Bitlis Eren Üniversitesi Fen Bilimleri Dergisi
BİTLİS EREN UNIVERSITY JOURNAL OF SCIENCE
ISSN: 2147-3129/e-ISSN: 2147-3188
VOLUME: 12 NO: 1 PAGE: 126-139 YEAR: 2023
DOI:10.17798/bitlisfen.1200742

An Investigation of Hydrological Drought Characteristics in Kızılırmak Basin, Türkiye: Impacts and Trends

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Keywords: Hydrological Drought, ITA, SDI, Kızılırmak Basin, Trend Analysis

Abstract
Drought is a natural disaster generally defined as precipitations significantly below the precipitation recorded in actual times. Many researchers classified drought as meteorological, hydrological, agricultural, and socio-economic. Hydrological drought occurs when deficiencies in the surface and ground waters occur due to the long-term lack of precipitation. In this study, a hydrological drought analysis has been performed for Kızılırmak Basin which is the second biggest basin in Türkiye, using the Streamflow Drought Index (SDI) and Innovative Trend Analysis (ITA) for the time scales of 1, 3, 6, 9, 12-month. Monthly mean streamflow records for 7 stations are obtained from the General Directorate of State Hydraulic Works (known as DSI. Drought severity and duration, which are two important drought characteristics, have been calculated for each time scale with their occurrence terms. Results show that Mild Drought and Wet (SDI≥0) have the highest percentage of occurrences. Using Run Theory, the longest lasted and highest drought has been noted in the SDI-12-time scale of E15A017 station with 149.72 and 103 months as severity and duration, respectively. From the highest severity and longest lasted droughts, it is seen that starting with 2000-year, the basin is exposed to the highest occurrence of droughts. The results of the ITA analysis show that in most of the SDI series of any time scale, a trend is existent and these trends are mostly decreasing trends. Therefore, these results have shown that the basin needs to be kept from the potential effects of droughts with an effective water resources management plan..

1. Introduction

A drought, a natural disaster, has been defined by many researchers and organizations from different viewpoints Mishra and Singh [1] have specified droughts as environmental disasters. In the Intergovernmental Panel on Climate Change report (IPCC,2022) drought has been noted as one of the migration's most common climatic drivers [2]. United Nations Office for Disaster Risk Reduction [3] has defined droughts as recurrent events which affect large areas around the world each year. Vicente Serrano et al. [4] have defined drought as one of the biggest natural hazards that impact sectors and systems that have big impacts on agriculture, water resources, and natural ecosystems. Eşit and Yüce [5] have specified that drought is the destruction that has important environmental and economic influences and that it may form in any part of the world and in any climate, independent from forests and deserts.
Although there are many classifications for drought, it has been classified into four classes by [1], [6]. These classifications are meteorological drought, hydrological drought, agricultural drought, and socio-economic drought. Hydrological drought is associated with a term when surface and subsurface

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Received: 07.11.2022, Accepted: 01.02.2023

water is insufficient for specified water uses [1],[7], [8], [9].

There are many methods to characterize the drought, and in addition to this, using indices is common [10], [11]. Considering the published literature, indexes such as the Palmer Hydrological Drought Severity Index (PHDI), Standardized Streamflow Index (SSFI), Standardized Reservoir Supply Index (SRSI), Standardized Water-level Index (SWI), Streamflow Drought Index (SDI), Surface Water Supply Index (SWSI) are used to analyze hydrological drought [12]. SDI, which has been used to analyze hydrological drought in this study, has been found formerly by [13]. This index whose application manner requires only monthly mean streamflow records as data is similar to the Standardized Precipitation Index (SPI) [9], [14], [15].

Drought is characterized by its duration and severity [16]. Drought duration has been described by Dracup et al. [17] as the time period between the start and end of a drought, while drought severity has been defined by Wilhite [18] as the level of precipitation deficit or the level of influences as a result of the deficit.

Analyzing droughts by trend methods such as Mann-Kendall, Sperman's Rho, and Innovative Trend Analysis have taken a great deal of attraction to scientists [19]–[23]. The innovative trend analysis (ITA) method which has been proposed by Şen [24] is a method that has been used in many studies because it is simple and efficient [25], [26].

