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Research Article

Investigation of Long-Year (1970-2019) Total Precipitation Based on Global Climate Change: A Case Study from Siirt Province of Turkiye

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Abstract
This research was carried out in order to evaluate the change courses of total precipitation data observed for many years (1970-2019) in the center of Siirt province over the years. In the study, long period total precipitation data were subjected to trend analysis. In this context, Mann-Kendall and Sperman's Rho order correlation tests and Sen's trend slope method tests were used. As a result of the research; The highest annual total precipitation observed for many years was found to be 1046.4 mm in 1988. The lowest annual total precipitation value was determined as 443.2 mm in 1973. As a result of the research, it was concluded that there was no increasing or decreasing trend in total precipitation for many years in Siirt province.

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KÜRESEL İKLİM DEĞİŞİKLİĞİNE DAYALI UZUN YILLAR (1970-2019) TOPLAM YAĞIŞ VERİLERİNİN ARAŞTIRILMASI: TÜRKİYE'NİN SİİRT İLİNDEN BİR ÇALIŞMA

Özet
Bu araştırma, Siirt il merkezinde uzun yıllar (1970-2019) için gözlenen toplam yağış verilerinin yıllara göre değişim seyrini değerlendirmek amacıyla yapılmıştır. Çalışmada, uzun dönem toplam yağış verileri trend analizine tabi tutulmuştur. Bu kapsamda Mann-Kendall ve Sperman'ın Rho sıra korelasyon testleri ile Sen'in trend eğim yöntem testleri kullanılmıştır. Araştırma sonucunda; uzun yıllar için gözlenen en yüksek yıllık toplam yağış 1988 yılında 1046,4 mm olarak bulunmuştur. En düşük yıllık toplam yağış değeri ise 1973 yılında 443,2 mm olarak belirlenmiştir. Araştırma sonucunda, Siirt ilinde uzun yıllar için toplam yağışta artış veya azalış eğilimi olmadığı sonucuna varılmıştır.

Anahtar Kelimeler
Toplam yağış
Trend analizi
Küresel iklim değişikliği
Siirt ili
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1. INTRODUCTION

Global warming is defined as the increase in the average temperature of the Earth near the Earth's surface, either naturally or due to human influence [1]. Global climate change is showing itself negatively in all regions. With the increase in greenhouse gas and carbon emissions, the Earth has become a threat of climate Change. The carbon element is an indispensable substance for life. However, the increase in the amount of CO_2 in the atmosphere over time due to human needs and consumption reduces the protective effect of the ozone layer and causes irregularities in temperature and precipitation. Studies have shown that the temperature will increase by 0.1 °C every ten years [2].

Some scientists have suggested that the Earth and Earth's movements can also cause global warming. Some climate scientists think that Earth's movements such as mountain formations and continental drift movements can also have an effect on global warming. Because such movements affect the winds in the atmosphere and the current systems in the oceans [3]

Regions that are in response to winds that bring precipitation and are especially located along the path of frontal depressions receive more precipitation. The Eastern Black Sea Region can be given as an example. The Eastern Black Sea Region is the region that receives the most precipitation in our country. The average annual precipitation is 1198 mm. In Giresun, one of the provinces in the Black Sea region, the annual precipitation is 1267.7 mm, and in Rize, it is 2346.3 mm [4]

It is estimated that the effects of climate change and global warming will occur in different ways in every region of the world. While floods, excessive precipitation and inundations are expected in some regions, it is thought that desertification and severe droughts may occur in other regions [5].

This study was conducted to evaluate the annual changes in total precipitation values observed for many years in the Siirt Center with trend analysis and to reveal the increasing or decreasing trends. In this research, a total of 600 monthly precipitation data in Siirt province between 1970 and 2019 were analyzed and the course of change over the years was tried to be revealed.

2. MATERIAL and METHOD

The research area is Siirt province located in the Southeastern region of Turkiye.. In the study, the total precipitation values of the Siirt province central meteorological station between 1970-2019 were used as material in the study. The location and position of Siirt province, which is the subject of the research, is shown on the map given in Figure 1.

