SEPTEMBER 2021 M.Sc. in Civil Engineering SEDA NACAROĞLU

REPUBLIC OF TURKEY

GAZİANTEP UNIVERSITY

GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES

TREND ANALYSIS OF TEMPERATURE AND PRECIPITATION VALUES IN KIZILIRMAK BASIN

M.Sc. THESIS

IN

CIVIL ENGINEERING

BY

SEDA NACAROĞLU

SEPTEMBER 2021

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M.Sc. Thesis

in

Civil Engineering

Gaziantep University

Supervisor

Asst. Prof. Dr. Ayşe YETER GÜNAL

by

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September 2021

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ABSTRACT

TREND ANALYSIS OF TEMPERATURE AND PRECIPITATION VALUES IN KIZILIRMAK BASIN

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M.Sc. Thesis in Civil Engineering
Supervisor: Asst. Prof. Dr. Ayşe YETER GÜNAL
September 2021
121 pages

Variations in temperature and precipitation values are common all over the world because of climate change. Turkey has also been affected by these variations as much as the world has been affected. Due to the limited water resources in some regions and the increasing water demand, necessary analyzes are needed while considering various conditions. In this study, the regions, which represent similar climatic features, in the Kızılırmak Basin are considered. The trend analysis is performed in this research using the precipitation and temperature data obtained from the General Directorate of Meteorology for the stations (Aksaray, Kulu, Keskin, Yozgat, Kayseri, Nevşehir, Çiçekdağı) covering the period of 1960-2020. While performing the trend analysis, the results of the Mann-Kendall Test and Şen's Trend Test were discussed. The study results showed that there is an increasing trend for temperature with respect to each method. For precipitation, the maximum monthly precipitation total showed an increasing trend at Keskin station while similar results are obtained by both methods. On the other hand, not a significant trend is obtained in the Menn Kendall test for precipitation parameter in other stations while the trend is not observed in Şen's Trend Test because of the inconsistency in scattered plots.

Key Words: Precipitation, Temperature, Precipitation Trend Analysis, Temperature Trend Analysis, Sen's Tendency Test, Mann – Kendall, Regression

ÖZET

TREND ANALYSIS OF TEMPERATURE AND PRECIPITATION VALUES IN KIZILIRMAK BASIN

NACAROĞLU, Seda
Yüksek Lisans Tezi, İnşaat Mühendisliği
Danışman: Asst. Prof. Dr. Ayşe YETER GÜNAL
September 2021
121 sayfa

İklim değişikliğinden kaynaklı olarak yeryüzünde sıcaklık ve yağış değerlerinde değişiklikler meydana gelmiştir. Dünyanın etkilendiği kadar Türkiye'de bu değişikliklerden etkilenmiştir. Bazı bölgelerde su kaynaklarının sınırlı olması ve suyu olan talebin artması sebebi ile çeşitli koşullar için gerekli analizlere ihtiyaç duyulmaktadır. Bu araştırmada Kızılırmak Havzasının kapsadığı iklimsel olarak birbirine yakın ; yağış ve sıcaklık yapılarının birbirine parallel olduğu yedi şehirden 1960-2020 yılları arasında (Aksaray, Kulu, Keskin, Yozgat, Kayseri, Nevşehir, Çiçekdağı) Meteroloji Genel Müdürlüğü'nden alınmış yağış ve sıcaklık verileri ile trend analizi çalışması amaçlanmıştır. Trend analizi çalışması yürütülürken Mann-Kendall Test'i ile Şen'in eğilim testi kullanılmıştır. Çalışma sonuçları sıcaklık için iki yöntemlede artan bir trendin olduğunu göstermiştir. Yağış için ise maksimum aylık yağış, Keskin istasyonunda iki yöntemlede aynı sonucu vererek artan bir eğilim göstermiştir. Fakat diğer istasyonlarda yağış için Menn Kendall testinde anlamlı bir trend göstermezken Şen'in eğilim testinde düzensiz dağılımlar sebebi ile bir trendin varlığından söz edilememiştir.

Anahtar Kelimeler: Yağış, Sıcaklık, Yağış Trend Analizi, Sıcaklık Trend Analizi, Şen Eğilim Testi, Mann – Kendall, Regresyon

ACKNOWLEDGEMENTS

In the realization of this study, she shared her valuable information with me, spared me her precious time whenever I consulted her, and did her best to be helpful to me with patience and great interest, that I could go to her without hesitation whenever I had a problem, who did not spare me her smiling face and sincerity, and who gave me her gift in my future professional life. My esteemed advisor, whom I think will benefit from valuable information I would like to thank Asst. Prof. Dr. Ayşe YETER GÜNAL and express my gratitude.

I would also like to thank my committee members for letting my defense be an enjoyable moment, and for your brilliant comments and suggestions, thanks to you.

Finally, I would like to thank my family for their support in my work, their trust in me, and my biggest chance in this life, who brought me to this day by raising me to know the meanings of the words love and respect.

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CRED	The Centre for Research on the Epidemiology of Disasters
ET	Evapotranspiration
EU	Europen Union
FAO	Agriculture and Food Organization
GAP	The Southeastern Anatolia Project
ICID	International Irrigation and Drainage Commission
IPCC	Intergovernmental Panel on Climate Change
ppmv	Parts Per Million by Volume
SPEI	Standardized Precipitation Evapotranspiration Index
SPI	Standardized Precipitation Index
UN	United Nations

CHAPTER I

INTRODUCTION

Warming in the atmosphere, which has been consistently increasing since the industrial revolution, has been becoming more pronounced in today's ultra-consumer society, with environmental and social effects that are becoming increasingly difficult to counteract. The main result of global warming is global climate change. Historical results have been observed from time to time in natural climate change, which revealed a team, mass production, and the beginning of the human-nature relationship with the absolute rule of the people as it is considered as a turning point that led to the industrial revolution gained with a different dimension. Following this procedure, faced with the reality of global climate change caused by human production and consumption and causing global warming.

Global warming is often regarded as one of the most pressing issues of our day. Almost all scientific institutions and news organizations agree that the planet is warming. The global temperature is expected to rise by 1.5 to 5.0 degrees Celsius per century. Summer and winter temperatures in Turkey are predicted to rise by 2.0°C - 3.0°C by 2030, while winter precipitation will increase by up to 10%, summer precipitation will decrease, and drought will increase in terms of soil moisture.

Turkey is one of the countries that will be affected mostly by climate change, especially due to global warming. It clearly can be observed in its complex climate structure. Since it is surrounded by seas from three directions, it has a defective topography and orographic features so that different regions of Turkey will be affected by climate change in different forms. Water resources in dry and semi-arid locations, particularly the quality of water resources in cities, will create new challenges, increasing the need for drinking water even more. For several years, Turkey's average precipitation was 631 mm, however, in 1999 and 2000, the amount of precipitation decreased by 15% and 7%, respectively. The departure in the precipitation regime, in addition to the decrease in average precipitation, is a reality to be recognized. Reduced precipitation and changes in the precipitation regime have a negative impact on agricultural production. Furthermore, if drought-related conditions persist, greater water-related issues are projected in the coming years.

The semi-arid and semi-humid regions of Turkey, such as central Anatolia, South-Eastern Anatolia, the Aegean, and the Mediterranean, which are particularly vulnerable to desertification, may have significant consequences for agriculture, forestry, and water resources.

Turkey's National Climate Change Strategy document (2010-2023) studies for climate change and adaptation activities within the scope of active and continuous coordination by providing a transparent, participatory, and based on scientific studies, decision-making processes are stated as the strategy to develop with.

The need for water and energy has caused us to become more sensitive about precipitation from a socio-economic point of view so that more studies on this issue are performed accordingly. In this study, precipitation and temperature trends of meteorological data in Aksaray, Kulu, Keskin, Yozgat, Kayseri, Nevsehir and Çiçekdağı were examined between 1960 and 2020. The purpose of the study is to investigate significant decrease or increase trends in precipitation and temperature for the study area.

Excessive and unthinking resource usage has recently resulted in global warming, which has resulted in climate change. Some global and regional repercussions of global climate change are likely to emerge. Forests, agriculture, clean water resources, vegetation, energy, sea level, biodiversity, and human health are all predicted to be impacted by global climate change. However, it appears that global climate change will have certain social and economic consequences. [1].

Besides, climate change affects stream flows, ground water, and water volumes in lakes depending on changes in temperatures and precipitation. This effect does not follow a predictable pattern, but it does result in a drop in precipitation in the winter, a spike in summer precipitation, and extreme seasonal temperature averages [2].

It is clear that climate change, which has direct and indirect effects on water resources, increases the importance of these resources. As a result of climate change, there are major issues with water resources. For example, it is projected to result in a drop in forestry and agricultural products, as well as energy shortages and population migration from coastal to interior locations [3].

In this study, the precautions and researches to be taken are summarized by examining the effects of climate change on water resources in Turkey. For this purpose, theoretical knowledge has been presented by making a literature review from various sources.

1.1 Climate Change, Its Effects and Possible Solutions

1.1.1 Climate Change

Climate change is defined as sudden and severe changes in average weather conditions as a result of human actions that disrupt the composition of the atmosphere over extended periods in a given place, either directly or indirectly.

Sometimes, the concepts of climate change and global warming are confused. Global warming is the case where human beings cause the earth to warm more than normal by triggering the increase in greenhouse gas as a result of various activities [4].

According to the United Nations' Intergovernmental Panel on Climate Change (IPCC) predictions, global temperatures would rise by 1 to 3.5 degrees Celsius between now and 2100. According to the most optimistic scenario, there will be a 0.1 degree increase every ten years. As a result, a rise in sea levels, changes in temperature, and precipitation regimes would have widely varied repercussions, some of which could be catastrophic [5].

Types and severity of disasters vary from country to country. For instance, hurricanes, floods, storms, tornadoes, drought, forest fires, and typhoons are frequently experienced in Asia and America where the most severe disasters are experienced and caused loss of life and property. Frost, floods, forest fires, drought, severe precipitation, snow, and storms are the most common meteorological natural disasters in Turkey.

Natural disasters are classified according to the disaster by The Centre for Research on the Epidemiology of Disasters (CRED) (Table 1.1).

Table 1.1 Classification of natural disasters with respect to the type of disaster [6]

Geophysical	Hydrological	Meteorological	Climatological	Biological	Extraterrestrial
Earthquake	Flood	Storm	Drought	Animal Accident	Effect
Mass Movement (dry)	Landslide	Extreme Temperature	Glacial Lake Eruption	Epidemic	Space Weather
Volcanic Activity	Wave Effect	Fog	Destructive Rural Fire	Insect Invasion	

In the twentieth century, the temperature increase at regional and global scales has been proven by scientific data. It is generally accepted that such an increase will cause climate change as it has already started [5]. The earth is in a dynamic position in terms of the energy it receives from the sun and emits it into space. Besides, such a balance governs the processes related to warming, wind, precipitation, evaporation, and ocean currents. The energy equilibrium of the earth is changing while fluctuations from the sun also affect internal factors, namely volcanic eruptions. Long-term global warming trends are determined to be higher between longitudes 40 ° -70 ° N and high altitude regions. Turkey is also taking place in this band. Particularly, the countries of the Mediterranean region are geographically one of the areas that are affected most by the current global change [7].

Today, among the factors of climate change that prevail in different parts of the world, there are large-scale air movements rather than temperature. Therefore, as in many countries of the world, Turkey is also affected by meteorological events. Increasing atmospheric temperatures will affect low and high-pressure centers and ocean currents. Excessive pressure types in the regions, for example, excessive-high pressure, high drought, and low pressure are expected to cause more precipitation. The change of ocean currents is about to affect the precipitation regime. In some areas, excessive precipitation will cause flooding. Floods are considered to cause death and economic loss in countries like Turkey, which are located near rivers.

Climate change is inextricably linked to the hydrological cycle and the global availability of water resources, both of which are critical. As a natural consequence of the increase of greenhouse gases in the atmosphere, changes in temperature, evaporation, air and soil moisture, and precipitation regimes are expected to affect the hydrological process, the state of water resources, agriculture, mining and hydro-energy activities, aquatic life in lakes and rivers, and other land-dwelling creatures, including human beings. Climate change, surface temperatures, evaporation, and precipitation regime variation are among the dominating factors accelerating the global hydrological cycle.

Changes in frequency and increase in the amount of precipitation will affect the amount and frequency of streamflow as well as will affect water resources at the regional and local scale. As a result, events such as floods, floods, and drought are expected to occur more frequently.

Factors such as drought and excessive precipitation disrupt the water quality as well as the amount of water. In case of a decrease in rivers and lakes during the dry months, the concentration of pollutants from point sources is about to increase. Such a problem is common in the vicinity of water bodies where Turkey is also located in. Particularly, the countries of the Mediterranean region are geographically one of the areas affected most by the current global change [7].

Large-scale air fluxes, rather than temperature, are among the climate change elements that exist in diverse places on the planet. Therefore, as in many countries, Turkey is also affected by meteorological events. Increasing atmospheric temperature is affecting low and high-pressure centers and ocean currents. Excessive pressure types in the regions, for example, excessive-high pressure, high drought, and low pressure are about to bring more precipitation. The change of ocean currents is predicted to change the precipitation regime. In some areas, excessive precipitation would cause flooding.

The hydrological cycle and the availability of water resources are directly linked to climate change. As a natural consequence of the increase of greenhouse gases in the atmosphere as well as variations in temperature, evaporation, air and soil moisture, and precipitation regimes affect the hydrological process, the state of water resources, agriculture, mining and hydro-energy activities, aquatic life in lakes and rivers, and other land-dwelling creatures, including human beings. Such factors as climate change, fluctuations in surface temperatures, evaporation, and precipitation regime accelerate the global hydrological cycle.

This is expected to impair the water quality. In the case of hot water, the dissolved oxygen, which is one of the water quality parameters, tends to decrease so that it would bring serious pollution problems. For instance, during floods, soil and other pollutants transported to a reservoir indicate low water quality. The loss of water quality as a result of climate change is predicted to raise the economic burden as well as put human health at risk. The recent rise in sea level, for example, causes saltwater intrusion into the aquifer and a decline in water quality in the Cukurova region. Furthermore, due to heavy and unexpected rains conveying parasite infections, the increasing temperature would cause a fall in the oxygen content in the water and deterioration of the water quality.

Climate change is not simply an environmental issue, but also a threat to long-term growth. Planning in this regard and managing the risks arising from it requires sustainable development and economic growth since ensuring the safety of life and property of the society is one of the basic needs of people's welfare [8].

1.1.1.1 Causes of Climate Change

The possible causes and effects of climate change are provided in Figure 1.1. Among them, greenhouse gases are the human-induced dominant factors causing climate change and global warming. They are originated from the burning of fossil fuels, industrial activities, cement production, transportation, and changing the use of agricultural land [9].

One of the most important effects of these factors is on water resources. The studies indicated that it has increased by 0.5-0.8° C in the last century and continues to increase.

The change in temperature fluctuation causes an increase in evaporation and the precipitation regime for sure. Besides, these affect the water cycle, present water resources, aquatic ecosystems, industrial and agricultural activities, briefly speaking all living species that need water to maintain their vital activities.

Figure 1.1 Causes and effects of global climate change [10]

1.1.1.2 Temporal Changes in Greenhouse Gases and Concentrations

The process, which regulates the energy balance effect but currently causes the earth to warm more than expected, is called the natural greenhouse effect.

This natural process, which is defined as the greenhouse effect and has been regulating the energy balance of our world for hundreds of millions of years, has an average temperature of 33 ºC higher than the average temperature under ambient conditions where this process does not exist. While today's world temperature is 15 ºC on average, without the greenhouse effect, this average temperature would have been -18 ºC [11].

Since the industrial revolution, human-caused greenhouse gas accumulation in the atmosphere has continued to rise. Since 1750, carbon dioxide, methane, and nitrogen dioxide concentrations have increased by 30%, 145 percent, and 15%, respectively. If the current rate of anthropogenic CO_2 emission is maintained, CO_2 buildup, which was around 280 parts per million by volume (ppmv) in the pre-industrial period and 358 ppmv in 1994, is expected to reach 500 ppmv by the end of the twenty-first century. The extent of the rise in greenhouse gas accumulation, the radiative structure of the gases, the lifetime of the atmosphere, and the accumulation of other gases in the atmosphere all influence the scale of global warming that may follow from the increased greenhouse effect [12].

The burning of fossil and biomass fuels is one of the most significant sources of greenhouse gases. Methane gas, on the other hand, is produced by landfills and agriculture, while cement manufacture is a source of carbon dioxide emissions. The use of fertilizers, nylon-made nitrogen oxide, refrigerators, and air conditioners also increase the greenhouse gas emissions caused by fluorine. Due to the opening of agricultural lands and the destruction of forests, structures such as trees and plants that hold and store CO_2 are decreasing.

1.1.1.3 Temporal Change of Temperature Rise

The global temperature and the warming tendency on the earth's surface have not been geographically uniform but regional differences are evident. Considering the annual average surface temperatures calculated for both the northern and southern hemispheres, the year 1998 has been indicated as the hottest year since 1860 as observations with respect to reliable instruments began to be used. In other words, global warming set another high-temperature record in 1998, both globally and semi-globally. This period corresponds to a hot circuit calculated in 1998, when the yearly average temperature of the Earth near the surface was 0.57 °C warmer than normal, compared to climatological anomalies between 1961 and 1990 [13].

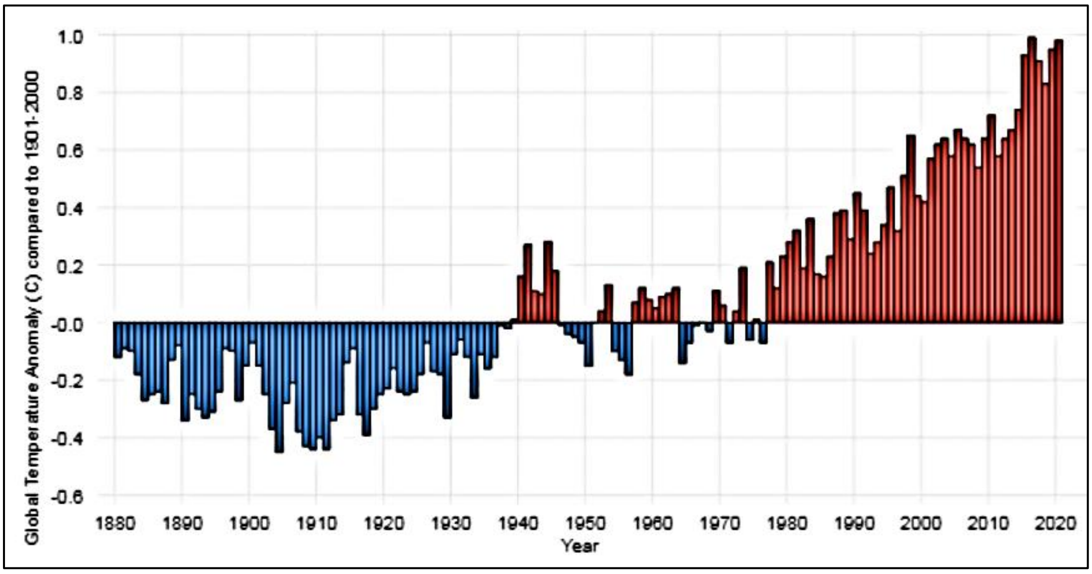


Figure 2.1 Variation of global annual mean surface temperature anomalies over the period 1860-2021 [14]

Global temperatures have been recorded since 1861. The temperature observations before these years are obtained by making various measurements such as tree rings, ice plates, and sea level. As a result of these measurements, it has been concluded that our world has experienced certain periods of heating and cooling for 4 billion years.

Between 1950 and 1993, the average maximum daytime and nighttime air temperatures increased by 0.2 °C every 10 years (Figure 1.2). In many middle and high latitudes, the increase of the frost-free season is considered as a result of increasing temperature. The water temperature in these periods was determined to be half of the earth's temperature. Besides, in recent years, the excessive development of the industry and the increase in fossil fuel use increased CO_2 emissions so that the temperature increase in the past 120 years indicates the same amount of increase in the last 20-years. In other words, the global temperature increase between 1860-1980 and 1980-2000 is equal to 0.4 °C and is a sign that human activities have increased with a negative effect on the climate [5].

According to the reasons explained, Turkey is among the risk group countries where the potential effects of global warming are about to be observed. One of the most striking changes in Turkey is the increase in summer temperatures. Summer temperature started to increase mostly in the western and southwestern regions. In addition, the amount of precipitation in the western part of Turkey in the last 50 years has decreased significantly in the winter season.

1.1.2 Possible Effects of Climate Change and Its Measures

The amount of greenhouse gases emitted into the atmosphere by the burning of fossil fuels, deforestation, land-use changes, and industrial operations has been steadily growing, since the industrial revolution. As a result, urbanization contributes to the strengthening of the natural greenhouse effect, causing global surface temperatures to rise. Surface temperature warming began at the end of the nineteenth century and became more noticeable after the 1980s when it broke world temperature records virtually every year and was warmer than the preceding year. In terms of both the worldwide average and the averages of the northern and southern hemispheres, the most recent high-temperature record was broken in 1998, which was also the hottest year since 1860.

The most sensitive climate models, which combine the impacts of greenhouse gases and aerosols, estimate a 1 - 3.5°C increase in world average surface temperatures until 2100, along with a 15-95 cm rise in sea level. Despite all its uncertainties, in the event of global warming, some serious potential changes are foreseen for some regions including extremely high temperatures, floods, widespread and severe drought events, scrub and forest fires. As a natural consequence of them, human health and the functionality of ecological systems are expected to be at a very high level of reliability [15].

Climate change due to global warming can only be avoided if the United Nations Framework Convention on Climate Change's ultimate goal is to "stop the accumulation of greenhouse gases in the atmosphere at a level that prevents the dangerous effects of human activity on the climate system," as stated in the Kyoto Protocol.

1.1.3 Possible Effects of Climate Change on Turkey

Changes in the hydrological cycle, melting of land and sea glaciers, sea-level rise, shifting of climate zones, and epidemic diseases are all projected to occur as global temperatures rise. Turkey is part of a broad climate zone known as the Mediterranean climate, which is developed in the western section of the continents in the subtropical zone. Many sub-climate types exist in Turkey, which is surrounded on three sides by seas and has an average altitude of roughly 1100 meters. Turkey will be impacted by the projected negative effects of global warming, such as water shortages, forest fires, drought, and desertification. As a result of the associated ecological degradation, it is one of the countries most vulnerable to the consequences of global warming. [16].

Climate change, which may occur in the next decades as a result of increased greenhouse gas accumulation in the atmosphere, has a variety of environmental and socioeconomic consequences. For instance, the frequency, impact area, and duration of forest fires may increase depending on the increase in the length and intensity of the hot and dry period. Furthermore, as in the geological history of the world, agricultural production potential climate zones will be able to shift hundreds of kilometers from the equator to the poles, and fauna and flora that cannot adapt to this shift in climate zones would perish. Desertification, salinization, and erosion will be aided by an increase in the duration and intensity of summer droughts, in addition to the spread of arid and semi-arid areas.

Increases in the direction of high statistical values, particularly in the frequency of hot days, may have an impact on human health and biological output. Additionally, water may submerge coasts. On the other side, the area covered by seasonal snow and permanent snow-ice cover, as well as the length of it, may be reduced. Aside from that, abrupt snowmelts and snow avalanches may become more common. Snowmelt changes the timing and volume of flow, which can have an impact on water supplies, agriculture, transportation, and recreation.

1.1.4 Potential Impacts of Global Climate Change

Global and regional repercussions of global climate change are predicted to emerge. Forests, agriculture, sea level, clean water resources, vegetative energy, biodiversity, and human health will all be affected by global climate change (Table 1.2). Global climate change, on the other hand, appears to be unavoidable in terms of social and economic consequences.

Table 1.2 Potential impacts of global climate change [17]

Sea Level Rise and Coastal Regions	Energy	Human health	Agriculture	Natural Environment and Species	Water Resources	Forests
Erosion on the beaches	Change in Energy Policies	Climate-Related Deaths	Product Losses	Losses in Natural Habitats	Reduction in Water Supply	Forest Composition
Floods	Change in Energy Consumption	Epidemic Diseases	Irrigation Problems	Decrease in Species Diversity	Decrease in Water Quality	Change in the Geographical Distribution of Forests
Costs to Protect Coastal Communities	Change in Energy Costs	Decrease in Air Quality	Change in Agricultural Lands		Competition for Water Resources	Decline in Forest Health and Productivity

1.1.4.1 Sectoral Water Pollution

People do not only use water as a physiological requirement but also use it in social, economic, cultural, and other aspects of life. Today, the places where water is used are agriculture, industry, and urban areas. A remarkable amount of water is required at home, in industry, and in agriculture in line with social and economic development throughout the world. The amount of water used for production has increased and has become directly dependent on water use. The dry regions need more water than the rainy regions due to the effect of the climate. Water requirement is also variable in developing countries and industrialized countries.

Water is also a source of energy generation, which is critical for the industry's establishment and development. As a result, measures to regulate surface waters have gained traction. The topic of water share and use has begun to rise to the fore in world politics as a result of the challenges that have arisen in water supplies as a result of climate change. Water pollution, on the other hand, has emerged as a problem that concerns all countries, as the frequency of water pollution rises in lockstep with the expansion of the consumption area. Water contamination caused by urban, industrial, and agricultural activity can all be categorized as artificial. Water contamination is caused by distorted urbanization, excessive fertilization in agriculture, and accidents in maritime shipping. Acid rain, septic tanks, and garbage spilling from landfills are just a few of the reasons that endanger water quality. [18].

The main reason for the deterioration of water quality in countries like Turkey is rapid urbanization and industrialization. Various residues from agriculture and improper agricultural practices that cause erosion and deforestation are other factors that pollute the water. Despite the high water pollution in the world, the idea of improving the water is crucial. There are limit values for the use of fresh water according to hygiene, technical, aesthetic, and political criteria. Therefore, apart from improving the quality of existing water, the social and economic structure we live in worsens the quality of it by the increase of technological activities [19].

1.1.4.2 Developments in the International Arena

Today, the main problem for many countries is the lack of water resources. However, a significant portion of water is necessary for the continuity of ecosystems but many living creatures in the world cannot even find the water necessary for their biological needs or reach water under very difficult conditions. To draw attention to the importance of water, the former United Nations (UN) secretary-general said that wars in the Middle East could arise because of water, not oil since many countries even in some industrialized countries suffer from water shortages. Currently, there is no water shortage in most industrialized countries, especially in the Europen Union (EU). However, there is a serious water quality problem due to environmental problems because of climate change problem. On the other hand, the water crisis inevitably tends to affect other developed countries in a global economy. In the next 20 years, problems of water sharing will increase both within and between countries while the problem of sharing water among agriculture, industry, and settlements is often brought to the agenda especially in countries with water shortages. If the balance between scientific and technological developments or between food and water is not resolved, then the future of mankind will face a dangerous period. It emphasizes the structural water scarcity, which is a definition brought to the fore by the critical perspective since the existing limited water resources are not equally distributed among the society. In other words, poor people cannot access water resources due to discriminatory and unfair allocation policies [20].

Water shortage is not only due to their geographical location but also the social, economic, and political decisions taken by the administrations. Water shortage can also result from wrong decisions, applied policies, and power conflicts. In a country, conflicts sometimes arise between farmers and city dwellers while it is sometimes between various settlements. For example, Bangladesh is a poor country and people meet their water requirements under very difficult conditions. As a result, the key issue is growing and sharing the country's water supply. The allocation of the restricted or precious resources available at the national level within the context of an effective and equitable institutional and legal water policy is becoming increasingly vital in order to fulfill the increasing needs, particularly in arid and semi-arid portions of the world [21].

1.1.4.3 Hydrological Effects

The availability of water resources and changes in water quality are two aspects of climate change's hydrological influence. Such changes have a profound impact on stream flows and groundwater levels. Due to changes in soil moisture and plant response to increased CO_2 concentration, evaporation from the surface of soils and plants, as well as the resulting changes in runoff, is also very relevant. Increased precipitation intensity and intensity, increased evaporation and decreased soil moisture, increased glacial melting, sea-level rise, and groundwater salinization are all major changes in the hydrological cycle as a result of climate change [22].

1.1.4.4 Effects on Water Quality

A decline in water quality may be the main reason for experiencing water scarcity. When freshwater resources are polluted by industry, urbanization, and agricultural activities, self-cleaning is limited. The increase in precipitation and the acceleration of the water flow cause a decrease in water quality. When this is the case, the water tends to carry more substances, pathogens, and pollution. Pollutants are included in the underground water and are mixed with the discharged water as the precipitation increases. Water quality is also low where arid conditions persist and underground water reserves are scarce [23].