According to the literature, there have been lots of studies in which SDI is used to analyze hydrologic droughts in Türkiye. Kale [27] has made a hydrological drought analysis for Akarçay closed basin in Türkiye by benefiting from SDI and four river gauging stations whose data range from 1966 to 2011 years for the periods of 3, 6, 9, and 12 months. In order to check the trend presence in the time series Mann-Kendall test has been utilized. In the relevant study, the author has found out that SDI values in k=1, 2, 3, and 4 reference periods mostly belong to the mild drought and wet categories. Gümüş et al. [28] have made a hydrological drought assessment for Murat River-Palu in the Euphrates Basin utilizing SDI for 1, 3, 6, and 12-month time scales based on dry, wet, and normal classes. In the relevant study, the normal class has been found to have the highest percentages in all time scales. Ozkaya and Zerberg [29] have made drought analyses for 47 stations of the upper Tigris Basin Türkiye using a data set ranging from 1972 to 2011 data period by using SDI for the time scales of 3, 6, and 12 months. In their study, it has been noted that nearly all stations have at least one severe drought during the study period and based on SDI-3 (October-December) analysis, all stations experienced droughts between 1999-2011. Katiopoğlu et al. [21] investigated trend analysis of hydrological droughts using SDI, Mann-Kendall, Innovative Trend Analysis, and Thiel Shen Approach. Authors have used DrinC (Drought Indices Calculator) for SDI calculation and stated that a lot of mild droughts have been observed while the number of extreme droughts is less. They also stated that out of 2 stations decreasing trends were recorded in both dry and wet terms accepting the 0 value as a threshold in the assessment. Altin et al.[30] have made a study about determining drought intensity by hydrological drought analysis in Seyhan and Ceyhan Rivers, Türkiye. They employed the analysis using the Streamflow Drought Index (SDI) and 43-year period data, which ranges from 1972 to 2014 in 4 stations, from 1973 to 2015 in 2 stations, and from 1969 to 2011 in 2 stations for 3, 6, 9, and 12-month overlapping periods. The authors stated that hydrological drought analysis shows that drought years are more predominant after 2000-2001. Kumanlioglu [7] has made a study for the characterization of meteorological and hydrological droughts for Gediz Basin and again with this study using SRI (Standardized Runoff Index) for hydrological drought analysis and SPI and SPEI (standardized precipitation and evaporation index) for meteorological drought analysis, it has been stated that mild drought class has been mostly detected drought category in the 12-month time scale for Acisu, Selendi, Deliinis, and Demirci sub-basins Simsek [31] performed a hydrological drought study on 3, 6, and 12-month time scales for Mediterranean Basins of Türkiye using SDI and streamflow data from 29 gauging stations. In the relevant study, the author has used the Mann-Kendall test for trend detection, Sen's slope method for slope values and the Inverse Distance Weighting (IDW) method for the spatial distribution of droughts. Then the author found out that mild drought type is the most recurring drought type and an important increase in drought severity has been detected in recent years. However, a few drought studies have been done for Kızılırmak Basin. For example, Arslan et al. [32] performed a meteorological drought analysis for the time scales of 1, 3, 6, 9, 12, and 60 months using SPI. Authors have specified that a 60-month time scale has been used as the first in their study on drought analysis of Kızılırmak Basin based on SPI. They have found out that notable increases have been noted in the duration of the last droughts on 12 and 60-month time scales. Akturk et al. [33] have made a meteorological drought assessment using SPI for the time scales of 1, 3, 6, 12, and 24 months and the spatial distribution of droughts has been done by IDW. The authors have found out that 31 of 58 years are drought years, while 28 of them are mild droughts. Also, they reported that the spatial distribution of historical droughts has shown that the basin was under extreme drought influences during 1973-2013.

In this study, the aim is to make a hydrological drought analysis for the Kızılırmak Basin using SDI for the time scales of 1, 3, 6, 9, and 12 months. For this purpose, 7 stations in the basin have been selected and monthly mean streamflow records have been taken from the General Directorate of State Hydraulic Works (known as DSI). Two important drought characteristics which are drought duration with their maximum ones have been calculated with their occurrence terms. The ITA method has been used to detect possible drought in two cases (SDI<0 and SDI≥0) for all time scales. The results of this study are expected to be beneficial for local authorities in water resource planning management plans, and drought action plans.

2. Material and Method

2.1. Materials

Kızılırmak Basin, which is situated at 32.80°–38.35° East longitudes and 35°–41.75° North latitudes [33], has 82. 221 km^2 area (almost 10.49% of Türkiye) is the second biggest basin in Türkiye (Figure 1). The basin covers all or parts of Ankara, Çankırı, Yozgat, Çorum, Kırıkkale, Kırşehir, Nevşehir, Kayseri, Sivas, Samsun, Sinop, Kastamonu, Aksaray, Niğde, Tokat, Erzincan, Amasya and Konya provinces of Türkiye. Because the basin covers a wide area, there are various types of climates in the basin [34]. While the semi-arid climate type prevails in the interior regions, the humid and semi-humid climate types are dominant in the coastal parts of the Kızılırmak Basin facing the Black Sea and therefore the climate conditions of settlements change according to their geographical position [34]. The Kızılırmak River which is the longest river in Türkiye has a length of 1263 km and spills its water into the Black Sea.

In this study, streamflow data from 7 gauging stations which are in Kızılırmak Basin and have been taken from the (DSI) were used to perform hydrological drought analysis. The details of these stations have been given in Table 1, and their locations have been shown in Figure 1

