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PRECISION OF DROUGHT BASED ON THE TOPSIS METHOD

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Abstract

In this study, Kahramanmaraş Central District is aimed to determine the years which are arid or rainy by taking average of annuals in winter, spring, summer, autumn seasons between the years 1995 and 2014, and to calculate the possibility of temporary dry or rainy in future years. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method was chosen to estimate as a creating a model requires 6 parameters (long-term, average minimum temperature and maximum temperature, average minimum and maximum relative humidity, average annual precipitation, total annual precipitation) in this direction. For this purpose, data of Kahramanmaraş Meteorological Station, which has the longest rainfall records in the region, are used. In this study, days with less than 2.5 mm of rainfall were considered dry, and days with 2.5 mm or more of rainfall were considered rainy. TOPSIS method resulted in 6 steps and meteorological droughts were detected in 2002, 2008 and 2011. In 2015, 2016 and 2017, there is the possibility of a gradual drought.

***Key words**: TOPSIS method, whether, precipitation, drought.*

INTRODUCTION

The development that lives in every area from the primitive society brings together many problems and continues to bring. Human activities such as population growth, industrialization and the consequent emergence of urbanization, such as the release of carbon dioxide and other greenhouse gases effects on temperature, precipitation and other weather-related events and causes global climate change. Drought is at the forefront of natural disasters brought by global climate change (Özfidaner et al., 2016; Keten, 2016).

Although drought is increasing its influence in the world, its scope has not yet been understood and its effects have not been adequately assessed. As a natural consequence of this, there is no definite definition of drought. According to professions, the definitions made are meteorological, hydrological, agricultural, geographic or industrial, energy production, water supply, maritime, recreation places (Sırdaş and Şen, 2010).

In a given time period, falling below normal values of precipitation is defined as meteorological drought.

As a result of the meteorological drought, it is inevitable that some problems such as the problems of irrigation of agriculture areas and the lack of adequate water collection in dams, inadequacy of drinking water resources, negative influence of environment and social structure are inevitable in terms of engineering (Dinç et al., 2016).

Pre-determination of arid circuits is of great importance in water resource planning. Because the maximum drought that will be called the critical drought is an effect on the economic, political and social situation of an country. In order to be able to take precautionary measures, it is necessary to estimate the time, severity and area under which critical drought circuits are affected (Şen, 1980; Sırdaş and Şen, 1999).

Drought is a meteorological natural hazard that has enormous negative effects on the lives of living things, which limits important activities of the people and causes important ecological problems (Şahin and Sipaoğlu, 2003)

Despite the fact that the climate is constantly repetitive, it is difficult to predict. When climate events occur, the duration, intensity and impact range from year to year. As a result, economic, social and environmental influences are taking place, and these effects are a great danger for humanity from time to time. In the analysis of droughts, the long-term average of the balance between precipitation and evapotranspiration in a region should be considered. Drought is a time-dependent parameter (Graedel et al., 2007).

The Palmer Drought Severity Index developed by Palmer (1965) is the first comprehensive drought index. While previous drought indices generally describe drought as descriptive, Palmer Drought Severity Index; precipitation, temperature and soil moisture parameters. The Palmer Drought Severity Index was used extensively between 1960-1990. Later, many drought indexes were developed (Palmer, 1965). The first step in calculating the Palmer Drought Severity Index is to determine the climatic water balance using input from long-term monthly precipitation and temperature data. Palmer uses a simple approach to define moisture accumulation by separating the soil into two layers (Topçuoğlu et al., 2005). Santos et al. (2011) used monthly rainfall data from 144 stations in the study of regional frequency analysis of drought events in Portugal between 1910-2004. To characterize drought events, the Standardized Rainfall Index's 1, 3, 6 and 12 month time periods were used. The drought amplitudes obtained by these time steps of the Standardized Rainfall Index were subjected to regional frequency analysis using two different approaches. According to the results of the analysis, it was determined that the general character of drought periods is evenly distributed throughout the country. Drought indices are either weak or superior to other indices. The advantages and limitations of some indices have been reported in studies (Heim, 2002; White and Walcott, 2009).