During heavy precipitation, sediments and dispersed pollutants carry them to stream beds. Flood events increase the risk of deterioration of the quality of water resources, especially with the overflow of sewers, agricultural lands, and urban runoffs. Depending on the flood events, it can be explained by the high salinity level or the passing of polluted water to the lower layers, or the high rate of these pollutants by the water bodies located nearby. Physicochemical parameters, micropollutants, and biological characteristics can be used to track the impact of climate change on water quality (temperature, pH, dissolved oxygen, dissolved organic matter, etc.) [24].

When there is a drop in precipitation and flow, the concentration of pollutants in the water rises, resulting in an increase in microorganisms in water channels and reservoirs. Pathogenic microorganisms, such as cyanobacteria and fish, green algae, and diatoms, are water quality indicators. Their impact on water resource quality varies depending on the type of water body and its characteristics. Increasing water temperature also causes a decrease in water quality. An increase in temperature affects human health negatively by increasing the bacterial population. For this reason, the increase in temperature in the water affects the ecosystem negatively. Besides, an increase in water temperatures will reduce the amount of dissolved oxygen, which will adversely affect water quality and aquatic organisms [24].

1.1.4.5 Effects on Precipitation

Increasing temperature also causes less amount of snowfall. It is clear that the reduction or complete cessation of snowfall will have important consequences for hydrological cycles [25]. On the other hand, climate change alters precipitation distribution. The amount of rain that occurs in different places of the world and at different times of the year varies. Autumn and winter precipitation increases in the Northern hemisphere's middle and high latitudes, whereas it falls in the tropics and sub-tropical parts of both hemispheres. It is estimated that a remarkable change in precipitation is observed on land since climate change is expected to occur in some equatorial parts, in Southeast Asia, and regions close to the pole. The increase in temperature will cause more water to evaporate from water bodies so that there will be more humidity. Such a result tends to an increase in precipitation. In the previous century, precipitation across the continents has increased by 1%. [26]. In the 20th century, an increase of 5-10% was determined in the precipitation over the continents in the middle and higher latitudes. Besides, an increase of 2-4% was observed in the frequency of heavy precipitation. In contrast, precipitation on land in subtropical areas decreased by 3% [27]. In particular, there has been a decrease in the precipitation of some northern and western African and Mediterranean countries. In the last 10 years, there has been an increase in drought and temperature intensity in some continents such as Asia and Africa [28-29].

1.1.4.6 Effects on Evaporation

Potential evaporation is driven by energy-constrained atmospheric moisture content in drought regions, for example, therefore changes in humidity are relatively unimportant. The moisture content of the atmosphere is a key evaporation limitation in humid places. Therefore, changes in the humidity rate significantly affect the evaporation rate.

The impact of the evaporation process has been demonstrated to be largely dependent on the relative importance of the various variables as well as the degree of change in the underlying climate. It has been observed that increases in potential evaporation are often correlated with increases in the vapor pressure gap caused by higher temperatures.

Evaporation is influenced by vegetation, types, and characteristics. The reduction of precipitation is also highly dependent on the type of vegetation since different types of vegetation have different transpiration rates. However, different vegetation types produce different turbulences in the air over the plant while evaporation increases with the turbulence amount. As a result, a change in vegetation cover in the watershed – whether caused directly or indirectly by climate change – has the potential to impact the water balance in the watershed.

Plants also experience perspiration to some extent although the perspiration of plants through the pores (stomata) is driven by the humidity and turbulence energy in the atmosphere. Pore conductivity increases as the vapor pressure gap close to the leaf diminish in many plants, especially where water is a limiting factor. Perspiration reduces when the temperature rises or as the amount of water available to the roots decreases. The effect of carbon dioxide concentrations in the atmosphere on the short-term changes in pore conductivity is added. Decreasing carbon dioxide concentrations and carbon decrease pore conductivity in plants. The water use efficiency of plants can therefore be significantly increased. As a result, there is also a reduction in sweating. However, higher carbon dioxide concentrations are due to a higher growth rate occurring in the plant. Plants are able to adjust to higher carbon dioxide concentrations.

When the carbon dioxide concentrations are increased to 550 ppmv, there is no noticeable change in water use per unit of soil area. The consequences of carbon dioxide enrichment on basin-wide evaporation are unknown, but it has been observed that reductions in pore conductivity do not always imply lower evaporation across the basin.

The actual evaporation rate is limited by the water availability rate. Despite an increase in evaporation expectations, a drop in groundwater during the summer season can nevertheless result in a decrease in evaporation in any basin.

1.1.4.7 Effects on Soil Moisture

Temperature and precipitation variations as a result of climate change are two variables that have the potential to alter soil moisture content. It is very important in terms of yield that the moisture required for the plant is present in the soil in sufficient amounts during the plant growth period [30].

1.1.4.8 Effects on Groundwater Resources

The misuse of these areas, which are the source of important carbon sinks, causes both the destruction of the fertile surface soil and the pollution of water resources by siltation and the rapid filling of the dam lakes. Incorrect land use prevents precipitation water from leaking into the soil and causes runoff. Thus, underground water resources cannot be fed [31].

1.1.4.9 Effects on Surface Flow

The majority of hydrological studies on climate change's consequences have focused on possible runoff changes. At times, the distinction between "river flow" and "runoff" might be difficult to discern. Generally, the term "river flow" is expressed in m^3 for water flowing in a riverbed (usually the rate of flow recorded near a particular point, ie m^3). The amount of precipitation that does not evaporate is known as surface runoff, and it is commonly described as the depth of water along the watershed. A simple link that can be established between the two definitions can be expressed as follows: Runoff can be defined as the division of river flow and watershed area, however, in drought regions this may not be the case because the runoff that occurs in the part of the basin reaches a riverbed and stream flow water flowing from a catchment outlet for short periods is often referred to as "river flow" [32].

1.1.4.10 Effects on Flood Frequency

Although changes in flood frequency are often cited as a potential effect of climate change, few studies after the early 1990s specifically examined changes that can occur at high flows [33]. This flaw stems from the challenges in articulating the scenarios that apply to changes in downpours/long precipitation (or snow melt) that cause floods. Today, global climate models cannot accurately and meticulously simulate short, high-intensity local downpours [34]

1.1.4.11 Effects on Drought

Compared to floods, droughts are much more difficult to characterize. Drought is a concept as old as human history, which is defined as “the natural event that causes the land and water resources to be negatively affected and the hydrological balance to deteriorate as a result of the precipitation falling significantly below the recorded normal levels". With the phenomenon of global warming and climate change, which has been felt strongly in the previous century, it has grown even more problematic [35].

The warming trend in the atmosphere leads to more evaporation and subsequent irregular precipitation, including drought. Therefore, according to the widely spoken climate change scenarios, in addition to the drought periods that have been experienced in the past and are likely to be experienced today, humanity has faced the risk of periodic droughts as a result of the decrease in useful precipitations due to irregular rains in almost every part of the world.

Turkey and many countries of the world are about to face a serious food crisis in the coming years. Turkey is pronounced to be among the countries that will have a food crisis in the near future by the UN authorities. It should be recalled that people in Egypt, Senegal, Ethiopia, Eritrea, Sudan, and many other countries in old times attacked the food shops and crushed and killed each other in order to buy a piece of bread. The current situation is really serious and dire. The administrators of our state, especially the government and local governments, should understand and see the importance and urgency of the issue, and accordingly, necessary measures should be considered.

To mitigate the consequences of agricultural drought in the world and Turkey, measures should be taken during droughts, procedures should be prepared separately, and implementation programs should be carried out. Even if it is not possible to ensure the continuity from having heavy precipitation, it may be possible to reduce the negative effects caused by drought to a certain extent.

Of course, drought is not just agricultural drought. Climate and meteorology experts group the drought into four categories: meteorological drought, hydrological drought, agricultural drought, and socio-economic drought.

Meteorological drought is determined by making comments according to the highest, lowest, and average values of climate data such as precipitation, humidity, and temperature while it is defined based on drought duration and drought level. It is considered as the deviation from the normals (usually at least 30 years) for a certain period. These definitions are generally regional and presumably based on a full understanding of regional climatology. Normally, meteorological measurements are the leading indicators for expressing drought. An ongoing meteorological drought can intensify quickly or end abruptly. Drought periods are defined as the number of days when precipitation falls below certain thresholds.

Hydrological drought refers to the decrease and deficiencies in the earth and groundwater that occur as a result of the long-term with lack of precipitation. It can be followed by river flow measurements and lake, reservoir, and groundwater level measurements. Since there is a temporal lag between lack of rain and lack of water in streams and reservoirs, hydrological measures are not one of the first signs of drought. Long after the weather drought has passed, the hydrological drought may continue.

Drought in agriculture is defined as a lack of moisture in the root zone of a plant that prevents it from growing and developing. Agricultural drought happens during the growing season when there is insufficient soil moisture during a critical phase when a particular plant needs water. After a meteorological drought and before a hydrological drought, agricultural drought is common. Even if the soil depths are saturated, agricultural dryness can drastically diminish crop production. The consequences of little precipitation are amplified by high temperatures, low relative humidity, and drying winds.

The supply and demand of some economic items will be affected as a result of the coexistence of these three droughts. In this scenario, socio-economic drought occurs when water scarcity has a significant impact on people's lives.

1.1.4.12 Effects on Water Quality

Water supplies are projected to be affected not just in quantity but also in quality as a result of global warming and climate change. As the temperature rises, pollution concentrations are likely to rise as a result of reduced precipitation and flow, resulting in worsening water quality issues [29, 36].

Drought and heavy precipitation express pressure on water quality. The amount of water that will decrease in rivers and lakes during the dry months will lead to higher concentrations of pollutants, especially from point sources as it will also decrease the water quality. Waters with higher temperatures refer to less oxygenated waters. The drop in dissolved oxygen levels, one of the most critical drivers of water quality, causes serious pollution issues. In warmer water, the dissolved oxygen concentrations are lower, and the increased temperature also encourages the proliferation of algae millennia that consume oxygen as they rot. The river water temperature increases less than the air temperature. The least increases occur in basins with a large contribution of groundwater. Biological and chemical processes depend heavily on water temperature. Only higher temperatures will increase the concentration of some chemical species and a decrease in others. On the other hand, the chemical load of the water depends on its reach to the river bed. For example, nitrates are often taken into rivers by downpours that occur after long periods of drought [30].

During floods, for example, the quality of water coming into a reservoir is very low due to the soil and other pollutants are carried with it. It should be kept in mind that changing climatic conditions will introduce water quality problems with them as they will seriously affect human health and increase the need for water treatment by bringing economic burdens [37]. As the capacity and reserves of the water basins will decrease with global warming, it will cause an increase in environmental pollution [38]. Excessive fertilizers and pesticides used for the sake of obtaining yield that will increase salinization and salinity in agricultural lands will increase the amount of water and soil pollution [39-40].

1.1.4.13 Effects on Usage of Water

The effects of climate change on water resources are not simply determined by resource changes. Changes in demand, both from people and the environment, are other factors. It examines the impact of climate change on the amount of water withdrawn for use and how that water is used (putting these effects in the framework of demand-driven and non-climate factors).

Demands can be classified as two-dimensional "in-river" or "off-river", alternatively consumption-related or non-consumptive demands. "In-river" demands take advantage of the water in the riverbed or lake while water is not drawn for use. As an example, the use of ecosystems, transport, hydroelectric power plants, recreation, and water channels for wastewater assimilation are in this group. In "off-river" demands, water is extracted from a river, lake, or aquifer. Among them are domestic, industrial, and agricultural demands, which include water used for cooling systems in industry and power plants. These may be demands that include and do not include consumption. Demands involving consumption thus "use" water - which cannot be returned to the river as a whole. For demands that do not involve consumption, the water can be returned to the river. The primary demands for consumption are for irrigation and some cooling processes that involve the springing of water applied in industry.

1.1.4.14 Effects on Water Resources

The hydrological cycle, water resources, local-regional-global management, and distribution are all affected by climate change. The aforementioned impacts are predicted to take a long time to manifest. However, humanity is now aware of the dangers associated with this. Rivers, streams, streams, and streams undergo numerous variations throughout the year. River flow patterns are shifting, and natural disasters such as floods and droughts are becoming more common. It creates forward and backward shifts in river flow over time. In addition, stream flows are changing while groundwater feeding increases or decreases depending on regional precipitation regimes [41].

Global warming is certain to have a large impact on water supply, while increased precipitation variability is predicted to cause significant problems in agriculture. Warmer air temperatures are expected to hasten the hydrological cycle, resulting in an increase in global precipitation and evapotranspiration (ET). The temporal distribution of precipitation may also differ from its historical forms, as is the runoff caused by the melting of snow in the mountains. Although some of these changes have occurred, their regional effects are not well known. The fact that relatively modest variations in precipitation and temperature, especially in arid and semi-arid environments, have enormous effects on surface flow and volume, as well as the timing of ET, creates hydrological uncertainties. In short, global warming exposes irrigation providers and society as a whole to significant new uncertainties and problems [42].

1.1.4.15 Climate Change and Water Management Policy

Climate change is putting more strain on water management today. It gives the argument over sound management practices new dimensions and elements. This new element is based on the similarities between climate change and global warming. How can water management be commercially and efficiently adapted to climate change when the amount and direction of the change are unknown? Water resource managers have always assumed that the future resource base will be similar to the past resource base. They believe that estimations of average water reservoir efficiency or the likely maximum flood level based on past data will be valid in the future based on this assumption. There are, however, two fundamental concerns. These are evaluation alternatives for situations where there is a lot of uncertainty and judgments are made based on these evaluations.

Scenario and risk analysis are two strategies used in the evaluation of alternatives. Scenario analysis is crucial in analyzing the impact of climate change, but it is also commonly used in water resource assessments. It is done by modeling the effects of several scenarios as a general trend, similar to how climate change impacts are assessed. Diverse demand and operating scenarios, rather than different climate scenarios, typically develop in water resource assessment. According to Stakhiv [43], “climate change does not offer extra conceptual issues for water management provided water managers use a scenario-based approach.” Climate change, according to him, can only be viewed as a different form of scenario. However, given the ambiguity of climate change and the exceptional potential that it has, the typical range of scenarios studied is too small, and more scenarios must be evaluated.

Scenario-based approaches are employed by a small number of water utilities in practice. Many countries' implementation of scenario analysis might complicate traditional water management strategies.

Risk analysis, on the other hand, evaluates the risk of exceeding certain thresholds according to “futures” with different possibilities [44]. Climate change is incorporated into the risk analysis in principle by altering the underlying observations from which the data is derived in accordance with climate change predictions. Matalas [45] investigates the role of predictive simulation in the context of climate change, taking into account the wide range of "futures" frequently simulated by assuming an unchanging climate by considering the "invariance in operation" assumption against climate change, despite the fact that this is not the case in some regions. However, climate change can also forecast "future" other than "future" forecasted in a state of "immutability".

1.1.5 International Solutions to Climate Change

Given the critical importance of climate protection for current and future generations' survival, it is clear that taking the required safeguards to prevent global warming is a top priority [46]. Global warming and climate change, which we encounter as one of the biggest global problems today, require urgent measures together with the search for global solutions. Given the consequences of climate change, such as drought, starvation, and migration, it is commonly understood that the issue is not merely an environmental one, but also one that necessitates economic and international collaboration [47].

As the impacts of human-induced activities lead to climate change grow gradually and the threats on the environment reach frightening levels, efforts to prevent them are increasing day by day [48]. Although developed countries have a greater role in the production of climate change, the problem's influence is not restricted to developed countries. As a result, climate change is a global issue that can only be addressed by worldwide initiatives. For this purpose, countries have started the process in which they work on the solution of the problem at the international level. Due to both the occurrence and the unbounded consequences of climate change, first regional and then national measures were not sufficient for the problem in the first periods and required countries to seek solutions and act together at the international level [49].

Kyoto Protocol is the protocol that draws the most attention to the steps taken regarding global warming and on which countries concentrate the most [50]. The Kyoto Protocol is a draft agreement signed in 1997 in Kyoto, Japan, as part of the United Nations Framework Convention on Climate Change, with the primary goal of lowering global warming by reducing fossil fuel use. Actions to be obeyed by countries accepting the Kyoto protocol are as follows [51].;

i) reducing the greenhouse gases emitted to the atmosphere between the years 2008-2012 to at least 5% below the 1990 level,
ii) switching to technology using less energy in all sectors, especially industry,
iii) using alternative energy sources to reduce fossil fuels.

In line with the recommendations of the Rio Summit in 1992, 43 new members were accepted to the World Water Council, which was established in 1996 by more than

160 members with 340 members from 65 countries [52]. In its own network architecture, the World Water Council has brought together public institutions, private sector enterprises, UN affiliates, and non-governmental organizations. It aims to increase awareness and sensitivity towards vital issues such as effective conservation, development, planning, management, and facilitation of use in all aspects and at all levels, including the highest level decision mechanisms based on the benefit of life as well as within the framework of the principle of sustainability [53].

The objectives of the EU water policy are the protection of surface and groundwater in a holistic manner, ensuring the improvement of water depending on the water quality categories specified in the directives in 2015, integrated management of river basins, evaluation of water quality standards, emission control, participation of citizens in water management, and management of demand in water use. Considering the environmental policy of the Union, these objectives can be added to the approaches of eliminating, reducing, and preventing pollution as well as preventing all kinds of activities that will harm the ecological balance of water resources by seeking a joint solution to the problems related to water resources with member countries and other non-member countries, especially with international organizations. Providing sufficient drinking water, mitigating the negative effects of flood and drought, protecting the environment, and providing sufficient water for other economic requirements are the main objectives of sustainable water policy [54].

The concept of sustainability in water resources management includes the principle of transferring all elements (water resources, vegetation, animals, etc.) to future generations under the best conditions without causing unwanted changes in the operation of the system in the environments they are connected to. In terms of sustainable agriculture, preserving the quantity and quality of water, not polluting ground and surface waters, and preventing water loss due to improper irrigation methods are important issues [55].

To protect the ecological balance and ensure the long-term growth of human societies, water resources should be utilized in the most sensible way possible to fulfill current and future needs. Rivers are the most widely used renewable water resource on the planet. Humankind uses rivers practically to the last drop in agriculture, which is the sector that consumes the most water, due to the rapid expansion in the world population and, as a result, the demand for food. Many big rivers, such as the Ganges, can no longer reach their deltas today. In the upcoming period, as the seas rise, such stream beds and saline waters will advance into the lands and cause salinization in soil and water resources [41].

It will be beneficial not to overload groundwater during periods of severe drought and to activate surface water resources during these periods. Especially in areas close to the seas, excessive use of groundwater causes sea waters to move to these areas and it is not possible to recover these salted resources [41]. The management of water resources, which has decreased due to climate change, requires the implementation of different ways of thinking today. Ensuring efficiency, fairness, and harmony in irrigated areas, especially in the transmission and distribution of water, is the first condition. As a matter of fact, high-yielding varieties that are very sensitive to water and fertilizers will be produced under the aforementioned conditions and the expectations of farmers from institutional change will be different [25]. Effective agricultural irrigation is required as a result of global warming and, as a result, a loss in water resources as a result of climate change. Although it will be difficult to swiftly adapt agricultural infrastructure to climate change, new tactics can be developed and implemented. These are, in summary, reduction of irrigated area, development of drought-resistant plants, increasing irrigation efficiency (fulfillment of technical applications required by irrigation method, application of modern irrigation technologies that save water, implementation of appropriate irrigation programs, etc.), development of appropriate crop rotation systems, and implementation of incomplete irrigation strategies [56].

Water resources in the world are limited according to the increasing demand. For this reason, the United Nations Agriculture and Food Organization (FAO) and other international organizations (International Water Management Institute, International Irrigation and Drainage Commission-ICID, etc.) It is emphasized that efficient use of resources is extremely important, and micro-irrigation methods should be expanded to achieve this.

Efficient and rational use of water should be ensured with the support of newer technologies such as desalination and water reuse instead of traditional methods. Conventional irrigation methods that cause soil desertification and excessive water consumption should be urgently changed, investments for the transition to closed system drip-sprinkler methods should be encouraged and farmers should be trained. Especially rainwater, city, and industrial wastewater should be treated and reused. In the construction, flow, and operation of infrastructure facilities for environmental protection such as water, wastewater, and solid waste, the most suitable systems and technologies should be preferred; technologies that consume less water and energy should be encouraged; effective use of water resources should be ensured by reducing losses and leakages in existing water supply facilities and water resources should be managed from a single source. Within the framework of integrated basin management, water resources should be planned with a long-term perspective. The use of water resources should be planned very well. In this sense, water storage systems should be given importance and necessary precautions should be taken. The effects of climate change on water resources should be modeled while adaptation needs and costs under different scenarios should be determined as well as reflected in long-term water plans.

Since climate change will change the frequency, severity, and impact areas of flood disasters, risk maps should be prepared for flood disasters. Measures should be taken to protect groundwater and its balance. The public should be educated to be aware of how much water to use while strategies should be established to make water use more efficient. Permanent solutions and projects should be produced instead of solutions that save the day. It should not consume water as if it is an unlimited resource, on the contrary, conscious consumption of water should be made widespread [57].

To mitigate the harmful consequences of climate change, necessary steps should be done within the context of water resource management. Within these measures, firstly, a water budget should be made by modeling the data available from the past to the present on a basin basis. Considering that healthy and sufficient data refers to correct projects, the number of meteorology and current observation stations should be increased. Climate change impacts on the basin should be modeled, and future predictions should be used in water resource initiatives such as drinking, irrigation, and energy. Water pollution brought on by industrialization and population increase must be appropriately addressed [58].

1.2 The Effects of Climate Change on Water Resources in the World and Turkey

1.2.1 Effects of Climate Change on Water Resources

Water has been a very important natural resource for all civilizations for centuries while all remarkable civilizations have been established by the water. With the advancement of technology, the increase in the demands of water use and the development of water resources for various purposes such as drinking, irrigation, and energy have played an important role since water has an indispensable place in the economic development of countries [59].

Of the 1,384 * 109 km^3 of water in the earth, 97.39% corresponds to seas and oceans while 2.01% is polar glaciers and 0.60% is fresh water resources such as groundwater, lakes, and rivers. 70 thousand km^3 of the 110 thousand waterfalls on the land every year are lost by evaporation while 26 thousand km^3 are spilled into the seas as floods. 14 thousand km^3 of water flowing back is the amount of usable water where a significant part of which should be left to natural flow to protect wetlands, deltas, lakes, and rivers and to preserve water quality [60]. Approximately there is 8000 m^3 of waterfall per person on average. Considering this average, the demand of humanity for water is far below the amount that can be renewed every year. However, this is not correct since there is no equal distribution of water in terms of time and place. Rapid population growth, urbanization, climate changes, economic development, and globalization gradually increase the pressure on water resources, especially in regions with scarce water. There is a water crisis in some of the world's population, which is still 40% but is predicted to affect 60% of the world population within 15 years [61].

Most of the rainwater flows by floods, either falling too far or to be used or necessary for the balance in the ecosystem. In addition, pollution is rapidly destroying usable water resources in many places. Looking at many major cities with the main food production regions signaling thirst, it is clear that the food production and economic life in the world are in danger. In addition, the regional water problem is expected to become an even more complex while serious problem as global warming caused by greenhouse gases changes the precipitation pattern as it is vital for agriculture and cities [61].

Climate change is expected to drastically alter precipitation distribution, amount, and temperature values. Temperature, precipitation, water resources, flow, evaporation, soil moisture, groundwater, surface water, flood formation, snow and ice, water quality, and erosion (erosion) are all effects of climate change that must be identified [62].

Possible effects of climate change on water resources are pronounced in various reports as well as by IPCC [63]:

- There may be more intense precipitations with differences in timing in places where precipitation has been habitual for many years.
- According to the general circulation models, changes in temperature from 1.5°C to 4.5°C will cause an increase of 3% to 15% in the amount of precipitation.
- Although there may be uncertainties in its regional distribution, precipitation will generally increase at high latitudes, especially in winter.
- There may be reductions in flows relative to the water balance as a result of high evaporation rates due to increased temperature in response to the tendency of precipitation to increase.
- There may be increased flows as a result of excessive precipitation at high latitudes. In some regions of low latitudes, there may be a decrease in flows with decreasing precipitation on the one hand and increasing evaporation effects on the other.
- Although the temperature rises, actual evapotranspiration may increase or decrease depending on ground humidity and groundwater level.
- With global warming, an increase in the number of floods can be expected after rains. In some areas, floods may be less frequent and frequent than usual.
- It can be concluded that it will be more effective as a result of decreasing precipitation in drought areas and periods by increasing temperature, decreasing precipitation frequency, and increasing evapotranspiration.
- Water shortages are becoming increasingly severe, especially in arid and semi-arid countries, and drought areas and time frames are expanding.
- As a result of the temperature increase in mountainous regions, excessive precipitation will occur so that snowfall tends to decrease. Even if there is snowfall, they would not remain on the ground due to the rain so that the snowmelt that occurs in the spring months causes a decrease in the surface water supply.

- In general, as a result of the decrease in the number of flows, deterioration in their water quality should be expected.
- The main approach to researching expected climate change is to match global circulation models with hydrological models.

Many scholars have looked at the effects of climate change on water resources and basin hydrology [64]. Temperature, precipitation, and flow patterns will all alter as a result of climate change, according to studies. However, significant changes will occur in water resources, surface water resources, snow storage, and groundwater potential. Therefore, changes in the natural and agricultural water requirements of plants will occur, and irrigation management will change as a result. In this case, issues such as water distribution between sectors, water treatment, water demand management, control of water use, expanding the observation network, and increasing large-volume storage structures will be considered as a priority. In addition, it is estimated that many endemic species may disappear with the possible climate change, some changes may occur in plant species in agricultural activities while important problems may arise in terms of hydrology and water resources and salinity problems may occur in soils [65].

1.2.2 Water Resources in the World

The world's total water volume is 1.4 billion km^3, with 97.5 percent of it being salty and 2.5 percent being freshwater resources. Lakes, rivers, dams, and ponds contain only 0.3 percent of all freshwater.

Such a distribution implies that the amount of freshwater available among the world's water resources is limited, if not non-existent. Approximately 1.5 billion people do not have enough drinking water, 2.5 billion do not have access to safe water, and 7 million people die each year from water-related diseases.

1.2.3 Water Resources in Turkey

Turkey's renewable water potential is 234 billion m^3, with groundwater accounting for 41 billion m^3 and aboveground water accounting for 193 billion m^3. The amount of surface and groundwater that can be utilized technically and economically for various purposes in Turkey has been calculated to be 110 billion m^3.

In order to be considered rich in terms of water, the average rate of 10.000 m^3 water per person per year is defined. “Water-Poor” countries are those with a water potential of less than 1,000 m^3. Turkey has a usable water potential of 3,690 m^3 per capita and is among the countries with water constraints although it is not water since it is well below the world average of 7,600 m^3. In Turkey, the per capita usable water amount is 1,346 m^3 [66].

1.2.3.1 Misuse of Water Resources and the Relationship between Climate Change

The uncontrolled water used in the soil in arid and hot climates to increase agricultural production and productivity in regions with low rainfall incorporates the naturally available salt in the soil. This surplus water also moves the salts in the soil and groundwater upwards by raising the groundwater. With the effect of the heat, it leaves the salts it carries to the soil surface where it evaporates rapidly forming icing on the soil surface, limiting agricultural production, and reducing productivity. Even the good quality water of the Euphrates River releases around 1.1 tons of soluble salts in an area of 10 decares every year [66].

With the use of diesel engine pumps in 1940, new areas in the Euphrates River basin of Syria, where irrigation costs decreased, were brought to agriculture. In the period until 1980, extremely high salt concentrations occurred in almost half of these lands while most of these areas were abandoned. The GAP Region faces the same problem today [67].

1.2.3.2 The Impact of Climate Change on Lakes in Turkey

The significant drying up of lakes in recent years demonstrates the disastrous effects of global warming. The most recent state of Turkey's major lakes is given below.

Beysehir Lake: As the largest freshwater lake in Turkey, the drought and the decrease in water potential of approximately 23% due to the effect of agricultural irrigation increase the drought concerns.

Egirdir Lake: It is a tectonic lake with its deepest point of 13 meters and is fed by three streams and several springs. The 56 cm decrease in the water level of the lake is the biggest evidence of the dry seasons and the residual evaporation of Isparta where the lake is located.

Manyas Lake: It is the place where the Bird Paradise National Park is located. It is experiencing the driest times of its history as a result of global warming. It is observed that the water depth of the lake has decreased by approximately 0.4 m due to the drought. On the other hand, the fact that people who live by fishing from the lake are not able to fish anymore because of the negative effects of the socioeconomic structure of the people living in the region.