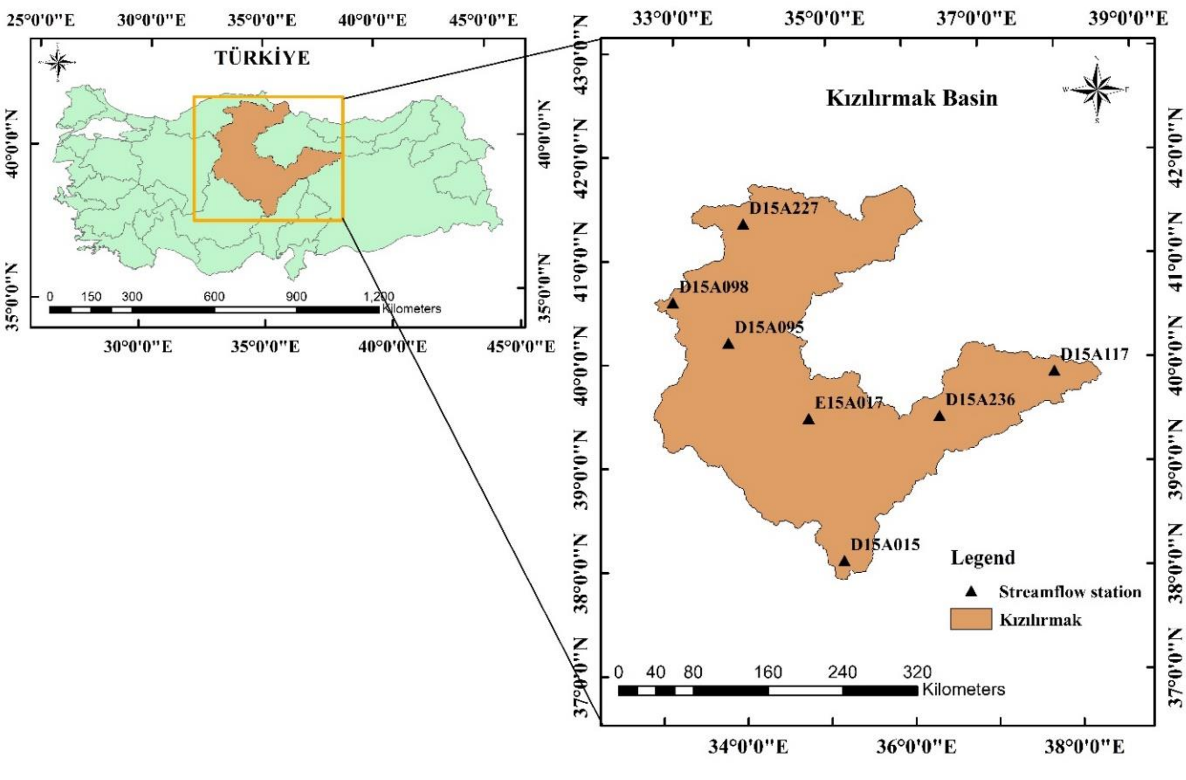

Figure 1. Kızılırmak Basin and Streamflow Gauging stations

Table 1. Data Stations

Station Name	Station Number	Latitude (N)	Longitude (E)	Height (m)	Data Range
Dündarli Suyu Hacibeyli	D15A015	38°7'51"	35°9'58"	1215	1961-2014
Taretözü D. Yeşilyazi	D15A095	40°13'54"	33°44'37"	684	1988-2013
Söğütözü Deresi Yuva	D15A098	40°37'3"	33°2'21"	1296	1995-2019
Kızılırmak Ahmethaci	D15A117	39°54'23"	37°49'33"	1361	1971-2019
Karadere Ç. Deliler	D15A227	41°22'52"	33°55'36"	710	1999-2019
Akcakişla D. Bozkurt	D15A236	39°30'34"	36°22'23"	1210	1988-2019
Karanlik D. Şefaatli	E15A017	39°30'11"	34°44'42"	895	1953-2019

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2.2 Method

2.2.1. Streamflow Drought Index (SDI)

Streamflow drought is an index that has been proposed by Nalbantis and Tsakiris [13] in order to perform hydrological drought analysis. The calculation process is similar to that of the Standard Precipitation Index (SPI) but monthly average streamflow records are used to calculate this index, instead of precipitation data [35]. To calculate the index, the total streamflow is denoted by $X_{i,j}^{k}$ in a given month j and year i depending on the time scale k (1, 3, 6, 9, 12 months) and it can be computed from given equations [36], [37].

$$X_{i,j}^{k} = \sum_{l=13-k+j}^{12} V_{i-1,l} + \sum_{l=1}^{j} V_{i,l} \quad if\ j < k \qquad (1)$$

$$X_{i,j}^{k} = \sum_{l=j-k+1}^{j} V_{i,l} \quad if\ j \geq k \qquad (2)$$

Where $V_{i-1,\,l}$, and $V_{i,l}$ represent streamflow volumes in the years of *i-1* and *i*, respectively. Based on the given information by Nalbantis and Tsakiris [13] because streamflow records can have skewed probability distribution, the Gamma distribution can be used. Therefore, before the computation of SDI, Gama distribution has been used by following steps.

The probability distribution function of Gamma distribution *g(x)* is determined by [38].

$$g(x) = \frac{1}{\beta^{a}\Gamma(a)} x^{a-1} e^{-\frac{x}{\beta}} \qquad (3)$$

Where *Γ(a)* is the gamma function and it is computed by [39].

$$\Gamma(a) = \int_{0}^{\infty} y^{a-1} e^{-y}\, dy \qquad (4)$$

For maximum likelihood method estimation, the parameters of Gamma distribution which are shape (α), and scale (β) can be calculated by [38] as follows:

$$a = \frac{1}{4A}\left(1 + \sqrt{1 + \frac{4A}{3}}\right) \qquad (5)$$

$$\beta = \frac{\bar{x}}{a} \qquad (6)$$

And where A is determined by [16], [38]

$$A = \ln(\bar{x}) - \frac{\sum \ln(x)}{n} \qquad (7)$$

n is the number of streamflow records instead of rainfall records and $\bar{x}$ is the mean of x. Then cumulative distribution function is computed by [38].

$$H(x) = q + (1 - q)G(x) \qquad (8)$$

Where q denotes the probability of zero and *G(x)* is the cumulative distribution for the selected month and time scale. If m is accepted as showing the number of zeros, then q can be calculated from $q=m/n$ [38]. Then, *H(x)* is converted to the standard normal variable Z which has 0 mean and

