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Drought and Flood Analyses of Samsun City

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ABSTRACT

The aim of this study is to analyze the flood and drought based on precipitation and streamflow data gathered from Samsun City, the most developed province of the Black Sea Region. Flood and drought analysis are important for the water resources management and important for anticipating the natural disasters that may occur in Samsun. The study has been carried out in two parts. In the first part, streamflow data, covering the period from 1964 to 2015, provided by the Current Observation Station, which is the most powerful parameter causing flood, was investigated for flood analysis by Mann-Kendall trend analysis. In the second part, the drought resulting from below-average precipitation value and it's adverse effects on animals, plants and other living things, mainly on humans, was analyzed through the Standardized Precipitation Index (SPI) and Percentage of Normal Index (PNI). In the first part of the study, with regard to monthly Mann-Kendall trend analysis of monthly streamflow, positive trend was found for November. However, no trend was found for in terms of seasonal trend analysis. In the second part, drought condition was determined as nearly normal to at a percentage of 49% with regard to SPI index whereas the drought status was also found to be normal and over 51% with regard to PNI index.

Keywords: Drought; Mann-Kendall; PNI; Precipitation; Samsun; SPI.

1. INTRODUCTION

The changes of the temperature and the precipitation cause events which affect our life during the periods specific for a region. Theese events such as drought and desertification etc. affect humanbeing's life and must be taken absolutely seriously. In this sense, drought and desertification occur when temperature values tend to increase continuously and precipitation values tend to decrease continuously (long periods) whereas the continual increase in precipitation or the continuous increase in the instantaneous precipitation tendency causes the floods, the landslides etc.

Although temperature values and precipitation amounts flactuate in different periods, continuous increases in temperature and changes in precipitation amounts (continuse decline or continuse increases) along with the increasing industrialitation change the world's ongoing scheme. In the light of studies in the literature, the average surface temperature appears to by 0.85 ºC between 1880, and 2012, and while the precipitations have increased at high latitudes, they have decreased at low latitudes. In addıtıon surface temperature is assumed to increase by 2 ºC between 2020, and 2029 [1, 2]. The heat wave events have affected thousands of people ,and even deaths enacted in some cases [3, 4].

Drought isn't an event that occurs abrubtly. It is a natural disaster that takes place due to ubnormally low precipitation as opposed to anticipated precipitation, In addition, precipitation forecasting is quite complicated. Temperature, precipitation and soil properties may be taken as dependant variables for this event [5].

In the light of the studies in the literature, it has been noticed that drought has direct correlation with forest fires to a large extent, while low meteorological moisture and thermal effects cause forest fires. In this sense, forests are one of the major and indispensable factors of our lives which provide the continuity of the ecosystem. Therefore, provided that the general course of the event is observed, precautions could be taken before it occurs , which may abate the losts forest.

The detection and attribution of past trends, changes and variability in climatic variables is essential for the understanding of potential future changes. For this purpose various trend detection studies were employed for different parts of the worlds, mostly for determination of climate change [6, 7].Parametric and non-parametric procedures are utilized to detect to trends in climatic variables. The parametric test requires that the data be normally distributed. If the time series have non-normal distribution, missing values and serial correlation, non-parametric procedures are proposed. Consequently, non-parametric procedures have been commonly used because of requirement of not much acceptance [6]. Trend of streamflow and precipitation have been investigated by many researchers using Mann-Kendall test [7–13].

The objective of this study is to analyze flood and drought based on precipitation and streamflow data for Samsun City, the most developed province of the Black Sea Region. The study has been executed in two parts. In the first part, streamflow data, from 1964 to 2015, provided by the Current Observation Station, was investigated for flood analysis by Mann-Kendall trend analysis. In the second part, the drought was analyzed based on the Standardized Precipitation Index (SPI) and Percentage of Normal Index (PNI).

2. MATERIAL AND METHODS

2.1. Study area and date

Samsun city, which is located in the Central Black Sea Region (long. 36º 14′ E, lat. 42º 21′ N, alt. 4 m), is the 16th most crowded city in Turkey and the most crowded city in the Black Sea region. Samsun city is confined with Black Sea, Amasya, Ordu and Sinop, to the North, to the South, to the East, to the West respectively. The study area and stations are shown in Figure 1.