Ladik Lake: It is one of the 3 lakes with floating islets in the world. It is drying up because of the extreme heat and irrigation purposes. The size of the lake, which is 1300 hectares, decreased to 700 hectares due to the decrease in the water level from 6 meters to 1.5 meters. The cows and sheep used to graze on the coast of the lake but the pike generation is also in danger due to the withdrawal of the water.

Sapanca Lake: The bottling factories established in the vicinity of the sources feeding the lake. The factories are drawing more water than the amount allowed to them. Besides, the construction in the water collection basin of the lake, water intake of the industrial establishments, and Yuvacık Dam in Izmit caused a significant decrease in the water of the lake [68].

1.2.3.3 The Impact of Climate Change on Dam Lakes in Turkey

Dams in Turkey, as in all other parts of the world, are seriously affected by global warming and the ensuing climate change. On the other hand, if dam lakes are considered artificial lakes, then it seems that there is no difference from natural lakes. Therefore, the negative effects of global warming on natural lakes are also seen in dam lakes. In this context, dam lakes are adversely affected by global warming in Turkey like in all parts of the world. These negative effects can be seen as a rise in the demand for water, particularly evaporation [66].

1.2.3.4 Climate Change in Turkey and Its Effects on Water Resources

Turkey is in a climate zone known as the Mediterranean climate. Because Turkey is surrounded on three sides by seas and has an average elevation of 1100 meters, many sub-climate types have formed. This variety of climate types is due to Turkey's location on a transition zone, which is influenced throughout the year by diverse pressure systems and air types originating from polar and tropical zones. As the Mediterranean climate is dominant, summers are hot and dry while winters are cold and rainy in the southern and western parts. The climate along the Black Sea coast, on the other hand, is cooler and rainier. In Northeastern Anatolia, winters are long and harsh, while summers are brief and cold, indicating a continental climate. The Central Anatolian plateau is dominated by a steppe climate with dry summers and cold winters [9].

According to the future scenarios, the expectations are summarized below [69].:

- Temperatures will rise throughout Turkey and for all seasons (increases in summer will be relatively higher),
- The amount of precipitation will decrease in the southern portions of Turkey while increasing in the northern parts,
- The rise in sea level will affect low elevation areas of coastal cities in river deltas,
- The risks of water shortage and stress will increase throughout Turkey,
- Landslides will become more likely as the amount of precipitation increases, particularly in the Eastern Black Sea Region.,
- Weakening of the snow cover will increase avalanche risks,
- Drought and heatwave risks will increase as well as their intensity will become stronger.

In another study examined the strong relationship between precipitation and drought by using the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI) considering precipitation (total, minimum and excessive amounts) data in Turkey between 1971-2000 where dry day lengths, dry periods, and drought severity were discussed. According to the findings of this study, climate change will increase the frequency of excessive precipitation and dry periods. The number of dry days in Turkey, the frequency of the dry season, and the intensity of the drought are predicted to double depending on changes in the precipitation regime [70].

Climate change-related effects in Turkey include rising summer heat, decreased winter precipitation, loss of surface water, increased droughts, soil degradation, coastal erosion, floods, and floods, all of which directly affect the survival of water resources [71].

In the study Bozkurt & Şen [72], it was stated that the agricultural production in the Fırat-Dicle basin was seriously affected in 2008 due to the drought in the winter months of 2007-2008. Drought periods are predicted to become more frequent in the future, and the negative effects of climate change, such as land loss and desertification, will be seen in the Euphrates-Tigris basin. It has been reported that due to the geological changes, the rock slope balance will change while the snow cover will continue to decrease along with landslide risk will increase accordingly. Water quality will be harmed as a result of the goods being transported, and the amount of available water will eventually decrease as a result of climate change, increasing the pressure on water supplies. Besides, more dams may be required to protect water resources due to changing runoff times.

Ertürk et al. [73] investigated the impacts of climate change on groundwater resources in the Köyceiz-Dalyan basin, concluding that the quality of groundwater resources is deteriorating and that the ecosystem is at risk as a result of groundwater resources. The decline in quality has been attributed to reduced groundwater recirculation due to reduced precipitation. Ecosystem deterioration has been associated with changes in soil and water variables. It has been reported that when increasing summer temperatures and vegetative sweating are added, the plant presence in the region and related wildlife will be endangered. It was also stated that the decrease in irrigation water will adversely affect the agricultural sector and increase the stress on water resources.

When considering the impact of climate change on Turkey's lakes, it's clear that both quantity and quality are likely to be significantly impacted. Tuz Gölü, for example, has shrunk in size from 92562 hectares in 1987 to 32552 hectares in 2005, a 35 percent reduction. On the other hand, in Lake Beyşehir, which is a freshwater lake, the water potential has decreased by 23% due to drought and agricultural irrigation. Likewise, the water amount and surface area of Eğirdir, Manyas, Ladik, Van, and Sapanca lakes have decreased significantly [74].

CHAPTER II

LITERATURE REVIEW

There are various studies on precipitation and temperature trends in the world and in Turkey. In these studies, Mann-Kendall (MK), Regional Average Mann-Kendall (BOMK) tests have been applied to meteorological variables such as precipitation and temperature so far. The main objective of this chapter is to conduct an exhaustive literature review of past climate change studies with the aim of identifying the types of changes in climatic data. This chapter includes researches which have been done in recent years on trend analysis related to precipitation and temperature.

2.1 Trends related to precipitation in the World

Keim and Müller (1992) stated in their studies that the 48-hour annual maximum precipitation series had a non-significant increasing trend at the 5% significance level over the last 14 years (1978-1991) [75].

Lettenmaier et al. (1994) looked for evidences of long-term trends in precipitation, mean temperature, temperature range, and streamflow over the continental USA by adopting the Mann–Kendall test. They also tried to investigate seasonal and spatial characteristics of climatic variables using large data sets of 1009 streamflow stations and 1036 stations, a subset of the Historical Climatologic Network throughout the continental USA. Increase in precipitation during autumn was found in a quarter of the entire stations, mostly located in the central part of the USA [76].

Gan (1998) applied the Mann-Kendall test to the temperature and precipitation data between the years 1949-1989 at 37 stations in Canada and determined that the temperature increased and drought began in the last 40-50 years. He stated that temperature was more effective than precipitation in the onset of drought [77].

Akinremi et al (1999) tested precipitation data in Canada by applying regression analysis to 75-year records of 37 stations. The result of the analysis showed several precipitation events with significant increases. It has been found that 16 of the examined precipitation stations have increased in the last 75 years. There was no change in precipitation during the 1921-1960 periods [78].

Naidu et al. (1999) applied linear regression test to 124 years of precipitation data between 1871-1994 at 29 stations. As a result of the test they applied, they determined that the west, north and east of India showed decreasing trend, while the northwest, west and peninsulas showed an increasing trend [79].

Molnar and Ramirez (2000) stated that the intensity, season and variation of precipitation are the climate movements that play an important role in the development of the dry valley. Here, the course of precipitation was analysed annually, daily, monthly, on the time scale of the last 50 years of data [80].

Robert and Stogner (2000), in their study between 1977-1999 in the Ruxton park and Pueblo region, found the annual precipitation in general above the average and in an increasing trend. They found no trends in Colorada, but found a slight significant increase in seasonal (April-June) trend analysis [81].

Zhang et al. (2000) analysed precipitation totals and ratios of snowfall to total precipitation in Canada during the 20th century and pointed out a prevailing wetter pattern in Canadian climate. They also emphasised significant increasing trends in annual precipitation totals and decreasing trends in winter precipitation [82].

Yue et al. (2003) applied cross-correlation Mann-Kendall test to data of approximately 100 years at 22 stations in 3 different geographical regions in Japan. As a result of the study, there was no increase in May in the I. Region, no decrease in April, September, October, and December, and no change in annual precipitation. They determined a decrease in annual precipitation in the region and a decrease in monthly precipitation during September-January and in December. III. In the region, they determined a decrease in annual precipitation and a decrease during September-February, in June and July, and it was revealed as a result of the study that the highest decrease occurred in December [83].

Gemmer et al (2004) applied the Mann-Kendall test to monthly precipitation data at 160 stations between 1951 and 2002 in China. They determined that the increase in precipitation data in China is mostly in January, June and July, and the decrease in precipitation data is in February, September and November [84].

Birsan et al. (2005) analyzed the trends in three different data periods (1931-2000, 1961-2000 and 1971-2000) with the MK test, using the average daily flow and precipitation and daily maximum and minimum temperature variables of 48 basins in Switzerland. They also showed the maps of the change of the 4 seasons in three different time intervals [85].

Modarres et al (2007) decided that there was no significant trend except for 2 stations according to the Mann-Kendall rank correlation test statistics they applied to the precipitation data at 20 stations in arid and semi-arid areas in Iran [86].

Gallant et al. (2007) examined trends in rainfall indices from January 1910 to August 2005 using an updated high-quality rainfall data-set from the Australian Bureau of Meteorology. Nine indices, reflecting changes to mean annual/seasonal rainfall and extreme daily rainfall (defined by the 95th and 99th percentiles), were evaluated for six regions in the east and southwest of Australia [87].

Caloiero et al. (2009) analysed annual and seasonal precipitation over 109 cumulated rainfall series with more than 50 years in Italy (Calabria). They used both nonparametric (MannKendall test) and parametric(linear regression analysis) procedures [88].

Tupe et al. (2010) analyzed the daily rainfall data of Akola for last 36 (19712006) years. The mean annual rainfall was 790 mm with 27 % variability. The monthly mean rainfall was observed to be11.8, 144, 195.7, 209.7, 115.1 and 53.2 mm for May, June, July, August,September and October respectively [89].

Rio et al. (2011) analysed annual, seasonal and monthly rainfall trends from 1961 to 2006 period applying various statistical tools to datafrom 553 Spanish weather stations. They applied geostatistical interpolation techniques to generate rainfalltrend surfaces. Trends revealed that rainfall is generally decreasing in January,February, March, April, and June [90].

Jain and Kumar (2012) reviewed studies pertaining to trends in rainfall, rainy days and temperature over India. They used Sen's non-parametric estimator of slope to estimate the magnitude of trend. There were differences in the results of the various studies, and a clear and consistent picture of rainfall trend has not emerged. In a study on basin-wise trend analysis, 15 basins had decreasing trend in annual rainfall; only one basin showed significant decreasing trend at 95% confidence level. Among six basins showing increasing trend, one basin showed significant positive trend. Most of the basins had the same direction of trend in rainfall and rainy days at the annual and seasonal scale [91].

Pal et al (2017) investigated and assessed the significance of the potential trend of three variables rainfall, temperature and runoff over the Rangoon watershed in Dadeldhura district of Nepal. Trend analysis was carried out on monthly, seasonal and annual basis using the data period between 1979 to 2010 for rainfall and temperature and 1967 to 1996 for runoff. Mann-Kendall test and Sen's slope estimate test were applied to identify the existing trend direction and Sen's slope estimator test were used to detect the trend direction and magnitude of change over time nvestigated The rainfall seasonal trend analysis indicates that monsoon and post-monsoon period showed a positive rainfall trend with z statistics of +1.93, and +1.12 respectively, whereas pre-monsoon and winter seasons showed a negative trend with z statistics of -1.02, and -0.54 respectively [92].

Getachew (2018) used the MK trend test for the analysis of rainfall and temperature trends in the south Gonder zone (Ethiopia). The study found that a statistically significant increase in Nefas Mocha and Addis Zemen for mean annual temperature [93].

Panda and Sahu (2019) examined long-term changes and short-term fluctuations in monsoonal rainfall and temperature over Kalahandi, Bolangir and Koraput (hereafter KBK) districts in the state of Odisha. They analyzed both rainfall and temperature data for period of 1980–2017. They used statistical trend analysis techniques namely Mann–Kendall test and Sen's slope estimator to examine and analyze the problems [94].

Alsubih et al. (2021) inspected and quantified the change of precipitation in the highland of Aseer region of Saudi Arabia. Forty-eight-year long historical rainfall data series (1970–2017) from 30 rain gauges scattered across the study region was used for the analysis. Considering high spatial and temporal variability of rainfall data, the temporal scale chosen for the study was annual, rainy season (Mar–Jun), and bi-monthly. The trend was investigated using Mann–Kendall (MK) test [95].

2.2 Trends related to precipitation in Turkey

Kadıoğlu et al. (1994) found an increase in seasonal and annual precipitation data for the periods after 1982 in the study they conducted at 68 stations located in the west of Anatolia between 1930-1932. Toros et al. (1994) concluded that although the trends of the annual and seasonal precipitation series of 18 precipitation observation stations in Turkey were not in a certain direction, there was a decrease especially in the winter months and an increase in the spring, although it was not significant [96].

According to the Mann-Kendall and Pearson tests applied to the long annual 1 and 24-hour annual maximum precipitation series of 14 precipitation observation stations located in the Eastern Mediterranean region, Atar (1996) obtained the result that the 24-hour precipitation series of Adana, Ceyhan and Mersin were important according to different importance levels [97].

Türkeş (1996) applied the Mann-Kendall test to annual and seasonal precipitation data at 91 stations in Turkey between 1930-1993. According to the test, a decrease was found in the Black Sea and Mediterranean Regions and a decrease in the annual series in Turkey. In addition, significant trends were found in 17 stations, and significant decreases were detected in 15 of them [98].

Topaloğlu (1999) applied the Spearman rank correlation test to the annual instantaneous maximum data (n = 15-56 years) of 13 stations in the Seyhan river basin and did not find a significant trend in the flows. However, a decreasing trend was found in basin flows in general (8 stations) [99].

Kadıoğlu (2000) applied the Spearman and Pearson rank correlation test to the monthly total precipitation data at 85 stations between 1931-1990 in Turkey and determined that the change and the percentage of precipitation vary from one region to another.

During the winter months, there was a decrease in precipitation in Anatolia and the Black Sea, and an increase in the Mediterranean and Aegean regions. In the spring, there was a decrease in Anatolia and coastal areas and an increase in the south of Anatolia. In addition, an increase in the eastern borders of Turkey and a decrease in the Black Sea were determined during the summer months [100].

Topaloğlu (2001) tested the usability of 24-hour maximum precipitation series at 5% significance level at 39 precipitation observation stations in the Seyhan basin. According to the Spearman test results, which he applied to determine whether there was a change in the series of Precipitation Observation Stations (POS), there was a 5% significance level and a trend towards a decrease in 17 of the precipitation observation stations and an increase in 22; It was determined that there was a significant trend in precipitation data at Adana, İmamoğlu and Kamışlı precipitation observation stations [101].

Aksoy (2002) investigated whether there is an increase or decrease in annual and seasonal precipitation by applying Mann-Kendall trend analysis to the annual and seasonal precipitation amounts of 12 stations in the Mediterranean Region. In the Mann-Kendall Trend analysis, no statistically significant increase or decrease in precipitation was detected in the Mediterranean Region [102].

Tecer (2004), in his study in Rize, determined two separate periods for precipitation and the Mann-Kendall Rank correlation test was used in both periods. The average precipitation amounts of these periods, which were between 1975-1984 and 1985-2001, were 2092 mm and 2279 mm, respectively. It was confirmed by the t-test results that the two periods had different mean from each other at the 99% confidence interval. While the trend of the first period was towards a drier climate, the second period indicates a more rainy climate [103].

Büyükyıldız and Berktay (2004) conducted various statistical tests to determine the trends of the forty-one-year (1960-2000) monthly precipitation data of twenty-five meteorological stations in the Sakarya Basin. As a result of these tests, they stated that they found a statistically significant decreasing trend in half of the stations [104].

Partal and Kahya (2006) applied Mann-Kendall Rank Correlation and Sen's T-test, which is one of the nonparametric tests, to 96 precipitation measurement stations between 1929-1993 on long annual average and monthly total precipitation series in Turkey. In addition, the same tests were applied to the regional average precipitation series. Some important decreasing trends were observed in the annual average, especially in January, February and September precipitation. They found noticeable decreases in the observed annual mean precipitation, mostly in the west and south of Turkey, as well as along the coast of the Black Sea [105].

Sarış (2006) analyzed the changes and trends in precipitation and precipitation intensity amounts in Turkey in terms of both area and time (111 stations and an average of 61.5-year observation period). In his study to analyze the long-term monthly, seasonal and annual changes and trends in daily precipitation intensity in Turkey, he determined decreasing trends in annual precipitation and precipitation intensities. Determining that this trend is quite strong in the Mediterranean and Black Sea precipitation regime regions, Sarış stated that there is a strong decreasing trend in precipitation in Winter but an increasing trend in Summer, Spring and Autumn seasons; also stated that there is a decreasing trend in precipitation intensities in all seasons [106].

Acar and Şenocak (2007) examined the trends of short-term precipitation from 5 minutes to 60 minutes in 46 precipitation stations in Turkey between 1938 and 2000. Trend analyzes were performed at $\alpha = 0.01$ and $\alpha = 0.05$ significance levels using the MannKendall test. While no significant trend was found in 31 stations, positive trend was found in 13 stations and negative trend was found in 2 stations. It was concluded that this change is related to regional and global climate change [107].

Türkeş, Koç and Sarış (2007) took into account the long-term changes and trends in the annual and seasonal precipitation totals and precipitation intensity sequences of 111 stations in Turkey, and the characteristics of time and area. Trends in precipitation total and density sequences were investigated using the Mann-Kendall rank correlation test method. According to this study; The decreasing trends, which are evident in annual total precipitation and precipitation intensity amounts, are stronger in Mediterranean and Black Sea precipitation regime regions. Although there is a significant decreasing trend in winter total precipitation, a general increase trend is dominant in Spring, Summer and Autumn total precipitation [108].

Özfidaner, Topaloğlu and Kapur (2007) examined the statistical trends of the monthly and annual total precipitation data of the precipitation observation stations in Turkey, covering the years 1968-1997, with the Regional Average Mann-Kendall test statistics for 7 geographical regions of Turkey. In the regional scale precipitation data, there is a general decrease in the Southeastern Anatolia Region, and the tendency to increase and decrease throughout the year in other regions is close to each other. The results showed that, contrary to expectations, there was an increase in precipitation, not a decrease. However, in the Mediterranean Region, there is a general decreasing trend in precipitation and this non-significant decrease is observed in February, May, June, July, September, October and November; It is stated that the increasing trend is in January, March, April, August and December [109].

Karabulut and Cosun (2009) examined trends in precipitation at annual, seasonal and monthly time scales for the periods of 1975-2005 for the Kahramanmaraş which is mostly located in the Mediterranean region of Turkey. They used non-parametric tests (such as Mann-Kendall), linear regression, coefficient of variation techniques to determine rainfall trends. The results showed that there was no negative or positive statistically significant trend in the study area, despite of slight precipitation decrease annually for the period of 1975-2005 [7].

Topaloğlu and Özfidaner (2012) used the regional average Mann-Kendall non-parametric test with both serial and cross-correlation to detect trends for a network of 52 Turkish precipitation gauging stations for a 30-year period (1968-1997) in seven geographical regions of Turkey. The application of regional trend analysis confirmed spatial and temporal changes in the behaviour of precipitation over Turkey. The regional trend analysis revealed that almost no evidence of significant change was experienced with a general upward re-gional direction appearing primarily in the Black Sea, Mediterranean Sea, Southeastern Anatolia, Eastern Ana-tolia regions and partly in the Marmara region compared to the Central Anatolia and Aegean regions [110].

Ay and Kişi (2015) detected possible trend in monthly total precipitation rate on the basis of Mann–Kendall (MK) and a new method recently proposed by Şen trend tests. They used the method for trend analysis of monthly total precipitation data recorded at Samsun, Trabzon, Ankara, Yozgat, Adana, and Antalya provinces in Turkey. According to the MK trend test, Samsun and Trabzon generally have statistically significant increasing trend. There is no statistically significant trend (trendless time series) for Ankara, Yozgat, and Adana provinces. While the February month of Antalya shows statistically significant decreasing trend, April month of Antalya shows statistically significant increasing trend [111].

Çeribaşı and Doğan (2015) made a trend analysis of the annual average precipitation data of meteorological stations in Sakarya Basin, West Black Sea Basin and East Black Sea Basin. As a result of the analysis, they stated that there was a decreasing trend in the Sakarya Basin, there was no trend in the West Black Sea Basin, and there was an increasing trend in the East Black Sea Basin [112].

Özfidaner et al. (2016) applied trend analysis with Mann-Kendall rank correlation test to monthly total precipitation data of seven meteorology stations in the Central Anatolia Region. They concluded that there was no statistically significant trend [113].

Ay and Özyıldırım (2017) detected possible trends in monthly total rainfall and monthly mean air temperature on the basis of Mann-Kendall (MK) and a new method recently proposed by Şen. The new method is used for trend analysis of both variables' data recorded at Yozgat province in Turkey over the period 1970-2016. There was no statistically significant trend for both variables at 95% two-tailed confidence interval in the period 1970-1992 and 1993-2016 according to the Mann-Kendall trend test [114].

Demir et al. (2017) investigated the annual, seasonal and monthly precipitation and temperature trends of the province of Bingöl, located in the Eastern Anatolia Region, between 1975 and 2016, and investigated the effect on the agriculture of the region. As a result, it was determined that there were changes in the annual temperatures in the increasing direction and in the decreasing direction in the precipitation amounts in Bingöl, but these changes were not statistically significant [115].

Tosunoğlu (2017) investigated trends of daily maximum rainfall series in three time scales including annual, seasonal and monthly time series by using Mann-Kendall (MK), modified Mann-Kendall (mMK), Theil–Sen (TH) and Sequential Mann-Kendall (SMK) trend tests. These tests are applied to daily maximum rainfall data of five stations located Çoruh Basin, Turkey. The MK and mMK tests are employed to quantify significance of the trend, the TH test is used to determine magnitude of the trend and the SMK test is also applied for defining starting year of the significant trend. The results of the MK and mMK tests showed that there are considerable significant increasing trends of daily maximum rainfalls in months including January, March, July, August and October. Significant decreasing trends were detected in daily maximum rainfalls of May and December [116].

Polat and Sunkar (2017) performed trend analysis on precipitation and temperature data of four meteorological stations (Trabzon, Rize, Pazar, Hopa) using Mann Kendall and Sen methods. They stated that there was an increasing trend in precipitation data at stations other than Hopa meteorological station, and an increasing trend in temperature data at Rize, Trabzon and Hopa stations [117].

Taylan and Aydın (2018) conducted a trend analysis for monthly precipitation data of Ağlasun, Barla, Aksu, Burdur, Yalvaç, Sütçüler, Kızılkaya, Kasımlar and Gelendost meteorological stations located in the Lakes region. As a result of their statistical analysis, they stated that there was a decreasing trend in most of the stations [118].

Keskin et al. (2018) investigated the trend analysis of precipitation and temperature data of the meteorological stations of 14 provinces in the Eastern Anatolia Region with the Mann-Kendall method. In the temperature data, they reached the result of an increasing trend in 12 provinces excluding Bitlis and Erzurum provinces. While there was an increasing trend in the precipitation data in Kars and Ardahan provinces, they stated that there was no trend in other provinces [119].

Çeribaşı (2018) investigated the trend analysis by applying the innovative Şen method to the precipitation data of ten meteorological stations in the Western Black Sea Basin. He stated that out of ten meteorological stations, he concluded that there was an increasing trend in one station, a decreasing trend in four stations, and no trend in five stations [120].

Dalkılıç (2019) aimed to determine the precipitation trends in the region with the data taken from 3 stations between 1978-2018 in the provinces of Gümüşhane, Erzincan, Bayburt, where the precipitation structure is parallel to each other. Sen trend test, Spearman Rho, Mann-Kendall and Seasonal Mann-Kendall tests were used to determine the presence of trend. As a result of these tests, it was observed that there was a decrease in precipitation in certain months in the summer period and an increase in precipitation in certain months in the winter period [121].

Köyceğiz and Büyükyıldız (2019) investigated the trend analysis of extreme precipitation with Innovative Şen, Mann-Kendall and Spearman's Rho methods for Konya, Karaman, Aksaray and Niğde stations.They concluded that there was a statistically insignificant decreasing trend at the stations outside the Konya station, and a statistically insignificant increase trend at the Konya station [122].

Coşkun (2020) conducted a trend analysis by applying Mann Kendall, Spearman's Rho and Şen Test to the average precipitation data of 7 meteorological stations in the closed basin of Lake Van. He stated that there was a decreasing trend in precipitation throughout the basin, except for the Van Regional meteorological station [123].

Tokgöz and Partal (2020) investigated the trend analysis of precipitation and temperature data of 16 meteorological stations in the Black Sea Region using the Innovative Şen method and the Mann-Kendall test. In the temperature data, Mann-Kendall test yielded an increasing trend result at 7 stations, while the Innovative Şen method gave an increasing trend result at all stations. However, they stated that they reached similar results in the precipitation data [124].

Terzi and İlker (2021) applied trend analysis to the precipitation data belonging to the meteorology stations at the ten city centers in Kızılırmak basin. The precipitations data has been acquired from Turkish State Meteorological Service. Non-parametric Mann-Kendall test has been applied to determine the trend of precipitation data. Moreover amount of exchange in unit time has been determined with Sen’s trend test. Trend analysis has been carried out as monthly, seasonally and yearly for the ten city centers. As the result of the study, the notion that there is no statistically meaningful trend in precipitation data at the ten city centers of Kızılırmak basin has been reached [125].

2.3 Trends related to temperature in the World

Whitfield and Cannon (2000) analyzed current and temperature data for Canada over two different time periods (1976–1985 and 1986–1995) using Mann-Kendall [126].

Tabari, H. et al. (2011), studied Trend analysis of climatic variables has received a great deal of attention from researchers recently. The main aim of this study was to investigate trends in maximum (Tmax) and minimum (Tmin) air temperatures in the annual, seasonal and monthly time-scales for 19 synoptic stations in the arid and semi-arid regions of Iran during 1966–2005. Tabari, used Mann–Kendall test, the Sen's slope estimator and the linear regression for trend analysis. The results of this study contributed to a better understanding of regional temperature behavior in the study area [127].

Sabohi et al. (2012) investigated long-term annual and monthly trends in mean maximum, mean minimum and mean temperature at 35 synoptic stations in Iran. They assessed the statistical significance of trends by the Mann–Kendall test. Most stations, especially those in western and eastern parts of country, had significant positive trends in monthly temperature time series in summer season. However, the maximum number of stations with the positive trend were observed in April (30 stations), and then in August (29 stations) while the negative trends were seen in February (16 stations) and March (15 stations) [128].

Sonali et al. (2013) performed the study for trend analysis of annual, monthly and seasonal maximum and minimum temperatures (tmax, tmin) in India. Recent trends in annual, monthly, winter, pre-monsoon, monsoon and post-monsoon extreme temperatures (tmax, tmin) was analyzed for three time slots viz. 1901–2003, 1948–2003 and 1970– 2003. This study showed that during last three decades minimum temperature trend was present in India as well as in all temperature homogeneous regions of India either at annual or at any seasonal level (winter, pre-monsoon, and monsoon, post-monsoon). Sonali, concluded that Sequential MK test revealed that most of the trend both in maximum and minimum temperature began after 1970 either in annual or seasonal levels [129].

Gocic et al. (2013) analyzed annual and seasonal trends of seven meteorological variables for twelve weather stations in Serbia during 1980–2010. Gocic, used nonparametric Mann-Kendall and Sen's methods to determine whether there was a positive or negative trend in weather data with their statistical significance. In this study the increasing 16 trends were indicated in both annual and seasonal minimum and maximum air temperatures' series [130].

Kousari et al. (2013) investigated the trends of maximum air temperature (T max) in three time scales including annual, seasonal, and monthly time series in 32 synoptic stations in the whole of Iran during 1960–2005. Results of this study, showed that there were considerable significant positive trends of T max in warm months including April, June, July, August and September and warm seasons. These trends could be found in an annual time scale which indicated almost 50% positive trends. However, cold months and seasons did not exhibit a remarkable significant trend [131].

Ram et al. (2015) studied temporal variation in temperature in India, during the period 1980-2011. The long-term change in temperature was evaluated by Mann–Kendall rank statistics and linear trend. An important aspect of the present study was the significant cooling trend in mean annual temperature, which was more predominant during winter season. The result indicated significant slightly decrease in winter temperature at 0.01 level. This suggested that the last decade witnessed a phenomenal epoch in temperature series, leading to a decreasing trend from non-significant to significant [132].