1 as variance and represents the SDI value. Then via Table 2 [37] SDI values in a month and desired time scale are associated with a drought class based on its value

Table 2. Drought classification [37]

SDI Value	Category
SDI ≥2.00	Extremely Wet
1.50≤ SDI <2.00	Severely Wet
1.00≤ SDI <1.50	Moderately Wet
0≤ SDI <1.00	Mildly Wet
-1≤ SDI <0.00	Mild Drought
-1.50≤ SDI <-1.00	Moderate Drought
-2.00≤ SDI <-1.50	Severe Drought
SDI ≤-2.00	Extreme Drought

2.2.2. Estimation of Drought Severity and Drought Duration

Drought severity and drought duration are two important drought characteristics in drought analysis, and they can be easily determined by Yevjevich's Run Theory [40] and are calculated SDI values of any time scale. Using definitions in the literature, drought duration (D) describes a period which is between the beginning and end of drought while severity (S) is a cumulative summation of SDI values below the critical level with the unit of the month [17], [37] as it is demonstrated in Figure 2

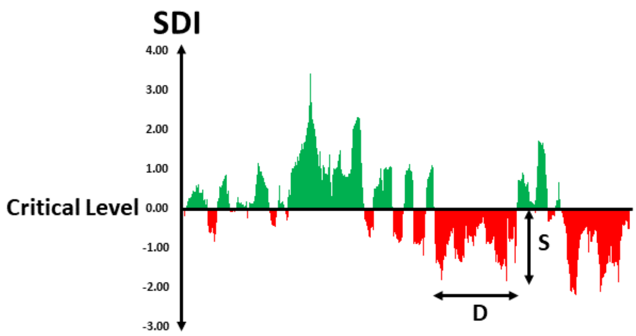


Figure 2. Drought severity (S) and duration(D)

2.2.3. Innovative Trend Analysis (ITA)

Innovative Trend Analysis (ITA) was proposed by Şen in 2012 [24], and it is a method that, unlike the most common methods, avoids a set of assumptions such as the independent structure of the time series, normality of the distribution, and data length. Based on the manner of application of the method, firstly, the data is divided into two equal parts, as both parts are in ascending order, and secondly, as it is shown in Figure 3, a 1:1 line (45°), that shows no trend line between increasing decreasing trends, is created [19], [24], [25], [41],[42]. As it can be seen from Figure 3, any point on 1:1 line indicates no trend case, while the points above the 1:1 line show an increasing trend, and the points below the line represent a decreasing trend. In this study, ITA has been applied to determine the SDI series (1, 3, 6, 9, 12), and trends of each series have been evaluated by two classifications which are SDI<0 and SDI≥0

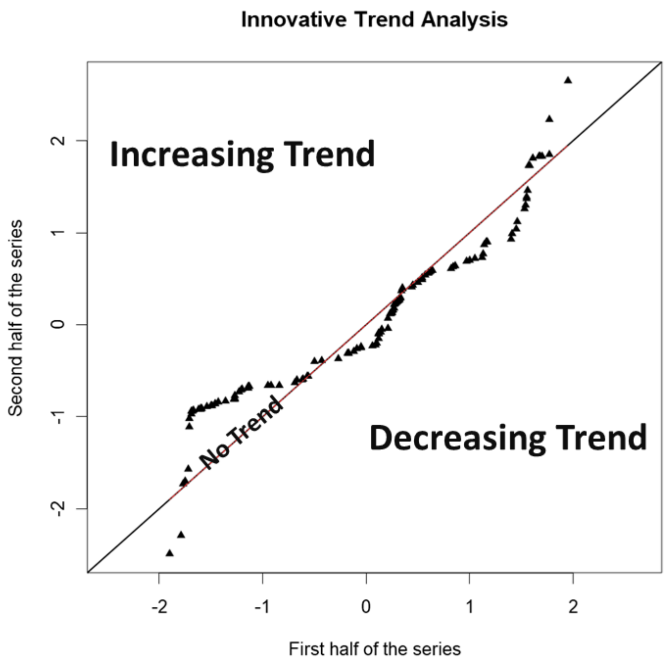


Figure. 3 ITA Template by Şen [24]

Results and Discussion

3.1. Results

In this study, using SDI, Yevjevich's Run Theory, and ITA, a hydrological drought analysis has been performed for the Kızılırmak Basin of Türkiye for the time scales of 1, 3, 6, 9, and 12 months. Calculated SDI values have been classified according to Table 1 and statistical analysis based on the percentage of occurrences has been given in Table 3. In all time scales of all stations, minimum and maximum percentages of occurrences of drought and Wet (SDI≥0) classes have been investigated, and Table 4 has been obtained. In both tables, the Wet categories given in Table 1 have been combined as "Wet" which includes SDI≥0. The following conclusions have been drawn from the findings.

- In all time scales for all stations, as can be seen from Table 3, the Mild Drought and Wet (SDI≥0) categories have the highest percentage of occurrences.

- Because Mild Drought and Wet (SDI≥0) classes have the highest percentage of occurrences, Table 4 includes the stations with the lowest and highest values of these categories among all stations. From Table 4 in all time scales, the E15A017 station, which is situated in almost the middle of the basin gives minimum values in the Mild Drought class, while the D15A236 station gives minimum values in the Wet class except at SDI-1. However, it is not possible to construct a similar relationship for maximum values.