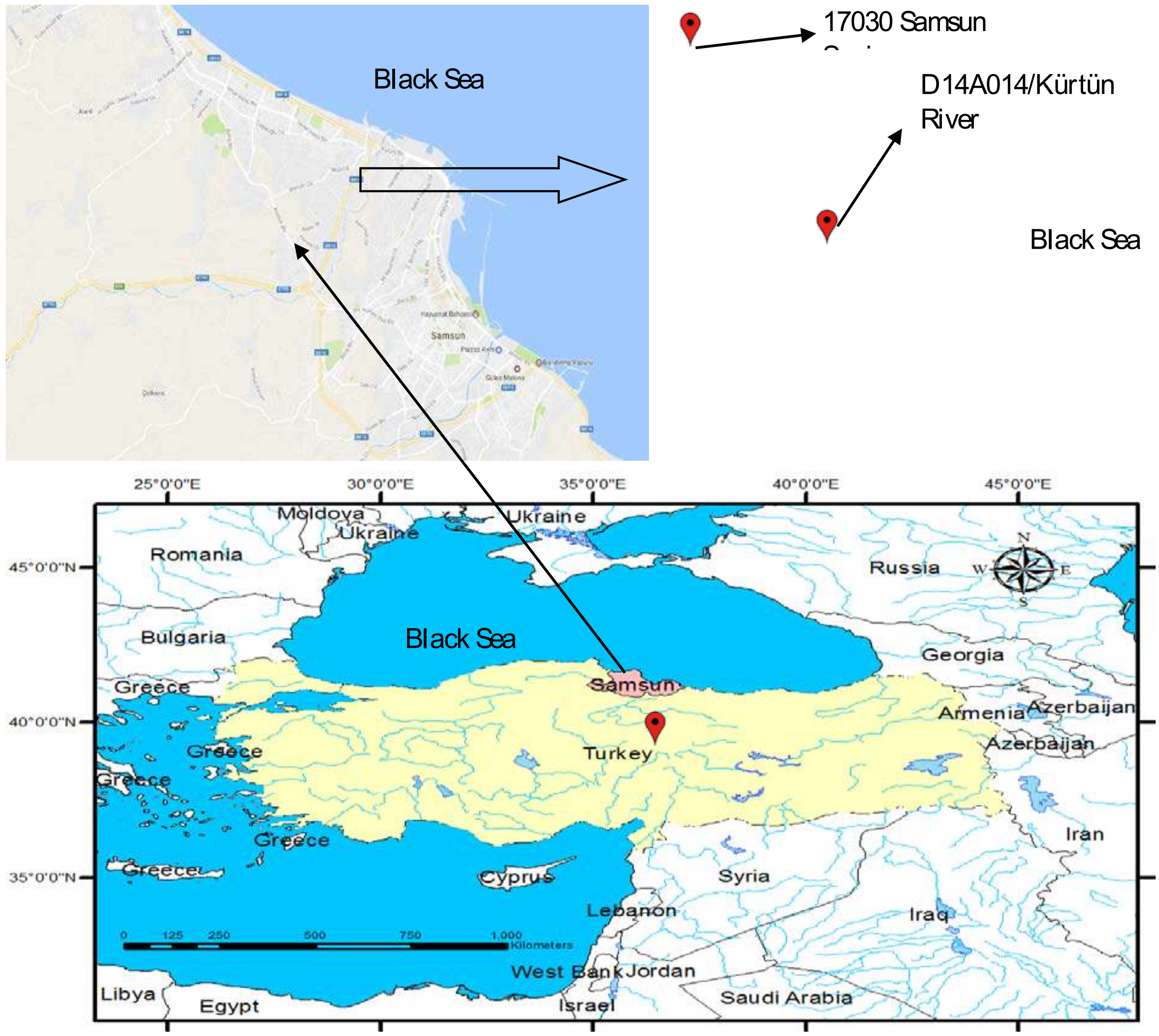

Figure 1. Study area and stations.

The monthly total precipitation data (for 17030 Samsun Station) from Turkish Meteorological Organization of Turkey (http://tumas.mgm.gov.tr/wps/portal/) and the monthly average streamflow data (for D14A014/Kürtün River) from General Directorate of State Hydraulic Works of Turkey (http://www.dsi.gov.tr/, http://rasatlar.dsi.gov.tr/) were used in our study of drought and flood. The streamflow dates include observations spanning from 1964 to 2015 and cover 51 years (51 years x 12 months= 612 months). The precipitation dates include observations spanning from 1960 to 2015 and cover 55 years (55 x 12 months= 660 months), which is considered to be long enough for a valid mean statistic [22]. Periods and basic statistical properties of the monthly total precipitation and streamflow data are provided in Table 1.

Table 1. Basic statistics of total precipitation and streamflow.

Station Number	Parameter	Minimum value	Maximum value	Mean, μ	Standard deviation, σ	CV*	SC*
(D14A014)	Streamflow(m^3/s)	0.028	8,64	1.41	1.78	1.26	+1.48
(17030)	Precipitation(mm)	0.001	350.3	58.86	8.97	0.15	+0.58

*CV variation coefficient (σ/μ), SC skewness coefficient

2.2. Methods

2.2.1. Mann-Kendall

Mann Kendall test metod is one of the non-parametric tests to catch trend in a time series especially in meteorological and hydrological time series. The Mann–Kendall test statistic S is calculated by using Eq.1 [9], [14], [15].

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}(x_j - x_i) \qquad (1)$$

In Eq. (1), n is the number of data points, x_i and x_j are the data values in time series i and j, respectively and in Eq. (2), sgn (xj − xi) is the sign function as;

$$sgn\,(x_j - x_i) = \begin{cases} 1; & \dot{I}f\ x_j > x_i \\ 0; & \dot{I}f\ x_j = x_i \\ -1; & \dot{I}f\ x_j < x_i \end{cases} \qquad (2)$$

The variance is computed by Eq.(3) ;

$$\mathrm{Var}(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{P} t_i(t_i-1)(2t_i+5)}{18} \qquad (3)$$

In Eq. (3), n refers to number of data, P shows the number of tied groups, and t_i indicates the number of ties of extent i. A tied group is a set of sample data and have the same value. In cases of sample size n > 10, the standard normal test statistic Z is calculated using Eq. (4);

In Eq. (3), P shows the number of tied groups (equal data in time series), and summary sign (∑) indicates the summation over all tied groups. t_i is the number of data values in P^{th} group. If tied groups do not exist, this summary process is ignored for this equation. After computing variance of time series with Eq. (3), standard Z value is computed using the following equation.