Bhuyan et al. (2018) found that average maximum temperature shows a positive trend of increase at a rate of 0.29°C and 5.3°C per century respectively, for BMD data and MPI-ESM-LR (CMIP5) model data. But the rainfall was decreasing at a rate of 8.8 mm and 40.1 mm per century respectively for BMD data and MPI-ESM-LR (CMIP5) model data. It was seen that July was the maximum monsoon rainfall month and January was the lowest rainfall month. The peak frequency was slightly smaller than 12 months, which indicates that the major events are occurring before ending a year compared to the previous year. According to MPI-ESM-LR (CMIP5) model data, future normal temperature on north-western region would be increased at a rate of 1.62°C during the period 2040-2100 [133].

Alemu and Dioha (2020) investigated the possible trend of temperature variation as well as the effect of climate change in the study area by using trend analysis of temperature and the effect of climate variation in the city of Addis Ababa, Ethiopia. The paper seeks to provide up-to-date information for the better management of climate change in the city. The analysis is based on the temperature difference in the city over two stations—Bole and Entoto [134].

Dong et al.(2020) applied the innovative trend analysis (ITA) method to investigate trends in air temperature and precipitation over the Jinsha River Basin (JRB), China, from 1961 to 2016 based on 40 meteorological stations. The ITA results showed that annual and seasonal temperatures had significantly increased whereas the variation range of annual temperature tended to narrow [135].

2.4 Trends related to temperature in Turkey

Karaca et al. (1995) applied the Mann–Kendall test and the method of linear regression to the monthly mean temperatures to detect the urban heat-island effects in Istanbul, which is the largest metropolis in Turkey. They found positive trends for southern stations and negative trends for northern stations, reflecting the importance of densely populated districts in Istanbul [136].

Kadıoğlu (1997) used the seasonal Kendall test to detect temperature trends across Turkey and observed that there was a tendency for a warming trend over the period 1939–89, in contrast to a tendency for a cooling trend lasting from 1955 to 1989. However, these implied temperature trends were not statistically significant [137].

Tayanç and Toros (1997) detected changes in temperature and precipitation in 4 big cities and it was concluded that these were significantly related to large-scale atmospheric changes [138].

Türkeş, Sümer and Demir (2002) examined the average maximum and minimum air temperatures and daily temperature amplitudes recorded at 70 stations in Turkey during the period 1929-1999. Annual, winter and spring average temperatures have tended to increase especially in the southern regions of Turkey. It has been determined that the increase in minimum air temperatures in 31 stations, especially in the summer minimum temperatures, is higher than the Spring and Autumn minimums. Warming rates in the Spring and Summer minimums; It is also one of the study results that Spring and Summer are stronger than the maximum warming rates [139].

Şensoy et al. (2005) stated that temperatures tend to increase in Turkey, and there is a decrease in the number of frosty and icy days with the width of the daily temperature. At the same time, he emphasized that while the number of cool nights decreased, the number of warm nights increased, and both maximum and minimum temperatures increased [140].

Tecer and Cerit (2009), in their study on the trend analysis of temperature values in Rize province between 1975 and 2007, found that there was an increase of 1.61 oC in maximum temperatures over a 33-year period, and an increase trend of 0.99 oC in annual minimum temperatures [141].

Altın and Barak (2012) calculated Erinç's aridity index, the climate type of 29 meteorological stations was designated and mapped using the mean temperature and annual precipitation data of in the Seyhan Basin and its surrounding area covering the years 1970-2009. The recorded temperature data have been examined as the period (1970- 2009) was divided into two parts: 1970-1992 and 1993-2009. The long term trend of the annual mean temperature, seasonal mean temperature and total annual precipitation were analyzed using the Mann-Kendall rank correlation coefficient test and their trend ratio was also calculated [142].

Erlat and Türkeş (2013), in their study with 97 meteorology stations for the increase in the number of summer days and tropical days in Turkey until 2010, concluded that there was a positive trend in the northwest of Anatolia [143].

Doğan et al., (2014), in their study on trend analysis of temperature series in Turkey by considering the period between 1950 and 2006, found that there was a turning point in the trend as of 1992 [144].

Doğan Demir and Demir (2016) tinvestigated trends in temperature at yearly and seasonal time scales for the periods of 1975- 2015 for the Bingol which is mostly located in the Eastern region of Turkey. They used nonparametric Spearman and Kendall statistical methods analyzed in temperature trends. In conclusion, that there were determined positive increases in annually temperature trend in Bingol, but not statistically significant [145].

Ülke et al. (2018) analyzed the temperature data of the provinces of Sinop, Ordu and Samsun, located on the coastline of the Central Black Sea Region. Mann-Kendall Trend Test and Sen's Trend Slope Test were applied to reveal the changes in the data over time. The results showed that the temperature generally has an increasing trend in the region, as expected [146].

CHAPTER III

METHODOLOGY

3.1 Material and Method

Precipitation and temperature data were obtained from the General Directorate of State Meteorological affairs of Turkey to study the variation of precipitation and temperatures in the study area. Dataset obtained from 7 meteorological stations (Table 4.1) are used in the study.

3.1.1 Trend Analysis

A trend is defined as the trend within any independent variable over the observed time [66].

3.1.2 Regression Analysis

Regression analysis is a method of estimating the value of the dependent variable based on the known values of the independent variables by expressing the relationship between two or more random variables as a mathematical equation. In this mathematical representation, which is expressed as a regression equation, there is always a dependent y variable (basis) and one or more X arguments (neighbors). In such a relationship, it is possible to estimate the value of the independent variable depending on the known value of the dependent variable. Although this estimate does not fully meet the actual value that the variable will receive, it is the best estimate close to the observed value. In regression analysis, it is necessary to decide which of the two (or more) variables to look for a relationship between them, and then accept the form of the equation that shows the relationship between these variables.

Here the relationship between the variables shown by X and Y

$$y_i = a + \beta X_i + \varepsilon_i \tag{4.1}$$

The expected value of Y for a given value of x0 of variable x is defined as:

$$E[Y \mid X = x_0] = a + \beta X_0 \tag{4.2}$$

where εi is a residual term with an expected value of 0. Accordingly, the regression equation of Y relative to X is defined as:

$$y = a + bx \tag{4.3}$$

where a and b, α, and β are regression coefficients of statistical values calculated from the sample at hand. The best estimate of the variable y yi for X = xi is calculated from the equation $y = a + bx$;

$$y_i = a + bx_i \tag{4.4}$$

The observation pairs in the example (xi, yi) are plotted in the X-Y plane to see if there is a linear relationship between X and Y (Figure 3.1).

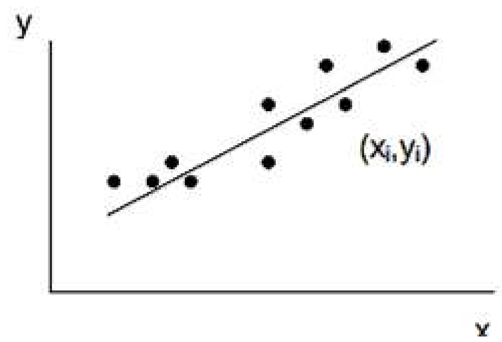


Figure 3.1 Scatter diagram of X and Y variables with a linear line fit

3.2 Mann-Kendall Test

Mann-Kendall is a nonparametric trend test. This test assumes the hypothesis that time ($x1$, $x2$, ... , xn) observation values are time-independent and random variables with similar distributions According to the $H1$ hypothesis, the distribution of xk and xj values in the series for ($k \neq j$) and (k,$j \leq n$) are not similar. Mann-Kendall test statistic,

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sgn(x_j - x_k) \tag{4.5}$$

The trend test is performed to a time series xi that is ranked from i = 1,2,………n-1 and x_j, which is ranked from j = i+1,2,………n. Each data point xi is used as a reference point, and the remainder of the data points x_j are compared to it by,

$$sgn(x_j - x_k) = \begin{cases} 1;\ x_j > x_i \\ 0;\ x_j = x_i \\ -1;\ x_j < x_i \end{cases} \tag{4.6}$$

For n ≥ 8, the statistic S is approximately normally distributed with the mean while the variance statistic is defined as,

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{k} t_i(t_i-1)(2t_i+5)}{18} \tag{4.7}$$

where t_i is the number of ties up to sample i. The test statistics of Z is computed as,

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}} \ ;S > 0 \\ 0 \qquad ;S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} \ ;s < 0 \end{cases} \tag{4.8}$$

where Z follows a standard normal distribution. An upward (downward) trend is indicated by a positive (negative) Z value. A significance level is also used to determine if a monotone trend is moving upward or downward (a two-tailed test). The trend is considered significant if Z is bigger than Z/2, where Z denotes the significance level [49,40].

3.3 Sen's Slope Estimator Test

It is a nonparametric test developed by [60]. Sen's Slope method is a test performed on the coordinate system. First, the observation times are sorted from small to large. The time intervals from the beginning to the midpoint of the time series and essentially "data of the time intervals with the order" are plotted on the X-axis while the time series and data from the midpoint to the last point are plotted on the Y-axis. Finally, the line is drawn at an angle of 0 to 45°. If the marked data remains above this line, then the trend is positive while it is negative if it remains below it.

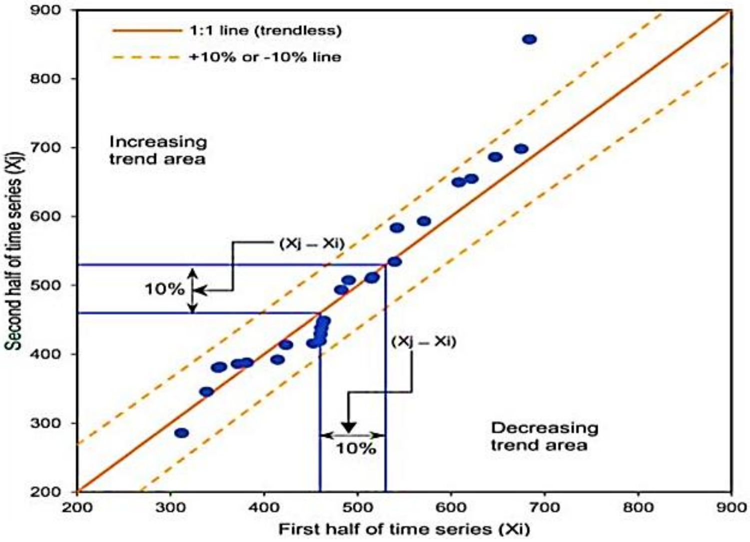


Figure 3.2 Sen’s’s Slope estimator graph

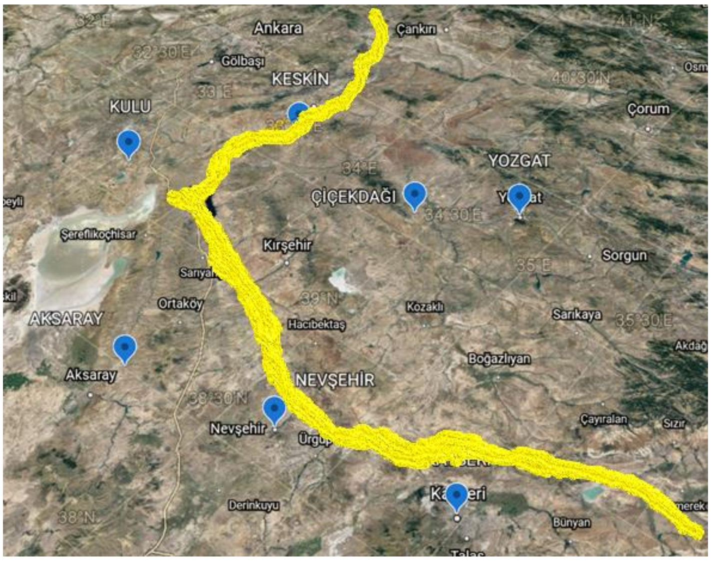
CHAPTER IV

DESCRIPTION AND STUDY AREA

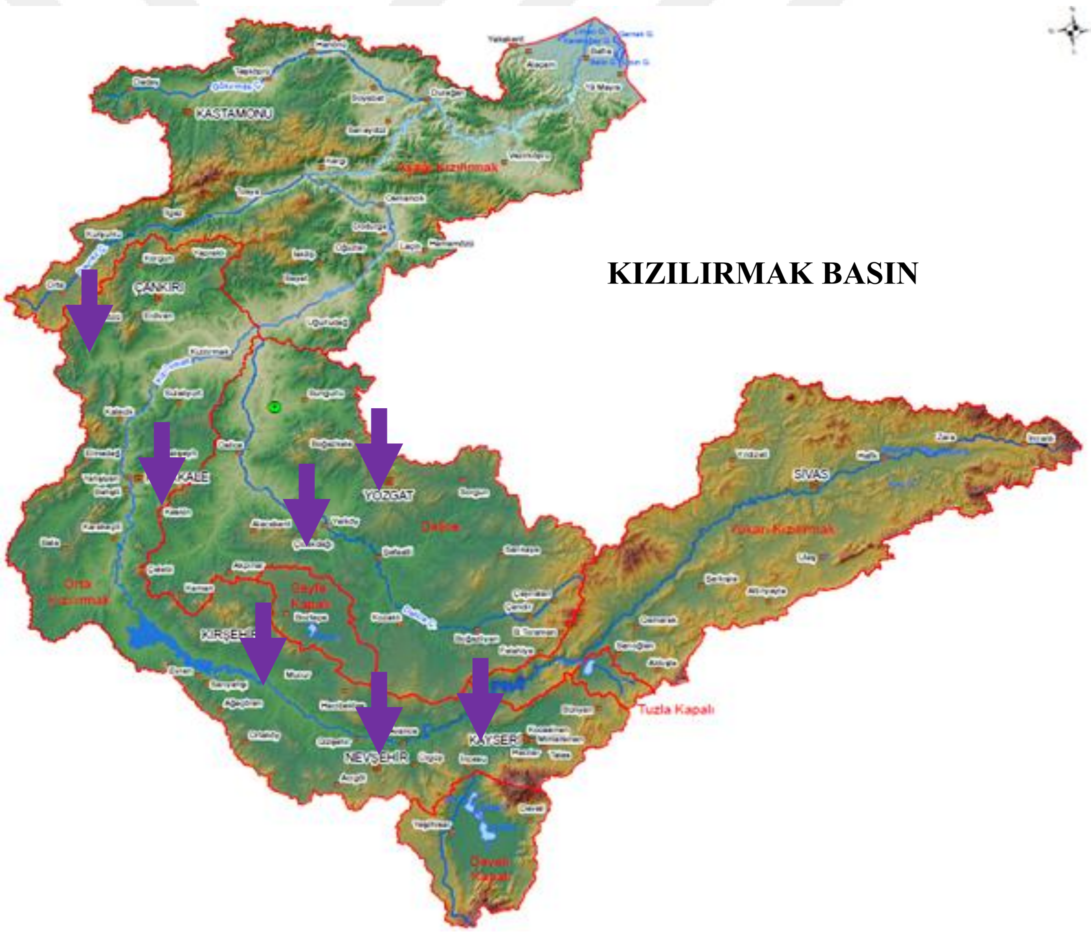
The study area selected in this study is located in the Central Anatolia Region, which is surrounded by mountains. The climate is hot and dry in summer, cold and snowy in winter because of the influence of the continental climate. The average air temperature over the domain is 13.7 °C while the annual precipitation varies from 300mm to 800 mm. It is one of the regions where drought is most intensively observed in Turkey.

The Kızılırmak River Basin was selected as the study area. For this reason, all stations used in this study are located in the Kızılırmak River Basin.

The study area covers the provinces of Aksaray, Kulu, Keskin, Yozgat, Kayseri, Nevşehir, and Çiçekdağı. The Kızılırmak Basin, located in the eastern part of the Central Anatolia Region, is the second-largest basin of Turkey. It covers the regions of Kırıkkale, Ankara, Çankırı, Çorum, Sinop, and Samsun provinces. Only the northern and eastern parts of the basin are mountainous while most of it is hilly and covers approximately 11% of the country's territory. Kızılırmak, being the longest river in Turkey, has a length of 1,151 km and a drainage area of 78,180 km^2. The total area of its basin is 8,210,007 hectares. The annual average precipitation amount of the basin, having a precipitation area of 72,278 km^2, is 164.15 m^3/s. The study area is covered with 7 meteorological stations having temperature and precipitation data covering the 1960-2020 period. The geographical location of the stations is provided in a Google Earth Pro image in Figure 4.1 while detailed maps about the province are covered in Figures 4.1.



a



KIZILIRMAK BASIN

b

Figure 4.1 a. Google map image of Kızılırmak Basin and 7 stations b. Physical map of Kızılırmak Basin

Figure 4.2 Aksaray Province map

Figure 4.3 Konya Province map

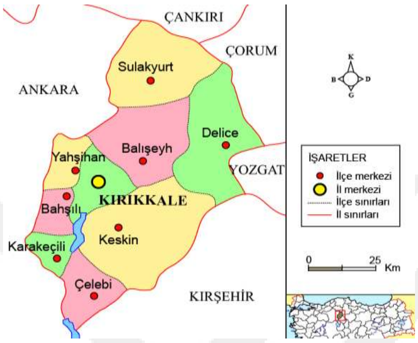


Figure 4.4 Kırıkkale Province map

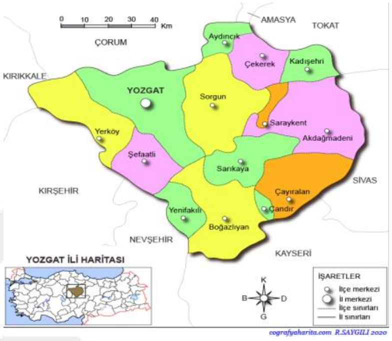


Figure 4.5 Yozgat Province map

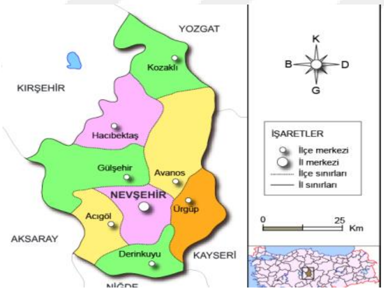


Figure 4.6 Nevşehir Province map

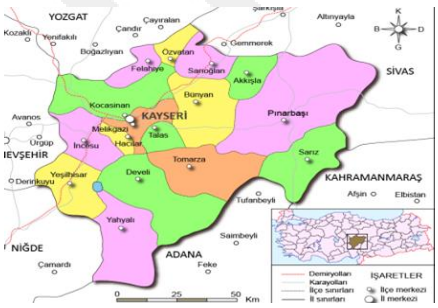


Figure 4.7 Kayseri Province map

Figure 4.8 Kırşehir Province map

A temperate continental climate is observed in the study area, where temperature differences are quite obvious. The average annual temperature is below 20 degrees, with significant temperature differences between the seasons. Four seasons are observed in the study area. The highest precipitation amount in the region is observed in the spring months. Short herbs, which bloom with spring rains and turn yellow due to summer drought, form the vegetation.

Table 4.1 Information about meteorological observation stations

Station No	Station Name	Latitude	Longitude
17192	Aksaray	38.3686°	34.0297°
17754	Kulu	39.0917°	33.0815°
17730	Keskin	39.6718°	33.6108°
17140	Yozgat	39.8210°	34.8086°
17196	Kayseri	38.7205°	35.4826°
17193	Nevşehir	38.6247°	34.7142°
17732	Çiçekdağı	39.6017°	34.4181°

CHAPTER V

RESULTS AND DISCUSSIONS

5.1 Mann-Kendall Test Results

5.1.1 Mann-Kendall Test Results For Maximum Temperature Parameter

The annual maximum temperature data is analyzed for each station using the Mann-Kendall Trend test. The visualizations of the parameters are provided separately while the statistical results are summarized in a table.

The temporal variation of the temperature parameter in the Aksaray station in Figure 5.1 indicates a significant positive trend. The S value is obtained to be positive while Z is 3.99. The Z value is greater than the 1.95 value, which is chosen as the 95% confidence interval. Therefore, the test result indicates a statistically significant increasing trend for the study period.

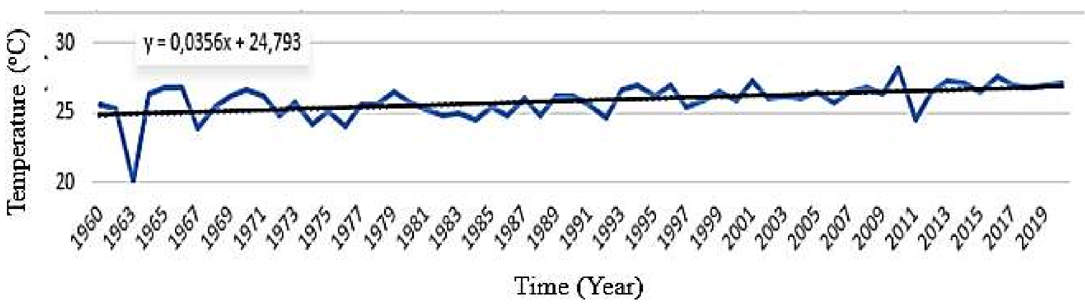


Figure 5.1 Temporal variation of maximum temperature parameter for the Aksaray station

The temporal variation of the maximum temperature parameter in the Kulu station is provided in Figure 5.2. The resulting S and Z values in Table 5.1 indicate a significant increasing trend for the parameter over the study period.

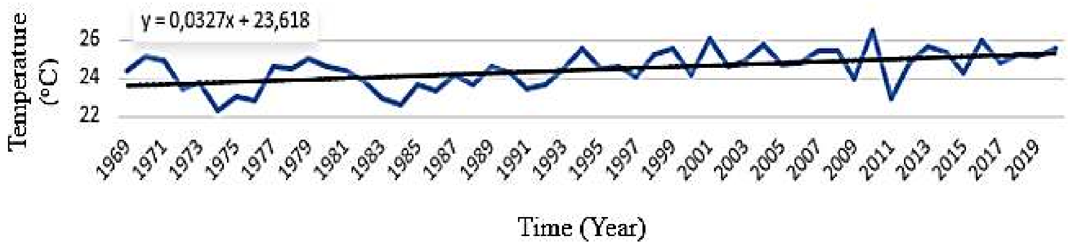


Figure 5.2 Temporal variation of maximum temperature parameter for the Kulu station

Concerning the maximum temperature data variation for the Keskin station (Figure 5.3), a significant decrease is observed in the second half of the 1980s. However, the overall analysis shows a positive trend, which indicates an increase in the maximum temperature parameter. On the other hand, the estimated S value is positive and the Z value is greater than 1.95 (Table 5.1) so that the test result indicates a significant positive trend.

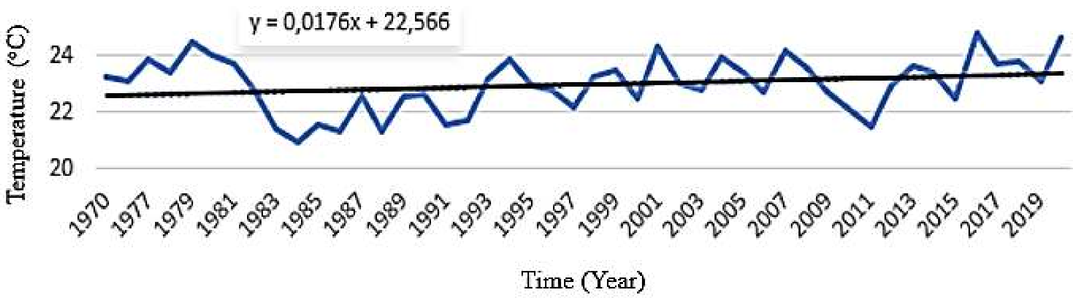


Figure 5.3 Temporal variation of maximum temperature parameter for the Keskin station

Considering the temporal variation of the maximum temperature parameter in Figure 5.4 as well as the S and Z values provided in Table 5.1, the test results for the Yozgat station indicate a positive trend for the study period.

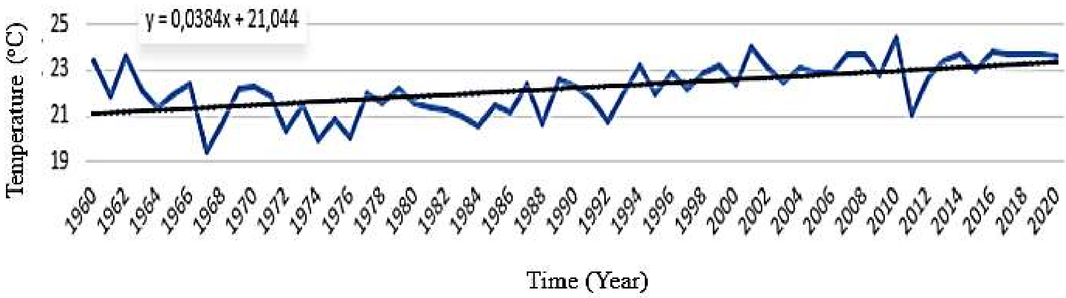


Figure 5.4 Temporal variation of maximum temperature parameter for the Yozgat station

The temporal variation of the maximum temperature parameter in Figure 5.5 for the Kayseri station indicates not a significant trend over the study period. The visual inspection of the figure shows that trends are not consistent and vary with the sub-periods. Besides, the estimated S value is zero (Table 5.1) so that the test result indicates no trend for the Kayseri station.

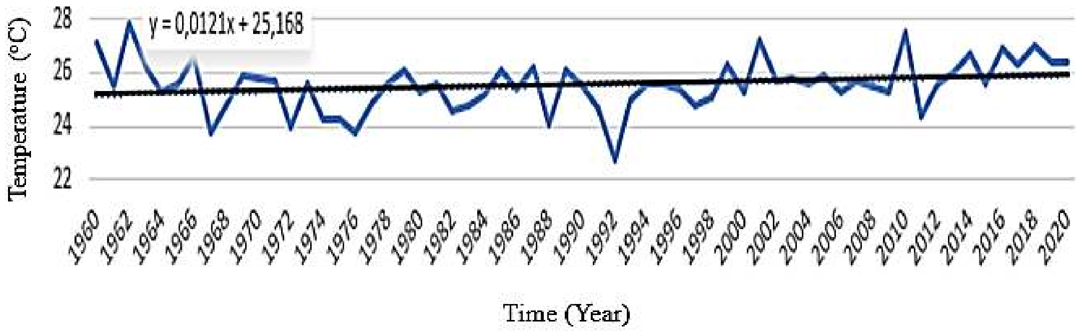


Figure 5.5 Temporal variation of maximum temperature parameter for the Kayseri station

The visual inspection of the maximum temperature parameter for the Nevşehir station in Figure 5.6 shows a varying trend behavior in subperiods. However, the estimated S value is positive and the Z value is greater than 1.96 (Table 5.1), corresponding to the 95% confidence interval. For this reason, the test result refers to a positive trend for the study period.

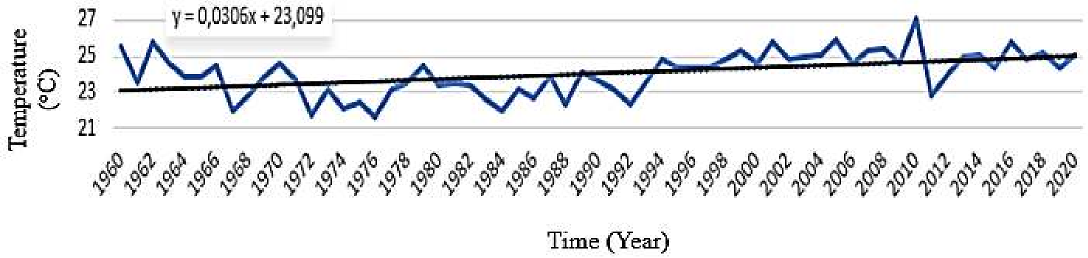


Figure 5.6 Temporal variation of maximum temperature parameter for the Nevşehir station

The maximum temperature data variation for the Çiçekdağı station in Figure 5.7 represents an increasing trend over the study period. In addition, the positive S value and the Z value being greater than 1.96 (Table 5.1) indicates an increasing trend for the whole study period.

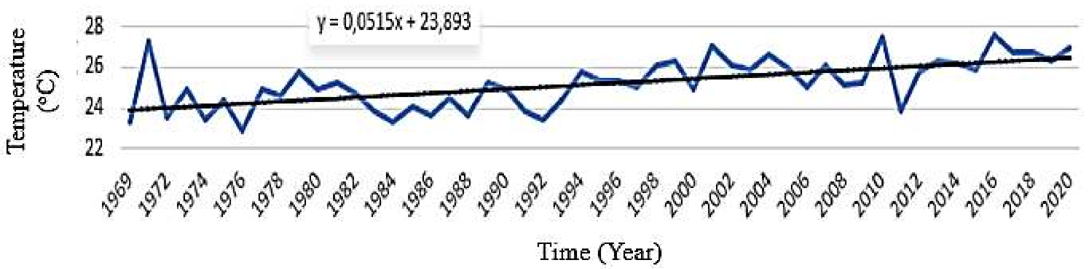


Figure 5.7 Temporal variation of maximum temperature parameter for the Çiçekdağı station

Considering the maximum temperature data obtained from the General Directorate of Meteorology for the 1960-2020 period, station-based Mann-Kendall Trend Test analysis is performed. The S and Z parameters of the Mann-Kendall Trend Test along with the test results, whether indicating trend or not, are summarized in Table 5.1 by considering 95% confidence intervals.

