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INVESTIGATION THE EFFECT OF THE DROUGHT YEAR OF 2014 ON THE VEGETATION IN THE SEYHAN BASIN

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Abstract

Drought is an event which affects a wide range from water resources to agriculture and vegetation. Drought is frequently experienced in Turkey and affects large areas. In this research, we studied the Seyhan Basin, which is one of the important water basins in Turkey. Previous studies show that the Mediterranean Region including the Seyhan Basin has been exposed to sever droughts in recent years. In this context, it is of great importance to monitor drought in the Seyhan Basin at regular intervals and study the impact of drought in this area on different environments.

In this study, we examined the impact of drought in the year 2014, which affect the entire Seyhan Basin, on photosynthesis activity and distribution of vegetation. 2000-2014 EVI data from the MODIS TERRA platform were used for this purpose. Lastly, EVI data were classified according to the Equal Interval method. In this way, vegetation areas with high and low photosynthesis activity were detected.

The findings obtained show that both agricultural and vegetation areas in the Seyhan Basin were significantly affected by drought conditions in 2014. Although drought conditions were present throughout the year in 2014, the vegetation was affected more severely by these conditions in spring and summer months. Results show that adverse affects of drought conditions on vegetation are particularly evident during the growth period.

Keywords: Drought, MODIS TERRA, EVI, Seyhan Basin, Vegetation

1. INTRODUCTION

It is reported in both previous scientific studies (Gao and Giorgi, 2008; Karabulut, 2011; Bozkurt et al., 2011; Kum and Çelik, 2014) and the warning of The National Aeronautics and Space Administration (NASA) (http://www.nasa.gov/feature/goddard/2016/nasa-finds-drought-in-eastern-mediterranean-worst-of-past-900-years) that the Eastern Mediterranean Basin is in a sensitive position concerning the climate change. The climate conditions of recent years in particular have been recorded as the driest period of the last 9 centuries. This finding was obtained by the team led by Benjamin Cook of NASA's Goddard Institute for Space Studies and the study was published in *Journal of Geophysical Research: Atmospheres*, a publication of the American Geophysical Union. The study is based on the examination of tree-rings in the region (Cook et al., 2016). The most significant negative effects of the climate change in the Eastern Mediterranean Basin, which manifests itself as increased temperature and reduced precipitation, will be on water resources, vegetation and agricultural activities (Türkeş et al., 2000:14). Therefore, it is necessary to investigate and reveal effects of the climate change.

Studies report that, similar to the Eastern Mediterranean Region, certain climatic changes occur in the Seyhan River Basin as well (Kimura et al., 2006; Kanber et al., 2010; Altın and Barak, 2012). Climatic models created for the Seyhan Basin report a temperature increase of 2-2.7 ^{o}C and a precipitation decrease of 159-161 mm (Fujihara et al., 2008:33). In this case, it is even more important to reveal effects of changing climatic conditions in the Eastern Mediterranean and the Seyhan Basin on these locations.

In this study, we investigated effects of drought conditions on the vegetation of the Seyhan River Basin, which constitutes a considerable part (20,600 km^2) of the Eastern Mediterranean Basin and is considered as one of the most important water resources of Turkey. The Seyhan River Basin's vegetation was examined using vegetation index models, because the remote sensing methodology presents great advantages when it comes to detect rapidly occurring changes in large areas. In this study, we tried to understand how drought conditions impact the Seyhan River Basin's vegetation harnessing the advantages of the remote sensing methodology.

The Seyhan River Basin's vegetation status was examined for the period between 2000-2014. The 15-year period starting from 2000 is the period through which effects of the global climate change have been felt

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immensely. From this perspective, it becomes even more important to examine the Seyhan River Basin's vegetation status. We monitored the vegetation of the basin area in monthly intervals and attempted to reveal reasons behind extreme conditions regarding vegetation and agricultural areas. Therefore, we tried to answer the question, "What effect do dry climatic conditions have on vegetation?"

1.1 Location and Properties of the Study Area

The Seyhan River flows through the province of Adana, Turkey and into the Mediterranean Sea. The length of the Seyhan River Basin including its tributaries is 560 km, whereas its length from where Zamantı and Göksu tributaries join where the river flows into the Mediterranean Sea is 137 km. All waters in of the basin flow into the Mediterranean Sea including the Seyhan River and its tributaries, Zamantı and Göksu. The Seyhan River draws the boundary between Seyhan and Yüreğir districts of Adana and meets the Mediterranean Sea from Cape Deli, which is located in the most western part of Çukurova at the Adana-Mersin border. The Seyhan River Basin flows through provinces of Niğde (Çamardı-Ulukışla), Kayseri (Tomarza-Sarız, Pınarbaşı), Kahramanmaraş (Göksun) and Adana (Figure 1).

