IRBAS www.irbas.academyirmbr.com October 2019
International Review of Basic and Applied Sciences Vol. 7 Issue.10

Analyzing the Relations between Drought and Crop Yield in Southern Plains of Şanliurfa (Akçakale, Ceylanpinar, Suruç)

MEHMET ALI ÇELİK
Department of Geography, Kilis 7 Aralık University, Turkey.
Email: mehmetalicelikk@gmail.com

TANER AYDIN
Department of Recreation, Iğdır University, Iğdır, Turkey.
Email: taner.aydin@igdir.edu.tr

Abstract

Semi-arid climates are areas where rainfall variability is 25% and above. In these regions, high rainfall variability often leads to arid conditions. The main motivation of this study is to answer the question of how agricultural products react to the high variability in rainfall in the lower plains of Şanlıurfa, one of the most productive agricultural areas in Turkey. In this context, the main purpose of our study is to determine the response of crop pattern to arid conditions by specifying test areas in a semi-arid area. For this purpose, plant indexes were created using MODIS data. In this study, the drought-yield relationship of Suruç, Akçakale and Ceylanpınar Plains was examined by using the advantages of remote sensing.

Keywords: *MODIS, Southern Plains of Şanlıurfa, Agricultural Drought, Remote Sensing*.

Introduction

Drought is the major factor that reduces crop yields in most of the world's agricultural fields. Agricultural production in semi-arid regions is usually done in dry agricultural areas and drought causes serious problems in agricultural yields in these areas (Öztürk, 1999:531). In this context, understanding the reactions of agricultural products in the face of drought is of great importance in solving the nutritional problems of the growing world population. For this, a detailed analysis of the ecological demands of agricultural products is required.

Semi-arid regions are areas where rainfall variability is 25% and above. In these regions, high rainfall variability often leads to arid conditions. The main motivation of this study is to answer the question of what reactions the plant production gives to the high variability in rainfall in the Southern Plains of Şanlıurfa, which shows arid and semi-arid climate characteristics. The main aim of our study is to determine the response of plants such as wheat, barley, red lentils, cotton and corn to arid conditions by specifying the test areas belonging to Akçakale, Ceylanpınar and Suruç districts, which show a semi-arid feature in the fertile agricultural lands south of Şanlıurfa. For this purpose, the effect of stress conditions on crops caused by drought on agricultural production was studied. The basis of our study is formed by monitoring of agricultural areas with remote sensing methodology and the detection of arid periods with Meteorology-based drought Analyses. The plant production data of the Turkish Statistical Institute (TSI) is also one of the important data used in the study.

Drought monitoring methods based on remote sensing provide quick and useful information for a sustainable management of drought impact on a region (Quiring and Papakryiakou, 2003). There are many studies on the detection and monitoring of drought in advance with remote sensing methodology (Wilhite, 2007). These studies show that agricultural drought usually occurs after a prolonged meteorological drought and leads to significant reductions in the amount of crops and yields obtained from agriculture (Simsek, 2010). In short, agricultural drought is the insufficient amount of water in the soil for the development of the plant (Uçan et al., 2007). Thus in this study, we tried to understand the relationship between plant-drought-yield with meteorology-based drought analysis in detail.

The issues of climate change and drought are increasing the pressure on agriculture. Due to this situation, there is a danger of famine and a shortage in the food supply. Therefore, these changes need to be registered, planned and sustainable in order to produce precautions, measures and policies in the face of these problems. In this context, remote sensing provides important facilities and advantages in monitoring and recording changes in the use of land cover, water resources and agricultural crop patterns in large areas of the Earth. In this study, the relationship between drought and yield of Suruç, Akçakale and Ceylanpınar Plains (Figure 1) was examined by using the advantages of remote sensing.