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var(S)}}; & If\ S > 0 \\ 0; & If\ S = 0 \\ \frac{S+1}{\sqrt{Var(S)}}; & If\ S < 0 \end{cases} \quad (4)$$

The computed standard Z value is compared with standard normal distribution according to the two-tailed confidence intervals (α =10 %, α =5 %). If the computed Z value is greater than $|Z| > |Z_{1-\alpha/2}|$, null hypothesis (H_0) is rejected and thus H_1 hypothesis is accepted. Otherwise, the H_0 hypothesis is accepted and this means that the trend is not statistically significant. In this study, two-tailed confidence intervals (α =10 % and α =5 %) are used for the Mann Kendall trend test [16].

2.2.2. Standard precipitation Index (SPI)

Mckee et al. (1993) developed the Standardized Precipitation Index (SPI) for monitoring drought condition based on rainfall value. The SPI is computed by dividing the difference between the normalized precipitation and its long-term mean by the standard deviation. The equation is follows as:

$$SPI = \frac{(x_i - x_i^{avr})}{\sigma}, \quad (5)$$

where, SPI; Standard precipitation index, xi; Current amount of precipitation and x_{iavr}; Average rainfall amount and " σ "; Standard deviation. The classification according to the SPI results is as shown in Table 2.

Table 2. Index values and classification according to SPI values.

SPI values	Classification
> 2	Extremely Wet
1.50 ~ 1.99	Very Wet
1.00 ~ 1.49	Moderately Wet
0.99 ~ 0	Normal
0 ~ -0.99	Near Normal
-1.00 ~ -1.49	Moderately Dry
-1.50 ~ -1.99	Severely Dry
< - 2	Extremely Dry

If the drought assessment is realized in terms of the SPI values, the period when the index indicates a continuous negative value can be defined as the dry period. While the first period in which the index falls below zero (indicated by the red colour) is assumed as the beginning of drought, the month when ındex shows positive value (indicated by the blue colour) is considered to be the end of the drought [17].

2.2.3. Percent of Normal Index (PNI)

The normal percentage index (PNI) is obtained by dividing the amount of rainfall within a given time period by the average rainfall. The time series can use the PNI method for periods of 12 months or less [18]. This method;

$$PNI = \frac{(x_i)}{x_i^{avr}} x100, \qquad (6)$$

where, PNI; Percentage of normal index, x_i; Current amount of precipitation and x_{iavr}; Average rainfall. Based on the PNI, five states of hydrological drought are defined through the criteria of Table 3.

Table 3. Index values and classification according to PNI values.

Period	Normal	Slight Drought	Moderate Drought	Extreme Drought
	No Risk	Start Monitoring	Warning	Emergency
1	>%75	%65-%75	%55-%65	<%55
3	>%75	%65-%75	%55-%65	<%55
6	>%80	%70-%80	%60-%70	<%60
9	>%83.5	%73.5-	%63.5-	<%63.5
12	>%85	%75-%85	%65-%75	<%65

If the drought assessment is realized with regard to the PNI values, the period when the index signifies smaller than the continuous threshold can be defined as the dry period. While the first value which falls below threshold values is acknowledged as the beginning of drought, the situation when value shows upper side of threshold values is considered to be the end of the drought.

3. RESULTS AND DISCUSSION

Drought analyses have been carried out in terms of Standardized Precipitation Index (SPI) and Percent of Normal Index for Samsun city precipitation station. Flood analyses have been carried out by Mann-Kendall trend method. The results have been comparatively examined monthly, annually and seasonally respectively.

3.1.Mann-Kendall Results

Monthly and annual results of streamflow data with regard to the Mann-Kendall test are given in Table 4, and seasonal results in Table 5.

Table 4. Monthly results of the Mann-Kendall (MK) test Z values.

STATION	MONTHS	MK Z values	Z, Critical probability Value (α=10%)	MK test Tendency (α=10%)	H_0 Hypothesis	Z, Critical probability Value (α=5%)	MK test Tendency (α=5%)	H_0 Hypothesis
	OCTOBER	-0.495	±1.645	NO	Accept	±1.96	NO	Accept
	NOVEMBER	1.665	±1.645	Yes (+)	Rejection	±1.96	NO	Accept
	DECEMBER	-0.057	±1.645	NO	Accept	±1.96	NO	Accept
	JANUARY	0.349	±1.645	NO	Accept	±1.96	NO	Accept
	FEBRUARY	1.048	±1.645	NO	Accept	±1.96	NO	Accept
	MARCH	1.194	±1.645	NO	Accept	±1.96	NO	Accept
SAMSUN/Kürtün	APRIL	0.187	±1.645	NO	Accept	±1.96	NO	Accept
	MAY	-0.398	±1.645	NO	Accept	±1.96	NO	Accept
D14A014	JUNE	0.593	±1.645	NO	Accept	±1.96	NO	Accept
	JULY	0.512	±1.645	NO	Accept	±1.96	NO	Accept
	AUGUST	0.828	±1.645	NO	Accept	±1.96	NO	Accept
	SEPTEMBER	-0.462	±1.645	NO	Accept	±1.96	NO	Accept
	ANNUAL	0.398	±1.645	NO	Accept	±1.96	YOK	Kabul

Table 5. Mann-Kendall test Z values seasonal results.