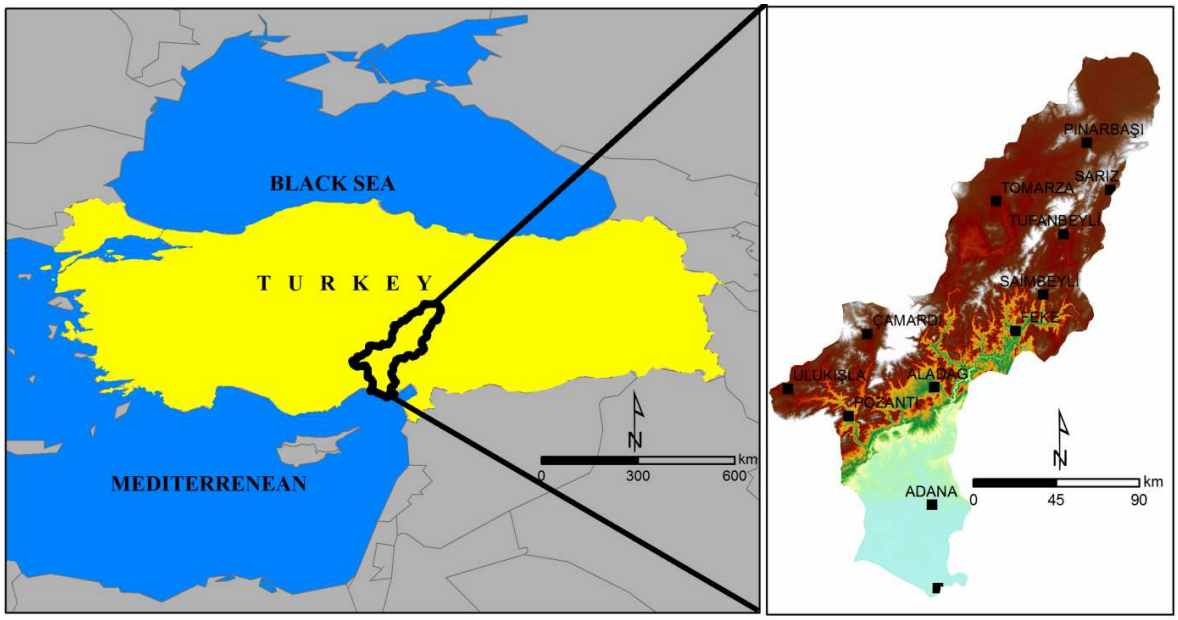

Figure 1. Location map of the survey area.

The basin terrain is mountainous and hilly except for Çukurova (Lower Seyhan Plain). Slopes are steep in the mountainous terrain, the soil is shallow and the vegetation is sparse. The hilly northern part is arid. The precipitation falls mostly during winter and spring (Figure 2). The runoff rate is high under these conditions. From the alluvial base to the northern section of the basin, Mediterranean soils with clear red colour are observed on limestone and conglomerate under the influence of the Mediterranean climate with dry-hot summers and humid winters. The precipitation increases and the temperature drops in the more northern parts. Leaching becomes more effective. The accumulation of organic matter is facilitated. Forest cover replaces meadows and shrubs. Brown Forest soils are observed in the lower slopes of the Taurus Mountains and Limeless Brown Forest soils are observed in higher parts with more intensive leaching conditions. Steep slopes prevent further soil formations in the forest zone. A significant portion of precipitation occurs outside the vegetation period in certain parts of the basin, especially those within the districts of Kayseri and Niğde. Underground water resources are used for irrigation. Problems arising from excessive irrigation in the basin include salinity and pollution problems, reduced underground water reserves, a large portion of precipitation occurring outside the vegetation period, low water level in ponds and dams, water losses due to inappropriate irrigation methods, uneconomic use of available water, drainage problems, problem experienced due to legislative regulations.

