

# The Evaluation of Precipitation Observed in Tokat Province for Long Years (1970-2019) by Trend Analysis

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**Abstract**— In this study, the monthly total precipitation between 1970-2019 belonging to the Tokat Province's center meteorology station were analyzed. In the research, it was aimed to reveal the change on the basis of years by analyzing the data with Mann-Kendall, Sperman's Rho correlation and Sen's slope method. "Trend Analysis for Windows program" was used to perform trend analysis. According to trend analysis results; In Tokat province (Turkiye), the average of total precipitation in winter months was 116,4±39.1 mm, spring months were 158,6±44,5 mm, summer months were 59,8±30,6 mm and autumn months were 101,9±45,4 mm. In the long annual total precipitation data, the minimum precipitation is 309 mm, the maximum precipitation is 592,9 mm and the average of total precipitation is 436,6±69,0 mm. As a result, it has been concluded that there is no increasing or decreasing trend in total precipitation of long years. The results obtained will be an example for the studies on monitoring and evaluation of global climate change in Tokat province.

**Index Terms**— Total Precipitation, Trend Analysis, Tokat Province, Turkiye

## I. INTRODUCTION

Water is the fundamental source of life for all living things on Earth. Because water is an indispensable resource for life, it has been the source of settlements, agricultural production, and wars between civilizations from past to present. The rapid increase in the global human population has contributed to the emergence of negative impacts. The rapid increase in urbanization and industrial growth, coupled with population growth, contributes to increased environmental pollution. This negative impact negatively impacts climate parameters. This negative impact will negatively impact the determination of water resource and use strategies. Indeed, analyses predict that a global crisis will occur by 2030, coupled with the rapid growth of the population and industrial growth [1].

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Rainfall has a significant impact on drought, water resources, and many other sectors. Turkiye's average annual precipitation, at 571 mm, is well below the global average. Rainfall distribution varies significantly across regions in Turkiye, and it is negatively affected by changes in the global system. The global climate system consists of the atmosphere, hydrosphere, cryosphere, lithosphere, and biosphere [2]. It is estimated that many changes have occurred in the global climate system from the past to the present [3].

Climate change has a greater impact on countries located in mid- and high latitudes [4]. Turkiye is one of the countries at risk of experiencing climate change [5].

The development of industrial activities over time has contributed to the emergence of negative impacts. With the rapid resumption of industrial activities, climate and ecological deterioration began to occur [6].

This situation, along with global warming, has led to seasonal changes and altered the effects of climate factors. Global warming is caused by the effects of greenhouse gases released into the atmosphere [7]. The effects of global climate change are particularly negative in temperature and precipitation. One of the most significant drivers of global climate change is carbon emissions into the atmosphere.

Carbon is a fundamental element. However, human consumption of more than needed leads to a significant increase in CO<sub>2</sub> levels in the atmosphere. This reduces the protective effect of the ozone layer and causes irregular rainfall. This increase in CO<sub>2</sub> and greenhouse gases accumulate in the atmosphere, leading to the formation of acid rain. Acid rain alters the pH balance in water, negatively impacting aquatic life and causing the deterioration of plant life.

Rainfall is particularly negatively affected by conditions such as global warming and seasonal changes. One study found that the highest annual precipitation coefficient of variability was in Mardin province, at 31,89% and the lowest in Rize at 11,92% [8].

Turkiye's being surrounded by seas and the varying topographic elevations due to the extension of mountains cause different precipitation distributions across regions [9]. This research was conducted to examine the changes in monthly total precipitation observed in Tokat province between 1970 and 2019 using seasonal trend analysis. The study revealed trends in the increase and decrease of total precipitation over the years.