STATION	MONTHS	MK Z values	Z, Critical probability Value (α=10%)	MK test Tendency (α=10%)	H_0 Hypothesis	Z, Critical probability Value (α=5%)	MK test Tendency (α=5%)	H_0 Hypothesis
	WINTER	0.552	±1.645	NO	Accept	±1.96	NO	Accept
SAMSUN/Kürtün	SPRING	0.244	±1.645	NO	Accept	±1.96	NO	Accept
	SUMMER	0.479	±1.645	NO	Accept	±1.96	NO	Accept
D14A014	AUTUMN	-0.422	±1.645	NO	Accept	±1.96	NO	Accept

With regard to to the yearly and seasonal Mann-Kendall method, no trend was observed while the confidence interval was 95%. However, while the confidence interval is 90% (Z ≈ +1.65), there is an increasing trend in November. The increasing trend in the non-statistically significant course was detected in March.

3.2. Standard precipitation Index (SPI) and Percent of Normal Index (PNI) Results

3.2.1. Annual review

SPI and PNI values for entire years between 1960, and 2015 are calculated for the station and are shown in Figure 2 and Figure 3.

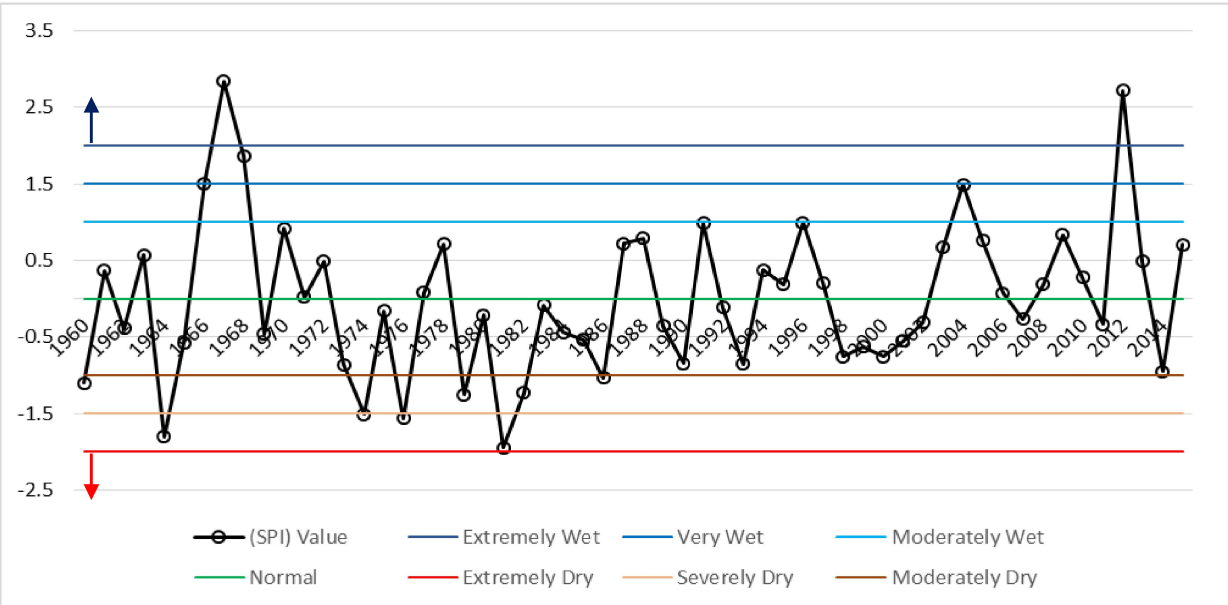

Figure 2. Standard precipitation index (SPI) results.

When the annual results reflecting the last ten years have been examined by SPI method, an approximate normal level of drought indication has been noticed in the years 2007, 2011, and 2014. These years are defined as turning point, which has no continuity for the following years For example, after the approximate normal level of drought indication which is observed in 2011, the direction of drought trend has changed by the extremely heavy precipitation (rainfall) in 2012. Many flood incidents occured in the wake of the extreme precipitation observed in Samsun in 2012 leading to both financial and emotional losts.

