INTERNATIONAL JOURNAL of ENGINEERING SCIENCE AND APPLICATION
S.U. Temelli and A.Alkan., Vol.4, No.3, September 2020

Drought Monitoring Based on Satellite Data of Seyhan Basin

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Received: 02.09.2020 Accepted:25.09.2020

Abstract- The occurrence of drought is mainly a climatic phenomenon which cannot be eliminated. However, its effects can be reduced if actual spatio-temporal information related to crop status is available to the decision makers. In this study, it is tried to evaluate the effectiveness of remote sensing and geographic information system techniques in order to monitor the spatial-temporal dimension of drought. This study covers the period from July 27 to August 11, 2014-2019. This study was carried out considering the vegetation changes of the Seyhan Basin between July and August. VCI (Vegetation Condition Index) drought monitoring was performed using 16-day NDVI time series and land cover maps. In this study, NDVI (Normalized Difference Vegetation Index) based equations developed by Kogan were used in drought monitoring. In the result 27 July-11 August 2014 was observed drought than other periods.

Keywords NDVI, Drought Monitoring, VCI, Remote Sensing.

Özet- Kuraklık, tamamen ortadan kaldırılamayan bir iklim olgusudur. Kuraklıkla alakalı olan gerçek mekansal – zamansal bilgiler, karar vericiler için mevcutsa kuraklığın olumsuz etkileri azaltılabilir. Çalışmada, kuraklığın mekansal – zamansal boyutunu izlemek için uzaktan algılama ve coğrafi bilgi sistemi tekniklerinin etkinliği değerlendirilmeye çalışılmıştır. Çalışma, 27 Temmuz – 11 Ağustos tarihleri arasında 2014 – 2019 yıllarını kapsamaktadır. Seyhan havzasının, Temmuz ve Ağustos ayları arasındaki bitki örtüsü değişiklikleri dikkate alınarak yapılmıştır. VCI kuraklık izlemesi, 16 günlük NDVI zaman serileri ve arazi örtüsü haritaları kullanılarak gerçekleştirilmiştir. Kuraklık izlemesinde, Kogan tarafından geliştirilen NDVI tabanlı denklemler kullanılmıştır. Çalışma sonucunda, 27 Temmuz - 11 Ağustos 2014 dönemi, diğer dönemlere göre kuraklık olayının gerçekleştiği dönem olmuştur.

Anahtar Kelimeler NDVI, Kuraklık İzleme, VCI, Uzaktan Algılama.

1. Introduction

Drought is considered one of the main natural hazards that affect a country's environment and economy. Unlike other natural disasters, drought events occur slowly over time, and their effects usually continue over a longer period of time. Weather data is not sufficient to monitor and evaluate drought areas, especially when these data are rare and incomplete. Development of weather data with satellite images to determine the location and severity of droughts is important for a complete, current and comprehensive coverage of the current drought conditions.

Although the meteorological information from ground stations is good and popular worldwide, the distribution and density of meteorological stations is insufficient for the required spatial information detection[1,2]. Unless the weather stations have a good distribution throughout the region, the spatial dimension of the drought cannot be accurately defined. Time and cost requirements for data preparation can sometimes be a difficult process in drought monitoring. In this context, drought monitoring with satellite-based information, low cost, synoptic vision, data collection and repetition of reliability have been widely accepted in recent years. In addition, the NDVI (Normalized

Difference Vegetation Index) and VCI (Vegetation Condition Index) have been adopted globally to identify agricultural drought in different regions with different ecological conditions[3-5] . NDVI is an index indicating the density of the plant obtained based on the remote sensing method. Electromagnetic waves are sent to the earth through satellites, and values are collected by the receivers on the satellites as a result of the response of the studied regions to

Fig.1 Study Area(Seyhan Basin)

the electromagnetic waves. While doing this, visible and em waves in the infrared band region are taken into consideration and the species diversity of the plants is determined[6].

RS (Remote Sensing) applications have increased rapidly,integrating with strong software-hardware opportunities and GIS (Geographic Information Systems). The ability to easily transfer spatial data from space to GIS via satellite and various location data, natural resource management, land cover and land use, environmental and ecological analysis, disaster and risk assessment increased meteorological, hydrological and agricultural analysis opportunities. Remote sensing data is used effectively and intensively in various hydrological applications. Drought studies are among these applications. Vegetation and soil moisture that can be obtained by remote sensing are the data sources commonly used in drought studies. High resolution vegetation change information provided by plant indices (such as NDVI) can contribute to drought information temporarily and spatially. Vegetation indices are preferred because they are both easy to use and do not require any assumptions or additional information other than themselves[7].