Table 5.1 Mann Kendal statistics for the maximum temperature parameter

City	Average Maximum Temperature (ºC)	S	Z	Trend Z (1.96)
Aksaray	25,88	626	3,99	Increasing Trend
Kulu	24,49	438	3,46	Increasing Trend
Keskin	22,24	732	4,56	Increasing Trend
Yozgat	22,98	75	1,97	Increasing Trend
Kayseri	25,28	0	-0,006	No Trend
Nevşehir	24,05	554	3,45	Increasing Trend
Çiçekdağı	25,23	566	4,60	Increasing Trend

5.1.2 Mann-Kendall Test Results For Minimum Temperature Parameter

The annual minimum temperature data is analyzed for each station using the Mann-Kendall Trend test. The temporal variations of the parameters are provided separately while the statistical results are summarized in a table.

In Figure 5.8, the minimum temperature parameter variation over the study period for the Aksaray station indicates a positive trend. In addition, the Mann-Kendall Trend test results indicated a Z value of 5.47, which is greater than 1.96 and is within the 95% confidence interval. For this reason, the test result indicates a significant positive trend for the minimum temperature parameter for the Aksaray station.

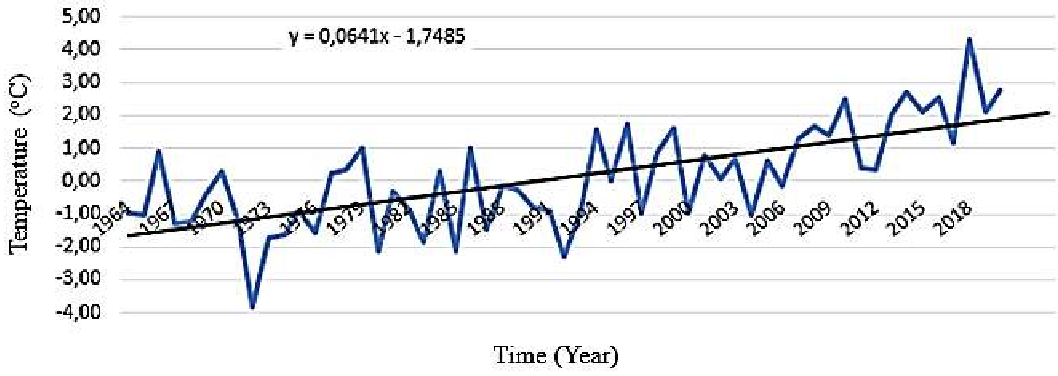


Figure 5.8 Temporal variation of minimum temperature parameter for Aksaray the station

The minimum temperature parameter variation for the Kulu station shows varying positive and negative trends for the sub-periods (Figure 5.9). However, the positive trend is dominant over the study period. Besides, the test results indicated a positive trend for the Kulu station concerning the confidence interval taken into account.

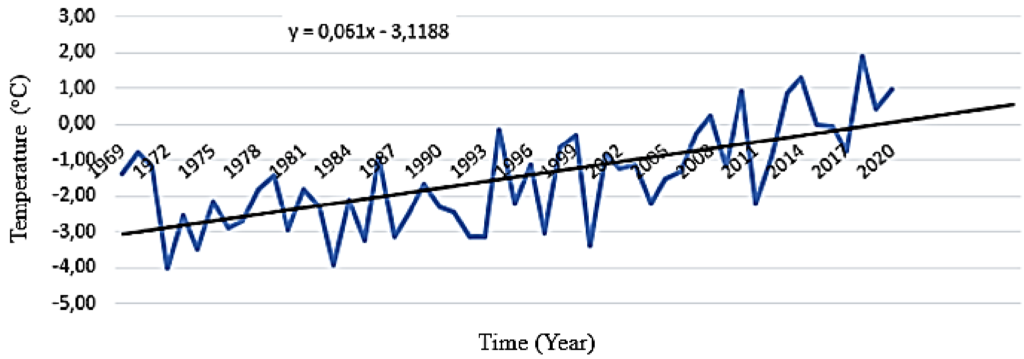


Figure 5.9 Temporal variation of minimum temperature parameter for the Kulu station

The temporal representation of the minimum temperature data for the Keskin station shows a positive trend over the study period. It is clearly shown that the parameter data represents an increasing trend. Besides, the positive S value and Z value of 4.50 (Table 5.2), which is greater than 1.96 with respect to the confidence interval, obtained from the Mann-Kendall Trend test indicates a significant positive trend.

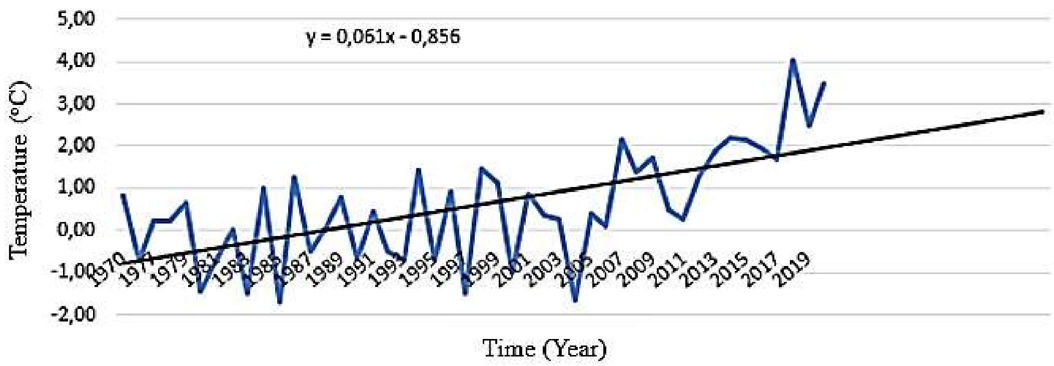


Figure 5.10 Temporal variation of minimum temperature parameter for the Keskin station

The temporal variation of the minimum temperature parameter data for the Yozgat station presented in Figure 5.11 represents a positive trend. Besides, the positive S value obtained and the Z value greater than 1.96 indicate that the analysis result refers to a significant positive trend (Table 5.2).

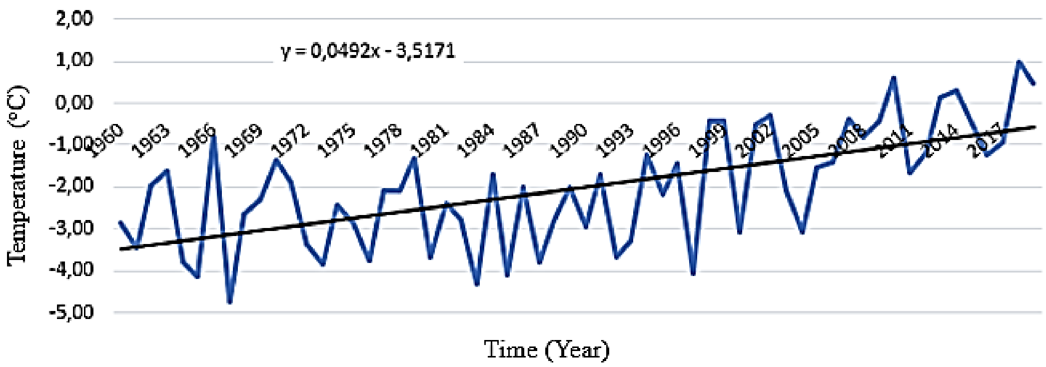


Figure 5.11 Temporal variation of minimum temperature parameter for the Yozgat station

Figure 5.12 represents that the minimum temperature parameter data for the Kayseri station represents a negative trend during the first years of the study period. However, there is a significant increase in the rest of the study period. In addition, the test statistics also indicate a positive trend when the whole study period is considered (Table 5.2).

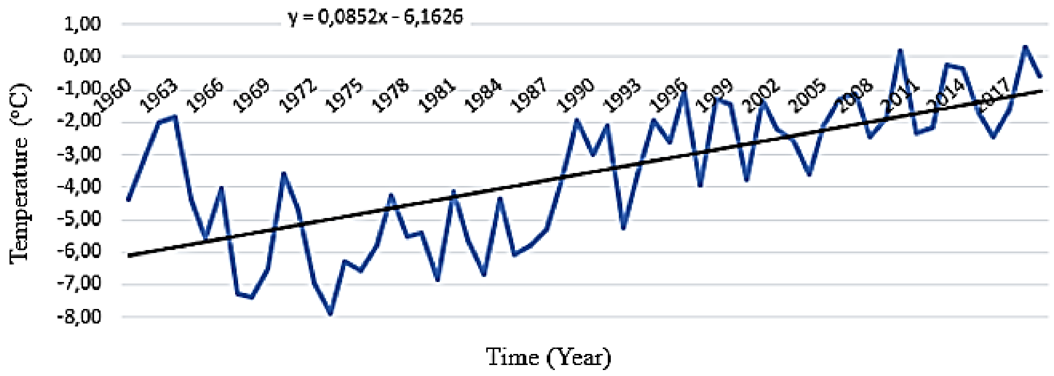


Figure 5.12 Temporal variation of minimum temperature parameter for the Kayseri station

The temporal variation of the minimum temperature parameter for the Nevşehir station shows a positive trend for the study period (Figure 5.13). The Mann-Kendall Trend test results also indicate a positive S value and a Z value greater than 1.96, which is within the 95% confidence interval. For this reason, the test result refers to a significant positive trend.

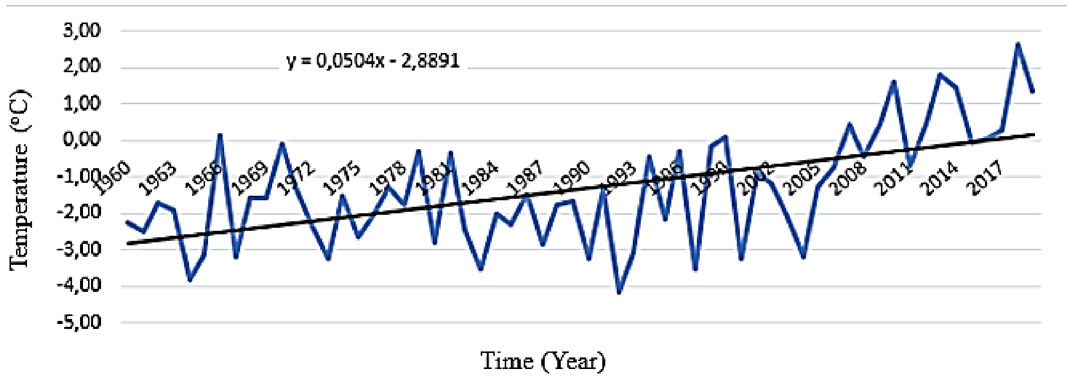


Figure 5.13 Temporal variation of minimum temperature parameter for the Nevşehir station

The temporal variation of the minimum temperature parameter for the Çiçekdağı station as well as the test results in Table 5.2 indicates that there is a significant positive trend considering the study period.

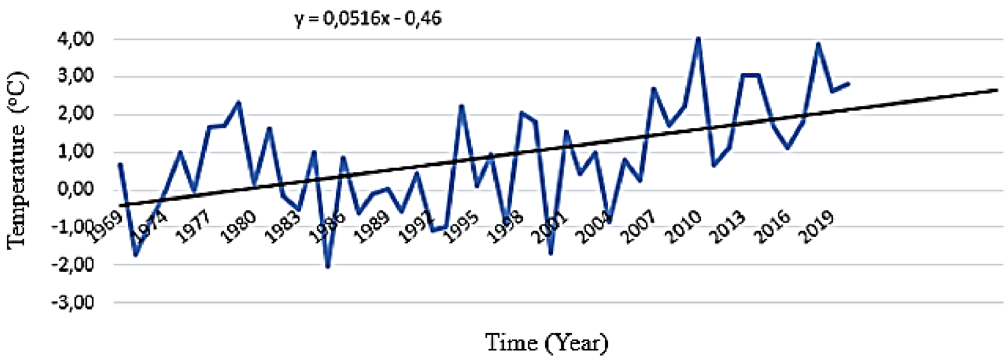


Figure 5.14 Temporal variation of minimum temperature parameter for the Çiçekdağı station

Station-based Mann-Kendall Trend Test analysis is performed considering the minimum temperature parameter data obtained from the General Directorate of Meteorology for the 1960-2020 period. The S and Z parameters of the test results, whether indicating trend or not, are summarized in Table 5.2 by considering 95% confidence intervals.

Table 5.2 Mann Kendal statistics for the minimum temperature parameter

City	Average Minimum Temperature (°C)	S	Z	Trend Z (1.96)
Aksaray	-0,82	815	5,47	Increasing Trend
Kulu	-2,29	634	5,01	Increasing Trend
Keskin	-0,19	475	4,50	Increasing Trend
Yozgat	-2,74	757	4,71	Increasing Trend
Kayseri	-4,41	931	5,79	Increasing Trend
Nevşehir	-1,31	763	4,75	Increasing Trend
Çiçekdağı	0,95	360	2,93	Increasing Trend

5.1.3 Mann-Kendall Test Results For Average Maximum Temperature Parameter

The average maximum temperature parameter is obtained by taking the maximum temperature parameter data into account. Then, the Mann-Kendall Trend test is performed for each station. The temporal variations are introduced, as well as, the test results are summarized in a table.

The temporal variation in Figure 5.15 indicates a positive trend for the average maximum temperature parameter for the Aksaray station. In addition, the test result of positive S and Z statistic, which is greater than 1.96, in Table 5.3 shows a positive trend considering the study period.

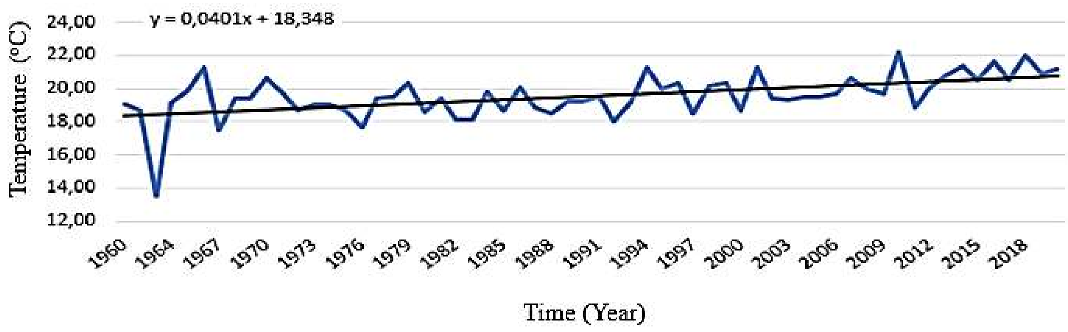


Figure 5.15 Temporal variation of average maximum temperature parameter for the Aksaray station

The temporal variation in Figure 5.16 indicates positive and negative trends for the varying sub-periods. However, the positive trend is dominant for the whole study period. In addition, the test statistics of positive S value and the Z value that is greater than 1.96 in Table 5.3 represent a significant positive trend.

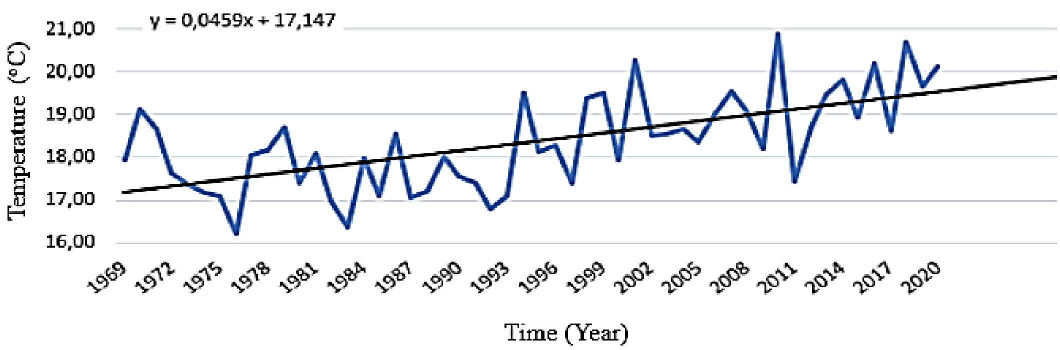


Figure 5.16 Temporal variation of average maximum temperature parameter for the Kulu station

The variation of average maximum temperature for the Keskin station is quite chaotic where negative and positive trends are observed in various subperiods (Figure 5.17). Considering the test results in Table 5.3, the Z value is obtained to be 1.93, which is positive but smaller than the value of 1.96 and not within the 95% confidence interval. Therefore, the test result indicates that there is no significant trend for the study period considered.

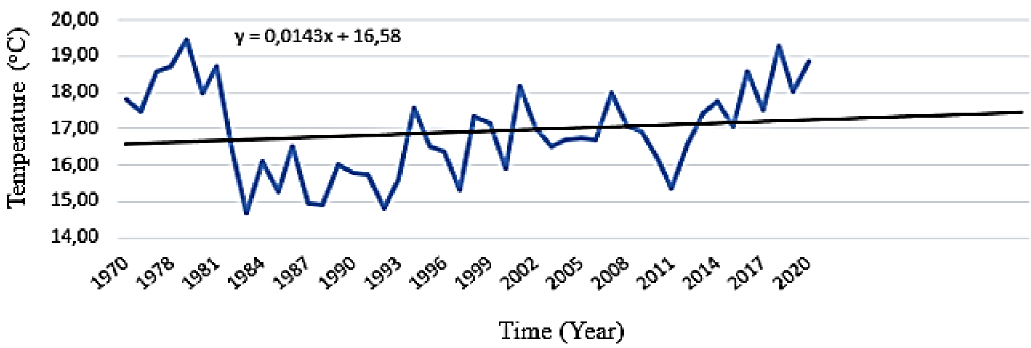


Figure 5.17 Temporal variation of average maximum temperature parameter for the Keskin station

Figure 5.18 illustrates a significant positive trend for the average maximum temperature parameter for the Yozgat station. In addition, the test results of positive S and Z value greater than 1.96 in Table 5.3 indicates a positive trend for the study period.

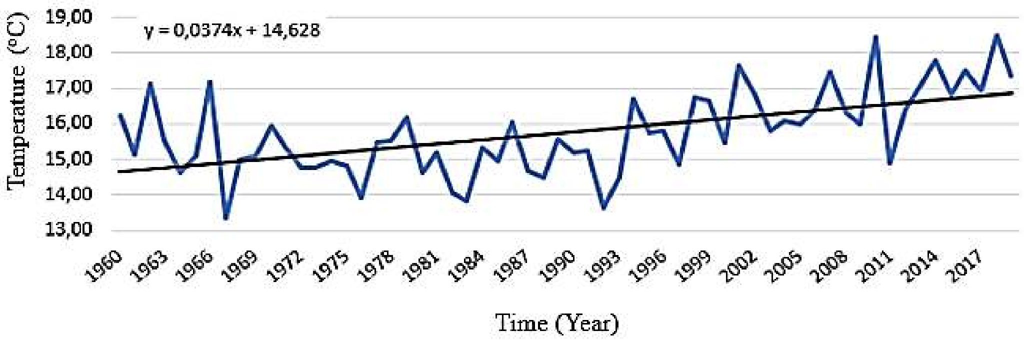


Figure 5.18 Temporal variation of average maximum temperature parameter for the Yozgat station

The temporal variation in Figure 5.19 represents negative and positive trends for the Kayseri station when sub-period are considered. However, a positive trend is dominant when the whole study period is considered. Besides, the positive S value and the Z value greater than 1.96 are provided in Table 5.3 as they indicate a positive trend.

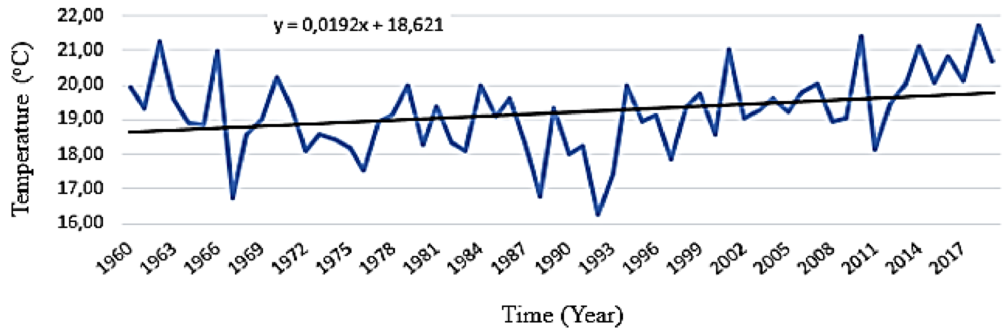


Figure 5.19 Temporal variation of average maximum temperature parameter for the Kayseri station

The illustration in Figure 5.20 represents a positive trend for the average maximum temperature parameter for the Nevşehir station. In addition, the positive S and Z value greater than 1.96 in Table 5.3 shows that the test result indicates a significant positive trend for the study period.

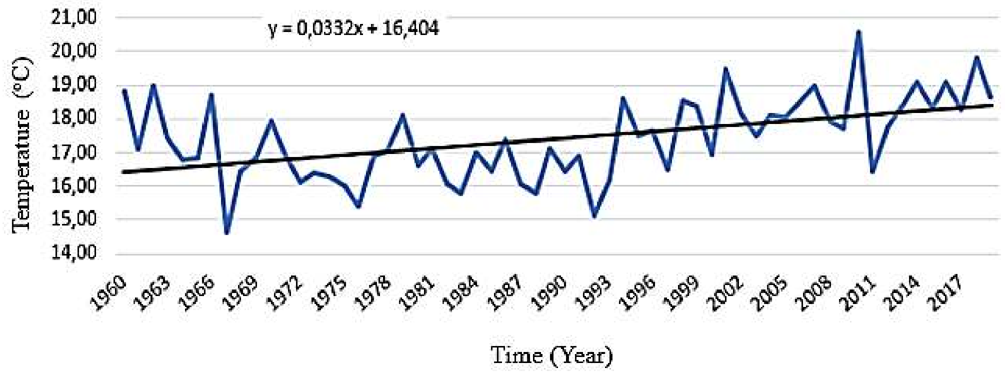


Figure 5.20 Temporal variation of average maximum temperature parameter for the Nevşehir station

Figure 5.21 represents the temporal variation of the average maximum temperature parameter data for the Çiçekdağı station. The figure indicates a clear positive trend. As the positive S and the Z value greater than 1.96 is considered in Table 5.3, it can be concluded that the test results indicate a significant positive trend for the study period.

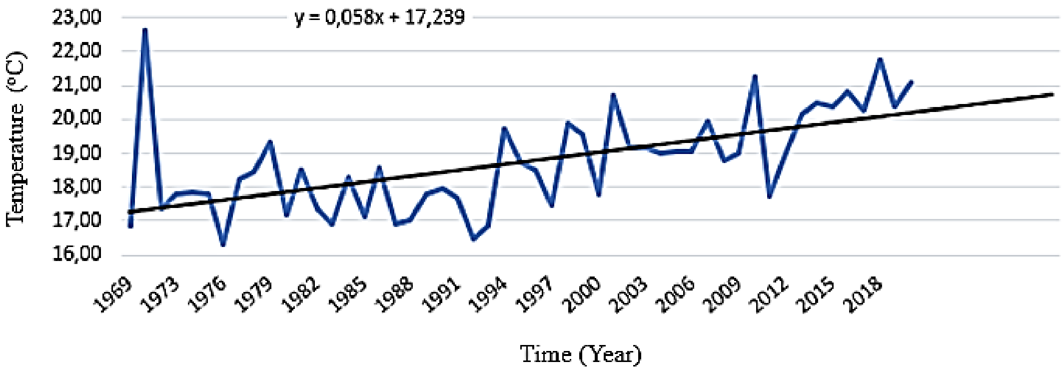


Figure 5.21 Temporal variation of average maximum temperature parameter for the Çiçekdağı station

Considering the average maximum temperature parameter data obtained from the General Directorate of Meteorology for the 1960-2020 period, station-based Mann-Kendall Trend test analysis is performed. The S and Z parameters of the trend test results, whether indicating trend or not, are summarized in Table 5.3 by considering 95% confidence intervals.

Table 5.3 Mann Kendal statistics for the average maximum temperature parameter

City	Average Maximum Temperature (°C)	S	Z	Trend Z (1.96)
Aksaray	18,53	648	4,13	Increasing Trend
Kulu	17,25	588	4,64	Increasing Trend
Keskin	15,88	203	1,93	No Trend
Yozgat	14,87	743	4,62	Increasing Trend
Kayseri	18,17	377	2,35	Increasing Trend
Nevşehir	16,48	611	3,80	Increasing Trend
Çiçekdağı	17,62	574	4,67	Increasing Trend

5.1.4 Mann-Kendall Test Results For Average Minimum Temperature Parameter

The average minimum temperature parameter for each station is determined by considering the minimum temperature parameter data. Then the Mann-Kendall Trend test is performed respectively considering this data. The temporal variations, as well as the test results, are summarized in a table.

The temporal variation of the average minimum temperature parameter data for the Aksaray station is provided in Figure 5.22. The figure shows that there is a positive trend for the study period. In addition, the positive S and Z value, which is greater than 1.96, shows that the Mann-Kendall test result indicates a significant positive trend for the study period.

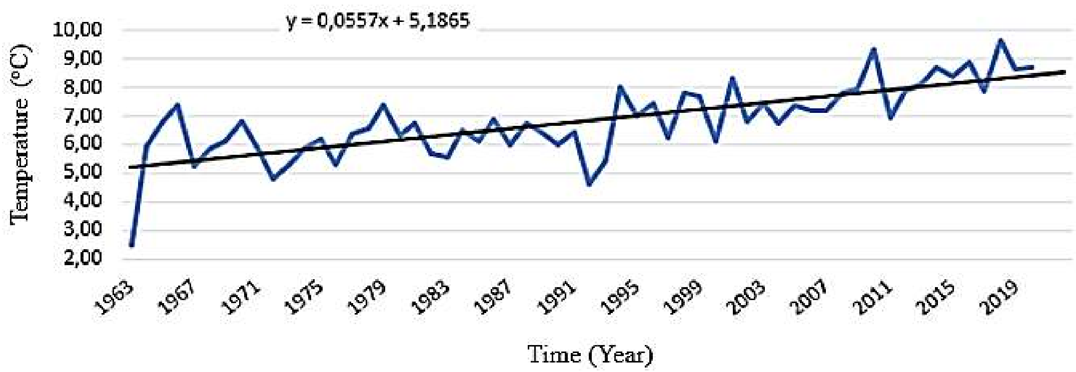


Figure 5.22 Temporal variation of average minimum temperature parameter for the Aksaray station

The variation of the average minimum temperature parameter data for the Kulu station is presented in Figure 5.23. The figure indicates a positive trend. Besides, the positive S and Z value greater than 1.96 show that the Mann-Kendall test results indicate a significant positive trend.

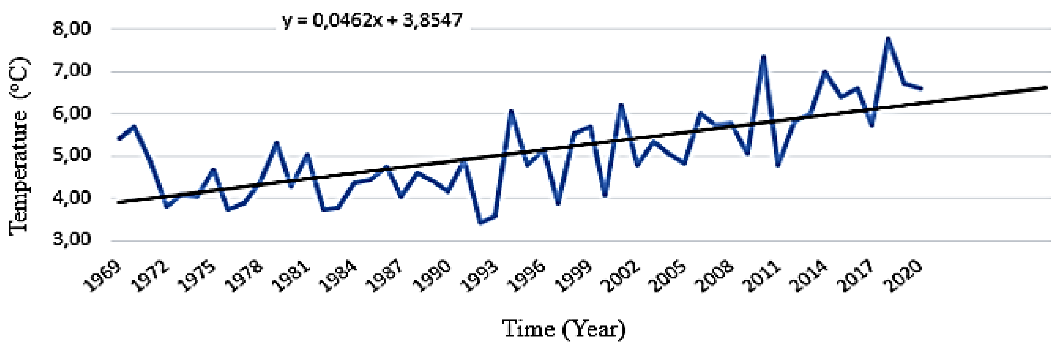


Figure 5.23 Temporal variation of average minimum temperature parameter for the Kulu station

Figure 5.24 represents that the average minimum temperature parameter data for the Keskin station has a positive trend. The positive S value and Z value, which is greater than 1.96, in Table 5.4 also show that the test results represent a positive trend for the study period considered.