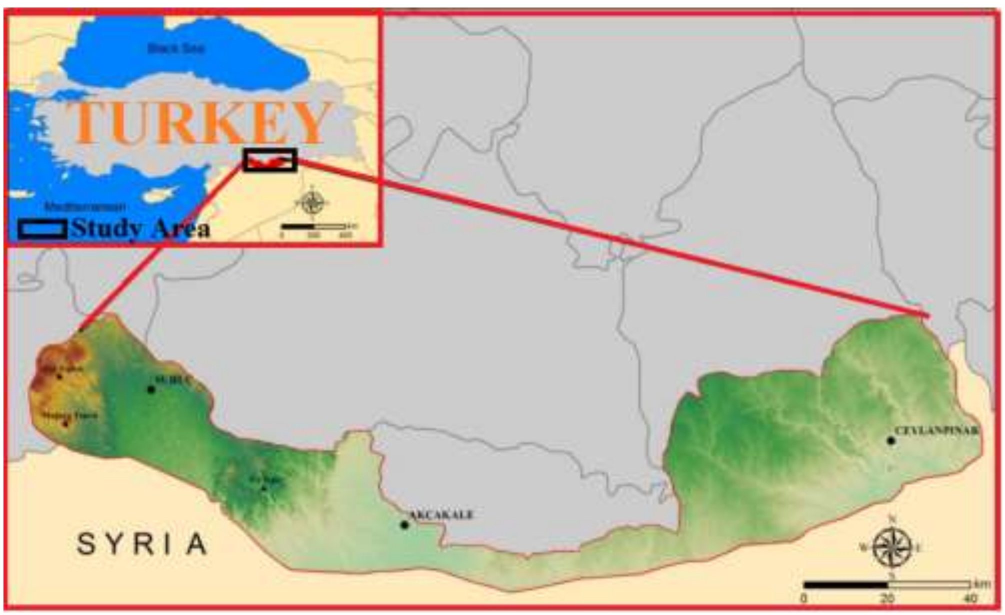

Figure 1. Field of study.

Data and Method

NDVI used in the study refers to normalized values obtained by subtracting the light values of the near infrared and red wavelength from each other and then dividing them into the sum of the two bands. NDVI is one of the most widely used plant indexes and is calculated by the following formula (Viovy et.al., 1992; Çelik and Karabulut, 2013; Kalfas et al., 2011):

$$NDVI = \text{Near infrared} - \text{Red} / \text{Near infrared} + \text{Red}$$

Another plant index model that has been used frequently recently is EVI. EVI images are not very much affected by aerosol and cloudiness. EVI images provided to users by MODIS are calculated using the following formula (Huete et al., 2002; Breunig et al.,2011; Pan et al.,2015):

$$EVI = G * (\text{Near Infrared} - \text{Red}) / (\text{Near Infrared} + C1 * \text{Red} - C2 * \text{Blue} + L)$$

G (gain factor) used in the formula is=2.5, L=1, C1=6, C2=7.5. With this formula, values in the band range ranging from -1 to +1 appear. EVI images, which are not affected by atmospheric conditions, do not have a trend to deviate much during the year. NDVI images can be affected by atmospheric conditions and show abrupt declines during the year.

Results

In 2001, in The Plain of Suruç, plant products belonging to dry agriculture are grown in areas suitable for agriculture. In 2001, barley and wheat were the most cultivated agricultural crops in The Plain of Suruç. These are followed by red lentils. Wheat and barley cultivation is carried out on an area of approximately 500 thousand decares and red lentils are cultivated in a 90 thousand decares area. According to TSI data, the wheat planting area in Ceylanpinar narrowed in 2001 compared to 2000. The most cultivated crop in Ceylanpınar Plain is wheat, with an area of approximately 540 thousand decares. With the year 2001, the yield of wheat in the southern plains of Şanlıurfa was increasing. Accordingly, wheat yield in Akçakale district is 340 kg/da while Ceylanpinar is 229 kg / da. In Suruç plain, the yield of wheat was 340 kg/DA in 2001. In 2001, wheat was the most cultivated agricultural crop in Akçakale district. Wheat is followed by cotton. Thanks to the channels transmitted from the Atatürk Dam Lake, irrigated farming activities are carried out extensively in Akçakale district. Cultivation of cotton plant is especially common in the district. Corn cultivation is done in a very narrow area (Table 1).

