Creatıng Antalya Drought Maps And Associatıng It Wıth Agrıcultural Lands

ABSTRACT

Aims: Drought is described as an insidious disaster that threatens a significant part of the world, including our country, in recent years. This study was carried out in order to examine the drought in depth and to associate it with Antalya agriculture.

Study design: Drought is one of the most dangerous natural disasters in terms of both the damage it will cause and the lack of awareness on this issue. Decreased water potential as a result of climate change due to global warming necessitates effective use of water resources. With this study, the drought situation in agricultural lands, which is one of the most important livelihoods of Antalya, was studied.

Place and Duration of Study: The study area covers the province of Antalya and its districts. The project was completed between 2021 and 2022.

Methodology: With this study, the drought situation of Antalya province was determined and mapped on the basis of districts with the Standard Precipitation Index (SPI), De Martonne Drought Index, Percent of Normal Index (PNI), Erinç Method, Aydeniz Method and NDVI methods.

Results: Upon calculating each drought method in the area, some differences were observed. This study aimed to address this issue by conducting separate analyses for each district of Antalya province using internationally recognized meteorological and agricultural drought methods based on meteorological data. The results of each analysis were evaluated separately to provide a comprehensive understanding of the drought situation in the region.

Conclusion: (wild irrigation) Drip irrigation methods should be preferred instead of wild irrigation. In regions where the risk of drought is high or likely to occur in the near future, it is important to select drought-resistant plant patterns and gradually replace varieties and species that consume excessive amounts of water with drought-resistant ones.

Keywords: [Drought, Agricultural soils, Drought analysis, Maps

1. INTRODUCTION

Drought is examined under four sub-headings as Meteorological, Agricultural, Hydrological and Socio-economic. Drought begins as a meteorological drought, develops as an agricultural and hydrological drought, and continues as a socio-economic drought [1]
Meteorological drought concept; It is a drought that occurs as a result of precipitation falling below the required level, increasing temperatures and decreasing humidity. On the one hand, precipitation decreases, on the other hand, as a result of the meteorological drought that occurs as a result of the increase in temperatures, the underground water level and the amount of moisture in the soil also decreases. [2]

The concept of agricultural drought; It is defined as the decrease in the amount of moisture in the soil below the level required for plant growth. The occurrence of agricultural drought is seen as a result of meteorological drought. Soil moisture does not decrease suddenly, this occurs as a result of a long process [2]
The concept of hydrological drought; It is defined as the decrease in underground and surface water resources in a region. As a result of evapotranspiration, which occurs as a result of low precipitation and excess temperature, the use of large amounts of underground water resources as a source of irrigation increases hydrological drought.
The concept of socioeconomic drought; It is defined as the effect of factors such as agricultural activity and energy production, which it affects after the drought occurs. It is also defined as the inability to meet the amount of water demanded by these factors [2].
Current drought maps are meteorological drought maps. These maps are insufficient, especially when associated with agriculture. However, when the drought is mentioned, meteorological drought should not be understood only. Drought, in its simplest form, is defined as "a natural phenomenon that causes the adverse effects of land and water resources and the deterioration of hydrological balance as a result of precipitation falling significantly below the recorded normal levels". However, agricultural drought must also be mapped and associated with agricultural lands.
They investigated drought analysis for Aksu-Antalya Irrigation Area with Aydeniz method and geographic information systems, and in this study they conducted using temperature, precipitation, humidity and sunshine duration data of Antalya, Isparta, Korkuteli and Manavgat meteorological observation stations, Aksu in Antalya. They determined the drought status of the Irrigation Area. According to the data obtained from the research, no dry period was observed in the region between 1985 and 2006. [3]

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

2.1 MATERIAL

Antalya province is located in the south of Turkey, on the Mediterranean coast at 29°-32° longitude and 36°-37° latitude. The surface area of Antalya has been measured as approximately 20,177 km² and covers 2.6% of our country.[4]. There are Mersin and Konya in the east of Antalya, Isparta and Burdur in the north, and Muğla in the west. Antalya province has a rough terrain. The altitude in the Taurus Mountains exceeds 2500-3000 meters. The coast and the plateau region differ from each other in terms of terrain and climate. The main material of the mountains is mostly limestone, but dolines, uvalas and caves are common (Figure 1).