- From Tables 3 and 4, Moderate Drought has higher minimum and maximum percentages than Severe and Extreme drought classes while Severe Drought has higher minimum and maximum percentages than Extreme Drought in all time scales.

To make the assessment simpler and more understandable if all drought categories in Table 1 are considered as “dry” (SDI<0) and all Wet categories are combined as “Wet” (SDI≥0), in SDI-1 5 stations, in SDI-3 3 stations, in SDI-6 3 stations, in SDI-9 3 stations, in SDI-12 2 stations dry percentages are higher than wet percentages.

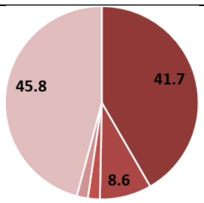
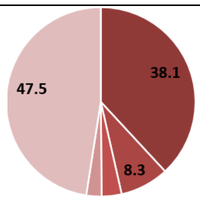
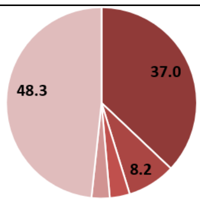
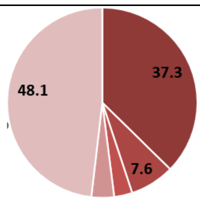
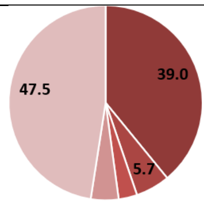
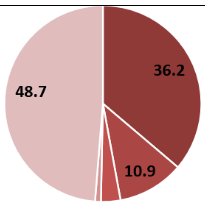
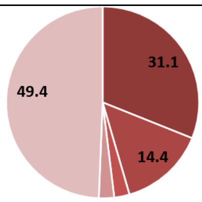
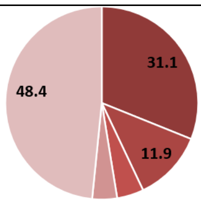
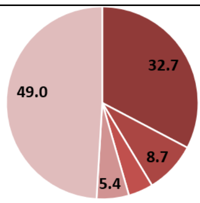
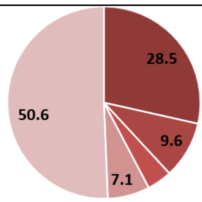
Using obtained SDI values in all time scales and Yevjevich’s Run Theory, drought severity, and drought duration have been calculated. Among these calculations, the droughts that have the highest severity and the longest-lasting have been analyzed to search the term in which the basin may have been affected and are given in Table 5. Figure 4 depicts the time series in which the most severe and/or longest-lasting events occurred. The following conclusions have been drawn from the findings.

- Among all time scales and all stations, both the longest and the highest droughts have been obtained in the SDI-12 time scale at the E15A017 station with 149.72 and 103 months as severity and duration respectively. But it is important to note that the same station also produces the same duration, but a slightly smaller severity on the SDI-9 time scale.

- From Table 5, it is clearly seen that in any time scale, it is possible that the highest values may not occur at the same time and same station. Unlike the time scales of SDI-6, SDI-9, and SDI-12, in SDI-1 and SDI-3, the highest values belong to different stations and time intervals.

Although there are drought events that have been detected before the 2000s, the basin has been exposed to the highest-valued droughts, which started in 2000

Table 3. Percentage occurrences of drought and wet categories based on SDI values