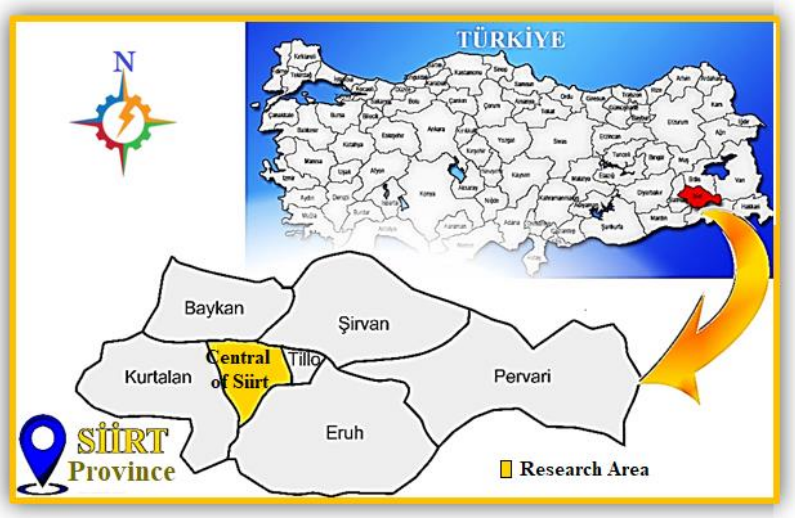

Figure 1. The location of research area

According to 2015 data, Siirt province has a population of 331,311 people. It ranks 58th among Turkish provinces in terms of population size. The landforms of Siirt province consist of high mountains and plateaus. The north and east of Siirt are steep and high areas. This mountain range, generally known as the Southeastern Taurus Mountains, draws a wide arc from east to southeast and joins the Hakkari Mountains [6].

After the South Mountains of Muş in the east of the Bitlis Stream Valley, the mountains extend southward and cover the east of Siirt. These mountains, which are rapidly decreasing in elevation and entering the Southeastern Plains, also join the Hakkari Mountains. The Siirt Doğusu Mountains mostly rise in individual clusters. These clusters are fragmented by valleys opened by small streams flowing into the Tigris River [6].

In the study, monthly values of total precipitation and number of rainy days observed between 1970-2019 at the Siirt central meteorological station were used [7]. Within the scope of the research, the total precipitation data of 600 months between 1970-2019 of Siirt province were evaluated with trend analysis. In this context, Mann-Kendall and Seprman's Rho tests and Sen's Trend slope analysis methods were applied to the data. The analyzes were made at a 95% confidence level [8,9].

In this study, Trend Analysis Program (Trend Analysis for Windows) was used to evaluate the data with trend analysis. [10].

Trend analysis is used to determine the gradual changes on the increase or decrease of meteorological data and for data that is not normally distributed [11].

The Mann Kendall Test is one of the widely used methods, but it is a non-parametric test [11]. In the Mann Kendall Test, the data does not require any special distribution, but it is less sensitive to sudden breaks [12]. Thus, the test is made by adhering to the null hypothesis and the decision is made according to the null hypothesis. The Mann Kendall Test is calculated using the following equation [8,9].

$$S = \sum_{i=1}^{n-1} \sum_{J=i+1}^{n} sgn(x_j - x_i) \quad (1)$$

Here; n is the number of data points, xi and xj; i and j are the data values in the time series (j > i), $sgn\ (xj - xi)$; is the sign function and is expressed as follows [11];

$$\text{sgn}\,(x_j\text{-}x_i)=\begin{cases}+1, \text{ eğer } x_j\text{-}x_i > 0\\ 0, \text{ eğer } x_j\text{-}x_i = 0\\ -1, \text{ eğer } x_j\text{-}x_i < 0\end{cases} \quad (2)$$

The variance is;

$$Var\,(S) = \frac{n(n-1)(2n+5)-\sum_{i=1}^{m} t_i(t_i-1)(2t_i+5)}{18} \quad (3)$$