Working with time series was done using MODIS data. The time series refers to a set of measurements of a magnitude of interest sorted over time. The purpose of analysis with the time series is to understand the truth represented by the observation set and to accurately predic the future values of the variables in the time series. Time series was used as a method of developing software codes at first in decision making processes [8].

Other than in-situ data, Remote sensing is a promising technology for monitoring drought status.In this study, it was aimed to reveal the drought analysis by using the satellite images between the changes in the Seyhan Basin between July 27 to August 11 from 2014-2019.

2. Materyal and Methods

2.1. Study Area

Seyhan River Basin study area north of Adana in Turkey's Eastern Mediterranean Region 36º 30 'to 39 ° 15' north latitude and 34º 45 'and 37º 00' is located between east longitude. The Seyhan Basin with a surface area of 22035 km2 extends to Ceyhan in the east, Konya and Berdan in the west, Develi Basin and Kulmaç Mountains in the north, and the Mediterranean in the south[9]. The study basin is shown in figure 1 .

2.2. Remote Sensing Data

The MODIS products are designed to provide consistent spatiotemporal observations of vegetation conditions, have been continually produced since 2001[10]. Some MODIS product has a 16-day NDVI combination with an approximate spatial resolution of 250 m. Like the Landsat NDVI product, the MODIS product 16-day combination period includes the composite date and 16 ensuing days. MODIS satallite combination are created using a constrained-view angle, maximum value composite technique, and the MODIS surface reflectance product[11].The 16-day NDVI(Normalized Difference Vegetation Index) combination based on 250m MODIS was obtained from the MODIS44 / NDVI Time Series section from the Global Agricultural Monitoring (GLAM) Project provided through the University of Maryland Department of Geography website. MODIS data can be accessed at (http://pekko.geog.umd.edu/usda/beta/). An example made NDVI of MODIS data is shown in Figure 2. To make VCI(Vegetation Condition Index), Land Cover map and MODIS data are required. Land Cover maps were provided from European Space Agency Land Cover website. Land cover maps can be accessed at (https://www.esa-landcover-cci.org/).

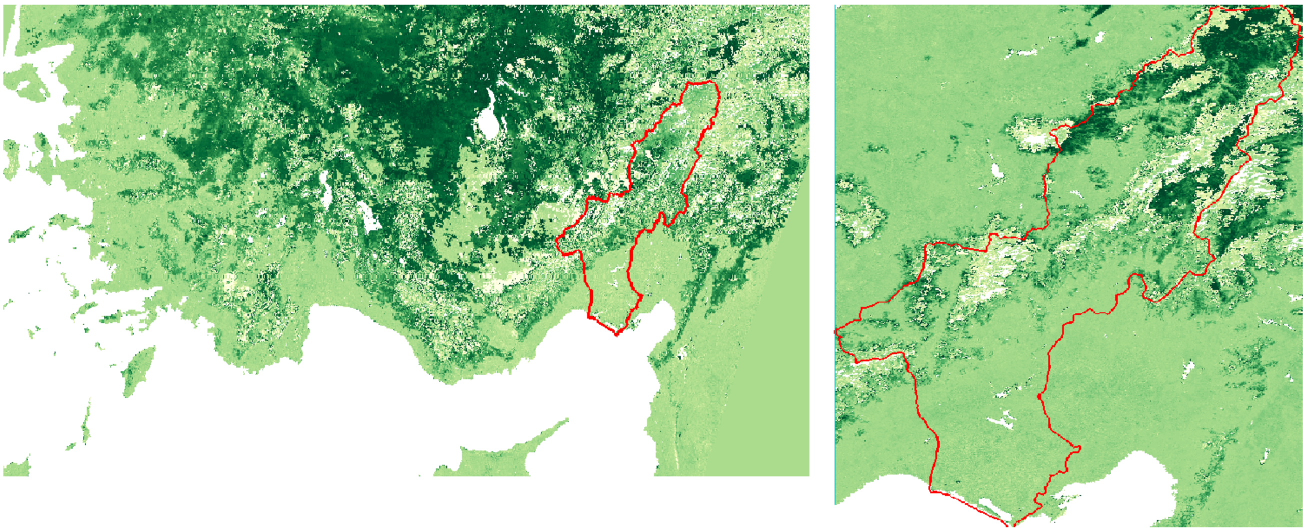

Fig.2. MODIS NDVI imaging of the Mediterranean region and Seyhan Basin

2.3. Normalized Difference Vegetation Index (NDVI)

NDVI is one of the most successful tools to describe the condition of vegetative areas. NDVI is closely related to vegetation density and cover, green leaf biomass, and crop status-related parameters [12, 13]. Thus, NDVI can be used as a general indicator of vegetation and viability. NDVI is calculated by the Kogan equation 1 as the ratio of the red (RED) band and near infrared (NIR) bands of a sensor system [4].