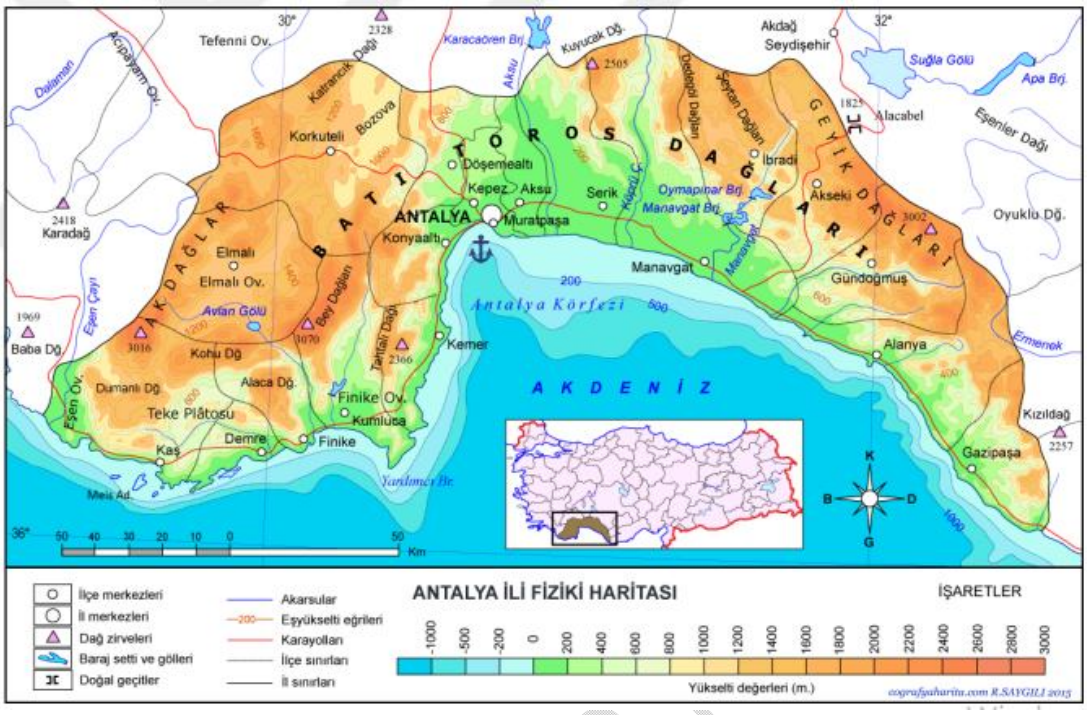

Figure 1.Physical map of Antalya

2.1 METHODS

Methods used for drought; Thornthwaite climate classification and water balance method [5]

Standardized precipitation index method (SPI), The standardized precipitation index method (SPI) is obtained by dividing the difference from the mean of the precipitation within the specified time period by the standard deviation [6], evaluation [7].

Erinç Method, it is assumed that the evaporation value in the Erinç precipitation efficiency index (Im) is controlled by the maximum temperatures, therefore evaporation increases during the day and during the hot seasons, while it decreases at night and during the cold season. Unlike other classifications, in this method, the average value of the maximum temperatures is taken into account [8].

Percent of Normal Index (PNI), Percent of normal index is a very common and simple to use index among meteorological drought indices. It is obtained by dividing the actual precipitation in a certain time period by the average precipitation amount. Precipitation of 12 months or less can be used in this formula [9].

Aydeniz Method, Aydeniz formula includes precipitation, average temperature, average relative humidity and average sunshine duration. In the calculations made with this formula, the humidity coefficient “(Nks)” and the drought coefficient “(Kks)” are found ([10].

De Martonne Drought Index, De Martonne formula includes Annual Average Temperature and Annual Total Precipitation. The Annual Drought Index (IDM) value is obtained as a result of the calculation made with this formula [11]. De Martonne - Gottman index was obtained by making some additions and corrections to the original form of the De Martonne index together with Gottman [12]

NDVI Method In the calculation of the Normalized Difference Vegetation Index (NDVI), the ratio of the difference between the near infrared band (NIR) and red band (R) and their sum is used. [13].

3. RESULTS AND DISCUSSION

Water is an important criterion for more effective use of the lands of Antalya province. Therefore, in order to associate the climate with the soil, it is very important to determine the drought situation of Antalya province from past to present due to global climate change. In this study, in this context, all analyzes for each district of Antalya province with meteorological data were made one by one with internationally accepted meteorological and agricultural drought methods and the results of each analysis were evaluated separately.
In order to manage water in the soil, first of all, the state and the movement of the existing water must be determined. For this purpose, Thornwaite water balance is calculated. It is very important in terms of combating drought and controlling the water used for agricultural irrigation. In this study, the water balance of Antalya province was calculated separately for each district whose data were obtained.