	SDI TIME SCALE				
SN	SDI-1	SDI-3	SDI-6	SDI-9	SDI-12
D15A015					
D15A095					

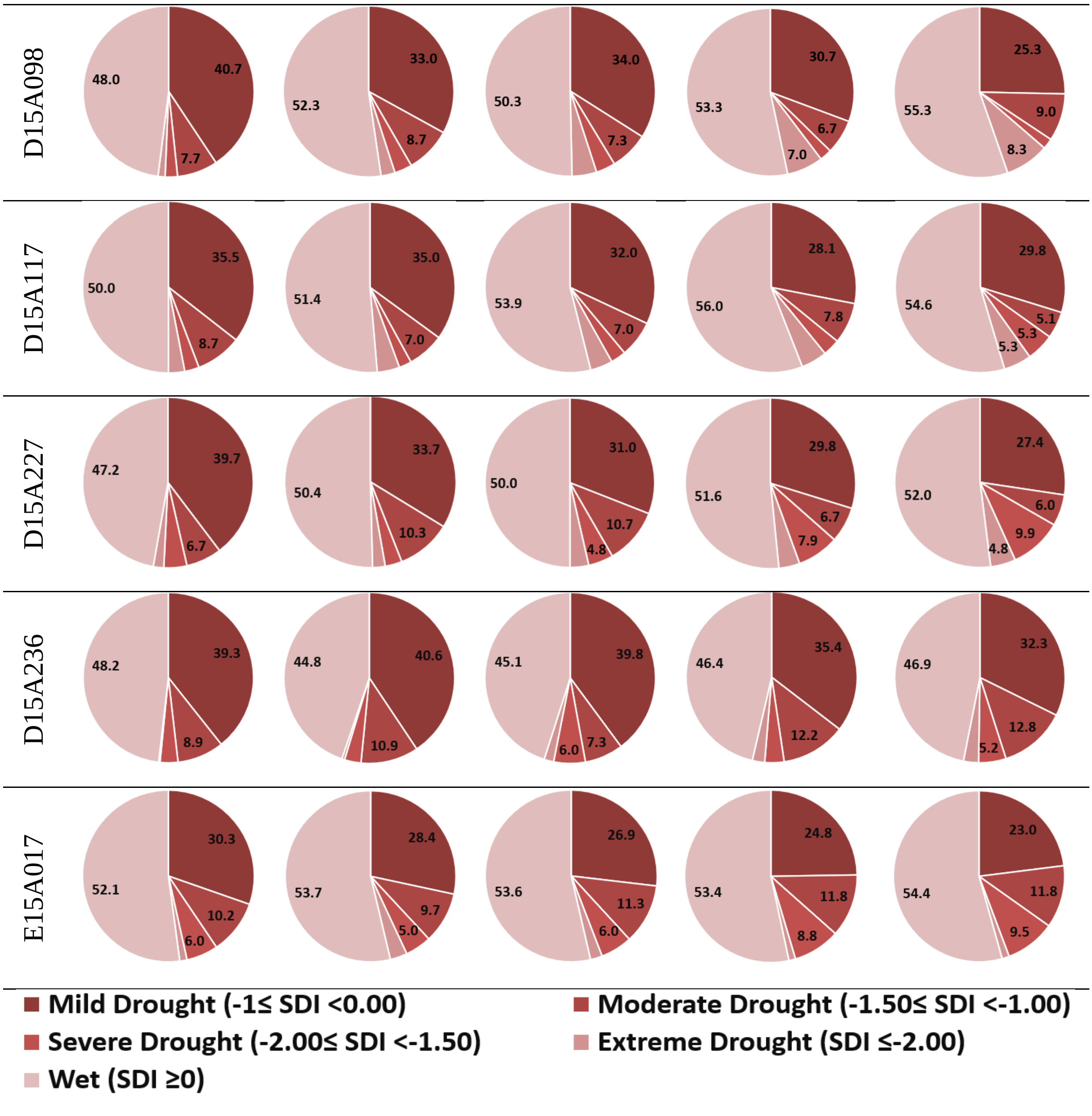


Table 4. Statistics of SDI Classes

Minimum Percentages (%)					
	SDI-1	SDI-3	SDI-6	SDI-9	SDI-12
Mild Drought	30.35	28.36	26.87	24.75	23.01
Moderate Drought	6.75	6.97	6.97	6.67	5.10
Severe Drought	2.01	2.38	2.89	2.33	2.00
Extreme Drought	0.26	0.52	1.82	1.24	1.37
Wet (SDI≥0)	45.83	44.79	45.05	46.35	46.88
Stations of Minimum Percentages					
	SDI-1	SDI-3	SDI-6	SDI-9	SDI-12
Mild Drought	E15A017	E15A017	E15A017	E15A017	E15A017
Wet (SDI≥0)	D15A015	D15A236	D15A236	D15A236	D15A236
Maximum Percentages (%)					

	SDI-1	SDI-3	SDI-6	SDI-9	SDI-12
Mild Drought	41.67	40.63	39.84	37.35	39.04
Moderate Drought	10.90	14.42	11.86	12.24	12.76
Severe Drought	5.97	4.98	5.99	8.83	9.92
Extreme Drought	3.06	4.25	4.67	7.00	8.33
Wet (SDI≥0)	52.11	53.73	53.91	55.95	55.33
Stations of Maximum Percentages					
	SDI-1	SDI-3	SDI-6	SDI-9	SDI-12
Mild Drought	D15A015	D15A236	D15A236	D15A015	D15A016
Wet (SDI≥0)	EA15017	EA15017	D15A117	D15A117	D15A098

