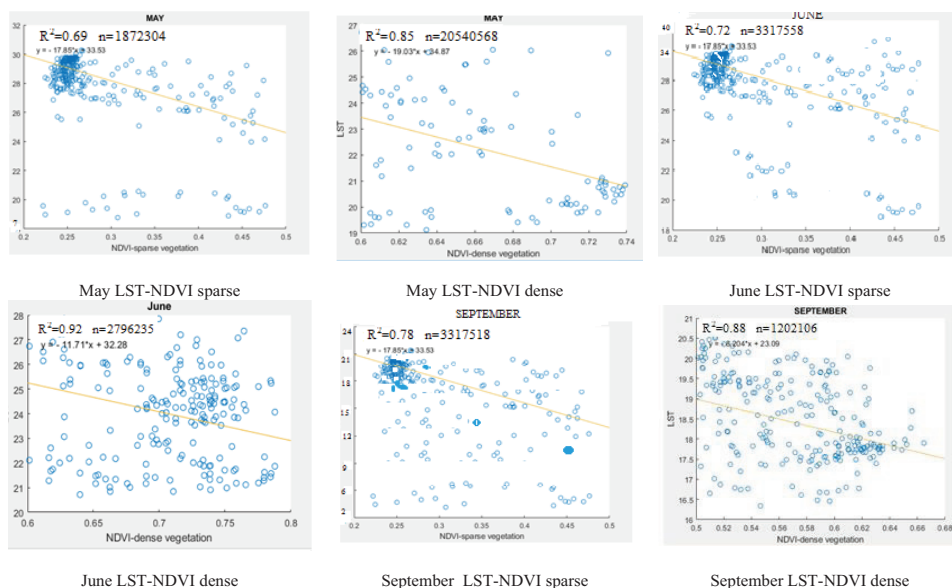Figure 2. LST and NDVI maps for sparse/dense area vegetation



Figure 3. Scatter plot and correlation coefficient between LST and NDVI sparse/dense vegetation

## CONCLUSIONS

In this paper was studying relationship LST-NDVI sparse/dense using Landsat 8 OLI data. An analysis based on statistical data indicates that, from the three times surveyed, the highest vegetation is in June, while in September vegetation is declining according to statistical data. LST data indicates that the maximum temperature is 40.1$^o$C, in June, and the minimum temperature is 1.76$^o$C in September.
It is noticeable that correlation coefficient has closer values to 1 for relationship LST-NDVI dense; $R^2$ is about 0.9, while $R^2$ is about 0.7 for relationship LST-NDVI sparse.

In conclusion, this correlation can be used to study vegetation health, drought damage, and areas where Urban Heat Island can occur.

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