3.1. Thornwaite Water Balance Sheet

According to the water balance chart we prepared with the findings we obtained for the central districts of Antalya (Figure 2); It was determined that the highest real evaporation took place in July, and there was a lack of water between May and October. It has been determined that there is excess water between December and March when precipitation is higher than evaporation. It is seen that the accumulated water in the soil is found in November-May. According to these data, it was determined that the months with water deficiency (May, June, July, August, September and October) were more than the months with excess water (December, January, February and March).

Figure 2. **Thornwaite Water Balance Sheet of Antalya**

3.2. SPI Analysis and Map

In the SPI (Standardized Precipitation Index) analysis, the drought situation of a region is determined by using 3-month, 6-month and 12-month long-term precipitation data. SPI values are calculated by dividing the precipitation averages for many years by the standard deviation. It is the most widely used meteorological drought analysis in the international literature. In Turkey, drought analysis is generally performed with this method. According to the findings we have obtained as a result of the analyzes we have made; In the analysis of the SPI analysis for the 12-month period of 2021, the SPI values of the central districts of Antalya were found to be -0.7, and it was determined that they entered the drought class close to normal. Likewise, the SPI value of Alanya district is 1.5 (very rainy), Finike district has 1.2 (moderate precipitation), Kas district is 0.2 (Normal), Korkuteli district is -1.6

(severely arid), Elmalı district is -1, 2 (Moderate Severe Arid), Manavgat district 0.6 (Normal), Demre district -0.5 (Near Normal Arid) and finally Gazipaşa district 0.4 (Normal) (Figure 3)