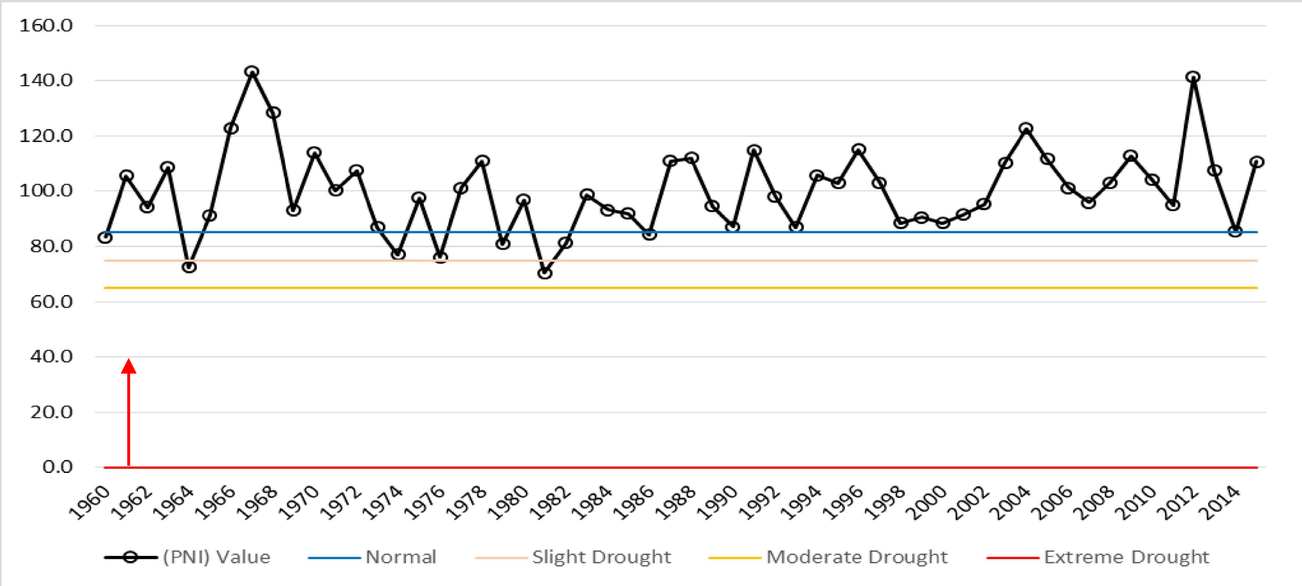

Figure 3. Percent of normal index (PNI) results.

In view of the annual results, obtained by PNI method, which reflect the last ten years, no indication of any drought has been observed in the station, which is studied by explaining normal and over index. The PNI results conform to the SPI result in general; however, the categories that PNI defines turn out to be less than those of SPI. Therefore PNI turns out to be confining the ability to describe the area which represents to the annual precipitation

When the results pertaining to the entire years is examined (56 years) , the biggest percentage proportions is observed as normal values by SPI method, and as normal and above by PNI method. The moderately dry drought has been observed in years 1960,1979,1982,1986 in terms of SPI method. However, this situation is discontinuous, in view of the years. The 'severely dry' has been observed in years 1964,1974,1976,1982 in terms of SPI method. Through PNI method normal and above drought indication was observed in between the years 1987-2015, a moderate drought in the years 1964 and 1981, and a slight drought in the years 1960, 1974, 1976, 1979, 1982, 1986. Frequency and percentages are submitted in Table 6-7.

Table 6. SPI method summary results.

SPI Classes	Frequency (times)	Percentages (%)
Extremely Wet	2	3.57
Very Wet	2	3.57
Moderately Wet	1	1.79
Normal	22	39.29
Near Normal	21	37.50
Moderately Dry	4	7.14
Severely Dry	4	7.14
Extremely Dry	0	0.00
Total	56 Years (1960-2015)	100.00

Table 7. PNI method summary results

PNI Classes	Frequency (times)	Percentages (%)
Normal	48	85.71
Slight Drought	6	10.71
Moderate Drought	2	3.57
Extreme Drought	0	0.00
Total	56 Years (1960-2015)	100.00

2.1.1. Monthly review

SPI and PNI index values for the station utilized in the current study were calculated separately in between the years 1960-2015, and the monthly results of last ten years are submitted in Table 8-10.

Table 8. SPI and PNI values of the last 10 years (2005-2015)

Months	Year	Total Precipitation (mm)	SPI value	SPI Results	PNI value	PNI Results
JANUARY	2005	62.8	-0.1	Near Normal	95.6	Normal
	2006	121.3	1.7	Very Wet	184.6	Normal
	2007	24.5	-1.2	Moderately Dry	37.3	Extreme Drought
	2008	42.7	-0.7	Near Normal	65.0	Extreme Drought
	2009	86.1	0.6	Normal	131.1	Normal
	2010	74.3	0.3	Normal	113.1	Normal
	2011	133.2	2.0	Extremely Wet	202.8	Normal
	2012	75.6	0.3	Normal	115.1	Normal
	2013	61.3	-0.1	Near Normal	93.3	Normal
	2014	5.1	-1.8	Extremely Dry	7.8	Extreme Drought
	2015	129.3	1.9	Very Wet	196.8	Normal
FEBRUARY	2005	43.1	-0.4	Near Normal	80.2	Slight Drought
	2006	98.7	1.8	Very Wet	183.7	Normal
	2007	43.8	-0.4	Near Normal	81.5	Slight Drought
	2008	67.9	0.6	Normal	126.4	Normal
	2009	91	1.5	Moderately Wet	169.4	Normal
	2010	35.9	-0.7	Near Normal	66.8	Moderate Drought
	2011	39.5	-0.6	Near Normal	73.5	Moderate Drought
	2012	64.7	0.4	Normal	120.4	Normal
	2013	30.8	-0.9	Near Normal	57.3	Extreme Drought
	2014	34	-0.8	Near Normal	63.3	Extreme Drought
	2015	84.5	1.2	Moderately Wet	157.3	Normal

