Assessment of Agricultural Drought in a Semi-Arid Area Using Remote Sensing

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Abstract

The impact of drought on vegetation is referred to as agricultural drought. Agricultural drought is commonly monitored at a basin scale using satellite based vegetation indices such as Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI). It is mainly the result of precipitation shortages, differences between actual and potential evapotranspiration, high temperatures and soil water deficits. Drought resulting from irregular or decreased rainfall, and increasing temperatures causes a reduction in NDVI and SAVI in areas of vegetation. The combination of NDVI, SAVI and surface temperature provides very useful information for agricultural drought monitoring. The study area is Kavakdere Basin in the west of Turkey which has a semi-arid climate. This study aims to evaluate the spatial and temporal drought using the vegetation indices and temperature data based on remote sensing. The correlation coefficients between NDVI, SAVI and surface temperature show negative correlation.

The Study Area

The study area is located at Seferihisar in Izmir which is Kavakdere plain (west of Turkey). The area has semi-arid climate. The average rainfall is 613.1 mm based on 1981-2010 years rainfall data. The major land use/land cover includes citrus (pink), grape (blue) and olive trees (green) (Fig. 1). Total agricultural area is around 500 hectares. The greatest part of it is cultivated with citrus (about 61%) and grapes (about 33%), while the rest is dominated by olive-trees.

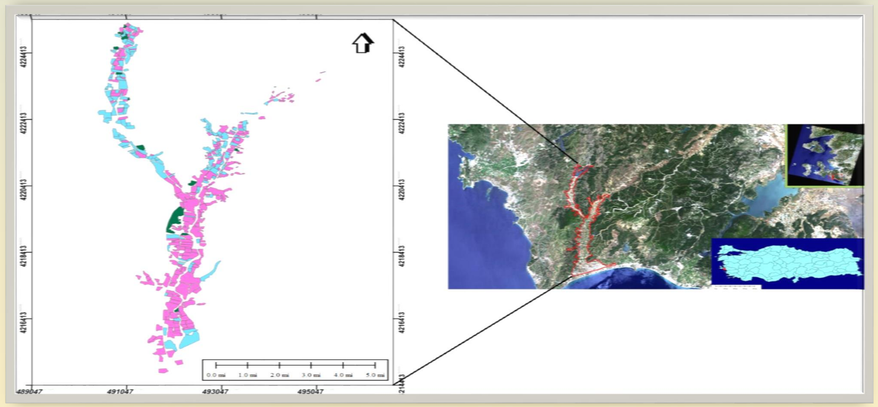


Fig 1. Kavakdere Plain

NDVI, SAVI and Surface Temperature

NDVI, SAVI and surface temperature were estimated by remote sensing techniques with Landsat 8 OLI-TIRS data.

The NDVI is the ratio of the differences in reflectivities for the near-infrared band (NIR) and the red band (RED) to their sum. The NDVI is a sensitive indicator of the amount and condition of green vegetation. Values for NDVI range between -1 and +1.

The SAVI is an index that attempts to “subtract” the effects of background soil from NDVI so that impacts of soil wetness are reduced in the index. It is computed using Equation 1:

$$SAVI = (1 + L)\,(NIR - RED) / (L + NIR + RED) \quad (1)$$

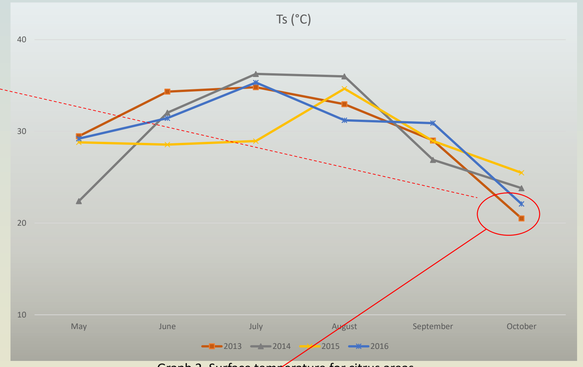
Surface temperature were calculated using Equation 2:

$$T_s = \frac{K_2}{\ln\left(\frac{\varepsilon_{NB} K_1}{R_C} + 1\right)} \quad (2)$$

ε_{NB} is narrow band emissivity, R_C is the corrected thermal radiance and K_1, K_2 are constants for Landsat images.