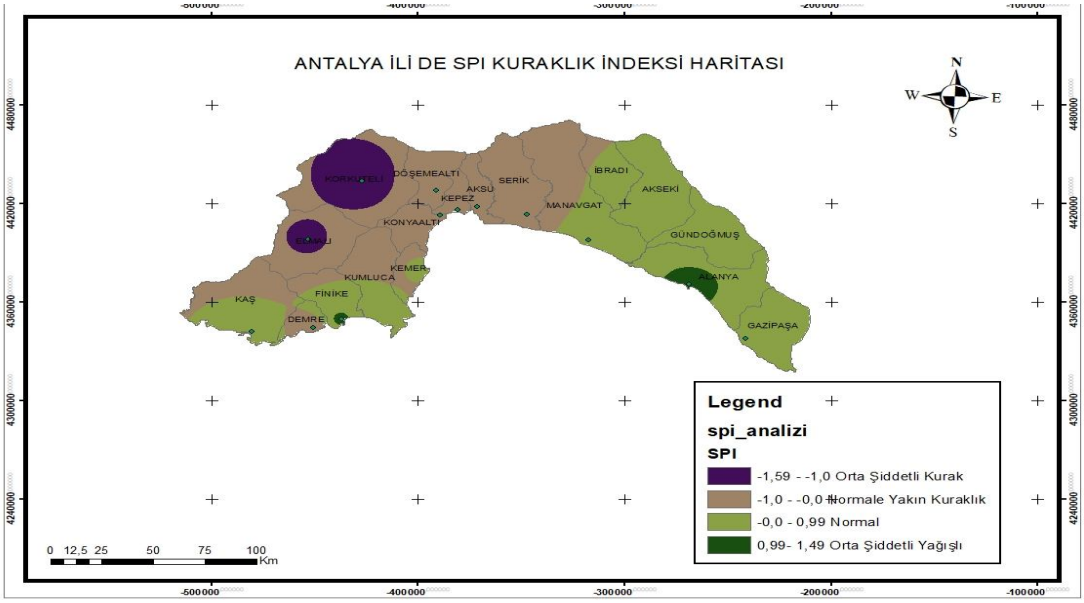

Figure 3. SPI Analysis and Map of Antalya

Moderate drought Near-normal drought Normal Near-normal humid

3.3. PNI Analysis and Map

The percentage of normal analysis is the data obtained as a result of the ratio of the 12-month actual precipitation data of a year to the average of many years. The Percent of Normal method is one of the most frequently used methods among meteorological drought methods. An analysis was made according to this method for the province of Antalya. According to the findings we obtained as a result of the PNI analysis; In the analysis made using the current 12-month precipitation data for 2021 and the precipitation averages for many years (1980-2021), it was determined that the PNI values of the central districts of Antalya were found to be 82.1 and entered the mild arid class. Likewise, the PNI value for 2021 for Alanya district is 49.0 (severely dry), Finike district is 70.7 (moderately dry), Kaş district is 39.8 (severely dry), Korkuteli district is 66.0 (moderately dry), Elmalı district of 68.7 (severely dry), Manavgat district 57.8 (severely dry), Demre district 54.4 (severely dry) and finally 71.8 (moderately dry) in Gazipaşa district (Figure 4).

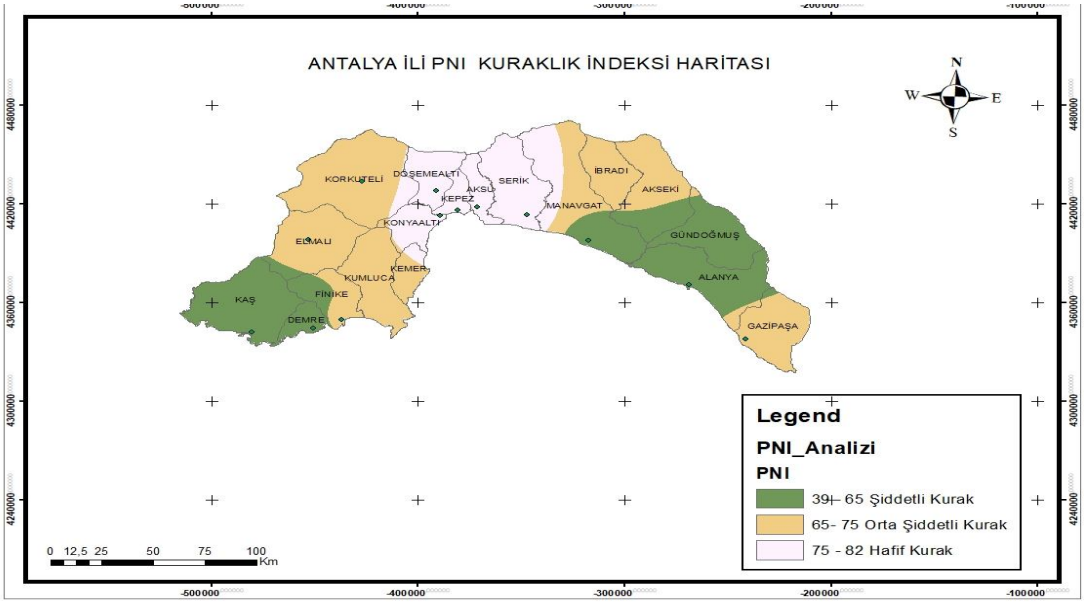

Figure 4. PNI Analysis and Map of Antalya

Dry	Medium dry	Less dry

3.4. Erinç Drought Analysis and Map

In the Erinç drought analysis, data are obtained as a result of the ratio of the precipitation data of many years to the 12-month maximum temperature averages in a region. Erinç method is one of the most used methods due to its practical application. For the province of Antalya, these values for each district were calculated and stated. According to the findings we obtained as a result of the Erinç analysis; In the analysis of the precipitation data for many years (2018-2021) by proportioning the monthly maximum temperature average, it was determined that the values of the central districts of Antalya entered the humid class with 40.2. Likewise, the value of Alanya district is 48.6 (humid), Finike district is 44.1 (humid), Kaş district is 38.1 (semi-humid), Korkuteli district is 26.7 (semi-humid), Elmalı district is 32.7 (semi-humid), Manavgat district is 51 It has been calculated that it is .8 (humid), 39.8 (semi-humid) in Demre district and 40.8 (humid) in Gazipaşa district (Figure 5).