II. MATERIALS AND METHODS

Long-term total precipitation data from the meteorological station located in the center of Tokat province were used as material in the research. Tokat province is located in the central inland part of the Black Sea region. Tokat province has 12 districts, 65 towns, and 609 villages [10]. The climate characteristics of Tokat province show a transition between the climate characteristics of the Black Sea region and Central Anatolia. The climate in Tokat province is generally hot and dry in the summer months, while the winter months are cold and snowy. The distance of Tokat to the sea and elevations have a significant impact on the different climate variables in summer and winter. There may be differences in the climate change experienced in Tokat province from the northern to the southern parts [11]. Mountains are generally in the form of mountain ranges running parallel to the Black Sea. The heights of the mountains increase towards the eastern parts [10]. The location of Tokat provincial center examined within the scope of the research and the meteorological station where the data were used are presented in Figure 1.

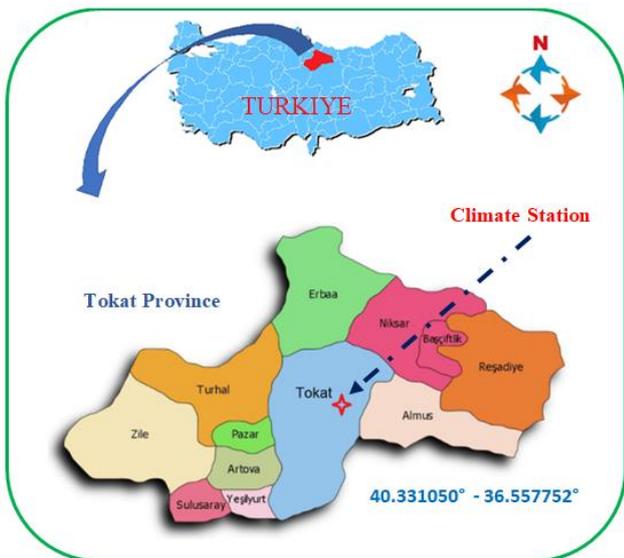


Fig 1. The location of research area

This study examined monthly total precipitation data from the central meteorological station in Tokat province between 1970 and 2019. The analyzed data was obtained from the "Mevbis database of the Turkiye General Directorate of Meteorology [12]. A total of 600 months were evaluated using trend analysis, and the results were statistically determined. Trend analysis is used to determine gradual changes in meteorological data, whether increasing or decreasing, and for data that is not normally distributed [13].

In this study, monthly total precipitation data for Tokat province between 1970 and 2019 were evaluated using trend analysis. In this context, Mann-Kendall and Sperman's rho correlation tests were used. In addition, Sen's trend slope tests were also applied to the data. All analyzes were performed at a 95% confidence interval [14,15,16]. "Trend Analysis for Windows" software, developed for trend analysis within the scope of the research was used [17].

III. RESULTS AND DISCUSSION

Total precipitation amounts of Tokat province for many years were examined and analyzed with seasonal trend analysis. The annual and seasonal changes in total precipitation amounts and trend analysis results are shown in Figure 2 and Table 1.

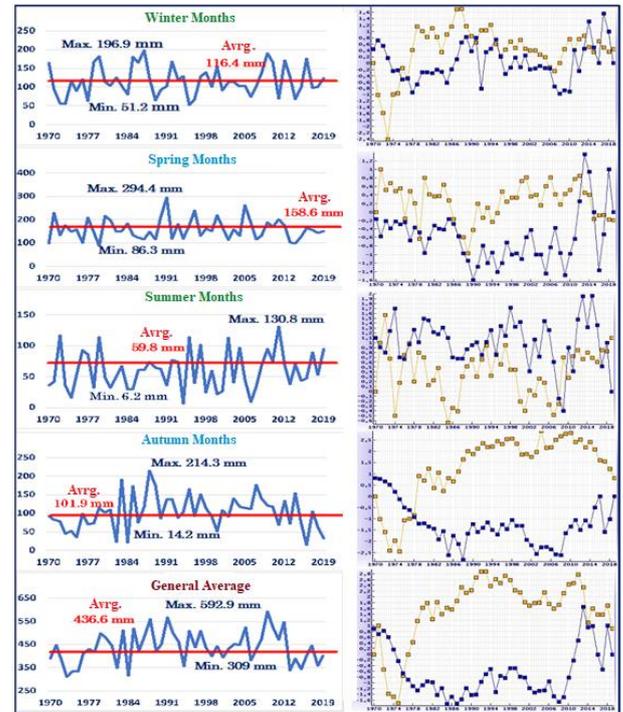


Figure 2. Changes in Total Precipitation Amounts by Years (1970-2019) and Mann-Kendall U(t)-U'(t) Graphics

