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# Trend Analysis of Precipitation Datas Observed for Many Years (1970-2019) in Niğde Center and Ulukışla District of Turkey

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**Abstract**— This research situated in Turkey's Anatolia region, Niğde center and Ulukışla district were conducted. Long annual precipitation data were subjected to statistical analysis on a monthly basis. Within the scope of the research, 50 years and 600 months long total monthly precipitation and maximum monthly precipitation values between 1970-2019 were examined. Spearman Rho test, Mann-Kendall Correlation test and Sen's slope methods were used in trend analysis. According to the total precipitation values; The highest total precipitation was observed in 2009 as 460,8 mm. The lowest total precipitation was calculated as 192,9 mm in 1973. Total rainfall average was calculated as 120,5 mm in spring and 98,4 mm in winter. The total rainfall average in the summer months was determined as 38,2 mm. In general, the average total precipitation for many years in the center of Niğde was found to be 325,9 mm. The highest total precipitation in Ulukışla district was determined as 428,2 mm in 1997. The lowest total precipitation for many years was 182,1 mm in 1989. The average total precipitation for long years was determined to be 318,5 mm. Total rainfall average was determined as 132,8 mm in spring and 80,7 mm in winter. Total rainfall average in the summer months was calculated as 42,4 mm. According to the trend analysis results; It is concluded that there is no significant trend in total precipitation values for many years in the center of Niğde and Ulukışla district. The maximum annual precipitation in the center of Niğde is calculated as 10,5 mm and in the Ulukışla district as 10,3 mm. The average maximum precipitation in spring was found to be 13,2 mm in the center of Niğde and 14 mm in the town of Ulukışla. The highest maximum precipitation was observed in 1978 in Niğde city center as 27 mm in winter. The highest maximum precipitation in Ulukışla district was found as 33,8 mm in 2003. According to the long annual maximum precipitation values; It has been determined that there is an increasing trend in Niğde center in the general average of winter, summer and all months.

**It is observed that there is an increasing trend in the Ulukışla district in the winter months and in general average.**

**Keywords**—Maximum and Total recipitation, Trend Analysis, Global Climate Change, Nigde Province, Turkey

## I. INTRODUCTION

Water is an indispensable source of life for all living things. It has been effective in settlement in terms of agriculture and life source of civilizations from past to present. Water, which people have fought for ages to find, is the main factor in the development of societies and has caused many civilizations to collapse in the past [1]. The rapid increase in the world population is an important factor in this situation. With the rapidly increasing population, the growth of the industry will start to be effective in the rapid consumption of water resources. Estimates show that the need for increasing water demand and decreasing clean water supply curves will intersect in 2030. This situation naturally means that there will be a universal crisis [2]. The five basic components called atmosphere, hydrosphere, cryosphere, lithosphere and biosphere constitute the complex system called the global climate system, the life on earth and the interaction between these components [3]. With the intensive industrialization movements that started in the 19th century, the fact that nature was commodified and regarded as an industrial raw material and a means of exploitation disrupted the balance of all ecology, especially the climate [6]. These changes, which emerged due to global warming, started to show their effects. According to the report of the Intergovernmental Panel on Climate Change (IPCC) announced in 2013, climate change has been stated as an event that has shown its effects without



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hesitation throughout the 21st century and is shown as the most serious problem of human beings as a result [7, 8].

Global warming has also had an impact on the reduction of water resources and climate change. Global warming caused by the greenhouse effect strengthened due to the greenhouse gases whose accumulation continues to increase in the atmosphere has become more evident especially after the 1980s and reached its highest values in the 1990s [9].

Influence of the global climate will have an effect on the change of seasons, especially in the observation of significant changes in temperature and precipitation. The biggest impact of climate change on the Earth is carbon emission into the air. Carbon is one of the basic elements of life when it is present in sufficient levels, but when people consume more than they need, it causes serious CO<sub>2</sub> in the atmosphere to increase and the protective effect of the ozone layer decreases and irregularities occur in precipitation. Increasing of this situation causes the formation of acid rains with CO<sub>2</sub> and greenhouse gases accumulated in the atmosphere and descending to the earth together with precipitation. Acid rains change the pH of the water and negatively affect the life of aquatic life. It causes the natural structure of plants to deteriorate.