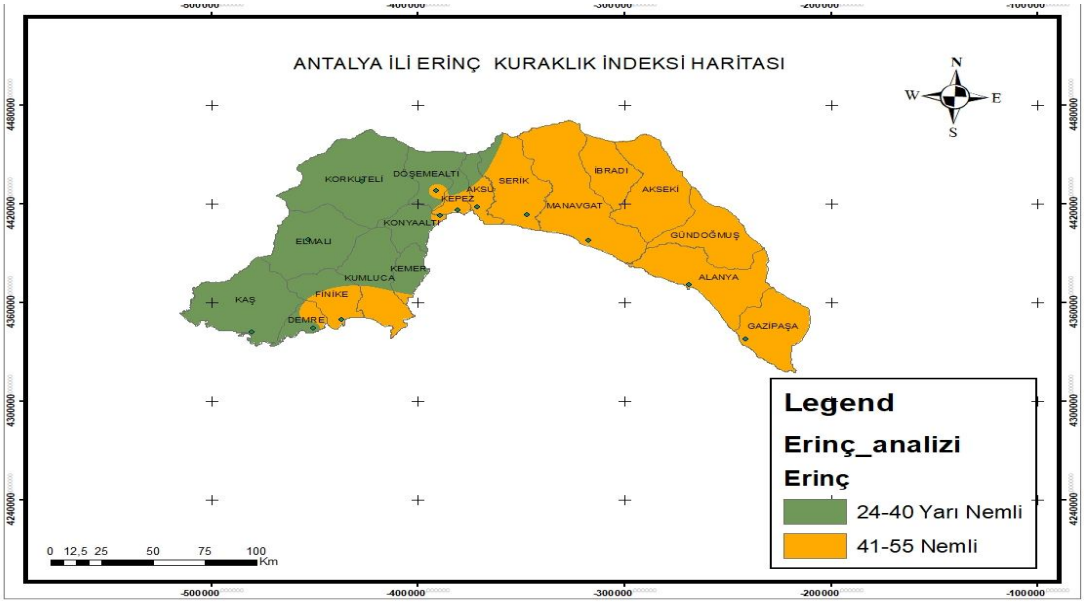

Figure 5. Erinç drought analysis of Antalya

Subhumid **Humid**

3.5. Aydeniz Drought Analysis and Map

In Aydeniz analysis, data are obtained by calculating with the help of parameters such as temperature and precipitation data for many years, humidity status and sunshine duration obtained from meteorology. The humidity coefficient obtained with the Aydeniz method expresses the drought situation within the determined limits. In all districts where the data were obtained from the Antalya province, this method analysis was performed and data were obtained. According to the findings we obtained as a result of Aydeniz analysis; In the analysis made using the precipitation average and temperature data for the years 1960-2021, it was determined that the values of the central districts of Antalya were found to be 0.6 and entered the Semi-humid class. Likewise, this value for Alanya district is 0.5 (humid), for Finike district 0.6 (semi-humid), for Kaş district 0.6 (semi humid), for Korkuteli district 1.3 (arid), for Elmalı district 1.00 (semi-humid, dry), Manavgat district 0.5 (humid), Demre district 0.6 (semi-humid) and finally Gazipaşa district 0.6 (semi-humid) value (Figure 6).