Table 1. Data on the most cultivated agricultural products in the field of study in 2001 (Source: TSI).

	Crop	**Planted area (Decare)**	**Production(tons)**	**Yield (kg / da)**
Akçakale	Wheat	495.730	168.386	340
	Barley	250,860	83.994	335
	Lentils (Red)	74.150	2.290	31
	Cottonseed	430,000	87.591	204
	Cotton (unseed)	430,000	150,500	350
	Cotton (Fiber)	430,000	57.190	133
Ceylanpınar	**Crop**	**Planted area (Decare)**	**Production(tons)**	**Yield (kg / da)**
	Wheat	542,900	124,475	229
	Barley	28.950	11.076	383
	Lentils (Red)	160,040	22.404	140
	Cottonseed	105,000	23.014	219
	Cotton (unseed)	105,000	40.950	390
	Cotton (Fiber)	105,000	16.380	156
Suruc	**Crop**	**Planted area (Decare)**	**Production(tons)**	**Yield (kg / da)**
	Wheat	208.210	70.722	340
	Barley	241.210	74.994	311
	Lentils (Red)	90.690	13.119	145
	Cottonseed	35.000	7.376	211
	Cotton (unseed)	35.000	13.125	375
	Cotton (Fiber)	35.000	5.250	150

Double crop cultivation is carried out annually in the southern plains of Şanlıurfa. It is possible to determine this from EVI data with spatial resolution of 1 km of MODIS data, with monthly temporal intervals. Accordingly, dry agricultural products are observed to have grown completely in March. This greening period lasts until April and May. With the month of June, it is seen that the agricultural products are in the harvest state. In July and August, activities for irrigated farming products begin. In the southern plains of Şanlıurfa, agricultural products are green until September. As of October, irrigated farming products such as corn and cotton are harvested (Figure 2).