Here; n = number of data points, m = number of connected groups, ti = number of ties within i [11]. Whether the Mann-Kendall test with the determined variance is significant is determined by calculating the standard normal variable Z with the following equation and comparing it with the critical Z value [13].

$$Z_s = \begin{cases}\frac{S-1}{\sqrt{Var\,(S)}}, eğer\ S > 0\\ 0, \text{eğer S } = 0\\ \frac{S+1}{\sqrt{Var\,(S)}}, eğer S < 0\end{cases} \quad (4)$$

If the test result has a positive correlation, the trend can be considered important, but if it has a negative correlation level, the trend importance can be ignored [14].

Sperarman's Rho Test is used in comparison with the Mann Kendall test [11]. While the H0 hypothesis means that there is no trend, the H1 hypothesis determines the increasing or decreasing direction of the trend [15]. This test statistic is given in the equation below [11];

$$Rsp = 1 - \frac{6\sum_{i=1}^{n}(Di-i)^2}{n(n^2-1)} \quad (5)$$

$$Z_{Sp} = R_{sp}\sqrt{\frac{n-2}{1-Rsp^2}} \quad (6)$$

Di = the sequence number of i observations, n = the total length of time series data, i = the observation order of the data, Zsp= (n−2) degrees of freedom. Positive values of Zsp indicate an increasing trend in the hydrological time series, while negative values indicate a decreasing trend [13,11].

3. RESULTS and DISCUSSION

The trend analysis and results applied to the long-term total precipitation and data of Siirt Center between 1970-2019 are presented in detail below.

3.1. Total Precipitation Change in Winter Months for Many Years

Siirt Center total precipitation winter months data analyzed on a long-term basis (1970-2019) were evaluated with trend analysis. The change course of long-term total precipitation values in winter months is shown in detail in the graph given in Figure 2.

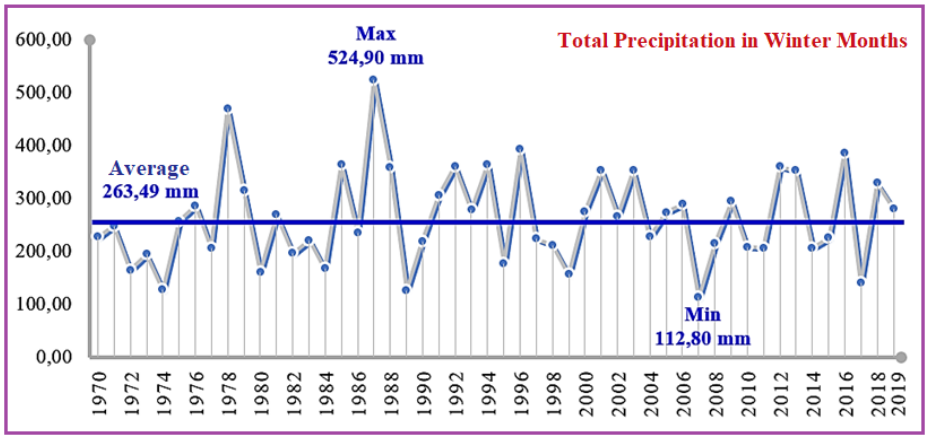

Figure 2. Total Precipitation Distribution Observed in Winter Months

When looking at the winter months of Siirt Center for many years, the lowest value was measured as 112.80 mm in 2007, while the average was 263.49 mm, and the highest total precipitation value in winter months was measured as 524.90 mm in 1987. The total precipitation was subjected to trend analysis test using winter months data. The test results are given in Table 1.

Table 1. Trend Analysis Results of Total Precipitation Data for Winter Months

Mann - Kendall Test Statistical		Spearman's RhoTest Statistical	
Za/2	1,96	Za/2	1,96
S	86	Rho Test Statistical (rs)	0,12
Sigma S	116,01	Z	0,86
Kendall Correlation Coefficient	0,07		
Z	0,73		
Result	There is no significant trend	Result	There is no significant trend
Q Median According to Sen's Trend Slope Method (Change in Unit Time)			0,667

When the summary table for the winter months total precipitation is examined, it is concluded that there is no trend in the time series examined since the absolute value of the Z statistic value is less than Za/2. If there was a trend, in this case, in order to decide whether the trend is increasing or decreasing, the S statistic value should be examined. If the S value is greater than zero, the trend will be in the increasing direction, and if it is less than zero, it will be concluded that there is a decreasing trend.