MARCH	2005	141.6	3.0	Extremely Wet	233.4	Normal
	2006	94.6	1.3	Moderately Wet	155.9	Normal
	2007	68.1	0.3	Normal	112.3	Normal
	2008	36.8	-0.9	Near Normal	60.7	Extreme Drought
	2009	49	-0.4	Near Normal	80.8	Slight Drought
	2010	93.2	1.2	Moderately Wet	153.6	Normal
	2011	75.3	0.5	Normal	124.1	Normal
	2012	71	0.4	Normal	117.0	Normal
	2013	92.8	1.2	Moderately Wet	153.0	Normal
	2014	40.8	-0.7	Near Normal	67.3	Moderate Drought
	2015	70.5	0.4	Normal	116.2	Normal
APRIL	2005	87.8	1.0	Normal	149.1	Normal
	2006	33.7	-0.8	Near Normal	57.2	Extreme Drought
	2007	25.9	-1.1	Moderately Dry	44.0	Extreme Drought
	2008	48	-0.4	Near Normal	81.5	Slight Drought
	2009	21.4	-1.2	Moderately Dry	36.3	Extreme Drought
	2010	72.7	0.5	Normal	123.4	Normal
	2011	65.4	0.2	Normal	111.0	Normal
	2012	30.9	-0.9	Near Normal	52.5	Extreme Drought
	2013	57.8	0.0	Near Normal	98.1	Normal
	2014	24.4	-1.1	Moderately Dry	41.4	Extreme Drought
	2015	95.7	1.2	Moderately Wet	162.5	Normal

Table 9. SPI and PNI values of the last 10 years (2005-2015) Continued

Months	Year	Total Precipitation (mm)	SPI value	SPI Results	PNI value	PNI Results
MAY	2005	34.7	-0.5	Near Normal	70.7	Moderate Drought
	2006	69	0.7	Normal	140.7	Normal
	2007	67	0.6	Normal	136.6	Normal
	2008	40.7	-0.3	Near Normal	83.0	Slight Drought
	2009	55.3	0.2	Normal	112.7	Normal
	2010	11.7	-1.3	Moderately Dry	23.8	Extreme Drought
	2011	86.2	1.3	Moderately Wet	175.7	Normal
	2012	24.8	-0.9	Near Normal	50.6	Extreme Drought
	2013	29.6	-0.7	Near Normal	60.3	Extreme Drought
	2014	48.1	0.0	Near Normal	98.0	Normal
	2015	30.4	-0.7	Near Normal	62.0	Extreme Drought
JUNE	2005	51.1	0.1	Normal	106.7	Normal
	2006	36.3	-0.4	Near Normal	75.8	Slight Drought
	2007	38	-0.3	Near Normal	79.4	Slight Drought
	2008	35.8	-0.4	Near Normal	74.8	Moderate Drought
	2009	8.2	-1.4	Moderately Dry	17.1	Extreme Drought
	2010	112.5	2.3	Extremely Wet	235.0	Normal
	2011	53	0.2	Normal	110.7	Normal
	2012	54.8	0.2	Normal	114.5	Normal
	2013	33.9	-0.5	Near Normal	70.8	Moderate Drought
	2014	62.3	0.5	Normal	130.1	Normal
	2015	80.3	1.1	Moderately Wet	167.7	Normal
JULY	2005	5.9	-0.8	Near Normal	17.9	Extreme Drought
	2006	9	-0.7	Near Normal	27.3	Extreme Drought
	2007	31.4	0.0	Near Normal	95.2	Normal
	2008	20.7	-0.4	Near Normal	62.8	Extreme Drought
	2009	80.6	1.5	Moderately Wet	244.4	Normal

	2010	19.5	-0.4	Near Normal	59.1	Extreme Drought
	2011	31	-0.1	Near Normal	94.0	Normal
	2012	167.3	4.1	Extremely Wet	507.2	Normal
	2013	10.6	-0.7	Near Normal	32.1	Extreme Drought
	2014	55	0.7	Normal	166.7	Normal
	2015	43.2	0.3	Normal	131.0	Normal
AUGUST	2005	114.2	1.5	Very Wet	276.4	Normal
	2006	0	-0.9	Near Normal	0.0	Extreme Drought
	2007	111.8	1.5	Moderately Wet	270.6	Normal
	2008	0.4	-0.8	Near Normal	1.0	Extreme Drought
	2009	20.9	-0.4	Near Normal	50.6	Extreme Drought
	2010	4.6	-0.8	Near Normal	11.1	Extreme Drought
	2011	15	-0.5	Near Normal	36.3	Extreme Drought
	2012	164.2	2.5	Extremely Wet	397.4	Normal
	2013	269.8	4.7	Extremely Wet	652.9	Normal
	2014	19.9	-0.4	Near Normal	48.2	Extreme Drought
	2015	15.8	-0.5	Near Normal	38.2	Extreme Drought

