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Irrigation water consumptive use changes in South Ptolemais lignite bearing hydrogeological basin (Greece) using NDVI remotely sensed data

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The present paper is a good example of using remote sensing data for temporal and spatial land use and in specific vegetation changes determination. In this case study of Sarigiol basin (South Ptolemais lignite bearing basin, Greece), irrigation water consumption assessment was correlated with the Normalized Difference Vegetation Index (NDVI). For this analysis two satellite images for the dates 26/07/2007 (Landsat-5) and 15/07/2018 (Landsat-8) were used.

Landsat-5 and Landsat-8 satellite images consist of quantized and calibrated digital numbers (DN) representing the multi-spectral image data. In order for the images to be appropriately used in various applications and analyzes, digital pixel values must initially be converted to Reflectance or Radiance values at the Top of the Atmosphere (TOA). This process is called Radiometric calibration.

The digital values of the spectral bands of the satellite images in the visible, near and mid infrared range of the spectrum are converted to TOA Reflectance with algorithms provided by the Landsat official website (the calibration coefficients are provided in the metadata file of the images).

The Normalized Difference Vegetation Index (NDVI) indicates the existence of vegetation in the area of interest and is the most widespread and acceptable of vegetation indices. Its calculation is made by utilizing the Near-Infrared (NIR) and Red spectral bands, calibrated in TOA Reflectance values, according to the following equation (Rouse et al., 1973):

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

NDVI ranges between -1 and 1, with the value 0 being the limit of vegetation and the values approaching 1 reflecting the younger and healthier vegetation. Figure 1 and Figure 2 below show the NDVI values of the areas of interest for the dates 26/07/2007 and 15/07/2018. These dates have been chosen for both the quality of satellite images and the fact that for these years there are data, recording electrical consumption of irrigation water pumping, which represent water consumption for various areas of the Sarigiol basin.

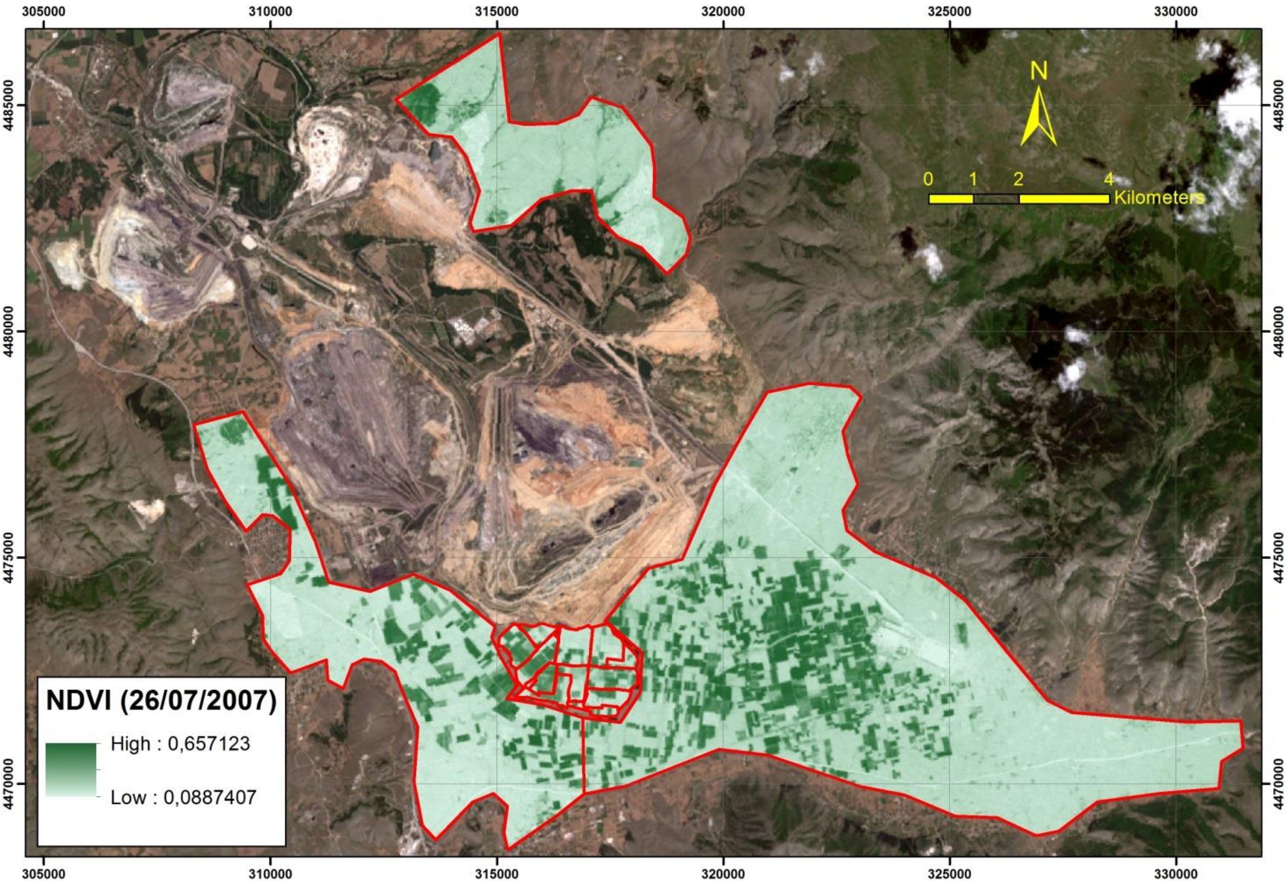

Figure 1. NDVI – July 26, 2007.