Increasing urbanization depending on the population also causes changes on the climate. Increasing energy consumption due to heating, traffic, industry in cities, artificial covers such as asphalt, concrete, city canyons formed by tall buildings and the streets between them, decreasing green areas cause climate differences [10].

Many studies on city climatology have revealed that the most obvious effect of urbanization on the climate is on temperature [11]. In the studies carried out within the scope of the metromex project, which is one of the most detailed researches on city climatology, In Louis, the city effect was found to show statistically significant increases in summer rains, heavy showers (> 25 mm), thunderstorms and hail rains [12]. Changes in precipitation trends in our country were mostly analyzed regionally. In a very few articles that examine the relationship between precipitation change and urbanization, no significant relationship was found between urbanization and precipitation change [10]. The greatest effects of climate change occur in countries located in middle and high latitudes [13]. The Central Anatolia Region is among the areas that will be affected by this change due to its geographical location [6]. In our country, it is affected by this situation. Turkey constitutes one of the risky countries can be experienced in the short or long-term climate variability [15].

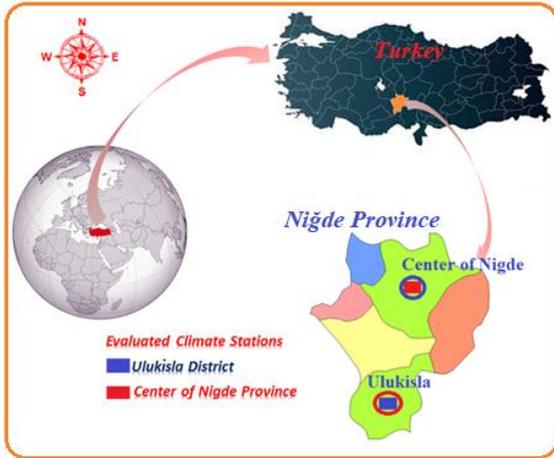
Turkey is well below average rainfall of 643 mm and falling world average. This situation corresponds to 501 billion m<sup>3</sup> of water in our country. In terms of annual distribution of rainfall in Turkey are major differences. As a matter of fact, while the annual rainfall in the Eastern Black Sea Region exceeds 2500 mm, this value decreases below 250 mm in some depressions surrounded by mountains [16]. Some of these waters evaporate and leak into aquifers. The remaining water from infiltration and evaporation combine with surface flow and groundwater to create gross water potential. Turkey's gross water potential of 193 billion m<sup>3</sup>. What it is Turkey's water potential by 2023 is estimated to be 112 billion m<sup>3</sup> [17]. Insufficient precipitation, drought, reduction in water resources, etc. It will be an inevitable end in our country to be adversely affected by many sectors such as.

In this research, trend analysis was applied to monthly total and maximum precipitation data observed in the center of Niğde and Ulukışla district between 1970-2019. For this purpose, Mann-Kendall, Spearman's Rho and Sen's Trend Slope methods are used. As a result of the research, the course of change of maximum and total precipitation values on years basis is revealed.

## II. MATERIAL AND METHOD

The study area is located in Nigde, Turkey's Central Anatolia Region is located in the province of Nigde centers and are Ulukışla district. Terrestrial climate is seen in Niğde. The causes of terrestrial climate are; It is surrounded by mountains, 1200 meters above sea level, unable to take overwhelming effects of the sea and winds from the sea, it is open to cold winds from the north. In this case, the general climate feature of Niğde; summers are hot and dry, winters are cold and snowy. Rainfalls are encountered in winter in snow and spring in rain [18]. In the study, meteorology observation stations in the center of Niğde and Ulukışla districts in Niğde Merkez and Ulukışla districts were examined. In the study, total and maximum precipitation values for many years between 1970-2019 were used as material in the study. The location and location of the districts subject to the research are shown on the map given in Figure 2.1.