Table 10. SPI and PNI values of the last 10 years (2005-2015) Continued

Months	Year	Total Precipitation (mm)	SPI value	SPI Results	PNI value	PNI Results
SEPTEMBER	2005	69.7	0.6	Normal	135.6	Normal
	2006	66.2	0.4	Normal	128.8	Normal
	2007	28.7	-0.7	Near Normal	55.8	Extreme Drought
	2008	74.6	0.7	Normal	145.2	Normal
	2009	62.6	0.3	Normal	121.8	Normal
	2010	22.5	-0.9	Near Normal	43.8	Extreme Drought
	2011	21.3	-0.9	Near Normal	41.4	Extreme Drought
	2012	42.6	-0.3	Near Normal	82.9	Slight Drought
	2013	26.3	-0.8	Near Normal	51.2	Extreme Drought
	2014	74.5	0.7	Normal	145.0	Normal
	2015	28.9	-0.7	Near Normal	56.2	Extreme Drought
OCTOBER	2005	62.9	-0.4	Near Normal	75.8	Slight Drought
	2006	48.7	-0.6	Near Normal	58.7	Extreme Drought
	2007	72.4	-0.2	Near Normal	87.3	Normal
	2008	128.8	0.9	Normal	155.3	Normal
	2009	113.4	0.6	Normal	136.7	Normal
	2010	183.1	1.9	Very Wet	220.8	Normal
	2011	31.8	-1.0	Near Normal	38.3	Extreme Drought
	2012	36.7	-0.9	Near Normal	44.3	Extreme Drought
	2013	51.3	-0.6	Near Normal	61.9	Extreme Drought
	2014	66.6	-0.3	Near Normal	80.3	Slight Drought
	2015	72.3	-0.2	Near Normal	87.2	Normal
NOVEMBER	2005	74.2	-0.2	Near Normal	88.8	Normal
	2006	65.8	-0.3	Near Normal	78.8	Slight Drought
	2007	96.5	0.2	Normal	115.5	Normal
	2008	109.5	0.5	Normal	131.1	Normal
	2009	129.6	0.8	Normal	155.2	Normal

	2010	10.7	-1.3	Moderately Dry	12.8	Extreme Drought
	2011	82.2	0.0	Near Normal	98.4	Normal
	2012	163.6	1.4	Moderately Wet	195.9	Normal
	2013	37.8	-0.8	Near Normal	45.3	Extreme Drought
	2014	93.7	0.2	Normal	112.2	Normal
	2015	31.3	-0.9	Near Normal	37.5	Extreme Drought
DECEMBER	2005	40.4	-1.0	Near Normal	51.5	Extreme Drought
	2006	71.4	-0.2	Near Normal	91.1	Normal
	2007	69.4	-0.2	Near Normal	88.5	Normal
	2008	120.7	1.1	Moderately Wet	154.0	Normal
	2009	78.5	0.0	Normal	100.1	Normal
	2010	95.8	0.4	Normal	122.2	Normal
	2011	36.9	-1.1	Moderately Dry	47.1	Extreme Drought
	2012	102.9	0.6	Normal	131.3	Normal
	2013	56.8	-0.6	Near Normal	72.5	Moderate Drought
	2014	79.3	0.0	Normal	101.2	Normal
	2015	100	0.6	Normal	127.6	Normal

When the monthly results reflecting the last ten years have been scrutinized via SPI method, ‘a near normal drought’ indication is noticed in general. While ‘severely dry’ indication is noticed only in October, the‘moderately dry’ is determined mostly in April. When the monthly results have been examined by PNI method, the normal and above drought indication is noticed in general. The ‘extreme drought’ has been major in August, (seven times), September (five times), July (five times). Furthermore, addition information has been given Table 11-12.

Table 11. Monthly Standard precipitation index (SPI) results.

MONTHS	Extremely Wet	Very Wet	Moderately Wet	Normal	Near Normal	Moderately Dry	Severely Dry	Extremely Dry	Total
JANUARY	1	4	4	13	26	5	3	0	56
FEBRUARY	3	2	3	14	29	4	1	0	56
MARCH	2	1	4	20	21	3	4	1	56
APRIL	2	4	3	13	26	8	0	0	56
MAY	4	1	3	15	26	7	0	0	56
JUNE	3	1	4	20	22	5	1	0	56
JULY	3	0	3	15	32	3	0	0	56
AUGUST	2	2	5	9	38	0	0	0	56
SEPTEMBER	2	3	3	18	19	11	0	0	56
OCTOBER	3	3	3	10	31	6	0	0	56
NOVEMBER	1	3	2	16	27	7	0	0	56
DECEMBER	1	2	4	15	29	2	1	0	56
Total	27	28	41	178	326	61	10	1	672
Percentages	4.02%	4.17%	6.10%	26.49%	48.51%	9.08%	1.49%	0.15%	100.00%

Table 12. Monthly Percent of Normal Index (PNI) results.

MONTHS	Normal	Slight Drought	Moderate Drought	Extreme Drought	Total (times)
JANUARY	31	7	4	14	56
FEBRUARY	27	11	8	10	56
MARCH	32	8	4	12	56
APRIL	32	4	2	18	56
MAY	27	8	4	17	56
JUNE	29	5	4	18	56
JULY	24	4	4	24	56
AUGUST	22	5	2	27	56
SEPTEMBER	28	3	5	20	56
OCTOBER	26	6	10	14	56
NOVEMBER	32	5	3	16	56
DECEMBER	33	1	6	16	56
Total	343	67	56	206	672
Percentages	51.04%	9.97%	8.33%	30.65%	100.00%

In view of the SPI method, When table 11-12 are examined; near normal drought indication is realized at a rate of 48.51 % and normal drought indication is realized at a rate of 26.49 %, moderately dry indication (9.08 percentage) and severely dry (1.49 percentage) are realized in 9.08 % and 1.49 % percentages respectively. When the classification of drought is realized under two main titles in the SPI method, while drought (including normal) doesn’t exıst 40.78%, drought exısts the rate of 59.22%. In view of the PNI method, however, the rate of normal and above drought appear as 51.04 % and severe drought as of 30.65 % respectively. When, similar to SPI methods, categories divided into two in terms of ‘normal and above’ identification, it is observed that 51.04% has no drought indication whereas 48.96% has drought indication.