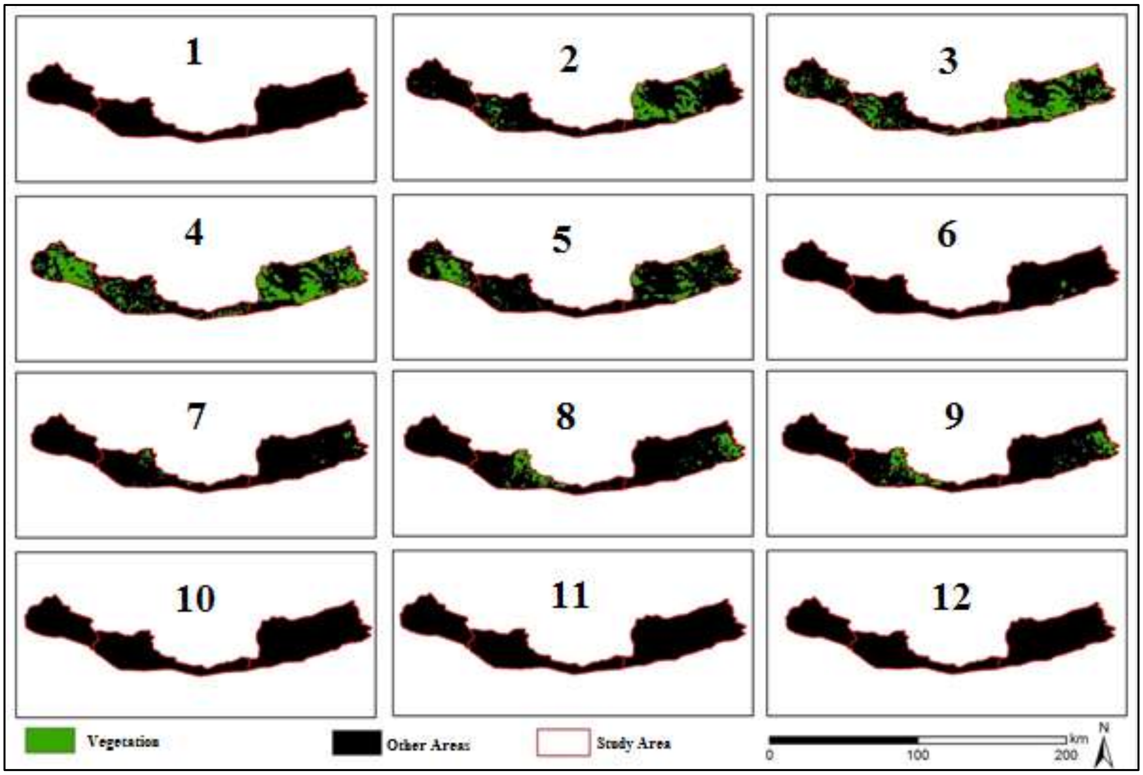

Figure 2. The distribution of vegetation areas in the study area by months in 2001.

Green vegetation in the study area was calculated monthly using the Natural Breaks classification method (Lin, 2013; Çelik, 2016). Accordingly, March and April are the densest months of vegetation in the southern plains of Şanlıurfa. In these months, dry agricultural products such as wheat, barley and red lentils are green. In May, a large portion of dry agricultural products are harvested in Akçakale district. Dry agricultural products have not yet been harvested in Suruç and Ceylanpinar in May. In June, dry agricultural products were harvested in the plains of Suruç and Ceylanpınar. In Akcakale, dry agricultural products are harvested earlier than Suruç and Ceylanpinar. In September 2001, irrigated farming products such as cotton and corn were green. In 2001, irrigated farming products were effective in the 21% of Akcakale district. In the Ceylanpınar Plain, this ratio was around 7%, and in 2001, irrigated farming activities in the Suruç Plain were almost nonexistent. Thus, the rate of vegetation in Suruç in July, August and September, which has high photosynthetic activity, was around 0% (Table 2).

Table 2. Proportion of agricultural areas by months in the study area in 2001 (%).

Months	SURUC	AKÇAKALE	CEYLANPINAR
January	0	0.99	7.7
February	0	0	8.13
March	52,72	17,24	44.91
April	61.39	16.26	46,53
May	53,18	2.79	29.62
June	0	0	0

July	0	6.73	0.22
August	0	17	3.72
September	0	21.26	7.25
October	0	0	0
November	0	0	0
December	0	0	0

In April, May and June 2000, the southern plains of Şanlıurfa were dominated by arid conditions during the 3-month period (Table 3), while in 2001 it was observed that wet conditions prevailed. As a result of this, in 2001, both dry and irrigated farming products increased efficiency is observed. At the same time, in 2001, the rate of vegetation with high photosynthetic activity increased. This is an important answer to the question of the effect of arid and wet climatic conditions on the yield of agricultural products and the cultivation area. Especially in places where irrigation is not developed much in agriculture, wet climate conditions have important effects on the yield of agricultural products and the cultivation area. For example, in April 2000, while 24% of the Suruç Plain was seen as dry agricultural land, in April 2001 this rate was 61%. 3-month wet climate situation period, covering April, May and June of 2001 in Suruç Plain, increased the yield of dry agricultural products. In 2000, while the yield of wheat in Suruç was 104 kg/da, in 2001 the yield increased by 3 times to 304 kg/da (Table 3).

Table 3. SPI analysis results in 3-month periods of 2001 (Source: MGM).

Station	Years	**January-February-March**	**April-May-June**	**July-August-September**	**October-November - December**
Akçakale	2001	Normal	Damp-dry	Normal	Moderate humidity
Ceylanpınar	2001	Normal	Damp-dry	Normal	Normal
Şanlıurfa (Centre)	2001	Normal	Damp-dry	Normal	Damp air

In the southern plains of Şanlıurfa, 2001 is notable as the period when wet climate conditions prevailed. For Akçakale, both the first 6 months of 2001 and the last 6 months were wet. In Şanlıurfa, the last 6-month period of 2001 is a very wet period (Table 4).