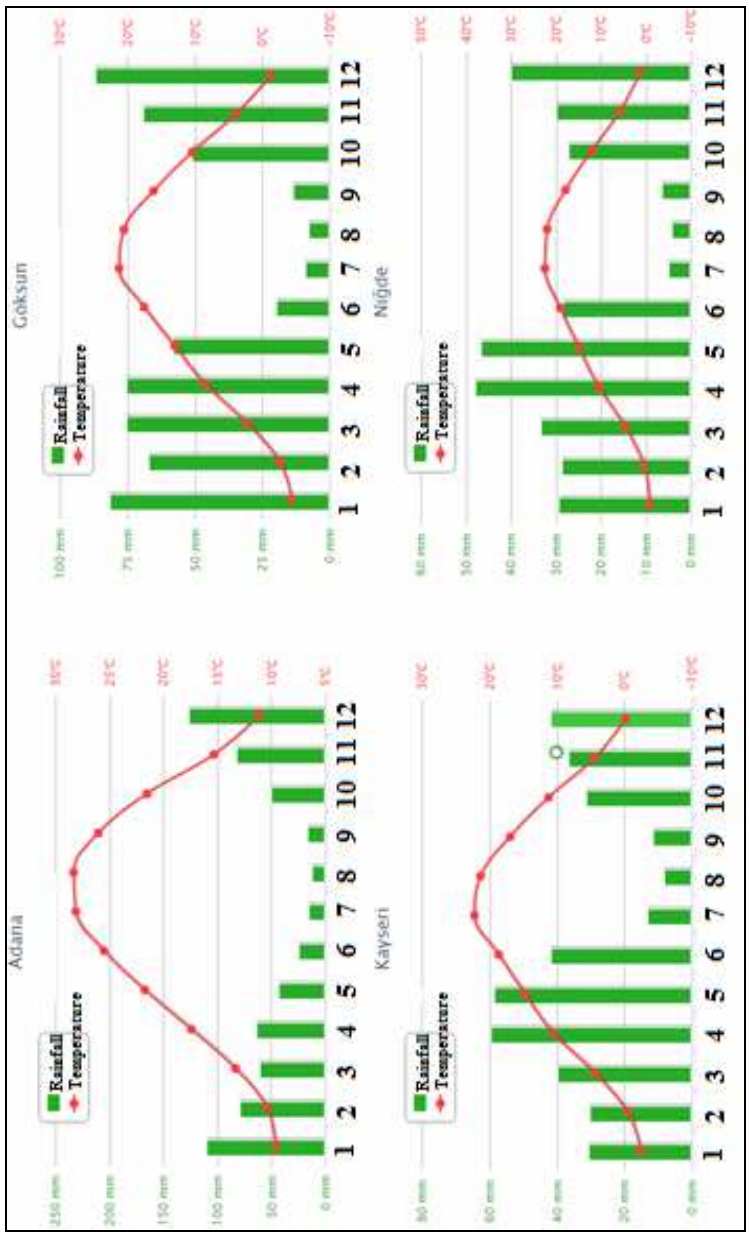

Figure 2. Temperature and precipitation diagram in certain stations in the survey area and its immediate surroundings (source: Turkish State Meteorological Service (MGM)).

The low population density in the Upper Seyhan leads to less pollution due to domestic wastewater compared to the Lower Seyhan. Comparing Upper and Lower Seyhan Basins, the most intense agricultural pressure is observed in the Lower Seyhan Basin, where agricultural areas are larger and irrigated farming activities are more intensive. In other words, there is a high level of agricultural pollution in the Lower Seyhan Basin, where large agricultural areas are present and intensive irrigated farming activities are carried out, due to intensive use of pesticides and fertilizers, whereas the agricultural pollution level is minimum in the Upper Seyhan Basin, where agricultural areas are limited and natural vegetation and forests are dense. According to the land use and cultivation area report of TÜBİTAK – TOVAG between 1985-2003, 37 km^2 of forest area in the Seyhan Basin was converted into cultivation area, 37 km^2 was converted into water surface and 5 km^2 was converted to residential area.

2. MATERIAL AND METHOD

Bands of the MODIS satellite were used in this study. MODIS satellites consist of 36 bands with a wavelength varying from 0.4 mm to 14.4 mm. In MODIS satellites, the 1st and 2nd bands have a spatial resolution of 250 m, 3rd to 7th bands have a spatial resolution of 500 m and the remaining 29 bands have a spatial resolution of 1 km (Huete et al., 2002; Kalfas et al., 2011).