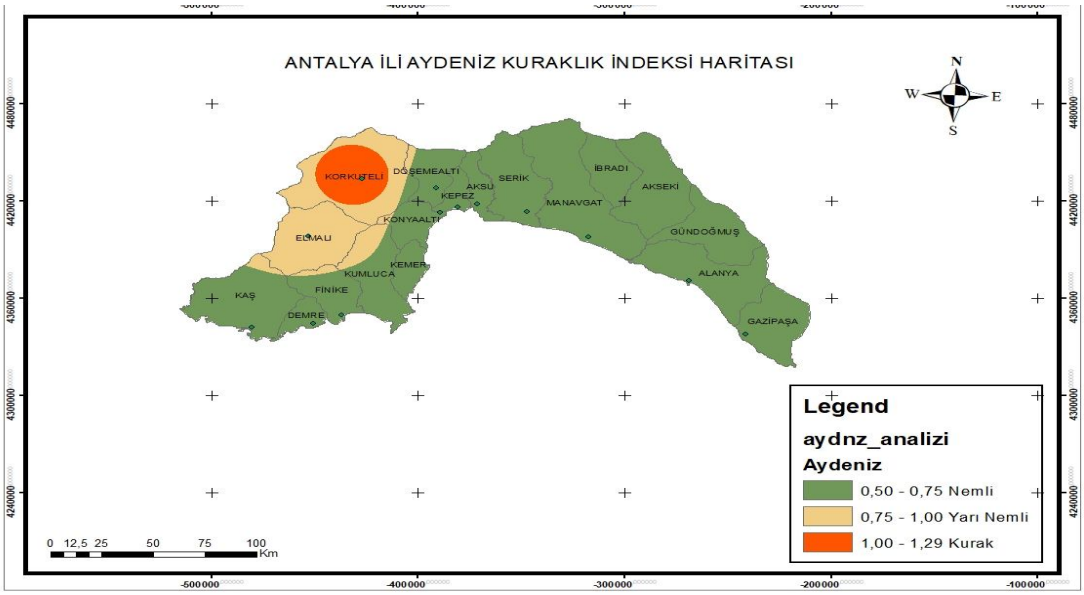

Figure 6. Aydeniz drought analysis in Antalya

Humid **Subhumid** **Dry**

3.6. De Martonne Drought Analysis and Map

In De Martonne analysis, analyzes are carried out using long-year precipitation averages and long-year temperature averages. It is one of the commonly used methods among meteorological drought methods. Data were obtained by making this analysis for the districts of Antalya province. According to the findings we obtained as a result of De Martonne analysis; In the analysis made using the precipitation average and temperature data for the years 1960-2021, it was determined that the values of the central districts of Antalya were found to be 11.1 and entered the semi-arid-humid class. For Alanya district, this value is 15.4 (Semi-arid-humid), in Finike district 12.9 (Semi-arid-humid), 11.1 (Semi-arid-humid) district in Kaş district, 7.4 (Semi-arid) in Korkuteli district), in Elmalı district 10.1 (Semi-arid), in Manavgat district 15.1 (Semi-arid-humid), in Demre district 11.1 (Semi-arid-humid) and finally in Gazipaşa district 11.7 (semi-arid-humid). between) was calculated (Figure 7).

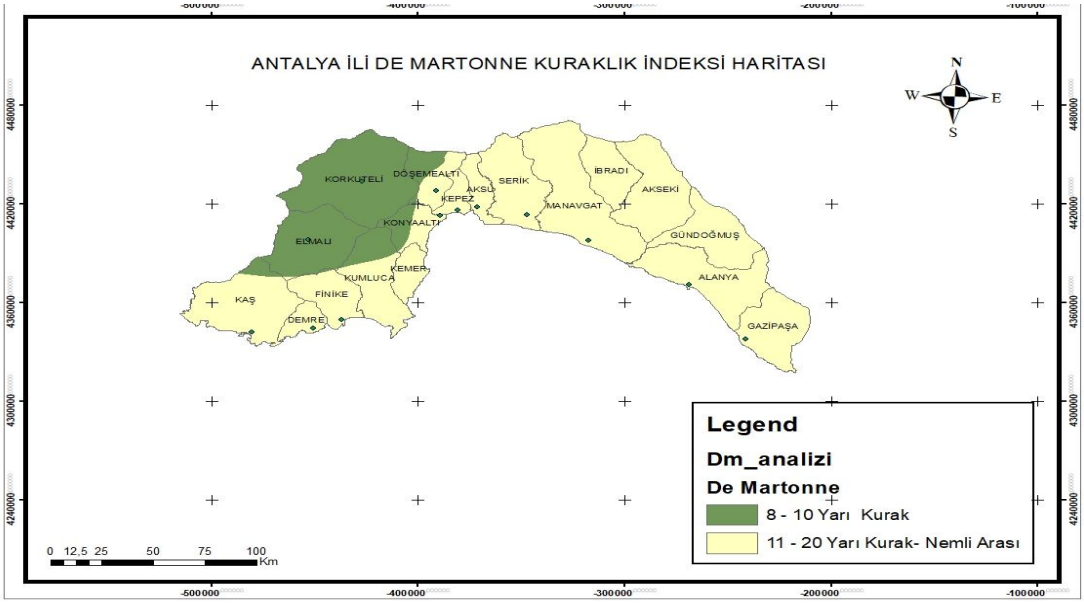

Figure. 7. De Martone Drought Index map in Antalya.
Semi drought Semi drought – humid

3.7. NDVI Analysis and Map

Different vegetation patterns may indicate some information of a region such as precipitation, temperature and drought. The examination of the change of plant pattern was carried out in this study to support the drought analysis. In order to monitor agricultural drought in Antalya province scale, NDVI values were used by using Landsat-4/5 and satellite data belonging to the years 1985 and 2010. NDVI analysis was performed using Sentinel-2 satellite data since 2021. The results obtained in the ArcGıs 10.7 program were mapped. The NDVI value range is from -1 to +1. Negative values indicate wet or glacial areas, while values close to +1 indicate areas with increased vegetation density and diversity.