Figure 2.1. Location of the Research Area and the location of the studied meteorological stations



Monthly changes of precipitation values observed between 1970-2019 in meteorology stations in Niğde Merkez and Ulukışla districts were used. A total of 600 months were analyzed seasonally. The results are presented statistically with graphs and charts. For the evaluation of the data, it was evaluated within Mann-Kendall and Spearman's Rho and Sen's slope method and it was done in the 95% confidence level [19, 20, 25].

Mann-Kendall test is frequently used in studies to investigate the changes in climate parameters [21, 22, 23]. Mann- Kendall test, which is carried out to determine the direction of changes in climate parameters, temperature and precipitation, also gives important ideas about the dimensions of climate change [4, 5]. In this study, a software called "Trend Analysis for Windows" was used. This software is a package program that applies Mann-Kendall test, Spearman's Rho test, Mann-Kendall Order Correlation test and Sen's Trend Slope method to the data and gives the result as graphics and text [14].

### III. RESEARCH FINDINGS

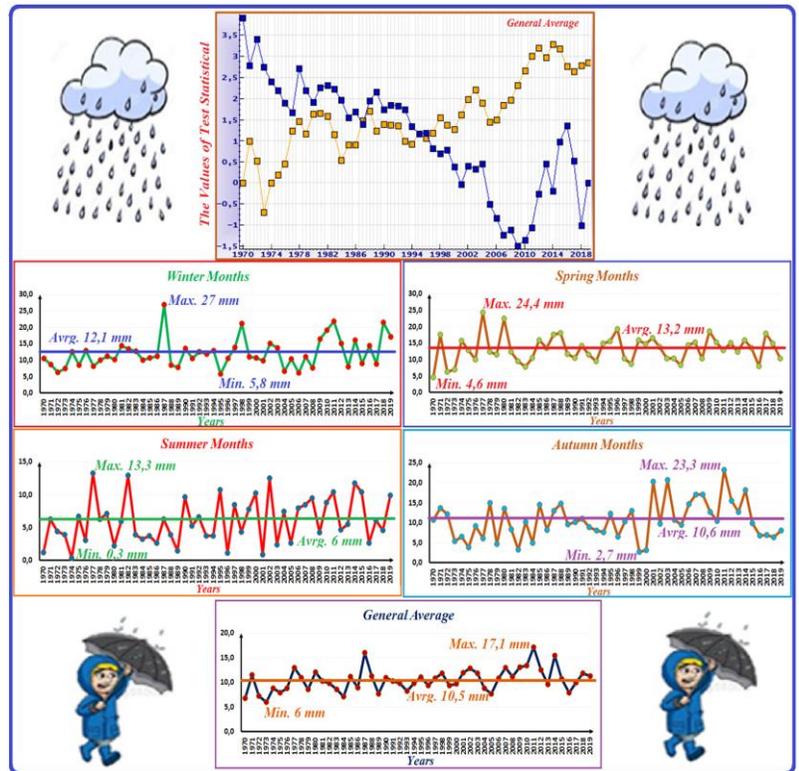
Trend analysis results of the maximum and total precipitation values between 1970 and 2019 belonging to Niğde Merkez and Ulukışla district are presented in detail below.

#### 3.1. MAXIMUM RAIN CHANGES

The maximum precipitation change values of Niğde Center and Ulukışla district, which were analyzed for many years (1970-2019), were evaluated seasonally (spring, autumn, summer and winter months) with trend analysis.

The course of the long-term seasonal maximum precipitation change values in Niğde Center is given in Figure 3.1.

Figure 3.1. Maximum precipitation changes in Niğde Center (mm)