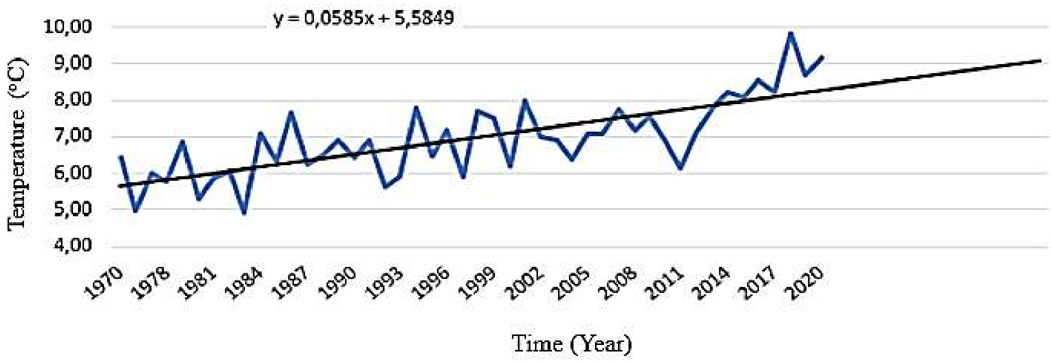


Figure 5.24 Temporal variation of average minimum temperature parameter for the Keskin station

The temporal representation of the average minimum temperature parameter data for the Yozgat station in Figure 5.25 slightly represents a positive trend. In addition, the test result presented in Table 5.4 shows that the S statistic is positive and the Z value is greater than 1.96. For this reason, it is concluded that there is a significant positive trend for the study period.

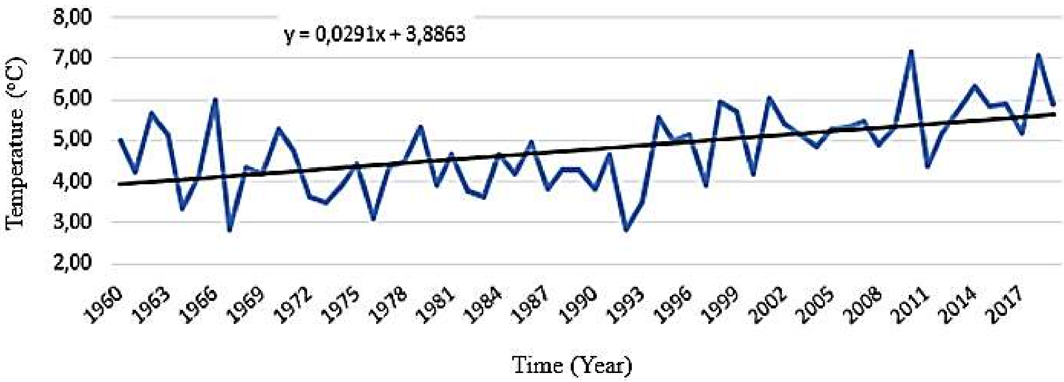


Figure 5.25 Temporal variation of average minimum temperature parameter for the Yozgat station

Figure 5.26 shows a positive trend for the average minimum temperature parameter data for the Kayseri station. In addition, the test results presented in Table 5.4 indicate that the positive S value and Z value, which is greater than 1.96, indicate a positive trend for the study period.

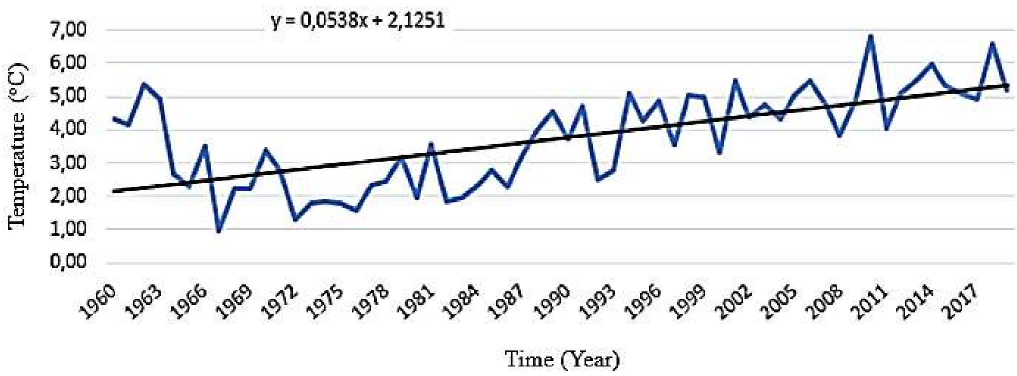


Figure 5.26 Temporal variation of average minimum temperature parameter for the Kayseri station

The temporal variation of the average minimum temperature parameter data for the Nevşehir station is presented in Figure 5.26. The figure represents a positive trend. In addition, the test results of positive S value and Z value greater than 1.96 are presented in Table 5.4. For this reason, it is concluded that the test results indicate a positive trend for the study period.

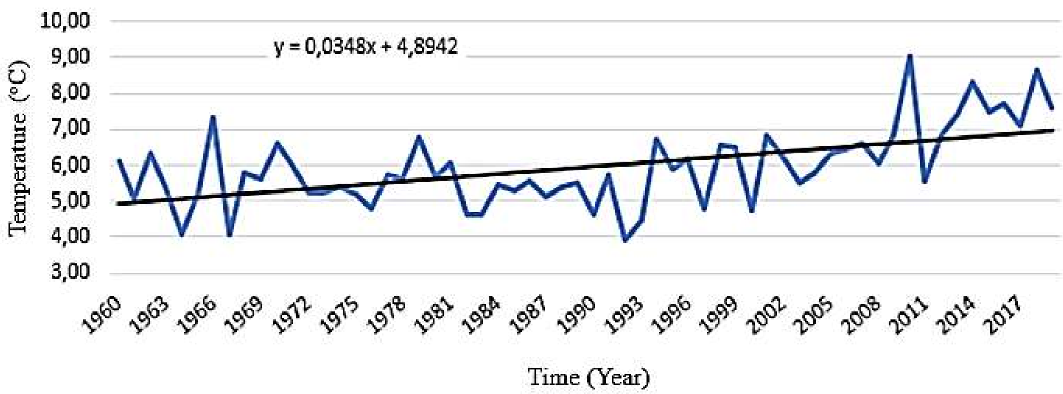


Figure 5.27 Temporal variation of average minimum temperature parameter for the Nevşehir station

Figure 5.28 illustrates the average minimum temperature parameter variation for the Çiçekdağı station. A positive trend is illustrated in the figure. In addition, the positive S value and Z value greater than 1.96 in Table 5.4 represents that the test result indicates a significant positive trend for the study period.

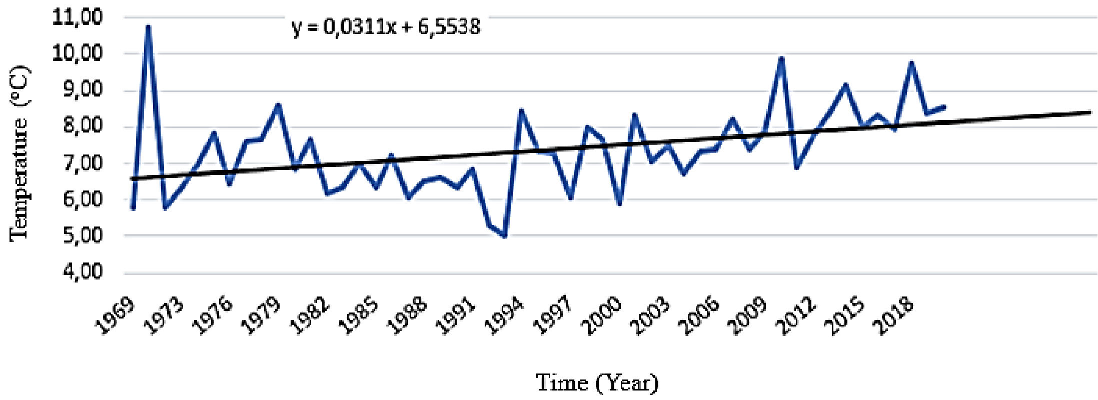


Figure 5.28 Temporal variation of average minimum temperature parameter for the Çiçekdağı station

Station-based Mann-Kendall Trend Test analysis is performed considering the average minimum temperature parameter data obtained from the General Directorate of Meteorology for the 1960-2020 period. The S and Z parameters of the test results, whether indicating trend or not, are summarized in Table 5.4 by considering 95% confidence intervals.

Table 5.4 Mann Kendal statistics for the average minimum temperature parameter

City	Average Minimum Temperature (°C)	S	Z	Trend Z (1,96)
Aksaray	5,93	821	5,51	Increasing Trend
Kulu	4,39	638	5,04	Increasing Trend
Keskin	6,24	619	5,87	Increasing Trend
Yozgat	4,16	671	4,18	Increasing Trend
Kayseri	3,12	867	5,40	Increasing Trend
Nevşehir	5,36	687	4,28	Increasing Trend
Çiçekdağı	6,60	444	3,61	Increasing Trend

5.1.5 Mann-Kendall Test Results For Average Temperature Parameter

The average temperature parameter data is analyzed for each station using the Mann-Kendall trend test. The temporal variations of the parameters are provided while the statistical results are summarized in a table.

The illustration in Figure 5.29 indicates a positive trend for the average temperature parameter variation for the Aksaray station. The Mann-Kendall test results in Table 5.5 also show that the S value is positive and the Z value is greater than 1.96. For this reason, it is concluded that the test result indicates a positive trend.

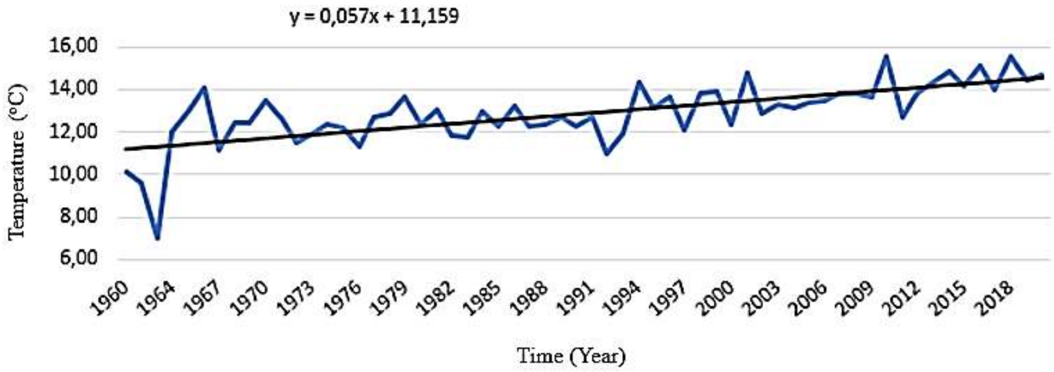


Figure 5.29 Temporal variation of average temperature parameter for the Aksaray station

The temporal variation of the average temperature parameter for the Kulu station is provided in Figure 5.30. A positive trend is presented in the figure. In addition, the positive S value, as well as the Z value greater than 1.96 presented in Table 5.5 shows that the test result indicates a positive trend for the study period.

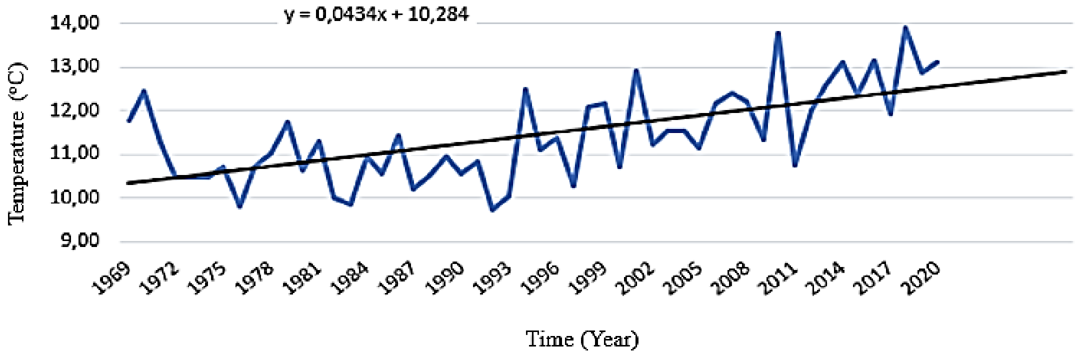


Figure 5.30 Temporal variation of average temperature parameter for the Kulu station

The illustration in Figure 5.31 shows that a slightly positive trend is present in the average temperature parameter data for the Keskin station. Also, the test results in Table 5.5 show that the S value is positive while the Z value is greater than 1.96. For this reason, the test result indicates that there is a positive trend for the study period.

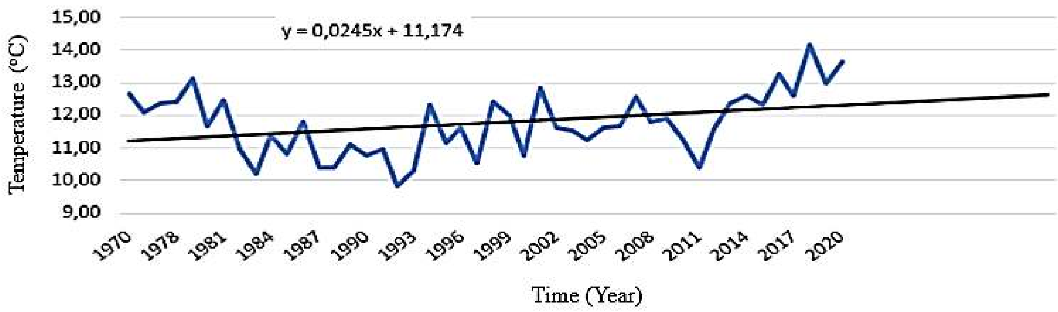


Figure 5.31 Temporal variation of average temperature parameter for the Keskin station

The temporal variation in Figure 5.32 indicates a barely positive trend in the average temperature parameter for the Yozgat station. When the test results are examined in Table 5.5, the S value is also positive. However, the Z value is 1.92, which is smaller than the critical value of 1.96 corresponding to the 95% confidence interval. For this reason, test statistics indicate that there is no trend for Yozgat station.

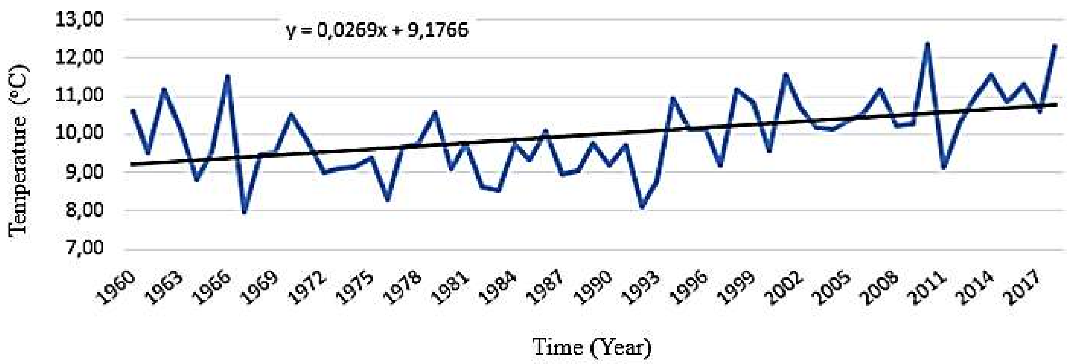


Figure 5.32 Temporal variation of average temperature parameter for the Yozgat station

Figure 5.33 represents the variation of the average temperature data for the Kayseri station. The illustration also indicates a positive trend. Besides, the test findings in Table 5.5 show a positive S value and a Z value greater than 1.96. For this reason, the test result refers to a significant positive trend for the study period.

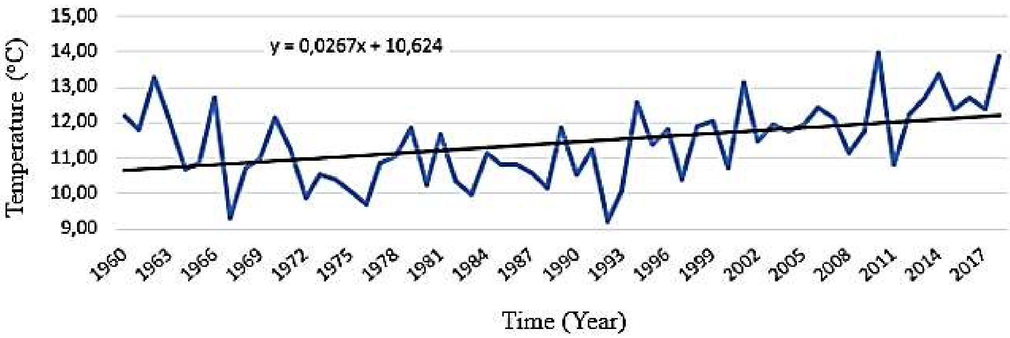


Figure 5.33 Temporal variation of average temperature parameter for the Kayseri station

A positive trend is presented in Figure 5.34 in the annual average temperature parameter data for the Nevşehir station. The test statistics in Table 5.5 also indicate a positive S value, as well as a Z value greater than 1.96. Therefore, the test results indicate a significant positive trend for the study period.

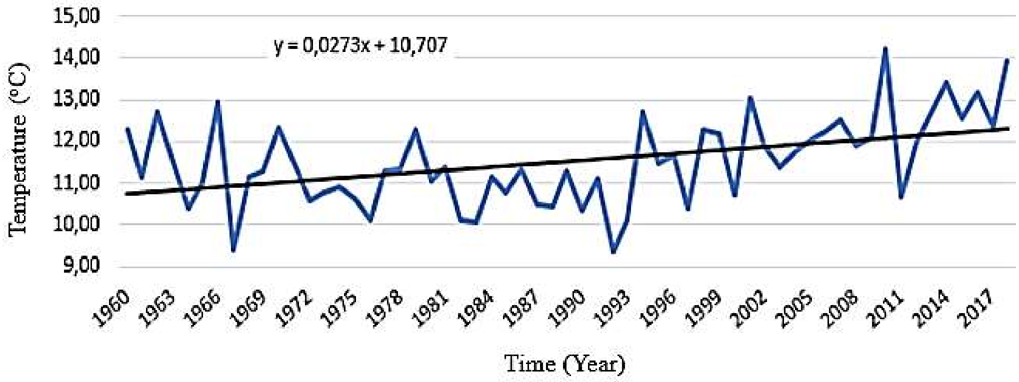


Figure 5.34 Temporal variation of average temperature parameter for the Nevşehir station

The temporal variation in Figure 5.35 represents a positive trend for the average temperature data for the Çiçekdağı station. In addition, the test results in Table 5.5 show a positive S value and a Z value which is greater than 1.96. For this reason, the test result indicates a positive trend for the study period.

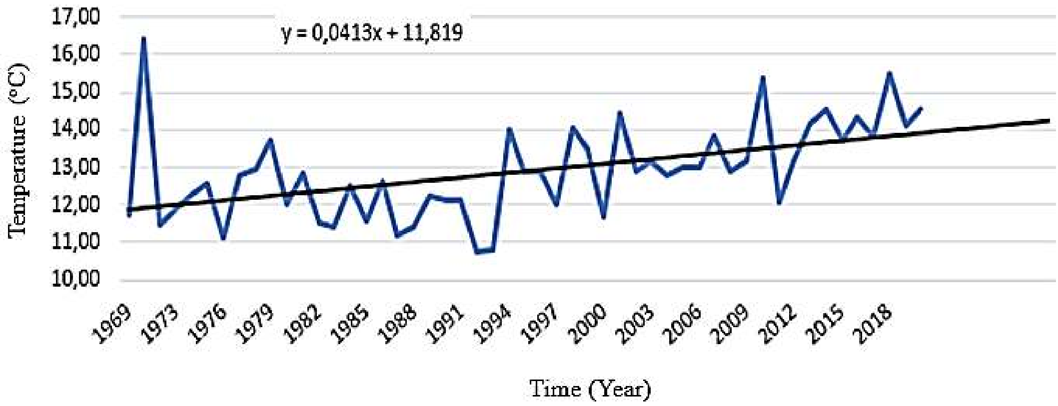


Figure 5.35 Temporal variation of average temperature parameter for the Çiçekdağı station

Considering the average temperature parameter data obtained from the General Directorate of Meteorology for the 1960-2020 period, station-based Mann-Kendall Trend test analysis is performed. The S and Z parameters of the Mann-Kendall Trend test along with the test results, whether indicating trend or not, are summarized in Table 5.5 by considering 95% confidence intervals.

Table 5.5 Mann Kendal statistics for the average temperature parameter

City	Average Temperature (°C)	S	Z	Trend Z (1,96)
Aksaray	12,01	892	5,69	Increasing Trend
Kulu	10,52	596	4,71	Increasing Trend
Keskin	10,57	286	2,63	Increasing Trend
Yozgat	9,23	637	1,92	No Trend
Kayseri	10,56	593	3,69	Increasing Trend
Nevşehir	10,76	573	3,57	Increasing Trend
Çiçekdağı	11,94	546	4,44	Increasing Trend

5.1.6 Mann-Kendall Test Results For Monthly Total Precipitation Parameter

The monthly total precipitation data is analyzed for each station using the Mann-Kendall trend test. The temporal variations of the parameters are provided while the statistical results are summarized in a table.

The temporal visualization of the monthly total precipitation parameter data for the Aksaray station is provided in Figure 5.36. The illustration represents no significant trend. In addition, the test result of S in Table 5.6 is obtained to be 92. However, the Z value is 0.59, which is smaller than the value of 1.96 corresponding to the 95% confidence interval. For this reason, the test results indicate no trend for the study period considered.

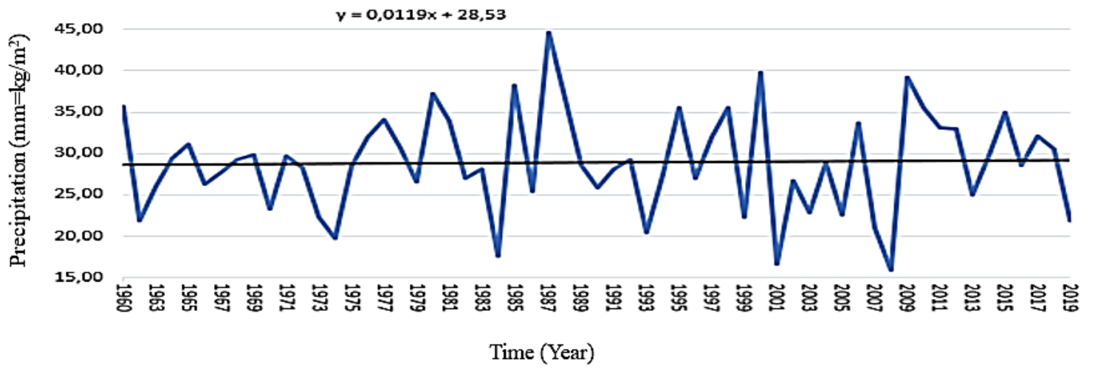


Figure 5.36 Temporal variation of monthly total precipitation parameter for the Aksaray station

The monthly total precipitation parameter variation is provided in Figure 5.37 for the Kulu station. The fit line indicates a negative trend while the S value in Table 5.6 is obtained to be -92. However, the obtained Z value is -0.97 and it is less than 1.96, which is used for the %95 confidence interval. For this reason, the test result indicates that there is no trend for the period of the study.

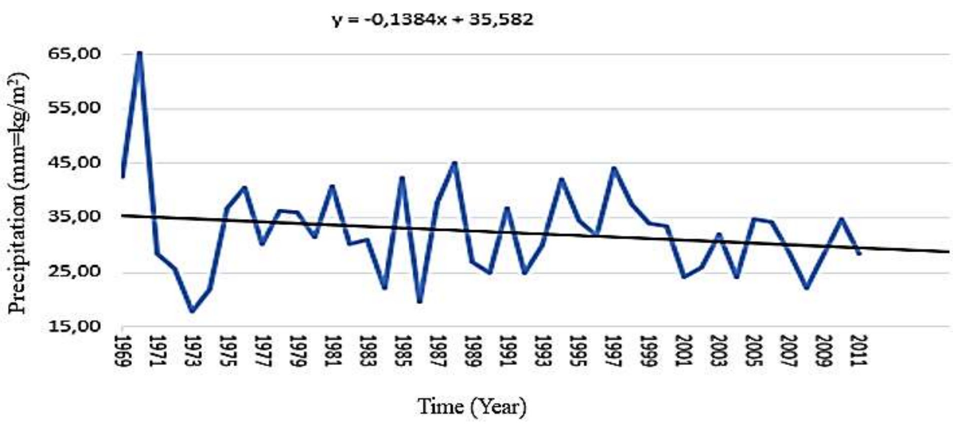


Figure 5.37 Temporal variation of monthly total precipitation parameter for the Kulu station

The illustration in Figure 5.38 for the monthly total precipitation parameter data for Keskin station does not indicate any significant trend. On the other hand, the S value obtained from the test result is determined as -9 (Table 5.6). However, the Z value is -

0.13, which is less than the value of 1.96 used for the %95 confidence interval. For this reason, it is concluded that the test result indicates no trend for the period considered.

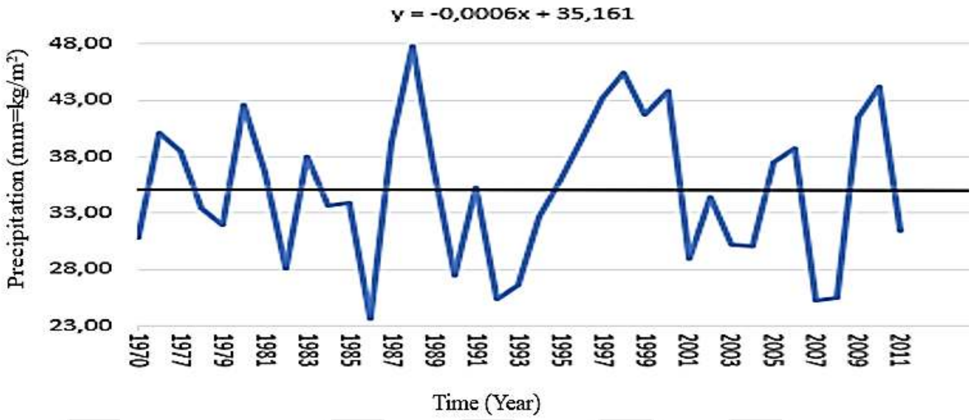


Figure 5.38 Temporal variation of monthly total precipitation parameter for the Keskin station

A slightly positive trend is presented in Figure 5.39 where the variation of monthly total precipitation parameter is presented for the Yozgat station. In addition, a positive S value of 456 is presented in Table 5.6. However, the Z value is 0.28 and it is smaller than the value of 1.96, which is used for the %95 confidence interval. Therefore, test results refer to no trend for the period of the study.

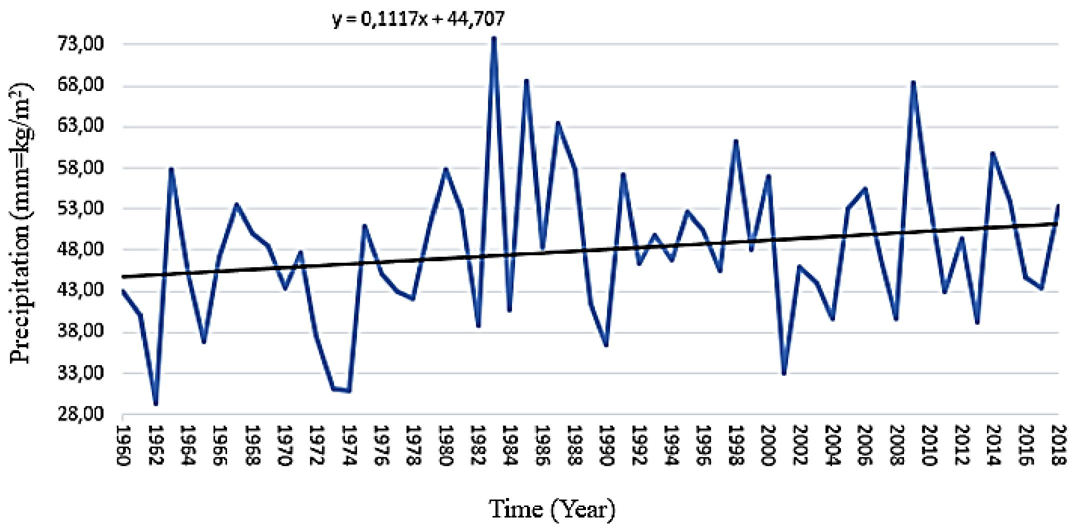


Figure 5.39 Temporal variation of monthly total precipitation parameter for the Yozgat station

The temporal variation of monthly total precipitation parameter data for the Kayseri station is presented in Figure 5.40. Even a slightly positive trend is presented in the figure, the test results in Table 5.6 indicate that the S value is 309 but the Z value is 1.92 and it is smaller than the value of 1.96, which corresponds to the 95% confidence interval. So, the test result shows that there is no trend for the study period considered.