3.2. Total Precipitation Change in Spring Months for Many Years

The Siirt Center total precipitation spring months data, which were analyzed on a long-term basis (1970-2019), were evaluated with trend analysis. The change course of long-term total precipitation values in the spring months is shown in detail in the graph given in Figure 3.

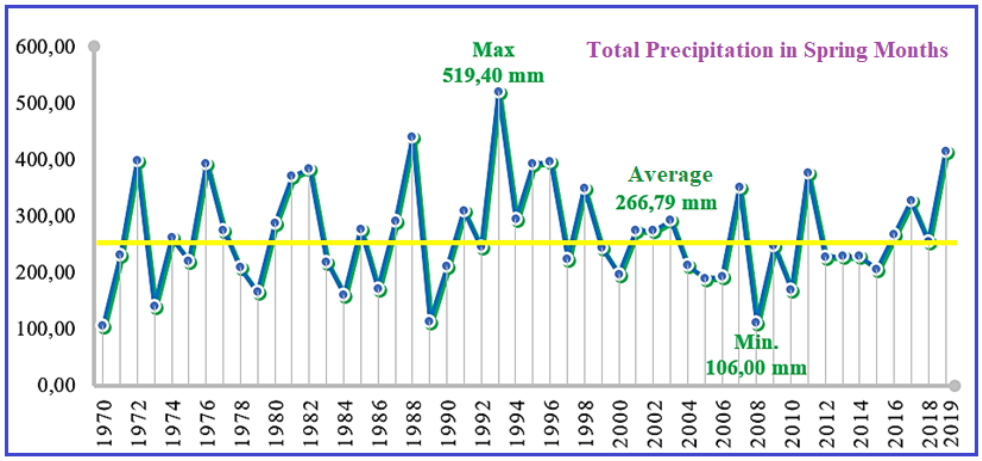

Figure 3. Total Precipitation in Siirt Center Observed for Many Years, Spring Months

When looking at the spring months of Siirt Center for many years, the lowest value was measured as 106.00 mm in 2008, while the average was 266.79 mm, and the highest total precipitation value in the spring months was measured as 519.40 mm in 1993. The total precipitation was subjected to trend analysis test using the spring months data. The test results are given in Table 2.

Table 2. Trend Analysis Results of Total Precipitation Data for Spring Months

Mann - Kendall Test Statistical		Spearman's RhoTest Statistical	
Za/2	1,96	Za/2	1,96
S	-8	Rho Test Statistical (rs)	-0,2
Sigma S	116,01	Z	-0,12
Kendall Correlation Coefficient	-0,1		
Z	-0,06		
Result	There is no significant trend	Result	There is no significant trend
Q Median According to Sen's Trend Slope Method (Change in Unit Time)			-0,068

When the summary table of total precipitation values for the spring months is examined, it is concluded that there is no trend in the examined time series since the absolute value of the Z statistic value is less than Za/2.

3.3. Total Precipitation Change in Summer Months for Many Years

The total precipitation data of Siirt Center, which was analyzed on a long-term basis (1970-2019), was evaluated with trend analysis. The change course of long-term total precipitation values in summer months is shown in detail in the graph given in Figure 4.