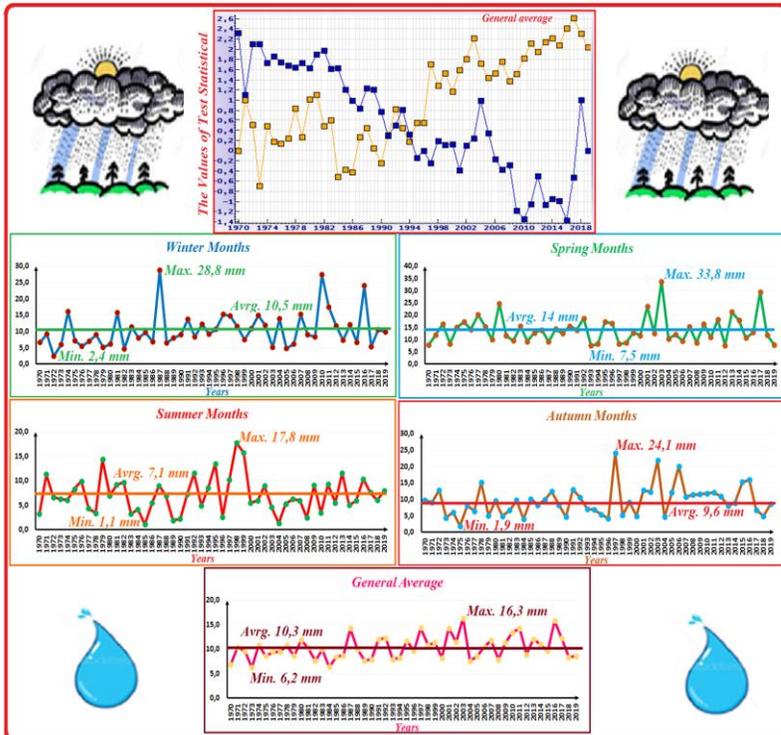
The highest maximum precipitation value for many years in the center of Niğde in the winter months was seen in 1987 with 27 mm. The lowest maximum precipitation value was in 1995 with 5,8 mm. The highest maximum precipitation value for long years in the spring months is 24.4 mm in 1977. The lowest maximum precipitation value was 4,6 mm in 1970. While the maximum maximum precipitation value in summer months was 13,3 mm in 1977, the lowest maximum rainfall value was 0,3 mm in 1974. The highest maximum precipitation value in autumn is 23,3 mm in 2011, while the lowest maximum rainfall value is 2,7 mm in 1999. On average, the lowest maximum precipitation value was 6 mm in 1973, while the highest maximum precipitation value was 17,1 mm in 2011. Long-term (1970-2019) and seasonal trend analysis results of maximum precipitation values for long years are given in Table 3.1.

Table 3.1. Trend analysis results of maximum precipitation data in the center of Niğde

Provinces	Years	Seasons	Mann-Kendall Test Statistical	Spearman's Rho Test Statistical
Center of Niğde Province	1970-2019	Winter Months	+	No Trend
		Spring Months	No Trend	No Trend
		Summer Months	+	No Trend
		Autumn Months	No Trend	No Trend
		General Average	+	+

According to the trend analysis results regarding the maximum precipitation values, it has been observed that there is an increasing trend in the general average of the long annual maximum precipitation value. No significant train was found in the autumn and spring seasons. In the summer and winter months, an increasing trend was observed according to the Mann-Kendall statistical test result. According to Sperman's Rho test, a meaningful train could not be reached. The course of change in the years of maximum precipitation in Ulukışla district is given in detail in the graphs given in Figure 3.2.

Figure 3.2. Maximum precipitation changes in Ulukışla District (mm)



The highest maximum precipitation value in Ulukışla district in winter is 28,8 mm in 1987. The lowest maximum precipitation value was 2,4 mm in 1972. The highest maximum precipitation value in spring is 33,8 mm in 2003. The lowest maximum precipitation value was 7,5 mm in 1993. The highest maximum precipitation value in summer is 17,8 mm in 1998. The lowest maximum precipitation value was 1,1 mm in 1985. The highest maximum precipitation value in autumn is 24,1 mm in 1994. The lowest maximum precipitation value was 1,9 mm in 1975. In general, the lowest maximum precipitation value was 6,2 mm in 1973. The highest maximum precipitation value is 16,3 mm in 2003. The average of the maximum precipitation values is 10,3 mm. Seasonal trend analysis results of maximum precipitation values for long years are given in Table 3.2.