Table 4. SPI analysis results in 6-month periods of 2001 (Source: MGM).

Station	**Şanlıurfa**	**Akçakale**	**Ceylanpınar**
2001 (first 6 months)	Normal	Damp-dry	Normal
2001 (last 6 months)	Damp air	Moderate humidity	Normal

By 2005, the highest yield on some agricultural products is seen in Akçakale. For example, the yield of wheat was 360 kg/da in Akçakale, 278 kg/da in Ceylanpinar and 249 kg/DA in Suruç. However, barley plant shows the opposite situation. In other words, the highest yield on barley is in Suruç and Ceylanpinar (Table 5).

In our study, TSI's plant product data were obtained to support satellite imagery and land use maps. According to these data, while there is not much change in the cultivation area of dry agricultural products in Akçakale, irrigated farming areas tend to increase continuously. Especially after the opening of the Şanlıurfa tunnel in 1995, significant increases were observed in cotton and corn which are suitable for irrigated farming. So much so that in 1991, while corn and cotton cultivation was almost nonexistent, by 2015, the corn cultivation area was 67 thousand decares and the cotton fields were 941 thousand decares. In general, according to TSI data, irrigated farming areas in Akçakale district have been increasing rapidly since 1995 (Çelik et al., 2016).

Table 5. Data of agricultural products most cultivated in the study area in 2005 (Source: TSI).

	Crop	**Planted area (Decare)**	**Production(tons)**	**Yield (kg / da)**
Akçakale	Wheat	283.340	101,870	360
	Barley	104,590	22.522	215
	Cottonseed	300,000	69.840	233
	Cotton (unseed)	300,000	120,000	400
	Cotton (Fiber)	300,000	45.600	152
Ceylanpınar	**Crop**	**Planted area (Decare)**	**Production(tons)**	**Yield (kg / da)**
	Wheat	500,410	139,080	278
	Barley	29.600	8.625	291
	Lentils (Red)	150,000	22.500	150
	Cottonseed	105,000	24.444	233
	Cotton (unseed)	105,000	42.000	400
	Cotton (Fiber)	105,000	15.960	152
Suruc	**Crop**	**Planted area (Decare)**	**Production(tons)**	**Yield (kg / da)**
	Wheat	137,100	34.109	249
	Barley	197,340	57.502	291
	Lentils (Red)	84.000	14.280	170
	Cottonseed	35.000	8.148	233
	Cotton (unseed)	35.000	14.000	400
	Cotton (Fiber)	35.000	5.320	152

Using the Natural Breaks classification method, the green vegetation in the study area was calculated monthly. In August 2005, the share of agricultural areas in Akçakale that engaged in photosynthesis was 16.1%. In Ceylanpinar, this rate is 7.27%. In August 2005, the irrigated farming area in the Suruc Plain was very low and was not reflected in satellite data. When the monthly proportional change of agricultural fields is examined, it is seen that agricultural products are in the growing cycle in January. The growing period of agricultural products continues until February, March and April. In may the plant which start to turn yellow is harvested. In June, agricultural products were harvested completely in the plains south of Şanlıurfa. There is no agricultural area giving high EVI value in June. When it comes to July, an area of 3.86% has greened in Akçakale. In August, this rate reaches 16.1%. In August, besides Akcakale, irrigated farming activities are carried out in the western part of Ceylanpınar Plain. It is seen that irrigated farming products are harvested in September-October (Figure 3 and Table 6).