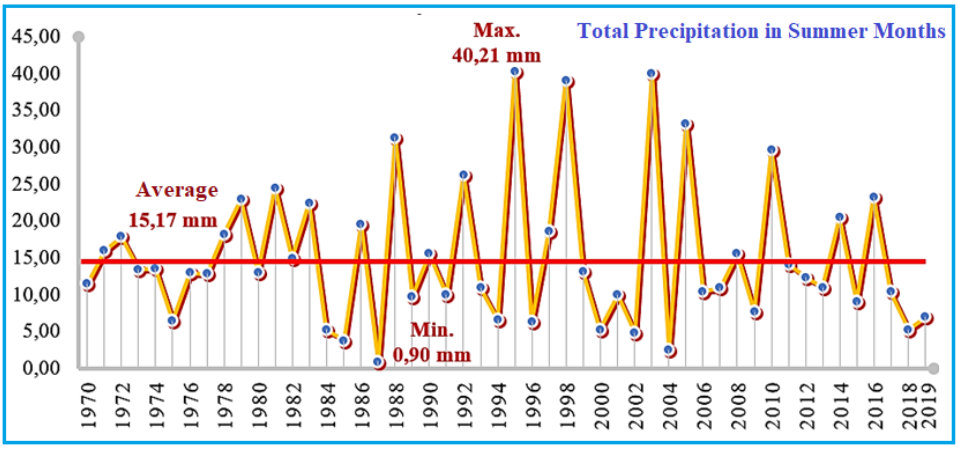

Figure 4. Total precipitation in Siirt Center Observed for Many Years, Summer Months

When the Siirt Center summer months are examined for many years, the lowest value was 0.90 mm in 1987, while the average was 15.17 mm, and the highest total precipitation value in the summer months was measured as 40.21 mm in 1995. Total precipitation was subjected to trend analysis test using summer months data. The test results are given in Table 3.

Table 3. Trend Analysis Results of Total Precipitation Data in Summer Months

Mann - Kendall Test Statistical		Spearman's RhoTest Statistical	
Za/2	1,96	Za/2	1,96
S	-96	Rho Test Statistical (rs)	-0,13
Sigma S	116,01	Z	-0,93
Kendall Correlation Coefficient	-0,08		
Z	-0,82		
Result	There is no significant trend	Result	There is no significant trend
Q Median According to Sen's Trend Slope Method (Change in Unit Time)			-0,071

When the summary table of total precipitation summer months is examined, it is concluded that there is no trend in the examined time series since the absolute value of the Z statistic value is less than Za/2.

3.4. Total Precipitation Change in Autumn Months for Many Years

The total precipitation data of Siirt Center, which was analyzed on a long-term basis (1970-2019), was evaluated with trend analysis. The change course of the total precipitation values of long years in the autumn months is shown in Figure 5.

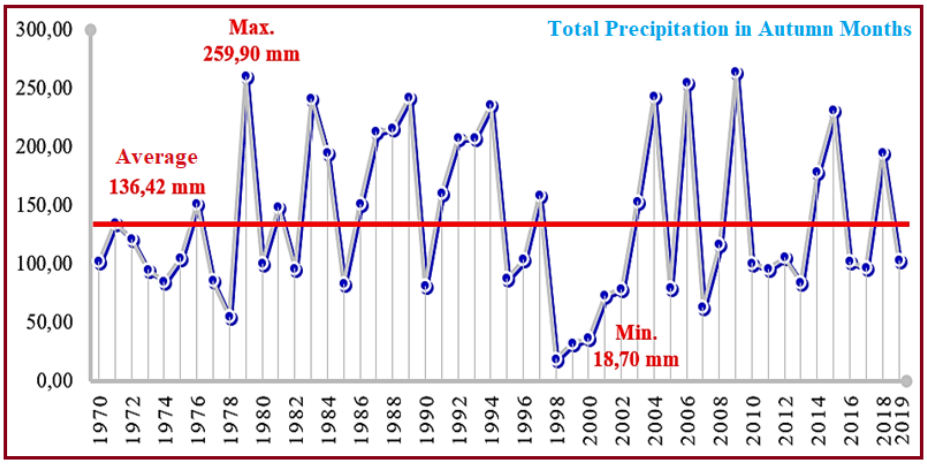

Figure 5. Total Precipitation in Siirt Center Observed for Many Years, Autumn Months

When looking at the autumn months of Siirt Center for many years, the lowest value was measured as 18.70 mm in 1998, while the average was 136.42 mm, and the highest total precipitation value in the autumn months was measured as 259.90 mm in 1979. The total precipitation was subjected to trend analysis test using the autumn months data. The test results are given in Table 4.