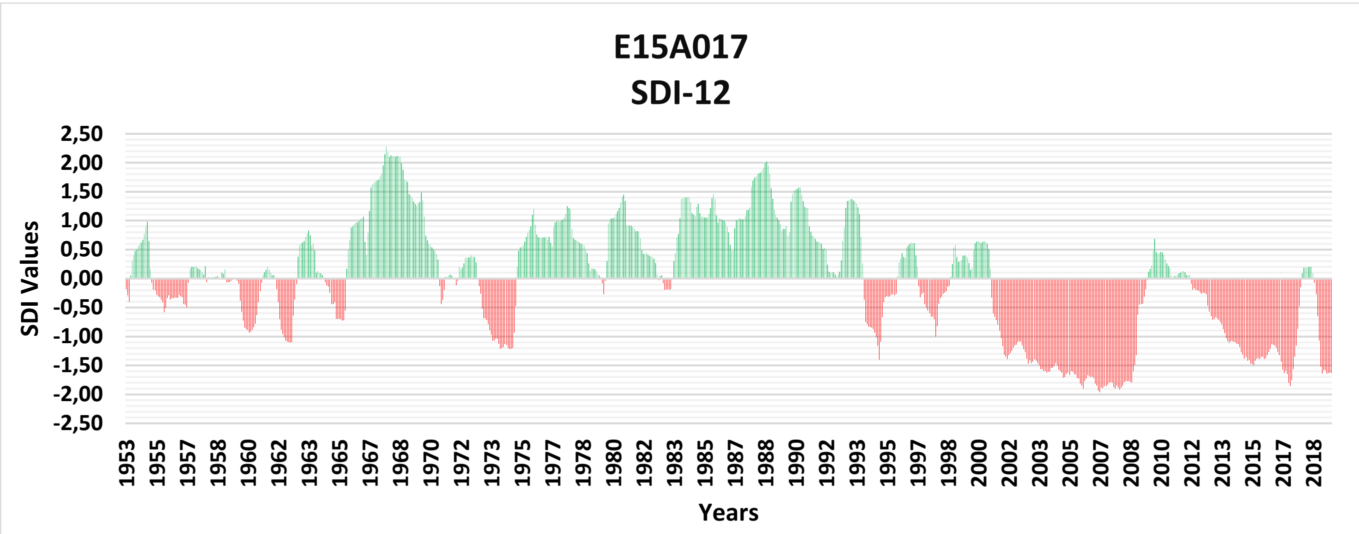


Figure. 4 The time Series of the Longest Lasted and Highest Drought

Table 5. Drought Severity and Duration Statistics

The Longest Lasted Droughts				
Time Scale	Date	Station	Severity	Duration (Months)
1	2016(3)-2019(7)	D15A236	30.48	41
3	2004(5)-2008(9)	D15A236	39.7	53
6	2001(3)-2009(7)	E15A017	127.7	101
9	2001(3)-2009(9)	E15A017	143.34	103
12	2001(5)-2009(11)	E15A017	149.72	103
The Highest Droughts				
Time Scale	Date	Station	Severity	Duration (Months)
1	2007(7)-2010(5)	D15A095	37.32	35

3	2007(9)-2010(9)	D15A095	45.57	37
6	2001(3)-2009(7)	E15A017	127.7	101
9	2001(3)-2009(9)	E15A017	143.34	103
12	2001(5)-2009(11)	E15A017	149.72	103

ITA methodology has been applied to the SDI time series separately in order to control SDI values, and obtained trend graphs have been given in Figure 5. In all analyses of both classes (SDI<0 and SDI≥0) trends with decreasing behavior have been presented as "↓" while increasing trend and no trend cases have been presented as "↑" and "0" respectively. The trend results have been given in Table 6. The following results have been obtained.

- Looking at Figure 5 and Table 6, it can be said that in most of the cases of all-time scales, a trend is present. Among 70 analyses (5*7*2=70), 78.57% of analyses have a decreasing trend, while percentages of increasing and no trend cases are 12.85% and 8.57% respectively.
- According to Table 6, D15A015, D15A098, and D15A236 stations have shown monotonic decreasing trends in both cases (SDI<0 and SDI≥0) of all time scales. E15A017 station also has decreasing trends in both cases of 3,6,9,12-month time scales. D15A117 have shown decreasing trends in both cases of 6, 9, 12- month time scales.
- D15A095 is the station where no trend case was mostly detected (5 times and 4 of them are in case of SDI≥0) while no trend case was detected only once in E15A017.
- An increasing trend of the case has been detected in D15A227 station most (7 times, and 5 of them are in SDI<0 cases). Also, in D15A117, increasing trends have been detected twice and both of them are in SDI≥0.

Again, from Table 6, a fixed trend behavior has not been detected for either SDI<0 or SDI≥0 considering all time scales of stations

Table 6. ITA trend results

		Stations						
Time Scale	SDI Class	D15A015	D15A095	D15A098	D15A117	D15A227	D15A236	E15A017
1	SDI<0	↓	0	↓	↓	↑	↓	↓
	SDI≥0	↓	0	↓	↑	↑	↓	0
3	SDI<0	↓	↓	↓	↓	↑	↓	↓
	SDI≥0	↓	↓	↓	↑	↑	↓	↓
6	SDI<0	↓	↓	↓	↓	↑	↓	↓
	SDI≥0	↓	0	↓	↓	↓	↓	↓
9	SDI<0	↓	↓	↓	↓	↑	↓	↓
	SDI≥0	↓	0	↓	↓	↓	↓	↓
12	SDI<0	↓	↓	↓	↓	↑	↓	↓
	SDI≥0	↓	0	↓	↓	↓	↓	↓

3.2. Discussion

Based on the literature review, several drought analyses have been done for different basins in Türkiye and worldwide. However, a few drought studies have been done for hydrological drought analysis in Kızılırmak Basin. The mild drought type was found to be the most common among all drought categories in this study. When it is compared to studies made for Kızılırmak Basin similar results have been detected. For example, Arslan et al. [32] discovered that the occurrence of mild drought terms is the highest among all drought categories across all time scales studied using SPI. As another example, in a meteorological drought analysis of Kızılırmak Basin by SPI, Akturk et al. [33] have obtained that 31 years of 58 years have been affected by droughts while 28 years of this 31 years belong to mild drought. When it comes to other basins, Simsek [31] has stated that Mild drought is the recurrent type of drought in the Mediterranean Basins. Katipoğlu et al. [21] have found that in Yeşilırmak Basin which is neighbour to Kızılırmak Basin, there are lots of mild droughts in the basin between 1970-2011 water years. The same drought years as in this study have been noted in many drought analyses [7], [21], [29], [31], and [33]. Because a high number of decreasing trends have been detected with ITA in this study, researchers of [21], [26], [42] have found decreasing trends using ITA methodology as well. Even Simsek [31] has found decreasing trends for Mediterranean Basins by Mann-Kendall test. Therefore, the trend results of these studies verify the trend results of this study.