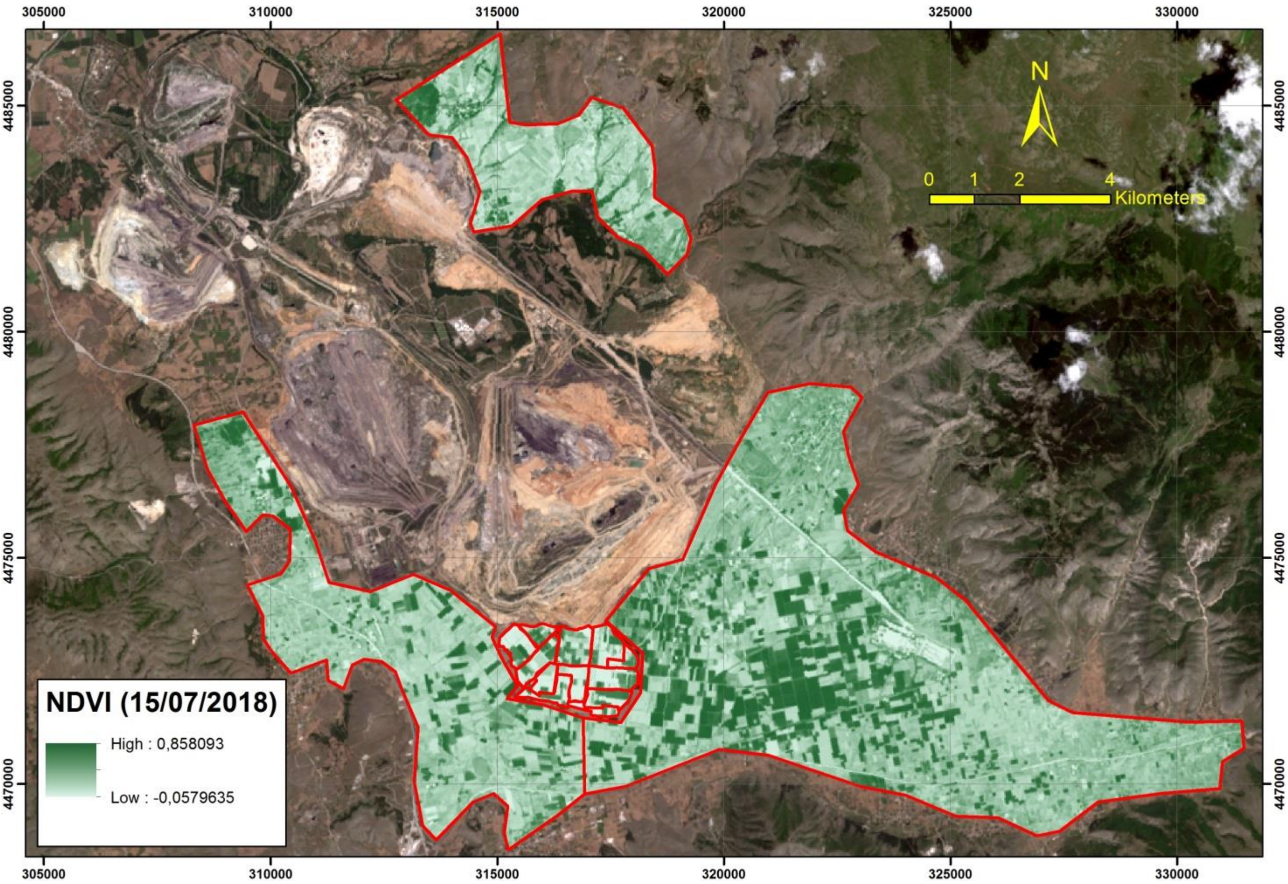

Figure 1. NDVI – July 15, 2018.

The linear regression analysis between NDVI (2007 satellite image) average values for the agricultural areas of interest and known water consumption for these areas (estimated by electric power consumption of irrigation pumps) produced the following equation:

$$y = 1.647 * x - 0.313 \text{, with } R^2 = 0{,}7896 \qquad \text{(Louloudis et al, 2019)}$$

Where:

y: mean annual water consumption (m^3/m^2)

x: NDVI average values

Additional to this the linear regression analysis between NDVI2007 and NDVI2018 for same regions is the following:

NDVI2018=NDVI2007*0.571+0.286 with R^2=0.85

Applying the previous equations to the average NDVI values (15 July 2018) satellite image the irrigation water consumption was estimated at 35.000.000 m^3 for the year 2018 with mean annual consumption 0.73 m^3/m^2. An analogous estimation was deduced introducing to Blaney Criddle water consumptive use crop coefficient Kc calculated by the following equation:

Kc=1.18*NDVI+0.05 (Masahiro, 2005)

Applying the previous equation to the average NDVI values of 0.57 returns a coefficient Kc equal to 0.72.

The study concludes that there is an annual increase of 1.000.000 m^3 for irrigation use. The results reinforce the arguments of Public Power Corporation of Greece (PPC) that the amount of water that is being pumped for lignite exploitation water inrush and geotechnical protection purposes, is negligible in comparison with the water consumption for irrigation and therefore the water balance of Sarigiol aquifer is mainly affected by farmers water pumping.

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