Table 4. Trend Analysis Results of Total Precipitation Data for Autumn Months

Mann - Kendall Test Statistical		Spearman's RhoTest Statistical	
Za/2	1,96	Za/2	1,96
S	14	Rho Test Statistical (rs)	-0,10
Sigma S	116,01	Z	-0,04
Kendall Correlation Coefficient	0,01		
Z	0,11		
Result	There is no significant trend	Result	There is no significant trend
Q Median According to Sen's Trend Slope Method (Change in Unit Time)			0,031

When the summary table of total precipitation values for the autumn months is examined, it is concluded that there is no trend in the time series examined since the absolute value of the Z statistic value is less than Za/2.

3.5. Long-term Annual Average Total Precipitation Change

The annual average total precipitation data of Siirt Center, which were analyzed on a long-term basis (1970-2019), were evaluated with trend analysis. The annual average change course of long-term total precipitation values is shown in detail in the graph given in Figure 6.

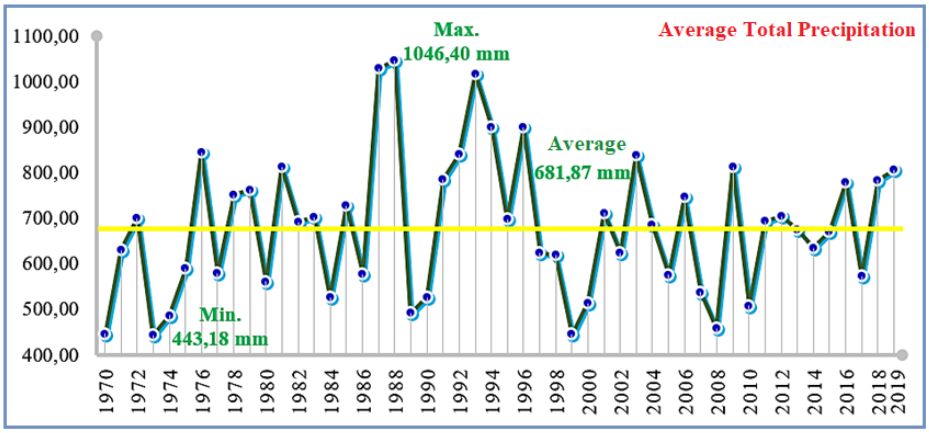

Figure 6. Distribution of Average Total Precipitation Over Many Years

When the long-term annual average of Siirt Center is examined, the lowest value was 443.18 mm in 1973, the average was 681.87 mm, and the highest total precipitation value in the autumn months was measured as 1046.40 mm in 1987. The trend analysis test was conducted using the annual average data for total precipitation. The test results are shown in Table 5.

Table 5. Trend Analysis Results of Long-Term Average Total Precipitation Data

Mann - Kendall Test Statistical		Spearman's RhoTest Statistical	
Za/2	1,96	Za/2	1,96
S	26	Rho Test Statistical (rs)	0,04
Sigma S	116,01	Z	0,28
Kendall Correlation Coefficient	0,02		
Z	0,22		
Result	There is no significant trend	Result	There is no significant trend
Q Median According to Sen's Trend Slope Method (Change in Unit Time)			0,431

When the summary table of total precipitation values for the autumn months is examined, it is concluded that there is no trend in the time series examined since the absolute value of the Z statistic value is less than Za/2.

The total precipitation and number of rainy days parameter data of Siirt province center were analyzed and the highest total precipitation value was 1046.40 mm in 1988, while the highest number of rainy days was measured as 119 days in 1976. The lowest total precipitation value of Siirt center was measured as 443.18 mm in 1973, while the lowest number of rainy days was measured as 69 days in 1989

The changes detected in prehistoric climates occurred through natural processes [16].There have been different climate zones on earth during geological periods, but the differences between them became apparent in cold periods and passive in hot periods [17,18]. Approximately 10,000-10,500 years ago, climate conditions, in other words, began to be effective in today's atmospheric circulation [19].