The data of EVI, which has become a frequently used vegetation index model in recent years, are not severely affected by aerosol and cloudiness (Zhang et al., 2014:53). EVI images provided for users by MODIS are calculated using the following formula (Galvão et al., 2011: 2352; Çelik and Karabulut, 2014:374; Çelik, 2016:71):

EVI= G*(Near infrared–Red)/ (Bear infrared+C1*Redd-C2*Blue+L)

In the formula, G (gain factor)=2.5, L=1, C1=6, C2=7.5. With this formula, values in the bandwidth ranging between -1 and +1 are obtained. EVI images, which are not severely affected by atmospheric conditions, do not show too much variation throughout the year in terms of trend.

Finally, agricultural and vegetation areas are detected applying the Equal Interval classification method to EVI images (Figure 3).

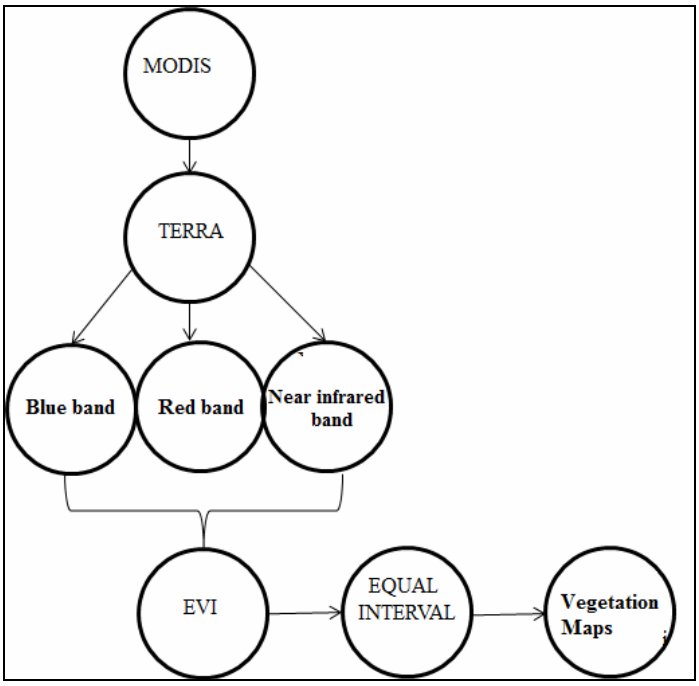

Figure 3. Flow chart of the study.

Equal Interval categorizes all classes throughout the equal-interval number line. For example, an image to be categorized as 15 classes is obtained using the following formula in the Equal Interval method:

$$\frac{\text{Range of Data}}{\text{Number of Classes}} = \frac{\text{(Highest Value} - \text{Lowest Value)}}{\text{Number of Classes}} = \frac{(100-10)}{15} = 6$$

According to this formulation, the rage of data is divided by the number of classes. In other words, the lowest vegetation index value of a 15-class EVI image to be obtained is subtracted from its highest vegetation index value and the result is divided by the number of classes. Thus, a 15-class EVI image with 6 value intervals is obtained.

3. FINDINGS AND DISCUSSION

SPI was calculated using the precipitation data from stations in the Seyhan Basin. Drought analysis was applied to the data from Tomarza, Kozan and Adana MGM stations. Thus, the dry period was detected. Then, the vegetation status of the dry period detected was analyzed. The drought analysis results of the period between 2012 and 2016 show that 2014 was a dry year. Drought analysis results of Adana, Kozan and Tomarza stations shows 2014 was a dry year in the Seyhan Basin. The year 2014 is the most important dry period experienced in the Seyhan Basin in recent times. It is observed that some months in the year 2013 were dry as well in Tomarza and Kozan stations, but 2014 stands out as the year when a drought occurred in all stations of the Seyhan Basin (Figure 4). Drought conditions in both spring months and autumn months in 2014 adversely affected both the vegetation and agricultural products (Table 1).