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

NDVI values range from [-1, + 1]. Due to the high yield in the NIR part of the electromagnetic spectrum, healthy vegetation is represented by high NDVI values from 0.5 to 1. In a year with normal precipitation conditions, agricultural areas are expected to show high NDVI values during agriculture. It shows low NDVI values in early growth and post harvest periods and plant growth periods. In drought conditions, photosynthesis decreases due to rain discharge. This reduces total dry matter buildup and yield, and therefore results in lower NDVI values. In addition, NDVI values of vegetative and urban areas are consistently low.

Table 1. VCI Research Variables

Variables	Classification	Unit	Class	Reference
Drought	<10 %	VCI	Extreme Drought	[14, 15]
	10-20%		Severe Drought	
	20-35%		Moderate Drought	
	35-50%		Normal	
	>50%		Wet	

2.4. Vegetation Condition Index (VCI)

VCI was developed by Kogan and used to predict weather effects on vegetation. Scales air-related NDVI events to NDVI as linear for 0 for minimum NDVI and 1 for maximum NDVI for each grid cell. VCI is used and calculated to detect drought and measure start time and intensity, duration and effect on vegetation[4]. VCI is calculated by equation 2.

$$VCI = \frac{NDVI-NDVImin}{NDVImax-NDVImin} x100 \quad (2)$$

The resulting percentage of the observed value is between the extreme values (minimum and maximum) by years. Therefore, lower and higher values indicate poor and good vegetation conditions, respectively.

3. Result and Discussion

The Vegetation Condition Index (VCI) for this study was calculated using the NDVI values obtained from MODIS satellite data for drought determined as a result of drought analysis for Seyhan Basin. MODIS NDVI MOD44 data was used to obtain VCI values. ESA CCI(European Space Agency Climate Change Initiative) Global Land Cover map was used in VCI data in land cover analysis. Taking into account the climatic conditions of the studied basin, the period between July 27 and August 11 was selected for drought analysis.The NDVI values of the Seyhan Basin vary between 0,05 and 0.552, and its change by years is shown in Table 2.

Fig.3. VCI Drought Monitoring July 27 to August 11 from 2014-2019 of Seyhan Basin