In this study, Kahramanmaraş Central District is aimed to determine the years which are arid or rainy by taking average of annuals in winter, spring, summer, autumn seasons between the years 1995 and 2014, and to calculate the possibility of temporary dry or rainy in future years.

MATERIALS AND METHODS

Materials

Coordinates of the study area are important for the climate data to be used. Kahramanmaraş is located between 37° 35' North Parallel and 36˚ 55' East Meridian Apartments. The height from the sea level is 568 m. Mediterranean climate is dominant in the region. Kahramanmaras is located in the Eastern Mediterranean region. Summers are hot and dry, winters are warm and rainy (Anonymous, 2015). According to the data taken from the Kahramanmaraş meteorological station, the average annual temperature varies between 16.5°C and 8.9°C (Anonymous, 2015). It is seen that the temperature values of Kahramanmaraş province center are above 0°C. The average lowest temperature (4.9°C) was observed in January. The highest average temperature is seen in August. Continuous temperature increase between January and August, from August until February until the continuous decrease in temperature is noticeable. The minimum temperature is observed in January, and the maximum temperature is observed in July - August (Anonymous, 2015).

Kahramanmaraş province 'Mediterranean Climate and Terrestrial Climate' is a transition area and the sea effect is also found in the 'Degraded Mediterranean Climate' is effective. In terms of temperature and precipitation 'Mediterranean climate is summertime hot and dry, winters are warm and rainy' is dominant. Higher areas are cooler in the summer and colder in the winter. It has a continental climate effect from south to north, west to east (Anonymu, 2015).

The total amount of evaporation in Kahramanmaraş province center is 1530 mm. This amount is more than annual precipitation. The annual precipitation is around 720 mm (Anonymous, 2015).

Kahramanmaraş province in winter and spring in the amount of abundance in the amount of rainfall, the Mediterranean precipitation regime shows that the domination. The weather is dry during the summer season from the end of spring. In September and October, there are occasional short periods of precipitation.

In this study, daily rainfall data measured during Kahramanmaraş Meteorology Station between 1994 and 2014 were used. These values were obtained from computer records archived by the General Directorate of State Meteorology Affairs. The evaluation of the data was carried out by accepting 28 days in February and 365 days in the year.

Methods

TOPSIS (Multiple Criteria Decision Making Method) was developed by Yoon and Hwang in 1980. Decision points are based on the principle of the ideal solution approximation. The TOPSIS method includes a 6-step solution process. The steps of the TOPSIS method are described below.

Step 1: Creating the Decision Matrix (A)

Step 2: Creating the Standard Decision Matrix (R)

Step 3: Creating the Weighted Standard Decision Matrix (V)

Step 4: Creating Ideal (A *) and Negative Ideal (A ~) Solutions

Step 5: Calculation of the separation measures

Step 6: Calculation of Ideal Solving Relative Proximity

Determinant C * Coefficient Value in Topsis Drought Analysis

Table 1. Topsis Method Index Values

Extremely Wet	**0.9**	**< TOPSIS <**	**1**
Severe Wet	0.8	< TOPSIS <	0.9
Medium Wet	0.7	< TOPSIS <	0.8
Weak Wet	0.6	< TOPSIS <	0.7
Normal	0.4	< TOPSIS <	0.6
Weak Drought	0.3	< TOPSIS <	0.4
Medium Dry	0.2	< TOPSIS <	0.3
Serious Dry	0.1	< TOPSIS <	0.2
Extremely drought		TOPSIS <	0

Model Example Application

The selection of the selected model for Kahramanmaraş Central district and the preparation of the excel program used are discussed in this section. Matrices are formed and formulated from the data from the required graphs.