4. Conclusion and Suggestions

In this study, using the monthly mean streamflow records of 7 gauging stations that have been taken from the General Directorate of State Hydraulic Works (DSI), SDI, and ITA, a hydrological drought analysis has been performed for the time scales of 1, 3, 6, 9, and 12-month for Kızılırmak Basin of Türkiye. According to the results of the study, the conclusions are as follows:

- Mild drought and Wet (SDI≥0) have the highest percentage of occurrences in all time scales at all stations. To make the assessment simpler, when all drought categories are combined as “dry” (SDI<0) and all Wet categories are combined as “Wet” (SDI≥0) except at SDI-1, the Wet category is higher than dry ones at least 4 stations.
- Based on analysis of drought classes, it has been concluded that among Moderate, Severe, and Extreme drought classes, Moderate Drought has the highest minimum and maximum percentages while Severe Drought has higher minimum and maximum percentages than Extreme Drought in all time scales.
- Using Run Theory, the longest lasted and highest drought has been noted in the SDI-12 time scale of E15A017 station with 149.72 and 103 months as severity and duration respectively.
- Considering the determined maximum values of drought severity and duration, the basin is exposed to the longest-lasting and highest droughts starting with the year 2000 and later.
- ITA results show that most of the SDI series in any time scale has a trend, and decreasing trends dominate the analysis with 78.57%, while 3 stations, which are D15A015, D15A098, and D15A236, have completely decreasing trends.

As a result of the study's findings, it is clear that effective precautions must be taken to protect water resources and water-related sectors from the potential effects of drought. This is clearly possible by making effective water resources management plans and updating current analysis continuously. The results of this study are expected to be beneficial for local authorities

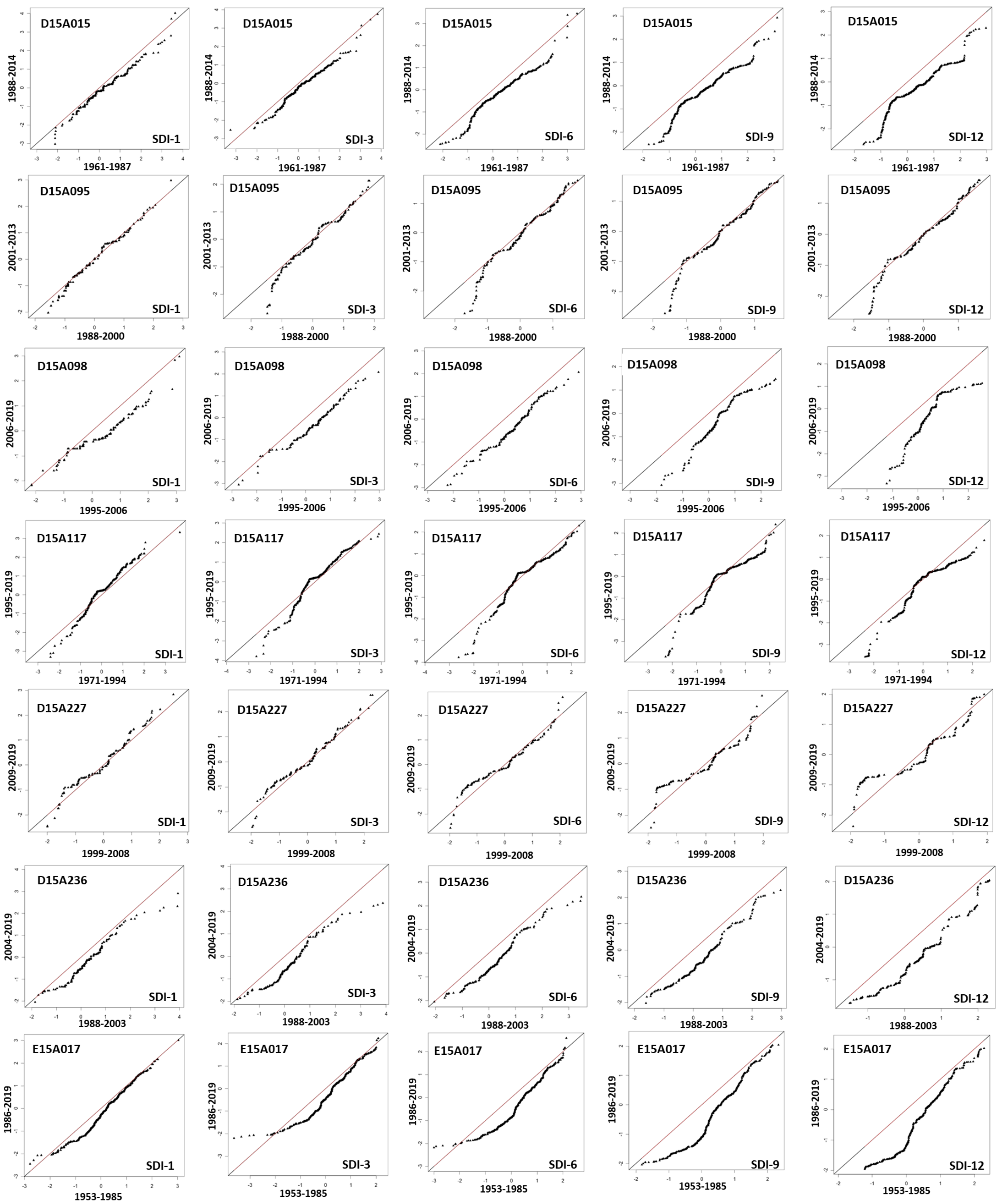


Figure. 5 ITA graphical results

Acknowledgment

The authors are thankful to the General Directorate of State Hydraulic Works (DSI) for providing the data which has been used in this study.

Contributions of the authors

The authors of this study have worked together in all steps of the study and contributed to the study equally.

Conflict of Interest Statement

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The study is complied with research and publication ethics.

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