Precipitation, on the other hand, generally increased in the high latitude land regions of the Northern Hemisphere, especially in the cold season. On the other hand, after the 1960s, a sudden decrease in precipitation was observed along the tropical and subtropical belts extending from Africa to Indonesia [20].

The decrease in precipitation rates brings with it the threat of drought. Therefore, the decrease in these rates is of vital importance. In many studies conducted on precipitation trends and precipitation in Turkiye, decreasing trends in precipitation rates have been detected in all of our Mediterranean coasts, especially in the Eastern Mediterranean [21].

There are many studies in the literature on the evaluation of climate elements with trend analysis [22, 23, 24, 25, 26, 27]. For example; similar to this subject, the evaluation of long-term (1986-2019) rainy day numbers covering the Nevşehir province center, Avanos and Ürgüp districts was made and in the study they carried out using trend analysis, it was concluded that there was a long-term, decreasing trend in the spring and autumn months in the Nevşehir city center as a result of Mann Kendal and Spearman's Rho test, and there was no trend in the other seasons [28]. We believe that such studies will be an example for other studies to be conducted.

4. CONCLUSION

The effects of climate change continue to increase their negative effects in Turkiye and the world. Rainfall irregularities due to global warming and melting of glaciers in the North Pole also cause sea level increases. It can be said that greenhouse gas emissions prevent the reflection of sunlight among the main factors of global warming. Many studies are being conducted on climate change and global warming. In particular, studies conducted to evaluate rainfall irregularities depending on the years reveal that rainfall is decreasing and temperatures are showing an increasing trend depending on the years. In this study, the rainfall data of Siirt province located in the Southeastern Anatolia Region of Turkiye between the years 1970-2019 were examined and analyzed. It is thought that the obtained results will be an example for similar studies.

REFERENCES

[1] Aksay S C, Ketenoğlu O, Kurt L. Global Warming and Climatic Change, *Selcuk University Journal of Science Faculty,* 2005; 25: 29-42.

[2] Anonymous. The Scientific Basic Contribution of Working Group I to The Third Assesment Report of The Intergovernmental Panel on Climate Change (IPCC), *Cambridge University Press,* Cambidge 2001.

[3] Sunay Ç. İklim Değişiyor. *Tübitak Bilim ve Teknik Dergisi,* 2000, 392

[4] Koçman A. Türkiye İklimi. Ege Üniversitesi Edebiyat Fakültesi Yayınları No: 72 Sayfa: 49-53, İzmir, 1993.

[5] Öztürk K. Küresel İklim Değişikliği ve Türkiye'ye Olası Etkileri. *Gazi Eğitim Fakültesi Dergisi,* 2002; 22(1), 47-65

[6] Anonymous. Siirt ili yapısı, http://www.siirt.gov.tr/ilimiz (Erişim Tarihi: 16.07.2020)

[7] Anonymous. Siirt Merkezi Meteoroloji İstasyonu 1970-2019 yılları arası toplam yağış verileri, Meteoroloji Genel Müdürlüğü, Ankara, 2019.

[8] Mann H B. Non-parametric Tests Against Trend. *Econometrica,* 1945; 13, 245-259

[9] Kendall M G. Rank Correlation Methods. Charles Griffin, London, 1975; 135p

[10] Gümüş V. Fırat Havzası Akımlarının Trend Analizi İle Değerlendirilmesi, Harran Üniversitesi Fen Bilimleri Enstitüsü İnşaat Mühendisliği Anabilim Dalı *Yüksek Lisans Tezi,* 2006, Şanlıurfa.