4. CONCLUSION

In this study, flood analysis has been carried out annually, seasonal and monthly by utilizing average streamflow data from General Directorate of State Hydraulic Works of Turkey (Current Observation Station) between the years of 1964 and 2015. The Mann-Kendall trend method has been used in the analyzes. As a result of the analysis, a statistically significant positive trend was observed in November (confidence intervals, α =10 %). However, no trend was found for other months and in terms of seasonal trend analysis.

Drought analysis has been carried out annually and monthly by utilizing precipitation data of Samsun Meteorological Station between the years of 1960 and 2015. Annually and monthly drought statuses have been examined by Standardized Precipitation Index (SPI) and Percent of Normal Index (PNI). The results are determined to be consistent with each other for some months and years. To categorize the drought, SPI method is more precise than PNI method, whoose the usage is more basic, because SPI method utilizes standart deviation. Whereas, the annual results for the last ten years do not reveal drought indication, the monthly results reveal flactuating drought indication. As a result of the analysis, drought condition was determined as nearly normal to at a percentage of 49% with regard to SPI index whereas the drought status was also found to be normal and over 51% with regard to PNI index.

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1 REFERENCES

[1] B. Efe and E. Özgür, 2014. *Standart Yağış İndeksi (SPI) ve Normalin Yüzdesi Metodu (PNI) ile Konya ve Çevresinin Kuraklık Analizi*, II. Uluslararası Katılımlı Kuraklık ve Çölleşme Sempozyumu, Konya

[2] D. Solomon, S., M. Qin, Z. Manning, M. Chen, K. B. Marquis, M. T. Averyt, Miller HL, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, New York Cambridge Univ. Press, 2007.

[3] URL1. [Online]. Available: www.ntvmsnbc.comid24998660. [Accessed: 12-Jul-2015].

[4] URL2.[Online]. Available: URL1 httpwww.amerikaninsesi.comcontentsicak- hava-dalgasi-tahmininde-sicak- gelisme1780749. [Accessed: 12-Jul-2015].

[5] H. Tatli, 2014. Statistical complexity in daily precipitation of NCEP/NCAR reanalysis over the Mediterranean Basin, Int. J. Climatol., 34, 1, 155–161.

[6] T. Partal, 2002. Trend Analysis in Turkey Precipitation Data, Inst. Sci. Technol., Turkey.

[7] V. Demir and O. Kisi, 2016. Comparison of Mann-Kendall and innovative trend method *(Şen trend) for monthly total precipitation (Middle Black Sea Region , Turkey*), 3rd International Balkans Conference on Challenges of Civil Engineering, Epoka University, Tirana, Albania.

[8] D. R. Mahajan and B. M. Dodamani, 2015. Trend Analysis of Drought Events Over Upper Krishna Basin in Maharashtra, Aquat. Procedia, 4, 1250–1257.

[9] B. Önöz and M. Bayazıt, 2003. The Power of Statistical Tests for Trend Detection, Turkish J. Eng. Env. Sci., 27, 247–251.

[10] T. Haktanir and H. Citakoglu, 2014. Trend, Independence, Stationarity, and Homogeneity Tests on Maximum Rainfall Series of Standard Durations Recorded in Turkey, J. Hydrol. Eng.,19, 9, 5014009.

[11] M. Gocic and S. Trajkovic, 2013. Analysis of changes in meteorological variables using Mann-Kendall and Sen's slope estimator statistical tests in Serbia, Glob. Planet. Change,100, 172–182.

[12] S. Yue, P. Pilon, and G. Cavadias, 2002. Power of the Mann-Kendall and Spearman's rho tests for detecting monotonic trends in hydrological series, J. Hydrol., 259,1–4, 254–271.

[13] S. Peng, Y. Ding, Z. Wen, Y. Chen, and Y. Cao, 2017. Agricultural and Forest Meteorology Spatiotemporal change and trend analysis of potential evapotranspiration over the Loess Plateau of China during 2011 – 2100, Agric. For. Meteorol., 233,183–194.

[14] M. G. Kendall, Rank correlation methods, Oxford University Press, New York, 1975.

[15] H. B. Mann, 1945 Nonparametric Tests Against Trend, Econometrica, 13, 3, 245.

[16] M. Ay and O. Kisi, 2014. Investigation of trend analysis of monthly total precipitation by an innovative method, Theor. Appl. Climatol., 120, 3–4, 617–629.

[17] T. B. Mckee, N. J. Doesken, and J. Kleist, 1993. The relationship of drought frequency and duration to time scales, AMS 8th Conf. Appl. Climatol., Anaheim, California.

[18] G. Willeke, J. R. M. Hosking, J. R. Wallis, and N. B. Guttman, 1994. The National Drought Atlas. U.S. Army Corps of Engineers.: Institute for Water Resources Report 94–NDS–4.