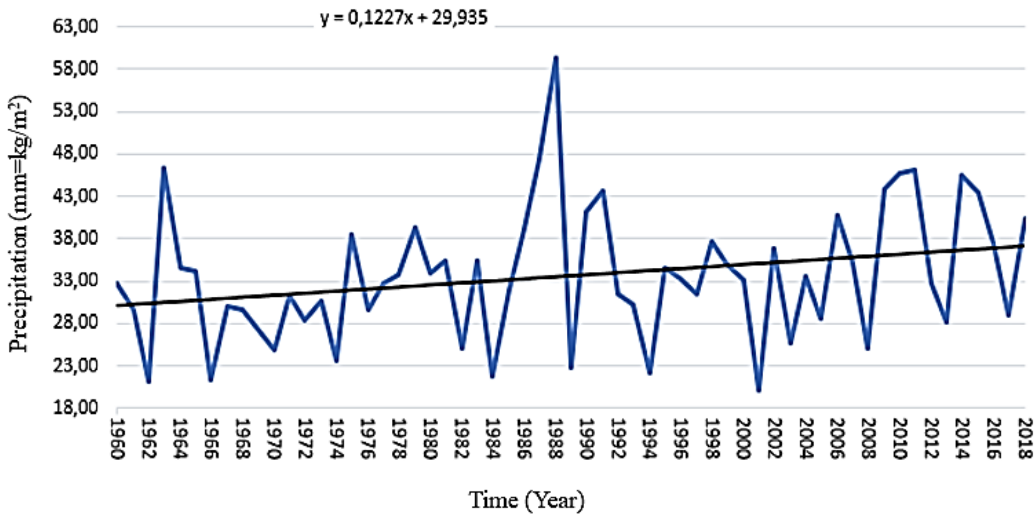


Figure 5.40 Temporal variation of monthly total precipitation parameter for the Kayseri station

The illustration of the monthly total precipitation parameter variation in Figure 5.41 shows no significant trend for the Nevşehir station. Besides the S value obtained is 113 but the Z value of 0.70 is smaller than the value of 1.96, which corresponds to the 95% confidence interval (Table 5.6). For this reason, the test results indicate no trend for the study period.

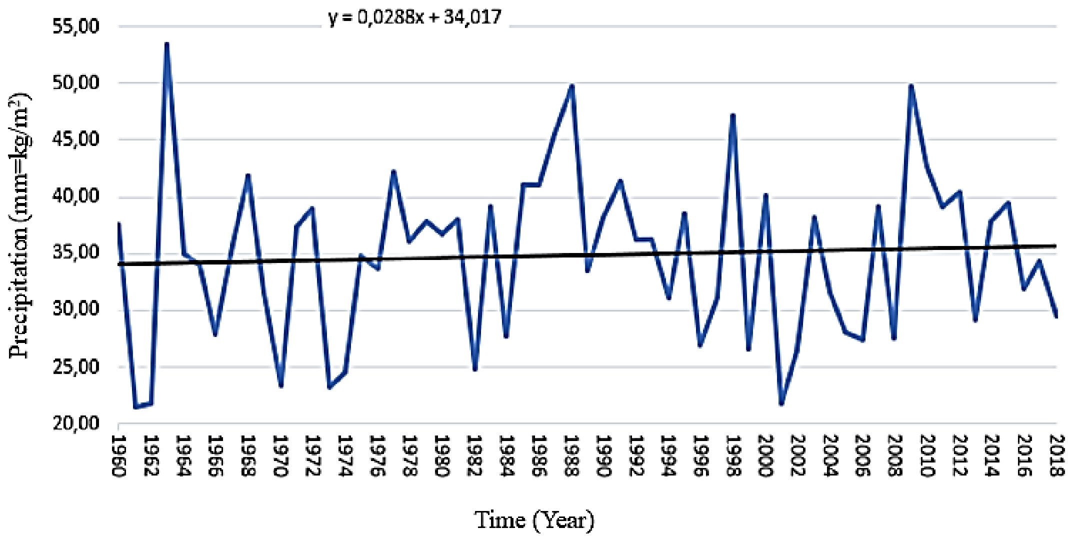


Figure 5.41 Temporal variation of monthly total precipitation parameter for the Nevşehir station

Figure 5.42 represents the monthly total precipitation parameter variation for the Çiçekdağı station. The illustration represents a slightly positive trend. On the other hand, a positive S value of 89 is presented in Table 5.6 while a Z value of 0.97 is obtained for the same station. Since the obtained Z value is smaller than 1.96, which is used for the 95% confidence interval, the test result indicates that there is no trend for the period considered.

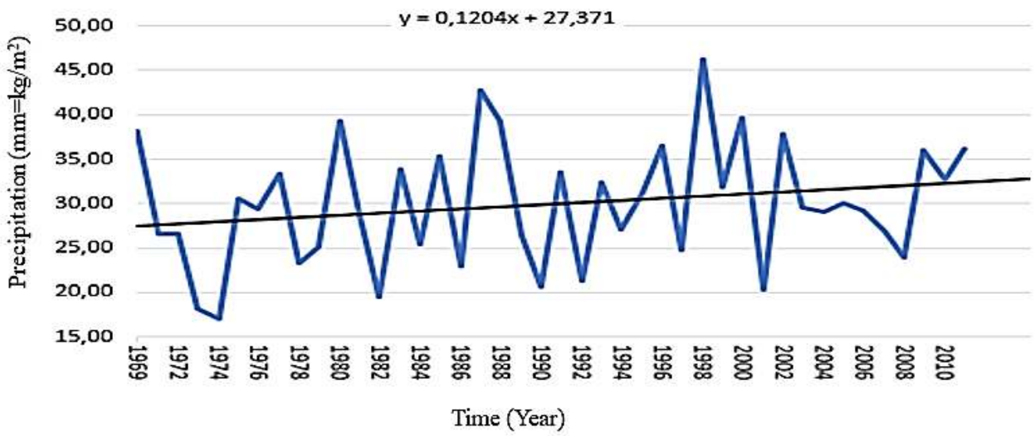


Figure 5.42 Temporal variation of monthly total precipitation parameter for the Çiçekdağı station

Station-based Mann-Kendall Trend Test analysis is performed considering the monthly total precipitation parameter data obtained from the General Directorate of Meteorology for the 1960-2020 period. The S and Z parameters of the test results are summarized in Table 5.6 to indicate the presence of a trend by considering 95% confidence intervals.

Table 5.6 Mann Kendal statistics for the monthly total precipitation parameter

City	Average Total Precipitation (mm)	S	Z	Trend Z (1,96)
Aksaray	30,31	92	0,59	No Trend
Kulu	34,15	-92	-0,97	No Trend
Keskin	36,47	-9	-0,13	No Trend
Yozgat	50,36	456	0,28	No Trend
Kayseri	34,09	309	1,92	No Trend
Nevşehir	36,27	113	0,70	No Trend
Çiçekdağı	29,96	89	0,97	No Trend

5.1.7 Mann-Kendall Test Results For Maximum Monthly Precipitation Total Parameter

By utilizing the Mann-Kendall Trend test, the monthly maximum precipitation total parameter data is analyzed for each station. The temporal variation of the parameters is provided while the statistical results are summarized in a table.

Figure 5.43 illustrates the maximum precipitation total parameter data of the Aksaray station. The figure indicates not a significant trend for the study period. In addition, the test statistics of S is determined to be 4. However, the obtained Z value is 0.03 and it is less than 1.96, which is the critical value for the 95% confidence interval. For this reason, the test results indicate no trend for the study period.

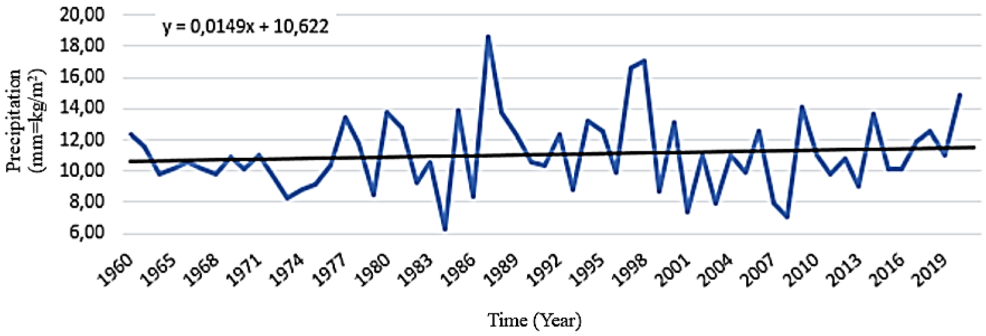


Figure 5.43 Temporal variation of maximum monthly precipitation total for the Aksaray station

The temporal variation of the monthly maximum precipitation total parameter data for the Kulu station is provided in Figure 5.44. The illustration indicates a slightly decreasing trend. However, the test statistics in Table 5.7 show that the determined S value is -162. The obtained Z value is also -1.28 but it is smaller than 1.96, which corresponds to the 95% confidence interval. For this reason, the test result shows that there is no trend for the period considered.

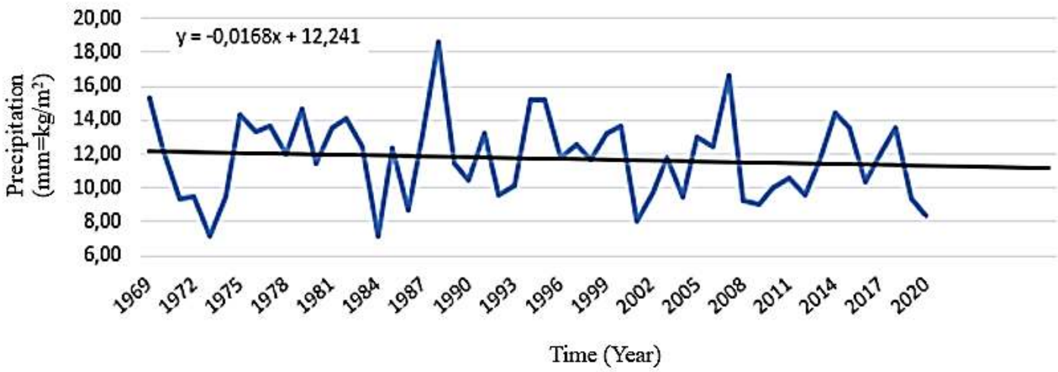


Figure 5.44 Temporal variation of maximum monthly precipitation total for the Kulu station

The temporal variation of the monthly maximum precipitation total parameter data for the Keskin station is presented in Figure 5.45. As the determined S value in Table 5.7 is -241, the -2.29 value is considered to be positive.

Since the determined 2.29 is larger than the critical Z value of 1.96, then the test result refers to a positive trend for the period considered.

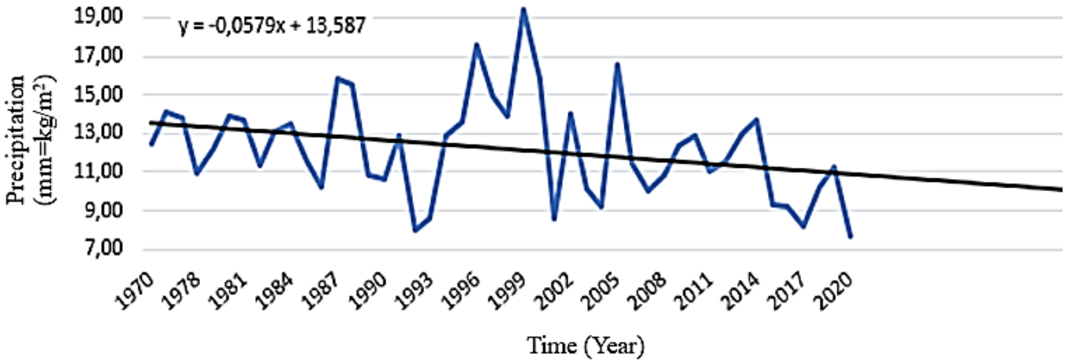


Figure 5.45 Temporal variation of maximum monthly precipitation total for the Keskin station

Figure 5.46 represents the temporal variation of the monthly maximum precipitation total parameter data for the Yozgat station. However, it does not indicate a significant trend. In addition, the test results in Table 5.7 show that the S value is 143. However, the Z value of 0.89 is smaller than 1.96, which corresponds to the 95% confidence interval. For this reason, the test result indicates no trend for the study period.

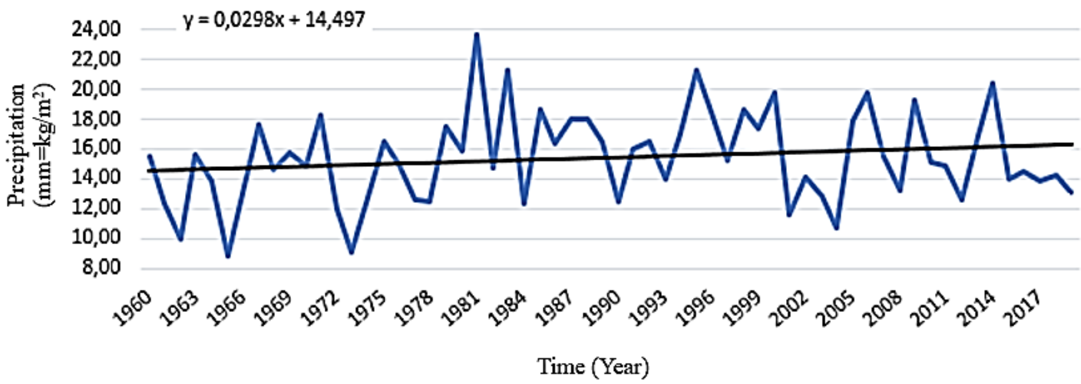


Figure 5.46 Temporal variation of maximum monthly precipitation total for the Yozgat station

The maximum monthly precipitation total parameter data is examined for the Kayseri station in Figure 5.47 but not a significant trend is observed. Besides, the S statistics in Table 5.7 is 223. However, the Z value is 1.39, which is smaller than the critical value of 1.96 corresponding to the 95% confidence interval. Therefore, the test result indicates no trend for the period considered.

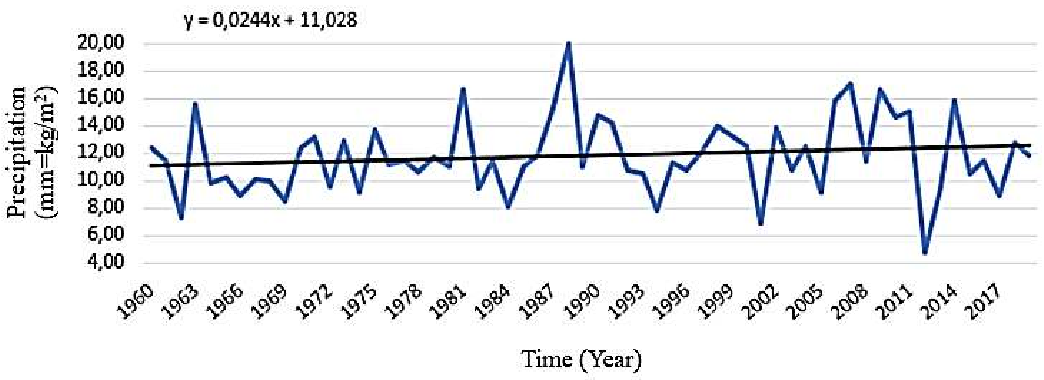


Figure 5.47 Temporal variation of maximum monthly precipitation total for Kayseri station

Figure 5.48 represents the variation of the monthly maximum precipitation total parameter data for the Nevşehir station. However, the illustration also does not present a significant trend. In addition, the test results in Table 5.7 show that the obtained S value is 109. On the other hand, the determined Z value is 0.68, which is smaller than 1.96 as it corresponds to the 95% confidence interval. So, the test result indicates that there is no trend for the study period.

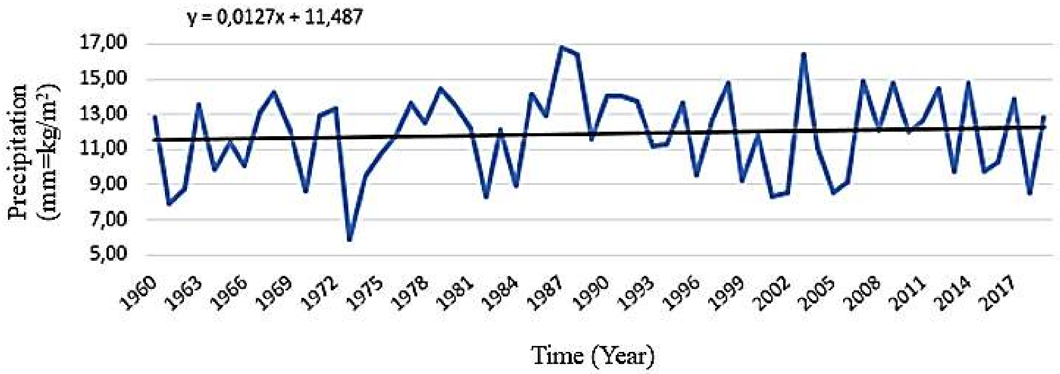


Figure 5.48 Temporal variation of maximum monthly precipitation total for the Nevşehir station

The variation of the monthly maximum precipitation total parameter data for the Çiçekdağı station is presented in Figure 5.49. Besides, the fit line does not represent any significant trend for the study period. However, the test statistics in Table 5.7 indicate that the Z value is -1.23 and it is smaller than 1.96, which corresponds to the 95% confidence interval. For this reason, the test results indicate no trend for the period considered.

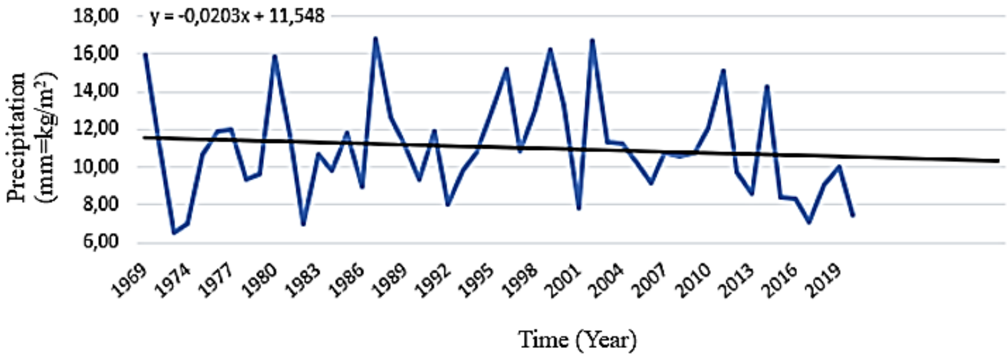


Figure 5.49 Temporal variation of maximum monthly precipitation total for the Çiçekdağı station

The monthly maximum precipitation total parameter obtained from the General Directorate of Meteorology for the 1960-2020 period is taken into account for the station-based Mann-Kendall Trend Test analysis. The S and Z parameters of the Mann-Kendall Trend Test along with the test results are summarized in Table 5.7 to indicate a trend or not by considering 95% confidence intervals.

Table 5.7 Mann Kendal statistics for the maximum monthly precipitation total parameter

City	Average Maximum Precipitation (mm)	S	Z	Trend Z (1,96)
Aksaray	11,45	4	0,03	No Trend
Kulu	12,04	-162	-1,28	No Trend
Keskin	12,33	-241	-2,29	Increasing Trend
Yozgat	16,07	143	0,89	No Trend
Kayseri	11,86	223	1,39	No Trend
Nevşehir	12,28	109	0,68	No Trend
Çiçekdağı	11,29	-147	-1,23	No Trend

5.2 Sen's Slope Test Results

5.2.1 Sen's Slope Test Results For The Maximum Temperature Parameter

The maximum temperature data is analyzed for each station by using Sen's Slope test. The scatter plots are provided with respect to each parameter along with some comments.

Depending on the analysis of the data for the Aksaray station, the maximum temperature parameter is obtained to be varying between 24 degrees and 28 degrees. The scatter plots in Figure 5.50 for the Aksaray station exhibits a trend since the data is cumulated in the upper side of the y=x line. For this reason, the plots indicate a positive trend.

For the Kulu station, the maximum temperature parameter is obtained to be varying from 23 degrees to 27 degrees. All of the scattered points take place in the upper side of the y=x line so that the test result indicates a positive trend (Figure 5.50).

The maximum temperature parameter for the Keskin station is determined to be between 21 degrees and 25 degrees. Besides, the scatter plot shows a cumulation in the upper part of the y=x line (Figure 5.50). Therefore, the test result represents a positive trend for the study period.

The maximum temperature parameter plots for the Yozgat station in Figure 5.50 indicate that the plotted data are clustered in the upper part of the y=x line so that the test result declares a positive trend for the dataset considered.

In Figure 5.50, the scatter plot is scattered around the y=x line for the Kayseri station. It indicates that the test result represents no trend for the Kayseri station.

The scatter plot for the Nevşehir station in Figure 5.50 takes place in the upper part of the y=x line so that the test result indicates a positive trend for the study period.

Figure 5.50 shows that the scatter plot for the Çiçekdağı station is dominantly clustered above the y=x line. For this reason, the test results indicate a positive trend.

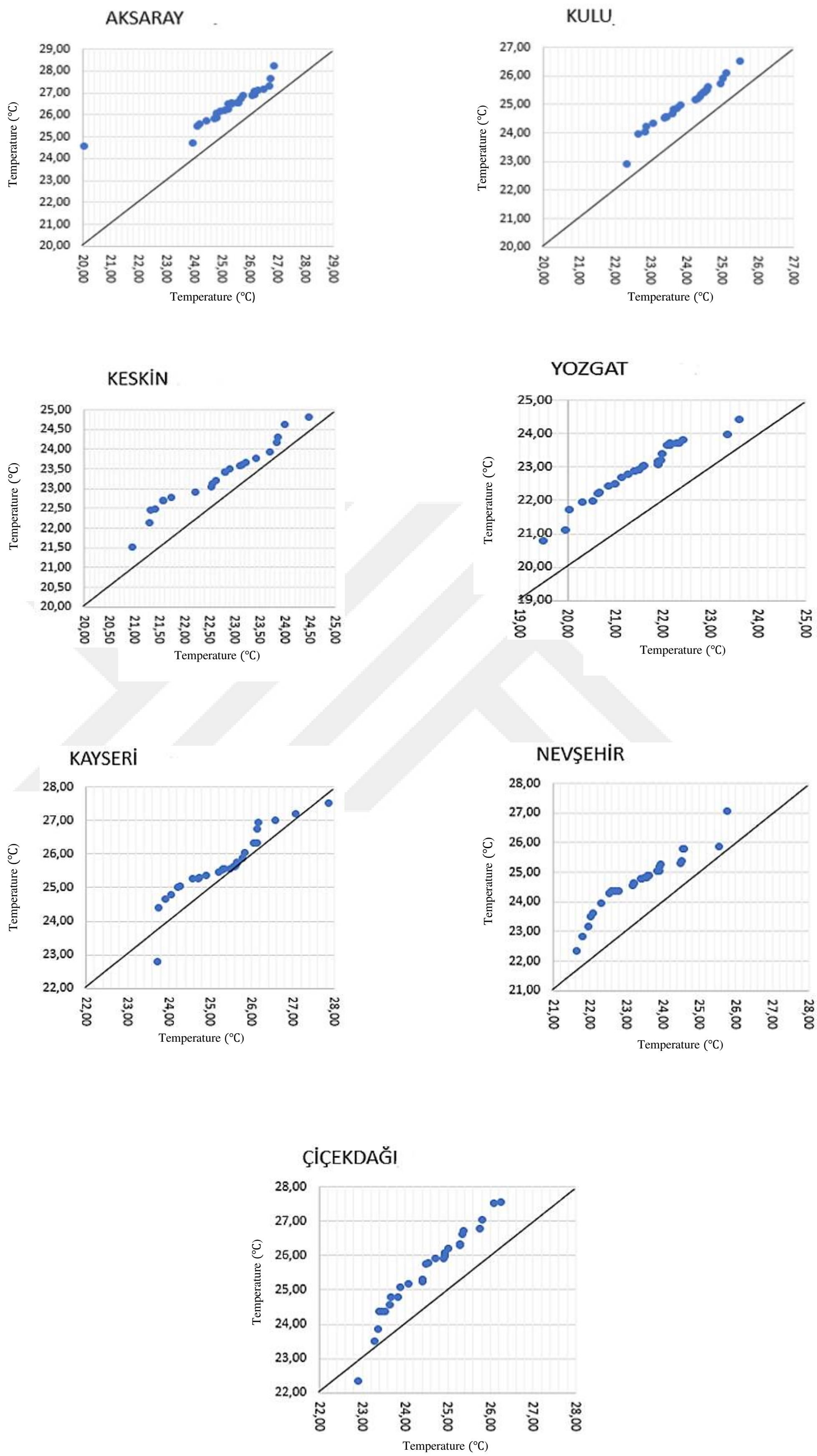


Figure 5.50 Sen’s Slope analysis for the maximum temperature parameter

5.2.2 Sen’s Slope Test Results For The Minimum Temperature Parameter

The minimum temperature parameter data is analyzed for each station by using Sen’s Slope test. The scatter plots are provided with respect to each parameter along with some comments.

The scatter plots in Figure 5.51 show that the scattered points are dominantly located in the upper part of the y=x line. For this reason, the test result for each station indicates a positive trend.

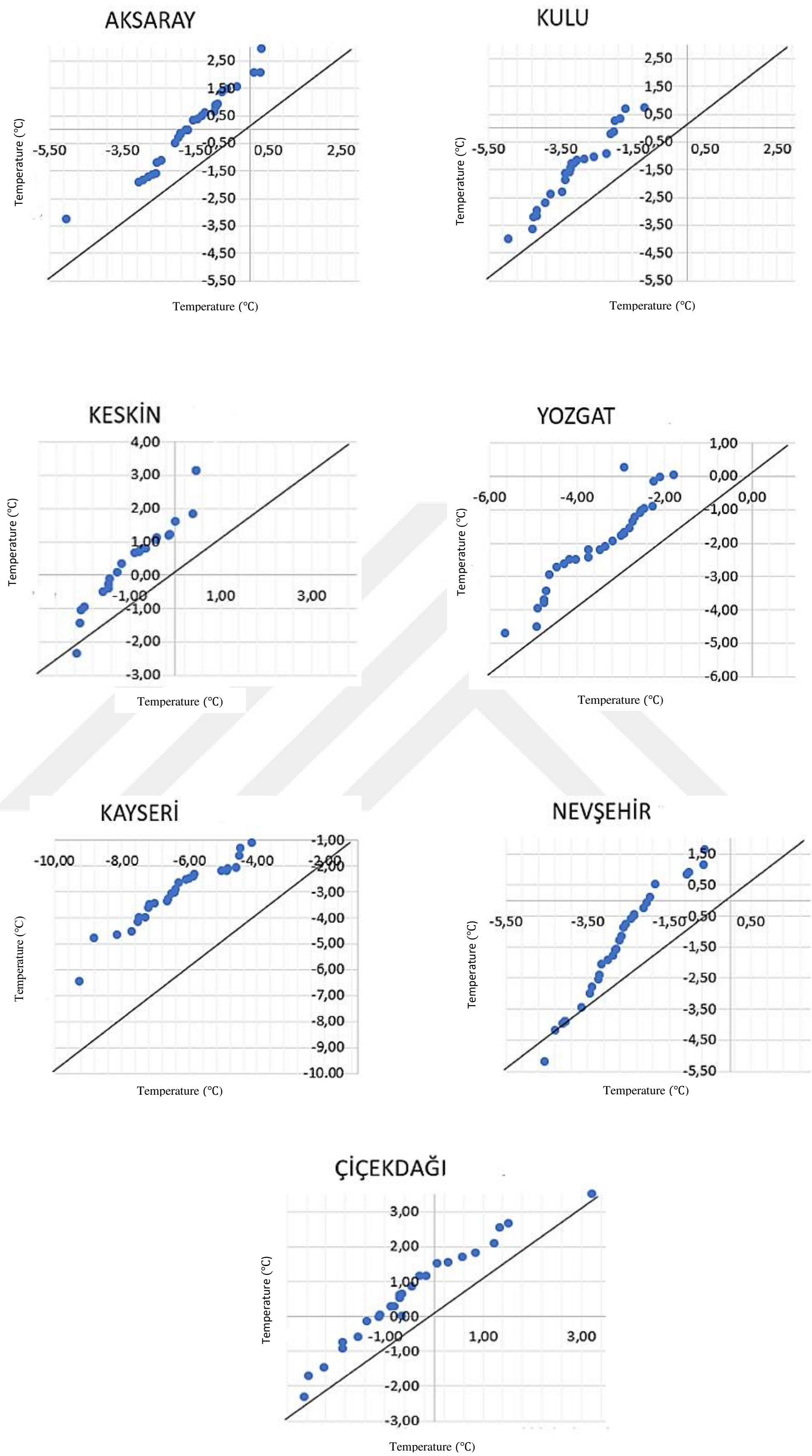


Figure 5.51 Sen’s Slope analysis for the minimum temperature parameter

5.2.3 Sen’s Slope Test Results For The Average Maximum Temperature Parameter

The average maximum temperature parameter data is analyzed for each station by using Sen’s Slope test. The scatter plots in Figure 5.52 indicate different results for each station dataset.