[11] Karakuş C B. Hidro-Meteorolojik Parametreler İçin Trend Analizi Yöntemleri, *International Journal of Scientific and Technological Research*, 2017; 3(2): 22-32

[12] Yu Y S, Zou S, Whıttemore D. Non-Parametric Trend Analysis of Water Quality Data of Rivers in Kansas. *Journal of Hydrology*, 1993; 150, 61-80

[13] Büyükyıldız M, Berktay A. Parametrik Olmayan Testler Kullanılarak Sakarya Havzası Yağışlarının Trend Analizi. *J. Fac. Eng. Arch. Selcuk Univ*., 2004; 19 (2):23-37

[14] Kumar R, Singh S, Randhawa S S, Singh K K, Rana J.C. Temperature Trend Analysis in The Glacier Region of Naradu Valley, Himachal Himalaya, India. C. R. *Geoscience, 2009;* 346: 213–222.

[15] Yue S, Pilon P, Cavadias G.. Power of The Mann-Kendall and Spearman's Rho Tests for Detecting Monotonic Trends in Hydrological Series. *Journal of Hydrology*, 2002; 259(1-4):254-271.

[16] Gönençgil B. Doğal Süreçler Açısından İklim Değişikliği ve İnsan. İstanbul: Çantay, 2008.

[17] Nişancı A. İklim Değişikliği, Küresel Isınma ve Sonuçları. I. Türkiye İklim Değişikliği Kongresi Bildiriler Kitabı: 84-92, İstanbul, 2007.

[18] Erinç S. Klimatoloji ve Metodları. İstanbul: İstanbul Üniversitesi Coğrafya Enstitüsü. 1969.

[19] Atalay İ. Genel Fiziki Coğrafya. İzmir: Ege Üniversitesi Basımevi, 1998.

[20] Türkeş M, Sümer U M, Çetiner G. Küresel iklim değişikliği ve olası etkileri, Çevre Bakanlığı, Birleşmiş Milletler İklim Değişikliği Çerçeve Sözleşmesi Seminer Notları: 7-24, Çevre Kirliliğini Önleme Kontrol Genel Müdürlüğü, Ankara, 2000.

[21] Gönençgil B, İçel G. Türkiye'nin Doğu Akdeniz Kıyılarında Yıllık Toplam Yağışlarda Görülen Değişimler (1975-2006), *Turkish Geographical Review*, 2014; 55: 1-12

[22] Bağdatlı M C, İstanbulluoğlu A, Altürk B, Arslan C. Evaluation of the Change Trend in Long-Year Temperature Data in Terms of Agricultural Drought: The Case of Çorlu, *Düzce University Journal of Science and Technology*, 2014; 2(1):100-107

[23] Bağdatlı M C, Belliturk K, Jabbari A. Possible Effects on Soil and Water Resources Observed in Nevşehir Province in Long Annual Temperature and Rain Changing, *Eurasian Journal of Forest Science*, 2015; 3(2),19-27.

[24] Bağdatlı M C, Can E. Analysis of Precipitation Datas by Mann Kendall and Sperman's Rho Rank Correlation Statistical Approaches in Nevsehir Province of Turkey, *Recent Research in Science and Technology Journal*, 2019; (11): 24-31
doi: 10.25081/rrst.2019.11.6082

[25] Bağdatlı M C, Arıkan E N. Evaluation of Monthly Maximum, Minimum and Average Temperature Changes Observed for Many Years in Nevsehir Province of Turkey,*World Research Journal of Agricultural Science (WRJAS),* 2020; 7(2), 209-220.

[26] Bağdatlı M C, Arslan O. Trend Analysis of Precipitation Datas Observed for Many Years (1970-2019) in Niğde Center and Ulukisla District of Turkey, *International Journal of Recent Development in Engineering and Technology (IJRDET),* 2020; 9(7): 1-8

[27] Bağdatlı M C, Can E. 2020. Temperature Changes of Niğde Province in Turkey: Trend analysis of 50 years data, *International Journal of Ecology and Development Research (IJEDR),* 2020; 6(2): 62-71.

[28] Bağdatlı M C, Arslan O. Evaluation of the number of rainy days observed for long years due to global climate change in Nevşehir/Turkey, *Recent Research in Science and Technology,* 2019; 11: 09-14