Table 3.2. Trend analysis results of maximum precipitation values for many years in Ulukışla district

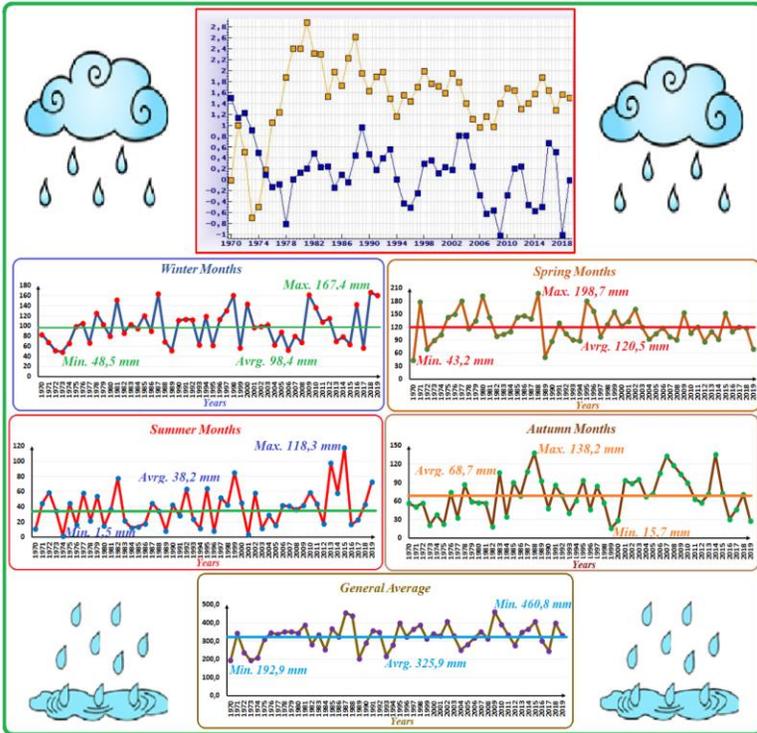
Provinces	Years	Seasons	Mann-Kendall Test Statistical	Spearman's Rho Test Statistical
Ulukışla District	1970-2019	Winter Months	+	+
		Spring Months	No Trend	No Trend
		Summer Months	No Trend	No Trend
		Autumn Months	No Trend	No Trend
		General Average	+	+

According to these results, it is seen that there is a significant trend in general average and increasing in winter season. There was no significant trend in the summer, autumn and spring seasons.

### 3.2. TOTAL PRECIPITATION CHANGES

The total precipitation change values of the Niğde center and Ulukışla district which were analyzed for many years (1970-2019), were evaluated seasonally (spring, autumn, summer and winter months) with trend analysis. The course of the long-term seasonal total precipitation change values in Niğde Center is given in Figure 3.3.

Figure 3.3. Long Years Total precipitation Changes in the Center of Niğde (mm)



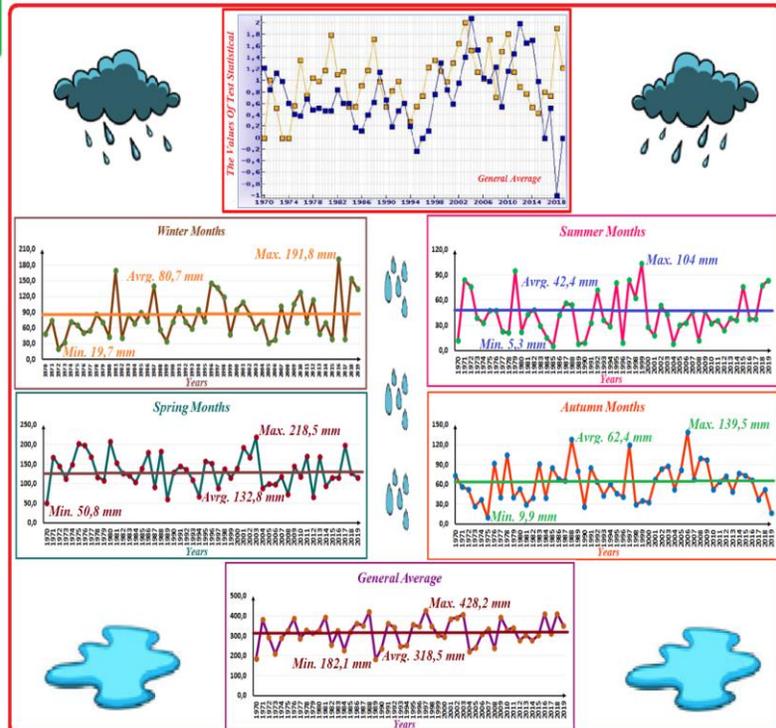
While the highest total precipitation value in the center of Niğde in winter was 167,4 mm in 2009, the lowest total precipitation value was 48,5 mm in 1974. The highest total precipitation in the spring months is 198,2 mm in 1987. The lowest total precipitation is 43,2 mm in 1970. The highest total precipitation value of the total precipitation values for many years in the summer is 118,3 mm in 2015. The lowest total precipitation value is 3,5 mm in 1975. While the highest total precipitation value of the total precipitation values for long years in the autumn months was 138,2 mm in 1986, the lowest total precipitation value was 15,7 mm in 1999. On average, the lowest total precipitation value was 192,9 mm in 1970. The highest total precipitation value is 469,8 mm in 2010. The average total precipitation value for long years is 325,9 mm. In trend analysis results of Niğde center total precipitation values for many years are given in Table 3.3.