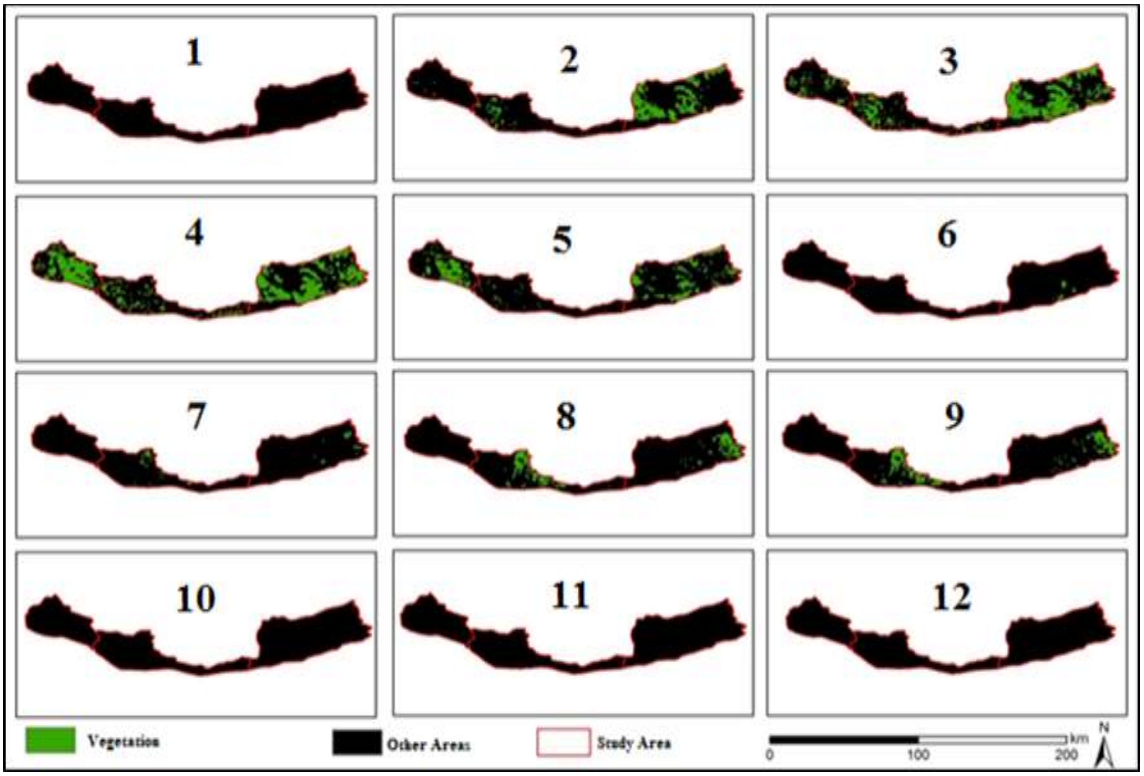

Figure 3. Distribution of vegetation areas by months in the study area in 2005.

Table 6. Proportion of agricultural land by months in the study area in 2005 (%)

Months	SURUC	AKÇAKALE	CEYLANPINAR
January	0	0	0
February	1.16	5.91	26.12
March	13.06	17.41	43.08
April	49.36	15.35	39.31
May	27.86	2.13	17.93
June	0	0	1.29
July	0	3.86	1.45
August	0	16.09	7.27
September	0	16.75	7
October	0	0	0
November	0	0	0
December	0	0	0

There is an important relationship between the yield of agricultural products and climatic conditions. It is possible to see this relationship in 2005. Agricultural products such as wheat, barley and red lentils in particular are heavily affected by the lack of rainfall. In this context, the data of Ceylanpınar and Akçakale meteorological stations in Şanlıurfa and its South were examined. SPI analyses were performed from this data. Thus, periods of arid and wet climate were identified. According to the results of the 3-month SPI analysis, in the first three months of the year climate characteristics in Akçakale was determined as normal, in Şanlıurfa as mildly arid and in Ceylanpınar as mildly arid. Ceylanpınar shows mildly arid climatic conditions in the period covering the months, January February March, in 2005. In the second 3-month period of 2005, Ceylanpınar and Şanlıurfa showed arid climatic conditions. While the severity of the drought in Ceylanpinar is mild, it is moderate in Şanlıurfa. In Akçakale, the climate is normal. In July, August and September 2000, the climate in Akçakale is slightly wet. The climate is normal in Ceylanpınar and Şanlıurfa. In the last 3 months of the year, the climate is normal at all stations (Table 7).