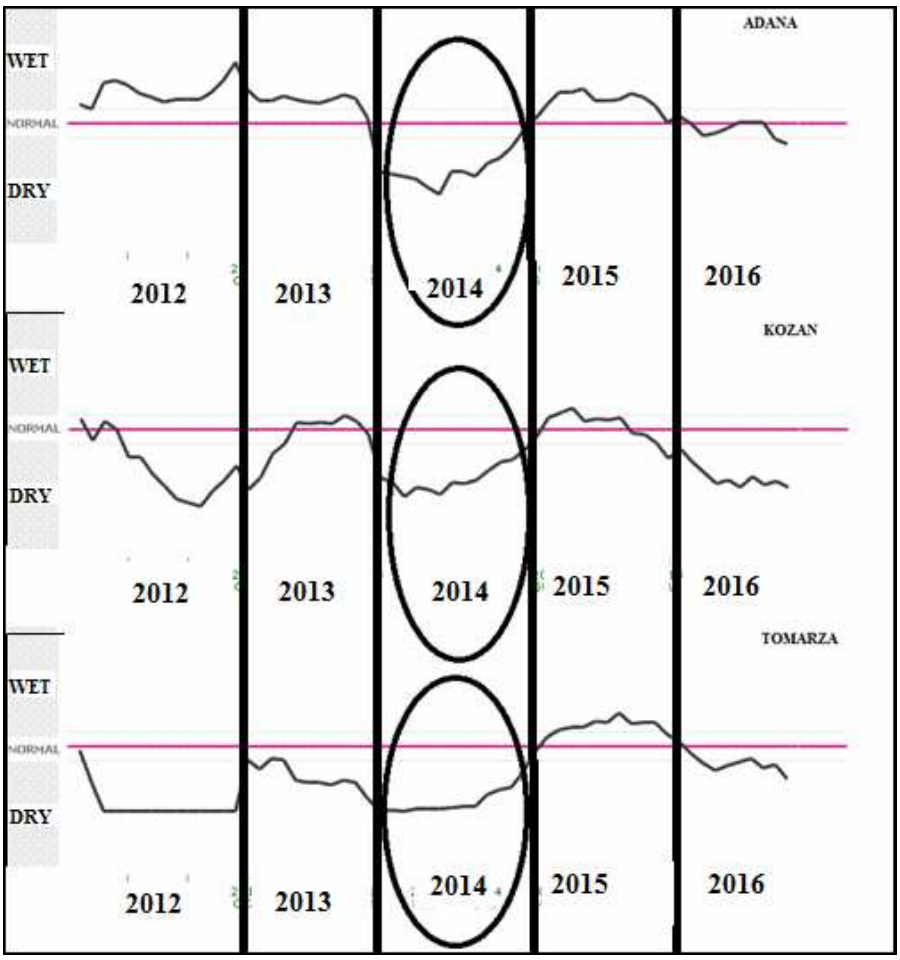

Figure 4. SPI drought analysis results from certain stations of the Seyhan Basin between 2012-2016 (source: MGM).

Drought is particularly effective on dry farming products. The water need of products such as corn and cotton is met via channels. Wheat, on the other hand, requires rain. Therefore, an examination of wheat yield gives a clearer idea about drought. Agricultural activities in the Seyhan Basin are conducted in fertile lands in the South. For this reason, we examined wheat, cotton and corn yields in Adana, Karataş and Yumurtalık in 2013, 2014 and 2015 in order to analyze effects of drought on agriculture. Accordingly, the wheat yield in Adana in 2014 was 286 kg/da. The wheat yield in 2014 was 449 kg/da in Karataş, located on the southern end of the basin, and 258 kg/ha in Yumurtalık. The wheat yield in Adana, Karataş and Yumurtalık in 2014 was lower compared to other years. Cotton and corn, which are irrigated farming products, were not affected by drought conditions (Table 1).

Table 1. The yield of some farming products in the Lower Seyhan Basin between 2013-2015 (source: TurkStat).

LOCATION	Year	2015	2014	2013
	Product	Yield (kg/da)	Yield (kg/da)	Yield (kg/da)
ADANA	Wheat	**390**	**286**	**371**
	Cotton	307	333	318
	Corn	1060	1094	1020
KARATAŞ	Wheat	**494**	**449**	**506**
	Cotton	311	335	324
	Corn	1108	1121	1139
YUMURTALIK	Wheat	**383**	**258**	**387**
	Cotton	280	304	276
	Corn	1067	950	936

In order to achieve a better analysis of effects of the drought experienced in 2014 on vegetation, values belonging to 2014 were removed from the average vegetation index value of 2000-2014. Thus, effects of the dry year of 2014 on the Seyhan Basin's vegetation were revealed more clearly. It is seen that vegetation index values during spring and summer in particular were much lower than the average (Figure 5), which indicates that the photosynthesis activity of plants during foliation was much lower in 2014 compared to previous years.