It is clearly seen in the maps obtained as a result of the NDVI analysis that the water resources of Antalya province have decreased in recent years. The decrease in wetlands and the increase in green vegetation show us that agricultural production has increased. The increase in agricultural production causes an increase in the amount of water used in agriculture, which can lead to drought if the right water management is not done. The fact that drought is not expressed numerically in our analysis does not mean that there is no danger. Because 77% of the water use in our country is used in agricultural irrigation. Considering this high rate, the increase in agricultural production increases the water consumption considerably. For this reason, water management is of much more importance. Below, NDVI analysis was performed on satellite images between 1985 and 2021 for Antalya province and the results are given with maps (Figure 8).

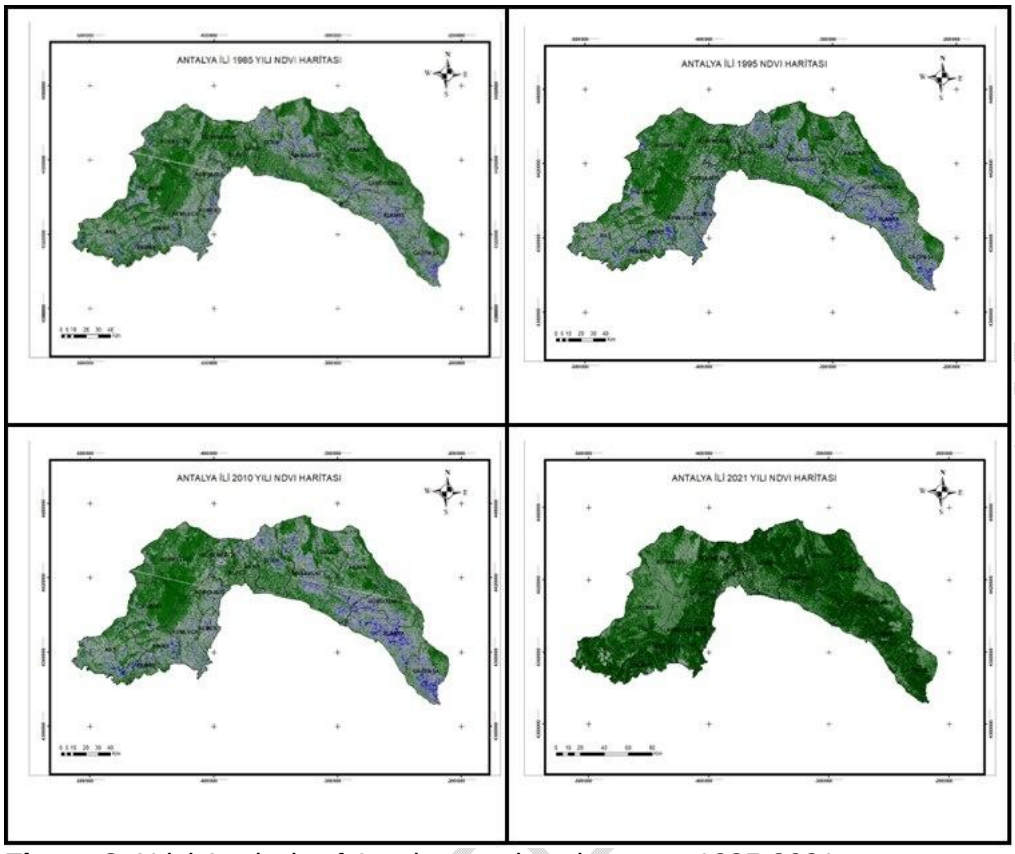

Figure 8. Ndvi Analysis of Antalya province between 1985-2021

4. CONCLUSION

Antalya Central districts were found to be Near Normal Arid according to the Standard Precipitation Index analysis, while similarly, they were found to be between Semi-Arid Humid according to the De Martonne Drought Index and slightly arid according to the Percent of Normal Index. In these analyzes, where we used precipitation and temperature data for many years, the results were close to each other. However, the central districts of Antalya, which were in the humid class according to the Aydeniz Method, were found in the humid class according to the Erinç Method. The reason for these differences is interpreted as the use of different data in Aydeniz and Erinç methods.