i= 1…m

J= 1…n

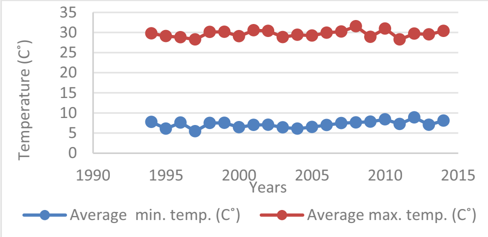

Figure 1. Average minimum and maximum temperatures

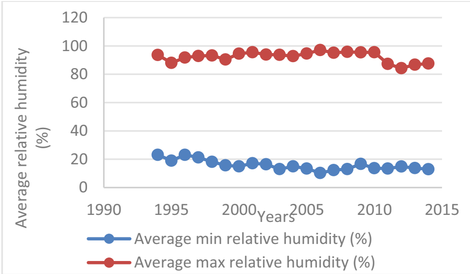

Figure 2. Average minimum and maximum relative humidity

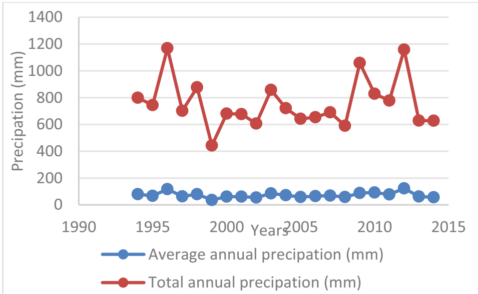

Figure 3. Average and total precipation

Creating the Decision Matrix

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}}$$

In the lines of the decision matrix, the years of supremacy are listed (1994-2014). The decision points in the decision points are the assessment factors to be used in decision making: average minimum temperature (C°), average maximum temperature (C°), average minimum relative humidity (%), average maximum relative humidity (%) total annual precipitation (mm).

The matrix A is the initial matrix generated by the decision maker. The decision matrix is constructed as follows Table 2.

Creating the Standard Decision Matrix (R)

The R matrix is formed from the formula results applied separately for each year.

Creating the Weighted Standard Decision Matrix (V)

The weight values (w) for the evaluation factors were determined. The weight values were found by dividing the sum of the numbers in each column by the number of the criterion.

$$\sum_{i=1}^{n} w_i = 1$$

The elements of each column of the R matrix are multiplied by the corresponding wj value to form the V matrix.

Determination of Ideal (A*) and Negative Ideal (A$^-$) Solution

At this stage, the weighted matrix shows the maximum and minimum values for each column.

Table 2. Climatic Data Observed in Kahramanmaras

Years	Average min temperature (C°)	Average max temperature (C°)	Average min relative humudity (%)	Average max relative humudity (%)	Average annual precipation (mm)	Total annual precipation (mm)
1994	7.75	29.77	23.08	93.58	79.90	799.00
1995	6.08	29.09	19.00	88.00	67.65	744.20
1996	7.59	28.80	23.08	91.75	116.90	1169.00
1997	5.43	28.26	21.25	92.92	63.82	702.00
1998	7.51	30.11	18.17	93.25	79.71	876.80
1999	7.54	30.15	15.67	90.42	36.89	442.70
2000	6.43	29.06	15.00	94.50	61.85	680.30
2001	7.01	30.53	17.17	95.58	61.56	677.20
2002	7.04	30.37	16.42	93.92	55.12	606.30
2003	6.41	28.83	13.00	93.67	85.75	857.50
2004	6.09	29.40	15.00	92.75	72.15	721.50
2005	6.49	29.21	13.42	94.58	58.37	642.10
2006	6.97	29.94	10.33	97.08	65.33	653.30
2007	7.45	30.21	12.33	95.17	69.05	690.50
2008	7.61	31.53	13.08	95.83	58.98	589.80
2009	7.83	28.91	16.67	95.42	88.28	1059.30
2010	8.39	30.96	13.67	95.58	92.12	829.10
2011	7.23	28.25	13.42	87.33	77.75	777.50
2012	8.89	29.71	14.83	84.25	123.10	1158.00
2013	7.03	29.51	13.75	86.75	62.91	629.10
2014	8.07	30.36	12.92	87.58	57.10	628.10

Calculation of Distance Measures Between Alternatives

After identifying the ideal points, the maximum and minimum ideal point distance values are calculated.