Table 7. SPI analysis results in 3-month periods of 2005 (Source: MGM).

Station	Years	January-February-March	April-May-June	July-August-September	October-November - December
Akçakale	2005	Normal	Slightly arid	Normal	Moderately arid
Ceylanpınar	2005	Slightly arid	Moderately arid	Normal	Slightly arid
Şanlıurfa (Centre)	2005	Slightly arid	Normal	Normal	Normal

6-month SPI analysis was applied to Akçakale, Ceylanpınar and Şanlıurfa stations. Accordingly, in 2005, the first 6 months were dry for Şanlıurfa and Ceylanpınar. The severity of the drought is higher in Ceylanpinar. In Şanlıurfa, the severity of the drought is mild. In Akçakale, the first 6 months of the year are normal and the last 6 months are moderately arid (Table 8).

Station	Şanlıurfa	Akçakale	Ceylanpınar
2005 (first 6 months)	Slightly arid	Normal	Moderately arid
2005 (last 6 months)	Slightly arid	Moderately arid	Slightly arid

Ceylanpinar has a general upward trend in both dry and irrigated farming products. The reason for this is to have crop rotation. While dry agricultural products are harvested in May of each year, irrigated farming products (corn, cotton) are cultivated in June. The upward trend in irrigated agricultural areas is observed in the late 1990s to early 2000s. Especially after 2010, the cotton plant was replaced by corn.

Conclusions

Remote sensing is both highly reliable and provides great convenience in monitoring vegetation change and revealing numerical data. While data collected through satellites in developed countries is heavily used in vegetation research, it is quite difficult for our country to say this. The work carried out by a limited number of scientists and members of the ministry closely involved in agriculture and vegetation matters appears to be insufficient. Within this framework, the spatial and qualitative change of vegetation, which is one of the important components of natural resources, depending on natural, human-economic-political factors, should be handled carefully by making use of technological means and contributing to the conscious use of our country's natural potential.

MODIS NDVI images with a high temporal resolution of 16 days and a high spatial resolution of 250 M were used in this study, calculated using red and close infrared band. The use of the data used in research is very common in scientific studies abroad and in drought analysis, but the use in institutions and organizations in Turkey is almost nonexistent. Therefore, this study tests both the identification and reliability of the uses of these images. The southern plains of Şanlıurfa have been selected as the study site for testing MODIS satellite images.

The change in agricultural crop pattern for the years 2000-2015 is generally dependent on agricultural irrigation and rainfall and temperature conditions. During the arid period from May to November, the natural steppes are drying out, while agricultural products continue to exist due to irrigation. In addition, the use of modern equipment, agricultural drugs and fertilizers in agriculture ensures that agricultural products more or less exist in the south of Şanlıurfa throughout the year.

Until 2015, all of the water used for agricultural purposes in Suruc is obtained by drilling from underground. Irrigated agriculture was carried out in Suruç plain between 1980 and 1990, especially cotton agriculture comes to the fore. But over time, the underground water used by illegal drilling wells and the unconscious public began to decline, even to the point of extinction. For this reason, cotton cultivation area is declining. Water brought from Atatürk Dam within the scope of GAP was given to a part of Suruç plain in mid-2015 by the Suruç plain pumping irrigation project. As a result of this water provided, an increase in the cultivation area of corn was observed in the plain of Suruc.