Although it was found to be very rainy and normal according to the 12-Month SPI analysis for Alanya and Kaş districts, they were found to be between Semi-Arid and Humid in the De Martonne analysis, Severely Arid according to the PNI Analysis, and Humid according to the Aydeniz and Erinç methods. This evaluation suggests that this difference in the PNI analysis is due to the use of only 2021 precipitation data. It has been concluded that the most accurate class for Alanya and Kaş districts is the Humid class. Although Finike district was found to be Moderately Rainy according to the 12-Month SPI analysis, it was found to be in the Semi-Arid Humid Intermediate Class in the De Martonne analysis, Moderately Arid according to the PNI Analysis, Semi-Humid in the Aydeniz Method and Humid in the Erinç Methods. In this evaluation, close results were obtained in all 5 methods for Finike district and it was determined that it was in the Semi-Dampy class.

Although similar values were found in 12-Month SPI, De Martonne, Aydeniz and Erinç Methods for Manavgat, Demre and Gazipaşa districts, it was found to be in Severe and

Moderate Drought class according to PNI Analysis. Again, it was concluded that such a difference was due to the use of only 2021 precipitation data in the PNI analysis. The decrease in precipitation in recent years has been observed very clearly in this analysis. The evaluation of only the last few years, of course, may not be able to reach the correct result, but it reveals that it is necessary to be careful. These districts are thought to be in the Semi-Damp class. For Elmalı and Korkuteli districts, classes such as Severe Arid, Semi-Arid and Arid were determined similarly in other methods, except for the Erinç Method. When examined among all districts, it was determined that the highest level of drought was seen in these two districts. Especially Korkuteli district and Elmalı district were found to be in the Semi-Arid class.

All districts were examined in terms of agricultural drought within the scope of NDVI analyses. Similarly, it has been observed that agricultural drought has also increased in recent years and the change has intensified especially in Korkuteli and Elmalı districts.

According to the findings obtained as a result of the drought analysis, it was observed that the dominant soils in the Korkuteli and Elmalı districts, where the drought intensified, were in the Large Soil Group class as Brown Forest Soil and Red Brown Mediterranean Soil. The fact that these lands, which develop under forest conditions under normal conditions, have different vegetation due to the decrease in forests in recent years is directly related to drought. As the plant pattern changes, the transpiration in the plants decreases and this causes less precipitation. The drought also changes the soil structure. Drought reduces the biological activity of living things in the soil, as a result, while aggregation decreases, massive soils increase. Plowing the lands unconsciously in these agricultural lands and not choosing the product according to the soil characteristics will increase the existing drought even more. It is important not to cultivate the soil in these soils, to choose a drought-resistant plant pattern and to drip irrigation methods in order to cope with drought.

Soil properties in the Alluvial plains in Antalya are very variable. Especially in the soils located on the ridge units, water is very difficult to keep, due to the light texture, it quickly moves away along the profile in a short time, and as a result, the plants cannot meet their water needs sufficiently. On the other hand, in flood plains, water can stay in the upper parts of the soil profiles for relatively long periods of time due to the heavier texture of the soil, but it may cause an increase in surface evaporation in the months when evaporation is high.

The same is true for coarse textured soils on colluvial lands. These soils are generally soils with mild to medium slope, shallow, slightly textured soils. Due to the slope, the water entering the profile is relatively less than the alluvial lands, and the movement of the water in the profile takes place quickly.

Brown forest soils are in a more advantageous position in terms of water requirement and water holding capacity, since they are located in areas with different slopes within the provincial borders, but are generally under forest cover.

The Red Mediterranean Soils, which cover the largest area in the research area, are fertile soils with a good profile development, rather formed in situ on limestone. Although the water retention of these soils varies according to the slope, altitude and rainfall, they are soils with high water holding capacity due to their clayey structure in general. However, in places where evaporation is high and precipitation or irrigation is low, unfortunately, the plant feeding capacity also decreases.

As a result, it is necessary to abandon wild irrigation, to irrigate with drip irrigation methods, to choose a drought-resistant plant pattern, and to gradually abandon the varieties and species that consume a lot of water, especially in places where the danger of drought is intense or likely to be experienced in the near future. The channels carrying the water should be closed systems as much as possible, the people of the region should be made aware of drought, and the sustainable use of water resources should be ensured by making savings in both use and agricultural irrigation. Water harvesting, which has been talked about frequently in recent years, needs to be planned and carried out within a system for Antalya.

We hope that this completed study will be used as a resource for the districts of Antalya, which are experiencing drought or are likely to live in the near future, and that the findings will contribute to the people living in Antalya or the institutions and organizations that have a say in its management.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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