Table 1. Trend Analysis Results of Total Precipitation

| Trend Analysis Results of Total Precipitation in Winter Months (1970-2019) |          |                                |          |
|--|----------|--------------------------------|----------|
| Mann-Kendall Test Statistical  |          | Sperman's Rho Test Statistical |          |
| Za/2   | 1,96     | Za/2                           | 1,96     |
| S  | 53       | Rho Test Statistical (rs)      | 0,07     |
| Sigma S  | 119,55   | Z                              | 0,5      |
| Kendall Correlation Coefficient  | 0,04     |                                |          |
| Z  | 0,43     |                                |          |
| Result   | No Trend | Result                         | No Trend |
| Q Median According to Sen's Trend Slope Method (Change in Unit Time)       |          |                                |          |
|  |          |                                | 0,15     |
| Trend Analysis Results of Total Precipitation in Spring Months (1970-2019) |          |                                |          |
| Mann-Kendall Test Statistical  |          | Sperman's Rho Test Statistical |          |
| Za/2   | 1,96     | Za/2                           | 1,96     |
| S  | -19      | Rho Test Statistical (rs)      | -0,1     |
| Sigma S  | 119,55   | Z                              | -0,7     |
| Kendall Correlation Coefficient  | -0,2     |                                |          |
| Z  | -0,15    |                                |          |
| Result   | No Trend | Result                         | No Trend |
| Q Median According to Sen's Trend Slope Method (Change in Unit Time)       |          |                                |          |
|  |          |                                | -0,06    |
| Trend Analysis Results of Total Precipitation in Summer Months (1970-2019) |          |                                |          |
| Mann-Kendall Test Statistical  |          | Sperman's Rho Test Statistical |          |
| Za/2   | 1,96     | Za/2                           | 1,96     |
| S  | 131      | Rho Test Statistical (rs)      | 0,15     |
| Sigma S  | 119,55   | Z                              | 1,05     |
| Kendall Correlation Coefficient  | 0,11     |                                |          |
| Z  | 1,19     |                                |          |
| Result   | No Trend | Result                         | No Trend |
| Q Median According to Sen's Trend Slope Method (Change in Unit Time)       |          |                                |          |
|  |          |                                | 0,32     |
| Trend Analysis Results of Total Precipitation in Autumn Months (1970-2019) |          |                                |          |
| Mann-Kendall Test Statistical  |          | Sperman's Rho Test Statistical |          |
| Za/2   | 1,96     | Za/2                           | 1,96     |
| S  | 97       | Rho Test Statistical (rs)      | 0,12     |
| Sigma S  | 119,55   | Z                              | 0,82     |
| Kendall Correlation Coefficient  | 0,8      |                                |          |
| Z  | 0,8      |                                |          |
| Result   | No Trend | Result                         | No Trend |
| Q Median According to Sen's Trend Slope Method (Change in Unit Time)       |          |                                |          |
|  |          |                                | 0,39     |
| Trend Analysis Results of Total Precipitation in Long Periods (1970-2019)  |          |                                |          |
| Mann-Kendall Test Statistical  |          | Sperman's Rho Test Statistical |          |
| Za/2   | 1,96     | Za/2                           | 1,96     |
| S  | 107      | Rho Test Statistical (rs)      | 0,11     |
| Sigma S  | 119,55   | Z                              | 0,78     |
| Kendall Correlation Coefficient  | 0,9      |                                |          |
| Z  | 0,89     |                                |          |
| Result   | No Trend | Result                         | No Trend |
| Q Median According to Sen's Trend Slope Method (Change in Unit Time)       |          |                                |          |
|  |          |                                | 0,61     |