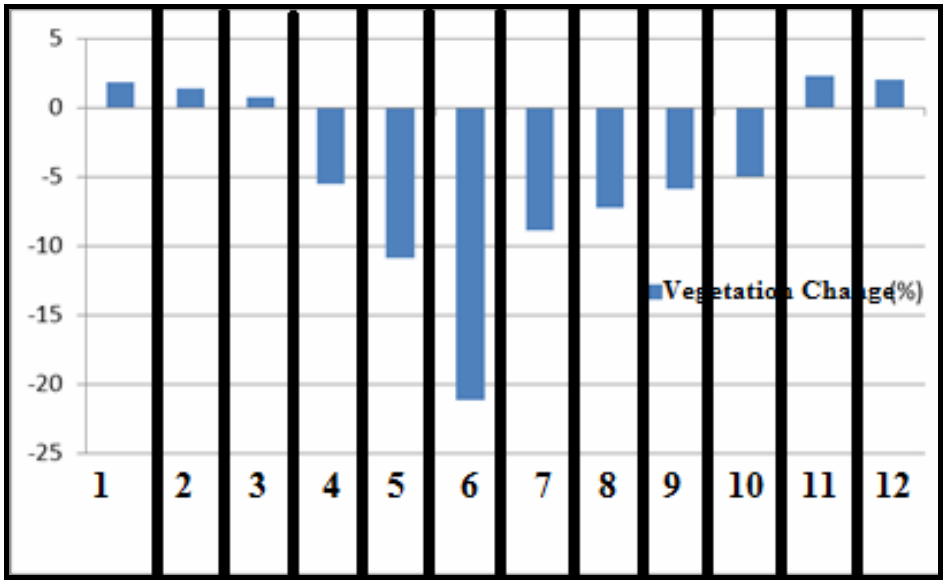

Figure 5. Deviation of the vegetation rate in 2014 from the average of 2000-2014 (%).

40.49% of the Seyhan Basin is covered with agricultural areas and 56.82% is covered with forests and semi-natural areas. Forests and semi-natural areas are divided into 3 classes. 22.86% is areas covered with scrubs, 12.62% is covered with forests and 21.34% is areas covered with sparse vegetation or naked areas (TUBİTAK, 2010:130). A large portion of the agricultural lands in the Seyhan River is located in the lower part of the basin. Irrigated farming activities are common in the Lower Seyhan Basin. Forests, which cover 56% of the basin, are located in the hilly terrains in the upper part of the basin. The scrub vegetation, which covers 22% of the basin, is located on slopes of the mountainous areas and places where the red pine species is damaged. The greenest period of the Seyhan Basin is spring and summer months. Vegetation index values increase with the forest vegetation turning green. In summer, vegetation index values are high due to irrigated farming activities such as cotton and corn especially in the Lower Seyhan Basin (Figure 6).

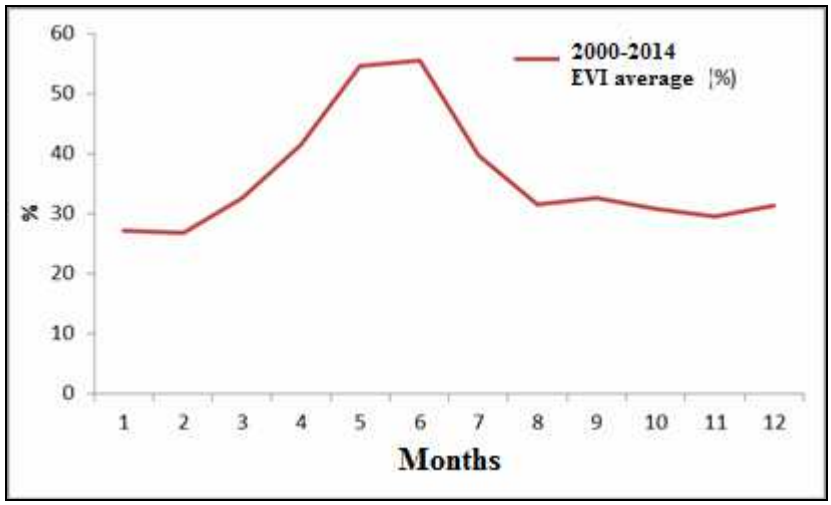

Figure 6. Monthly averages of EVI values in 2000-2014

The southern area which constitutes 11% of the Seyhan Basin is referred to as the Lower Seyhan Basin. The remaining 89% is the Upper Seyhan Basin, which is relatively rugged and high, covered by natural vegetation and has little agricultural land. Agricultural areas do not cover a large portion due to topographic conditions of the Upper Seyhan Basin. Therefore, the natural vegetation rate is high. Vegetation