Table 3.3. Trend analysis results of total precipitation values in Niğde Center

Provinces	Years	Seasons	Mann-Kendall Test Statistical	Spearman's Rho Test Statistical
Center of Niğde Province	1970-2019	Winter Months	No Trend	No Trend
		Spring Months	No Trend	No Trend
		Summer Months	No Trend	No Trend
		Autumn Months	No Trend	No Trend
		General Average	No Trend	No Trend

According to the results of the trend analysis, it was concluded that there was no significant trend in total precipitation in all seasons and overall average. In Ulukışla district, the course of change of total precipitation on years basis is also shown in detail in the graphs given in Figure 3.4.

Figure 3.4. Total precipitation Changes in Ulukışla district (mm)



The highest total precipitation value in Ulukışla district in winter is 191,8 mm in 2016. The lowest total precipitation value is 19,7 mm in 1973. The highest total precipitation value in spring is 218,5 mm in 2003. The lowest total precipitation value is 50,8 mm in 1970. The highest total precipitation in summer months is 104 mm in 1998. The lowest total precipitation value is 5,3 mm in 1984. The highest total precipitation value in the autumn months was 139,5 mm in 2006. The lowest total precipitation value is 9,9 mm in 1975. According to the general average of total precipitation; The lowest total precipitation value was 182,1 mm in 1984. The highest total precipitation value is 428,2 mm in 1992. Total precipitation average for long years was found to be 318,5 mm. Trend analysis results of total precipitation values for many years in Ulukışla district are given in Table 3.3

Table 3.3. Trend analysis results of total precipitation values in Ulukışla district

Provinces	Years	Seasons	Mann-Kendall Test Statistical	Spearman's Rho Test Statistical
Ulukışla District	1970-2019	Winter Months	No Trend	No Trend
		Spring Months	No Trend	No Trend
		Summer Months	No Trend	No Trend
		Autumn Months	No Trend	No Trend
		General Average	No Trend	No Trend