In Ceylanpınar district, irrigated agriculture became widespread as of 1995 and after, and high-income crops such as cotton and corn came to the fore in agricultural production. with the increase of cultivation areas, groundwater started to be used more, resulting in a decrease in groundwater level. As in the plain of Suruç, there was an increase in the depth of the borehole that was opened due to the decreasing water level. In Ceylanpınar district, it is necessary to encourage dry agriculture to prevent the reduction of groundwater, and to provide irrigation facilities in agriculture from Dam lakes. Otherwise, it is inevitable that Ceylanpinar will live the fate of Suruc plain. The practice of dry farming before 1970 was common in the plain of Suruç. After this date, relatively few irrigation operations were carried out by local farmers with simple and shallow boreholes, while over time excess water began to be withdrawn from the existing reserve in the face of increasing high demand. As a result, the groundwater level began to drop rapidly. In conclusion, this study is important in the context of revealing the relationship between water resources, drought, crop yield and agricultural crop pattern change.

References

Breunig, F. M., Galvão, L. S., Formaggio, A. R., & Epiphanio, J. C. N. (2011). Directional effects on NDVI and LAI retrievals from MODIS: A case study in Brazil with soybean. International Journal of Applied Earth Observation and Geoinformation, 13(1), 34-42.

Çelik, M. A. (2016). Monitoring Of Agricultural And Vegetation Areas In Aegean Region By Natural Breaks (Jenks) Classification Method. *Ege Coğrafya Dergisi*, 25(1), 37-49.

Çelik, M. A., & Karabulut, M. (2013). Analysis of the relations between vegetation and rainfall conditions on Ahir Mountain (Kahramanmaraş) and its environs using modis data (2000-2010). Havacılık ve Uzay Teknolojileri Dergisi, 1(6), 123-133.

Çelik, M. A., Doğantürk, I.H., Güney, İ. (2016). Investigation of subsurface water level and land cover changes in the Plains south of Şanlıurfa using Remote Sensing and GIS. VI. Remote sensing Information Systems Symposium, Pp. 391-401.

Huete, A., Didan, K., Miura, T., Rodriguez, E. P., Gao, X., & Ferreira, L. G. (2002). Overview of the radiometric and biophysical performance of the MODIS vegetation indices. Remote sensing of environment, 83(1-2), 195-213.

Kalfas, J. L., Xiao, X., Vanegas, D. X., Verma, P. B., & Suyker, A. E. (2011). Modeling gross primary production of irrigated and rain-fed maize using MODIS imagery and CO2 flux tower data. Agricultural and Forest Meteorology, 151(12), 1514-1528.

Lin, Y. (2013). A Comparison Study on Natural and Head/tail Breaks Involving Digital Elevation Models. Faculty of Engineering and Sustainable Development.

Öztürk, A. (1999). Effect of drought on the development and yield of winter wheat. Turkish Journal of Agriculture and Forestry, 23(1), 531-540.

Pan, Z., Huang, J., Zhou, Q., Wang, L., Cheng, Y., Zhang, H., ... & Liu, J. (2015). Mapping crop phenology using NDVI time-series derived from HJ-1 A/B data. International Journal of Applied Earth Observation and Geoinformation, 34, 188-197.

Quiring, S. M., & Papakryiakou, T. N. (2003). An evaluation of agricultural drought indices for the Canadian prairies. Agricultural and forest meteorology, 118(1-2), 49-62.

Şimşek, O. (2010) drought assessment and crop development model in Turkey and drought-yield analysis in wheat. AÜ Agricultural Fac. (Doctoral dissertation, Ankara).

Uçan, K., Kıllı, F., Gençoğlan, C., & Merdun, H. (2007). Effect of irrigation frequency and amount on water use efficiency and yield of sesame (Sesamum indicum L.) under field conditions. Field Crops Research, 101(3), 249-258.

Viovy, N., Arino, O., & Belward, A. S. (1992). The Best Index Slope Extraction (BISE): A method for reducing noise in NDVI time-series. International Journal of remote sensing, 13(8), 1585-1590.

Wilhite, D. A., Svoboda, M. D., & Hayes, M. J. (2007). Understanding the complex impacts of drought: A key to enhancing drought mitigation and preparedness. Water resources management, 21(5), 763-774.