areas cover a larger portion in the Upper Seyhan Basin in the period starting with November. Vegetation areas in the Upper Seyhan Basin shrink starting from March, when the temperature increases. On the other hand, the exact opposite is the case for the Lower Seyhan Basin. In the Lower Seyhan Basin, the crowded population and intensive industrial activities particularly in Adana and intensive agricultural activities in Çukurova are of great importance. The presence of Çukurova Delta in the basin increases the product variety. Grain farming is common in the upper part of the basin. Different plant products, mainly cotton and citrus, are cultivated in the part where Çukurova Delta is located. The vegetation rate increases in summer months in the Lower Seyhan Basin due to intensive irrigated farming activities. On the other hand, the vegetation rate decreases in July in the Lower Seyhan Basin in connection with the harvest of irrigated farming products such as cotton (Figure 7 and 8).

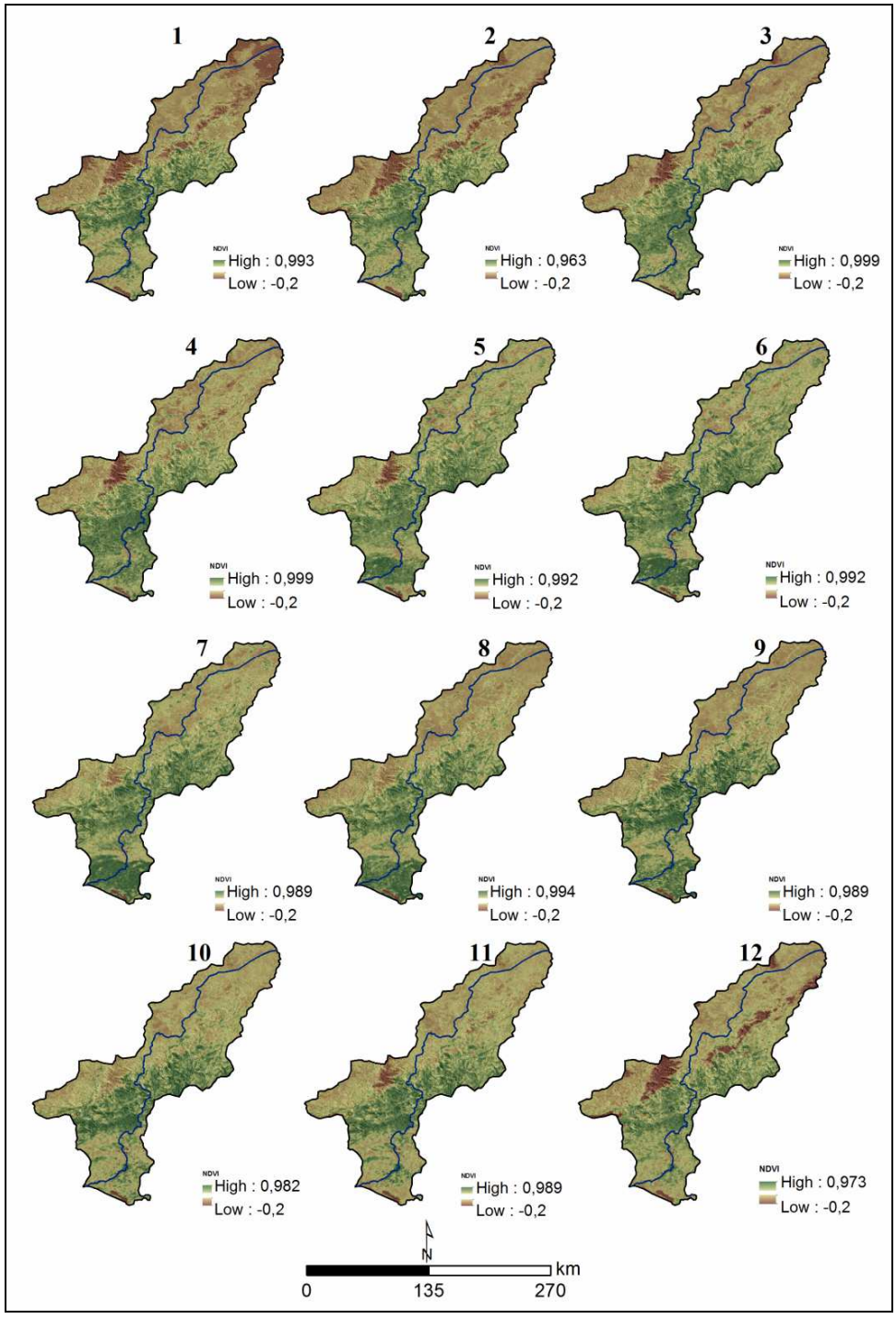

Figure 7. Monthly EVI images of the Seyhan Basin in 2014.

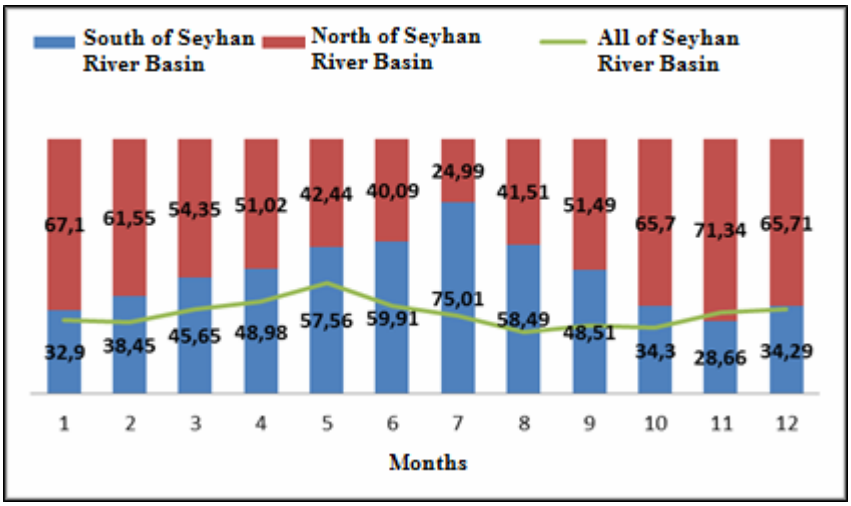

Figure 8. The distribution of the vegetation rates in the Lower and Upper Seyhan Basin in 2014 (%).

4. CONCLUSION

In this study, we investigated the relationship between drought conditions and vegetation in the Seyhan Basin. To this end, we firstly determined that the year 2014 was the dry period in the Seyhan Basin. Then, we examined the status of vegetation in the dry year in question. EVI data from the MODIS TERRA platform were used to reveal the status of the vegetation. According to the results of the study, the vegetation of the Seyhan Basin showed significant changes in the dry period. The average vegetation index values of 2000-2014 showed significant deviations in 2014. Vegetation areas showing high reflection properties according to 2000-2014 averages produced lower values in 2014. In other words, drought conditions caused the vegetation in the Seyhan Basin perform less photosynthesis