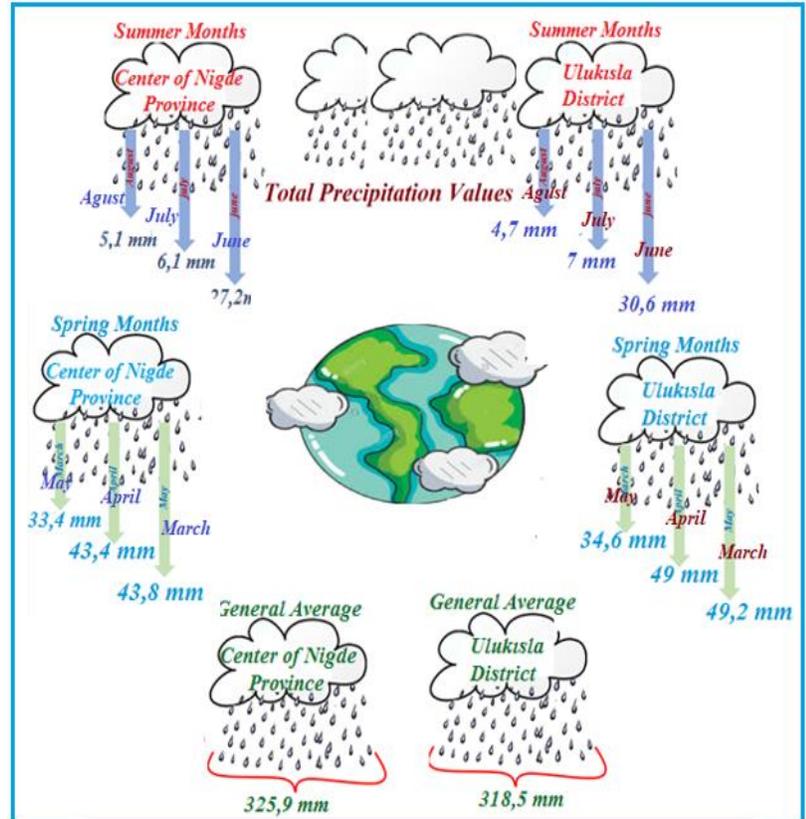
According to the trend analysis results made for the total precipitation values for many years; It is concluded that there is no train in the overall average of all seasons and long total precipitation.

#### IV. CONCLUSION AND SUGGESTIONS

Between 1970 and 2019, 50 years and 600 months total and maximum precipitation values were subjected to analysis in Niğde center and Ulukışla district. In this study, Mann-Kendall test and Sperman's Rho tests and Sen's slope methods were used. Total and maximum precipitation data were analyzed using the "Trend Analysis for Windows software" [14].

Long-term total precipitation values in the Niğde center and Ulukışla district, the changes of summer, spring months and general averages are presented in Figure 4.1.

Figure 4.1. Summer, spring months and long annual total precipitation changes in Niğde center and Ulukışla district



According to the total precipitation values for many years; The average total rainfall in the center of Niğde in summer was 5,1 mm and 6,1 m in July and 27,2 mm in June. In spring, it was calculated as 33,4 mm in the month and 43,4 mm in April and 43,8 mm in March. Looking at the general average, the average total precipitation for many years was found to be 325,9 mm in the center of Niğde. According to the total precipitation values for many years; In the summer months, the average total precipitation in Ulukışla district was 4,7 mm and 7 mm in July and 30,6 mm in June. In spring, it was calculated as 34,6 mm in the month and 49 mm in April and 49,2 mm in March. Looking at the general average, the average total precipitation for many years was found to be 318,5 mm in the Ulukışla district.

The long-term maximum rainfall averages of Niğde Center are 13,2 mm for the spring months, 12,1 mm for the winter months, 10,6 mm for the autumn months, 6 mm for the summer months and the overall average is 10,5 mm.



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Long-term total precipitation averages are 129,5 mm for spring, average 98,1 mm for winter, 68,7 mm for autumn, and 38,2 mm for summer. In the Ulukışla district, the maximum annual average precipitation is 33,8 mm for the spring months, the average for the winter months is 5,1 mm, the average for the autumn months is 21,8 mm, the average for the summer months is 4,6 mm and the general average is 16,3 mm. Long-term total precipitation averages were 132,8 mm for the spring months, 80,7 mm for the winter months, 62,4 mm for the autumn months, and 42,4 mm for the summer months.

Water, which is the life source of all living things, is decreasing gradually and it is expected that the problems of water crises will be experienced in the coming years. The decrease in precipitation due to climate change affects the living life in the ecosystem. Among the climate parameters, the amount of precipitation is the most variable climate element according to time and place [24]. Undoubtedly, global warming is also an important factor affecting precipitation. Increasing temperatures are important factors in decreasing precipitation. From this point, if trends in temperature and precipitation amount of any place are detected, the direction and severity of climate change can be determined [6]. Therefore, changing climate conditions will be an important factor in the current situation and the problems that may arise in the coming years. For this reason, solutions are needed for global warming and reduction of greenhouse gases that cause climate change.

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