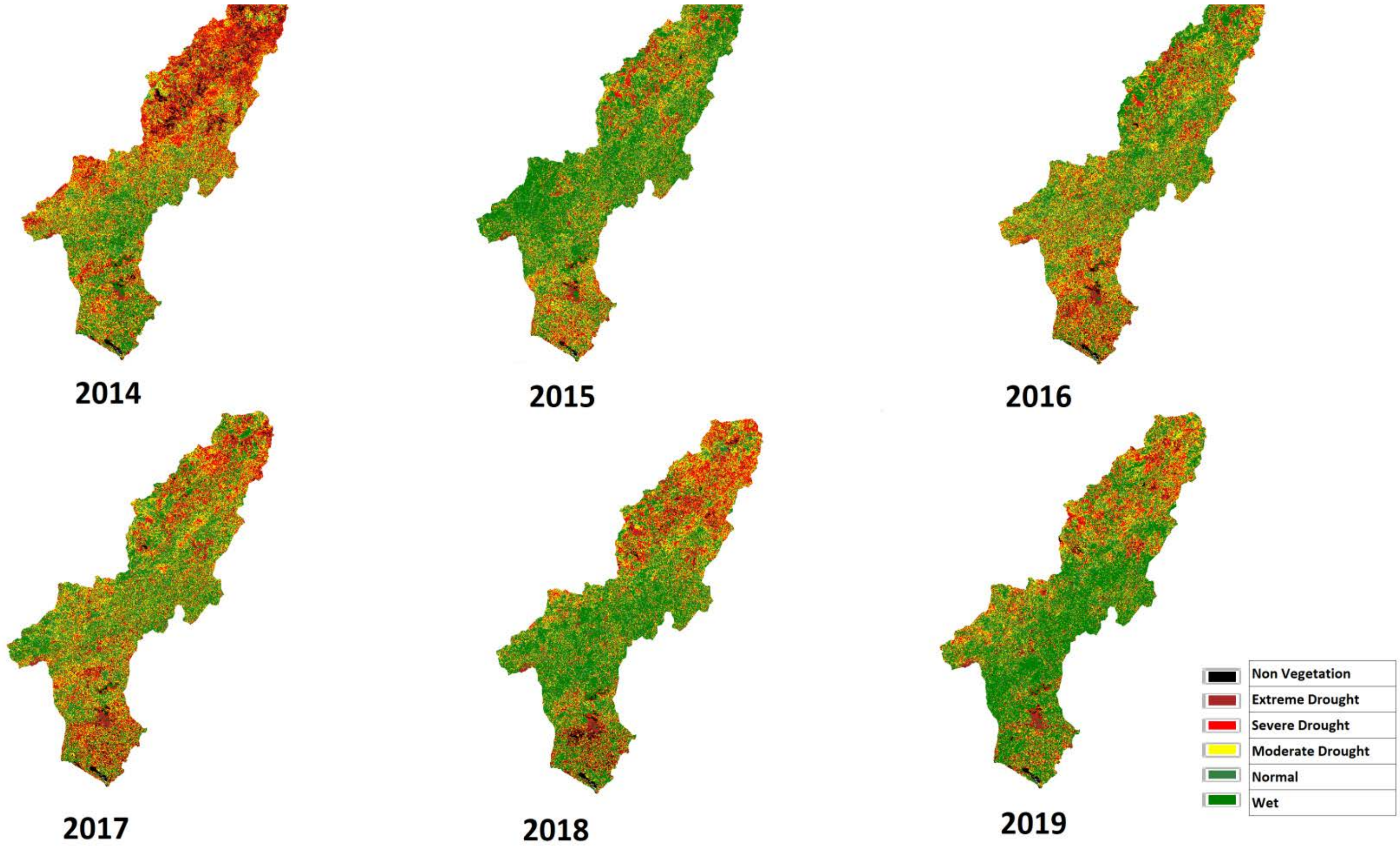

Table 2. Average Monthly NDVI data for 2014-2019

Year	Min	Max	Mean	StdDev
2014	0,050	0,524	0,400	0,168
2015	0,104	0,536	0,455	0,140
2016	0,230	0,503	0,430	0,099
2017	0,041	0,522	0,259	0,197
2018	0,037	0,529	0,264	0,170
2019	0,083	0,552	0,308	0,129

Within the scope of drought index studies, drought changes in the vegetation areas of the Seyhan basin should be analyzed. Land cover data layers to be used for these analyses were determined and changes in the NDVI time series in these layers were calculated. The RMSE (root mean square error) value between NDVI time series is 0.36. The correlation coefficient value is 0.44 (r = 0.44) for July 27 to August 11 from 2014-2019. There is a positive trend among the variables. The standard deviation of the NDVI time series is between 0.099-0.197. VCI was calculated according to time series July 27- August 11 from 2014-2019 NDVI values. According to the VCI images calculated for each July 27-August 11 for the years 2014-2019, it was seen that July 27-August 11 2014 was drought compared to the others. As can be seen in Figure 3, the classification is made according to the drought classification in Table 1. (Refer to figure 3.)

In this study, VCI regional drought monitoring was carried out with the help of NDVI based drought monitoring indexes. Drought variation was observed in the same time interval of different years. If this study is done on a larger scale, it will help map risk analysis in drought monitoring. The major advantage of the presented methodology is the high spatial information content in satellite data that allows the provision of drought risk maps.

4. Conclusions

Remote Sensing allows observing the effect of air and objects between ultraviolet rays and microwave rays of different wavelengths. These impressions are selected, then the change in vegetation index in the electromagnetic spectrum is measured by location and years. remote sensing sensors located at a certain distance measure the electromagnetic beam interacting with the Earth's surface. The direction, intensity, wavelength content and polarization of the electromagnetic beam can be different from each other. Like this way, changes in land cover can be monitored. VCI is calculated based on time series, NDVI values between years. Between 27 July and 11 August 2014-2019, NDVI values vary between 0.005 and 0.552 depending on the seasonal change. The RMSE (Root Mean Square Error) value between NDVI time series is 0.36. The standard deviation of the NDVI time series between these dates is between 0.099-0.197. Positive orientation was observed between these time series. VCI shows the state of vegetation at a given time, according to its best and worst state over a period of time. VCI helps reduce the effects of a disaster such as drought by monitoring it over the years. VCI helps mitigate the effects of these disasters by studying the effects of disasters seen during the year, such as drought. Also, VCI is an ideal method for analyzing meteorological variables and off-station regions.

As a result of this study, it was observed that the vegetation cover of the Seyhan Basin was more drought between 27 July and 11 August 2014 compared to the same times of the other selected years. In drought monitoring, using combination of climatic and meteorological factors (temperature and precipitation, etc.) in different regions will increase the effect of prediction models. Thus, it will help in reducing the effects of drought and taking precautions against drought.

Acknowledgements

We would like to thank Prof. Dr. Mustafa Tombul from Eskisehir Technical University Civil Engineering, Hydraulics Division for his support and assistance to us.

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