activities than normal. Especially the growth period of the vegetation was adversely affected by the dry period. In this case, whilst low photosynthesis activity was observed in forest areas, agricultural areas in the southern part of the basin showed low yield. Although the yield of irrigated farming products such as cotton and corn did not decline, the yield of wheat declined significantly.

Drought climatic conditions are experienced often in the Seyhan Basin. It was emphasized in this study that the vegetation status in the Seyhan Basin is significantly affected by drought conditions. In this context, it is important understand the effect of dry climatic conditions on the location. Otherwise, there is a high risk of decreased agricultural yield and destruction of the vegetation in the region. It is important to monitor drought using meteorology data as well as satellite-based data and methods in drought monitoring centres. In this way, it shall be possible to answer the question, "How do drought conditions impact ecosystems in different regions of Turkey?" in more detail.

It was also shown in this study that it is possible to detect drought conditions not only by examining climate data, but also using reflection values obtained from vegetation indices. Vegetation index values of 2014 shows significant deviation from average EVI values of 2000-2014, which indicates a drought. Therefore, it is possible to have important ideas about the beginning, severity and duration of dry periods using vegetation index values.

Future studies on drought should be conducted in regions of Turkey where drought is experienced frequently and using various methods. It is necessary to answer questions such as "How often is drought experienced?" and "How does drought impact vegetation, water resources and agricultural activities?" in detail for areas with high drought risk. It is important to analyze both satellite-based and station-based data together in studies involving drought analysis.

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