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2} \qquad \text{i= 1, 2,…, m}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \qquad \text{i= 1, 2,…, n}$$

Calculation of Ideal Solving Relative Proximity

The criterion used here is the share of the negative ideal difference measure within the total difference measure. The calculation of the ideal solution relative affinity value is shown in the following formula.

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*} \qquad \text{i= 1, 2,…, m}$$

The ideal solution relative proximity (C) of each decision point is calculated using the equation given earlier.

RESULTS AND DISCUSSIONS

In this study, climate data for Kahramanmaraş Central district was used. In this study, days with less than 2.5 mm of precipitation and dry days of 2.5 mm and more were evaluated as rainy. Based on this feature, the probabilities calculated by the TOPSIS method and the actual probabilities represented by the observational data for the winter, spring, summer and autumn seasons of annual precipitation between 1995 and 2015 have been determined.

Within the scope of analysis within 20 years; no year was not very dry, four years were medium dry, five years were weak dry, seven years were at normal climate, two years were poor wet and two years were extremely wet.

When the 'C' values in the scope of the analysis are examined, the years of 2002, 2008, 2009 and 2011 medium dry, 2003, 2004, 2005, 2007 and 2010 weak arid, 1996, 1998, 2000, 2001, 2006, 1995 and 2012 are wet wet, 1997 and 1999 are extremely wet past.

Table 3. Topsis Outcome Values

1995	0.62126	C1	2005	0.31867	C11
1996	0.45146	C2	2006	0.48927	C12
1997	0.91077	C3	2007	0.39368	C13
1998	0.45146	C4	2008	0.27408	C14
1999	0.91077	C5	2009	0.29526	C15
2000	0.44964	C6	2010	0.35944	C16
2001	0.58279	C7	2011	0.29525	C17
2002	0.23485	C8	2012	0.66832	C18
2003	0.33265	C9	2013	0.55671	C19
2004	0.38798	C10	2014	0.43982	C20

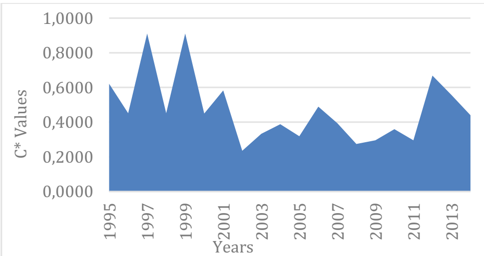

Figure 4. C * Values of Years

Within the information observed in this study; there are two years between two very wet periods and the climate returns to its normal level afterwards.

The closest wet period is between 1 year and the longest wet period is 15 years.

The period between the nearest middle dry period is 1 year, and the longest medium dry period is 9 years.

In this study, where the drought analysis is performed with the TOPSIS method, it is highly likely that a drought or a wet (wet) period is experienced near the same level for two consecutive years. Kahramanmaraş Central has been in the district since 1999, after a normal level and then to a moderate dry level.

CONCLUSIONS

According to various meteorological data and calculated drought method, Kahramanmaraş Central District is experiencing meteorological drought in 1999-2008 period. The drought that we have been living in recently has been turned from meteorological drought to agricultural and hydrological drought with a considerable decrease in winter precipitation. As a result of this study, which is aimed at predicting the next generation analysis, determining the product design to be trained and taking precautions for the future disasters, a drought should be expected at a weak level near 2015, 2016 and 2017. Along with climate change in the near future, these droughts are expected to become a part of our everyday life by becoming a repetitive nature event in the long run.

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