Results

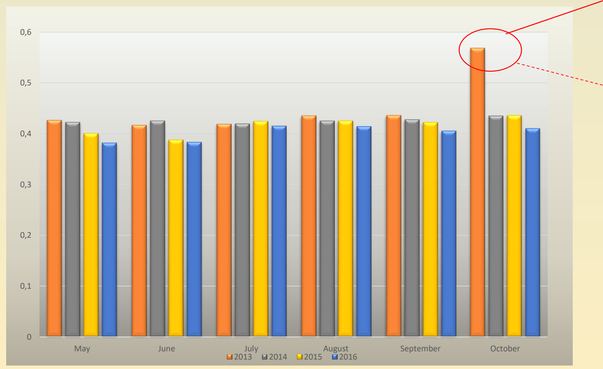
Graph 1. NDVI values for citrus areas



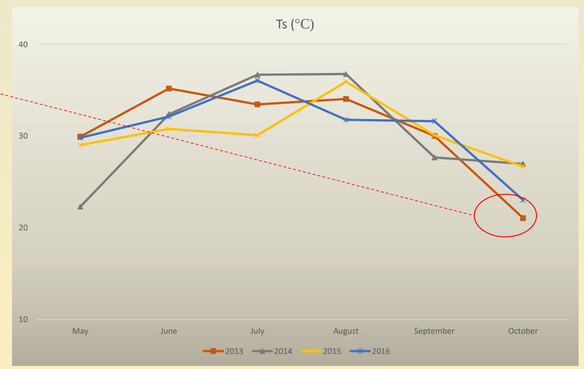
Graph 2. Surface temperature for citrus areas

Table 1.Precipitation data

	May	June	July	August	September	October
2013	48,2	0,4	0,0	1,4	0,2	107,2
2014	4,4	21,8	0,0	0,0	4,0	39,6
2015	51,4	0,0	0,0	0,0	5,2	57,1
2016	10,4	12,8	0,0	0,0	15,7	0,0



Graph 3. NDVI values for grape areas



Graph 4. Surface temperature for grape areas

Reflection values of NIR started to display increase on June when citrus trees were growing, but were followed by a decrease in September (Graph 1, 3).

In all of the years it can be seen that the NDVI values are lower during the hottest months of June, July and August (the irrigation season) whereas September and October show a higher vegetation density for citrus areas. On the otherhand NDVI values are similar during months of June, July, August and September for grape areas. The decrease in soil moisture due to irregular or no rainfall together with increased temperature causes the agricultural drought to be severe (Graph 2, 4). By calculating the correlation coefficients between surface temperature and NDVI, SAVI, it can be clearly seen that they show a high negative correlation. During irrigation seasons, a negative correlation between NDVI, SAVI and temperature was found on the Kavakdere Plain, where significantly increased temperature and decreased rainfall reduced moisture availability for plants.

The correlation coefficients between NDVI and SAVI are 0.98 for citrus and 0.97 for grape areas. The correlation coefficients between NDVI and surface temperature are -0.893 for 2013, -0.60 for 2014, -0.32 for 2015 and -0.726 for 2016 in citrus areas. The correlation coefficients between SAVI and surface temperature are -0.857 for 2013, -0.783 for 2014, -0.212 for 2015 and -0.596 for 2016 in citrus area s. The reason why the coefficient of correlation for 2015 is different from the other years is that it is rainy in 2015 (Table 1).

The correlation coefficients between NDVI and surface temperature are -0.928 for 2013, -0.363 for 2014, -0.063 for 2015 and 0.043 for 2016 in grape areas The correlation coefficients between SAVI and surface temperature are -0.90 for 2013, -0.893 for 2014, 0.285 for 2015 and 0.353 for 2016 in grape areas.