Data obtained from the central meteorological station in Tokat province indicate that the lowest total winter precipitation was 51,2 mm in 1995, while the highest was 196,9 mm in 1987. The average winter precipitation was 116,4 mm. The lowest total spring precipitation was 86,3 mm in 1987, while the highest total precipitation was 294,4 mm in 1991. The average spring precipitation was 158,6 mm. The lowest total summer precipitation was 6,2 mm in 1994 and the highest total precipitation was 130,8 mm in 2011. The average summer precipitation was 59,8 mm. The lowest total autumn precipitation was 14,2 mm in 2014, while the highest total precipitation was 214,3 mm in 1988. The average precipitation in autumn was found to be 101,9 mm.

Looking at the long-term average, the lowest total precipitation was 309 mm in 1973, while the highest total precipitation was 592,9 mm in 2009. The total precipitation average for many years (1970-2019) was calculated as 436,6 mm.

Monthly total precipitation data for Tokat province center over many years (1970-2019) were evaluated using trend analysis. In this context, total precipitation amounts were subjected to Mann-Kendall and Sperman's Rho and Sen's Trend Slope Method tests within a 50-year and 600-month dataset.

When total precipitation values were evaluated on a long-term and seasonal basis, the average total precipitation in winter was  $116,4 \pm 39,1$  mm, while the average total precipitation in spring was  $158,6 \pm 44,5$  mm. The average total precipitation in summer was  $59,8 \pm 30,6$  mm, and the average total precipitation in autumn was  $101,9 \pm 45,4$  mm. The long-term average total precipitation in Tokat province between 1970 and 2019 was  $436,6 \pm 69,0$  mm. The trend analyses concluded that there was no significant trend over time in the total precipitation data in Tokat province center.

According to the results of the trend analysis of long-term total precipitation in Tokat province, no significant trend was observed in the time-dependent change of total precipitation amounts across all seasons. It was also concluded that there was no significant trend in the overall average of long-term total precipitation data.

A study evaluating long-term total precipitation data examined the Nevşehir Central and Ürgüp districts. The study found a negative trend in long-term total precipitation in spring and autumn, but no significant trend in other seasons [18].

In a study conducted in the Black Sea region, the Mann-Kendall and Sen's Trend Slope method was used to evaluate the trend analysis of total precipitation amounts in six provinces [19]. In a research conducted in Kazova district of Tokat province, the Mann-Kendall test was used to evaluate the annual changes in long-term precipitation and temperature data (1966-2006) in terms of drought. The study found a decreasing trend in annual winter precipitation averages, while overall there was no change in precipitation over the years. A gradual decreasing trend was observed in average temperatures. All the aforementioned studies effectively used trend analyses to determine annual changes in precipitation, and the results supported this study.

#### IV. CONCLUSION

The world's water resources are gradually diminishing due to global warming. This is causing water crises. The climate change that is already being experienced and felt worldwide, and the resulting global warming, is causing a decrease in rainfall. As a result, living creatures in Earth's ecosystems are at risk. [4]. The rapid development of industrial activities is also making global warming increasingly noticeable and is a significant factor influencing precipitation. Climate change can be determined by identifying trends in temperature and precipitation [6]. To assess the precipitation pattern on a regional basis, based on global trends, it is crucial to analyze long-term meteorological data using trend analysis and to reveal the course of change over time. This and similar assessment studies will assist in assessing the climate trends of the regions. The results obtained will undoubtedly contribute to investment organizations, and this study, which evaluates total monthly precipitation over many years in the Tokat province example, will serve as an example for similar studies to be conducted in the region.

#### CONFLICT OF INTEREST

The authors declare no conflict of interest.

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