Unlike the other plots, the scattered data for the average maximum temperature parameter data is cumulated in the lower part of the y=x line (Figure 5.52). For this reason, the test result indicates a negative trend for this dataset.

For the Keskin station, on the other hand, the scatter of data is observed around the y=x line but mostly located in the upper section of it (Figure 5.52) so that the test result indicates a positive trend.

For the rest of the stations, the scattered data takes place in the upper side of the y=x line, indicating a positive trend for each station.

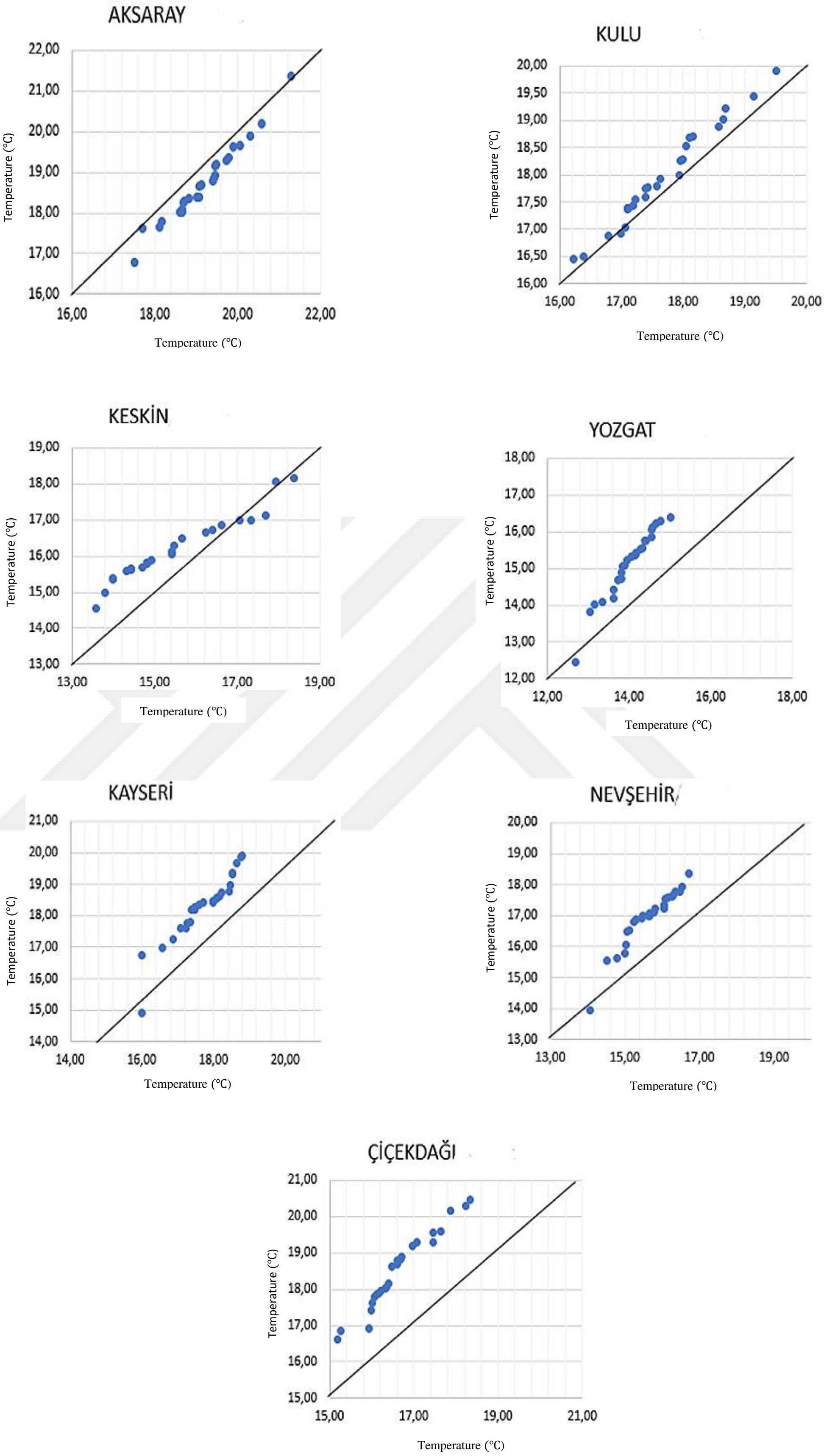


Figure 5.52 Sen’s Slope analysis for the average maximum temperature parameter

5.2.4 Sen’s Slope Test Results For The Average Minimum Temperature Parameter

The scatter plots for the average minimum temperature parameter for each station are provided in Figure 5.53. The figure shows that the scattered data is dominantly located on the upper side of the y=x line for each station. For this reason, the test result for each station indicates a positive trend.

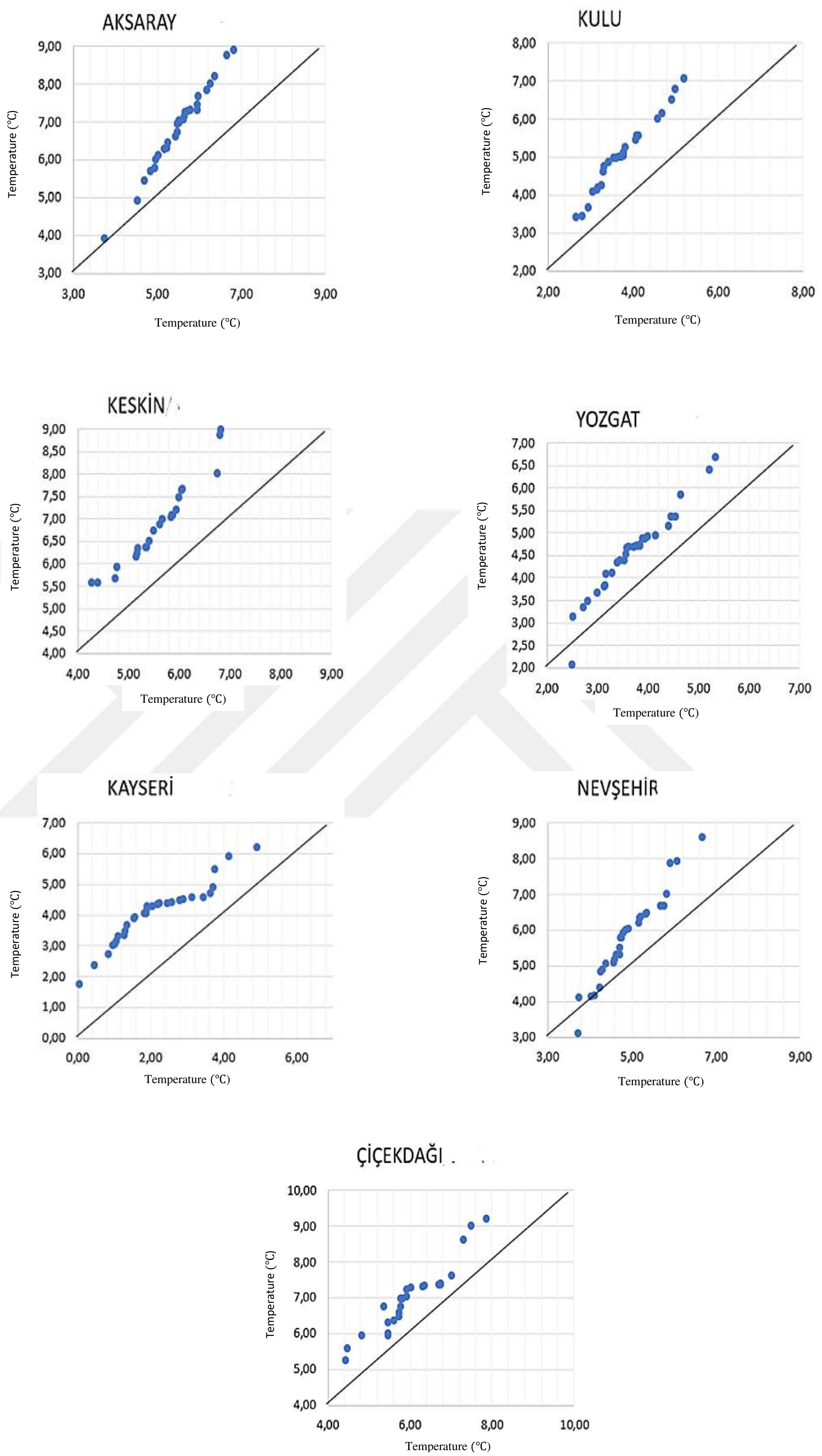


Figure 5.53 Sen's Slope analysis for the average minimum temperature parameter

5.2.5 Sen’s Slope Test Results For The Average Temperature Parameter

In this section, the average temperature parameter data is analyzed by using Sen’s Slope test to examine the presence of any trend in the dataset.

The scatter plot for the Yozgat station in Figure 5.54 shows a heterogeneous pattern as it fluctuates along the y=x line. Unlike the other scatter plots, the scattered data is dominantly cumulated in the lower part of the y=x line. For this reason, the test results indicate a negative trend for this station while it is a positive trend for the others.

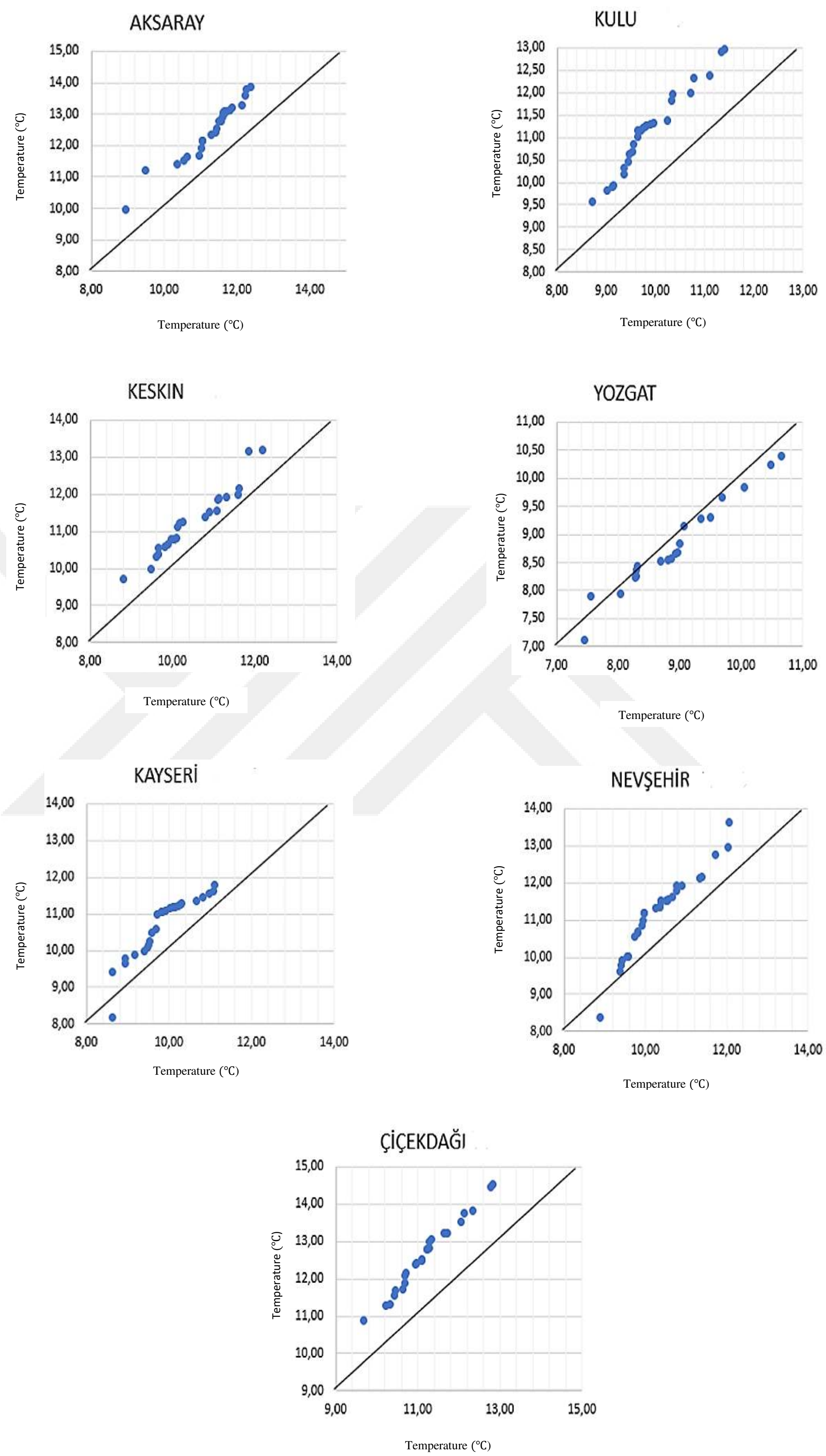


Figure 5.54 Sen's Slope analysis for the average temperature parameter

5.2.6 Sen's Slope Test Results For The Monthly Total Precipitation Parameter

The scatter plot of the monthly total precipitation dataset for each station with respect to Sen's Slope test is provided in Figure 5.55.

A varying pattern is observed for the scatter plots for each station in Figure 5.55. Most of them fluctuate around the y=x line either taking place in the upper or lower part of the y=x line. For this reason, the test result for each station indicates no trend for all stations.

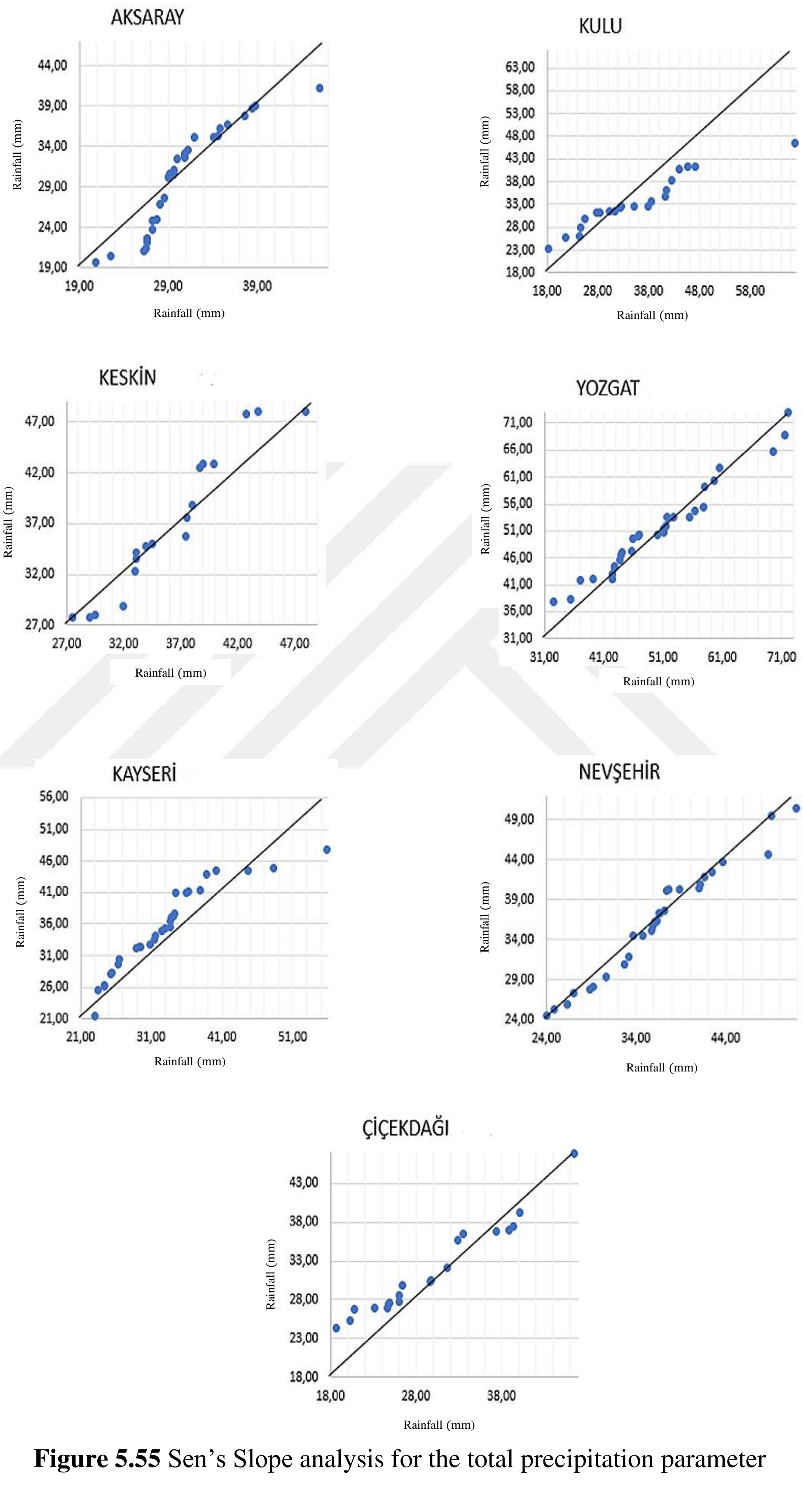


Figure 5.55 Sen's Slope analysis for the total precipitation parameter

5.2.7 Sen’s Slope Test Results For The Maximum Monthly Precipitation Total Parameter

The maximum monthly precipitation total parameter is analyzed for each station by using Sen’s Slope test. The scatter plots are provided with respect to each parameter in Figure 5.56.

The scatter plots in Figure 5.56 indicate that the data is fluctuated along the y=x line for the stations Aksaray, Yozgat, Kayseri, Nevşehir, and Çiçekdağı. For this reason, the test result for these stations indicates no trend for each of them. On the other hand, the scatter plots for the Kulu and Keski are cumulated in the lower part of the y=x line, referring to a negative trend for these stations.

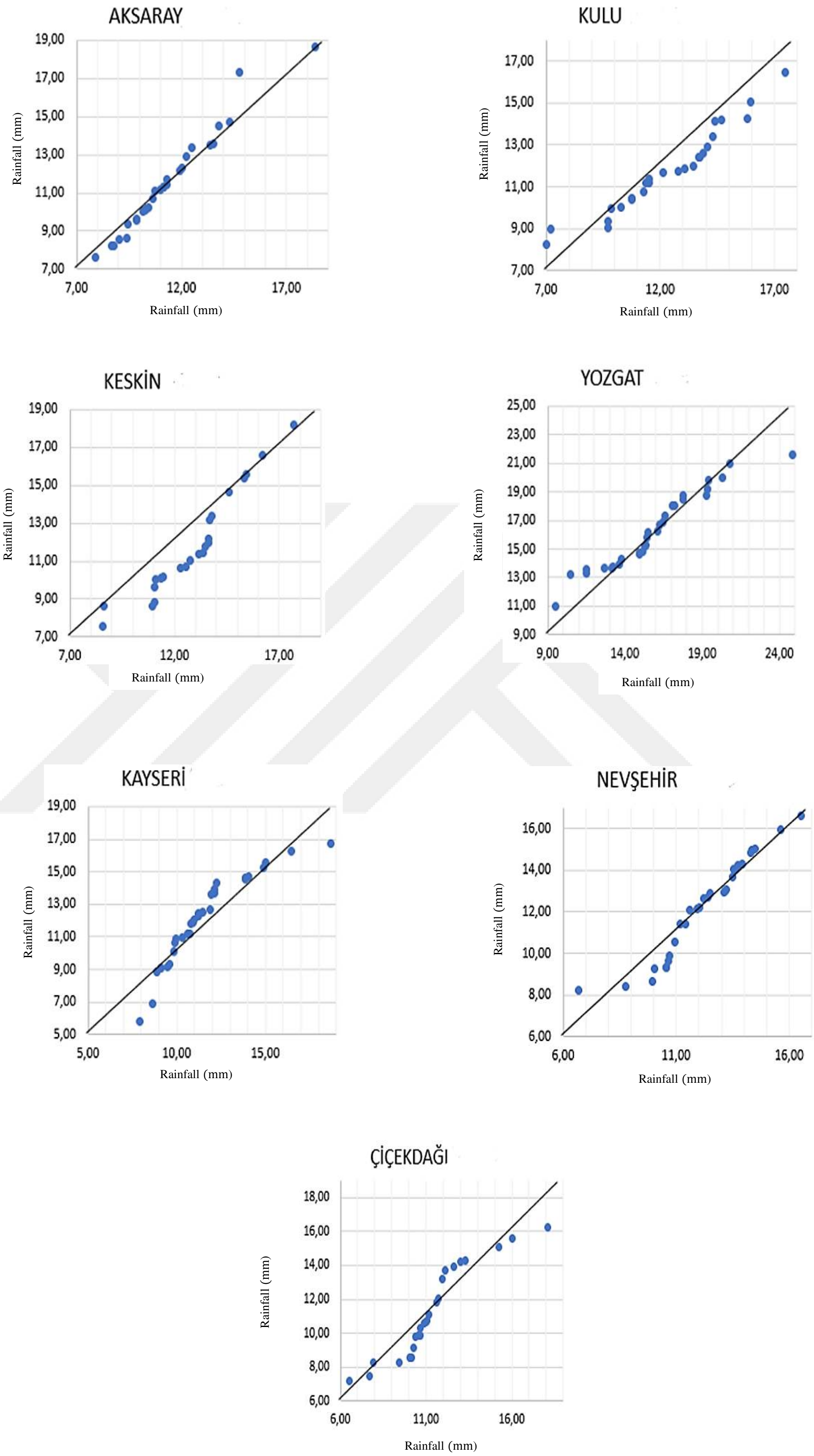


Figure 5.56 Sen's Slope analysis for the maximum precipitation parameter

CHAPTER VI

CONCLUSION

In this study, the trend analysis is performed for the precipitation and temperature parameter data obtained from the General Directorate of Labor Meteorology. The trend analysis is performed covering the period of 1960-2020 for 7 stations (Aksaray/17192, Kulu/17754, Keskin/17730, Yozgat/17140, Kayseri/17196, Nevşehir/17193, Çiçekdağı/17732) where each station is located in a similar climatologic region having comparable precipitation and temperature variations.

So, 40 years of precipitation and temperature parameter data of Aksaray, Kulu, Keskin, Yozgat, Kayseri, Nevşehir, Çiçekdağı stations were analyzed using 2 different trend analysis tests, called Mann-Kendall Test and the other is Sen's Slope Test.

The Z=1.96 value, which is used in the Mann-Kendall Trend Analysis, was used since it represents the 95% confidence interval. The test results are compared with respect to this reference Z value. According to the test results for each station and varying parameters, a positive trend is assigned if the obtained Z value is greater than the reference Z value. On the contrary, the test result is considered to be addressing a negative trend if the obtained Z value is smaller than the reference Z value. Apart from that, the S value is also used to determine the direction of the trend. For instance, if the S value is negative while the Z value is negative, then -1.96 is referenced as specified in the Standard Normal Distribution Curve. Or, all values are considered to be positive and the test results are interpreted accordingly.

When the Mann-Kendall test result for the maximum temperature parameter is examined, a positive trend is observed for all stations since the Z value was greater than Z(1.96) while the S values were positive.

However, no trend was determined for the Kayseri station since the S value was 0 and the Z value was negative as well as very close to zero.

Mann-Kendall test results for the minimum temperature parameter indicated a positive trend for all stations.

In addition, the test results for the average maximum temperature parameter indicated no trend only at Keskin station. For the rest of the other stations, the test results exhibited a positive trend.

For the average temperature parameter, the Mann-Kendall test results indicated a positive trend for all stations except the Yozgat station since even the temporal plot for this station did not represent a significant trend.

When the monthly total precipitation parameter is considered, not a significant trend is observed for all stations so that it is concluded as no trend for each.

On the other hand, a positive trend was observed at Keskin station when the monthly maximum precipitation parameter was examined with respect to Mann-Kendall test results. However, the test result did not indicate any trend for the rest of the stations.

For the temperature parameter, a positive trend is observed by the Mann-Kendall test results. On the other hand, not a significant trend is determined for the precipitation parameter. Such findings can be projected that the average maximum temperature and average temperature parameter might be increased in the future and cause dought type of disaster for the Kızılırmak River basin, where the analyzed stations are located.

In Sen’s Slope Test application, the parameters are scattered along the y=x line. The trend analysis was carried out by taking the average of the values from the first value to the middle degree as well as the values up to the last degree in the middle value. The presence of points above the y=x line in the figures indicates a positive trend while the presence of points below the y=x line represents a negative trend. If the scattered points fluctuate around the y=x line, then it is concluded that the test result represents no trend.

While considering the Sen’s Slope Test results for the maximum temperature parameter, a positive trend is determined for each station since the scattered data is concentrated in the upper side of the y=x line (Figure 5.50). Among them, only the scatter diagram for the Kayseri station is observed to be close to the y=x line but still represents a positive trend.

On the other hand, only a single point for the Çiçekdağı station is observed to be below the y=x line while the rest took place on the upper side. Therefore, the test result represents a positive trend.

For the minimum temperature parameter, the scatter plots for all parameters are observed to be taking place in the upper part of the y=x line. For this reason, the result of the Sen’s Slope test for all stations is obtained to be positive.

For the average maximum temperature parameter, only a negative trend is obtained for the Aksaray station since the scattered points are located in the lower part of the y=x line. On the other hand, the scattered points are observed to be fluctuating around the y=x line for the Keskin station, referring to no trend. For the rest of the stations, all scattered points are located in the upper part of the y=x line so that a positive trend is concluded with respect to Sen’s Slope test.

About the average minimum temperature parameter, the scattered data for each station is obtained to be located in the upper part of the y=x line. For this reason, the Sen’s Slope test result for each station is concluded to represent a positive trend.

For the average temperature parameter analysis, the only different station was observed to be the Yozgat station with respect to Sen’s Slope Test. The scattered points are observed to be located in the lower part of the y=x line for this station with the test result indication of a negative trend. For the rest, it was concluded a positive trend since all the scattered plots took place in the upper part of the y=x line.

When the Sen’s Slope test results are considered for the monthly total precipitation parameter, the scattered data for each station is obtained to be fluctuation along the y=x line. For this reason, the test result is concluded to be representing no trend for each station.

For the monthly maximum precipitation total parameter, the scatter plots with respect to Sen’s Slope test are observed to be fluctuation along the y=x line. For this reason, the test result is obtained to be representing no trend for each station. On the other hand, for the Keskin station, the scattered data is dominantly obtained to be located in the lower part of the y=x line. For this reason, only a negative trend is assigned for this station.

The overall evaluation of the Sen’s Slope Test indicates that there is a positive trend for temperature. On the other hand, the same test results represent no trend for the precipitation parameter, except for some stations.

If two tests are compared, then the temperature parameter shows a positive trend in both tests.

For precipitation parameter, an increasing trend was observed only at Keskin station for maximum monthly precipitation total parameter in both Mann-Kendall and Sen’s Slope test while no trend was observed in other stations.

It is important to keep in mind that the Mann-Kendall test answers questions such as whether there is a significant trend for the selected certain confidence level as well as the level of significance.

On the other hand, Sen’s Slope test provides information about the type of the trend.

In this study, a study considering a 5% significance level is conducted for the Mann-Kendall test.

So, the presented and discussed results depend on the selected criteria. On the other hand, a different result would be obtained if a different significance level, let’s say 10%, was selected. For instance, no trend results would be representing a trend while a 10% significance level is considered.

For this reason, the type of the trend obtained by Sen’s Slope Test can sometimes be more important than the no trend result obtained from Mann-Kendall. So, it depends on the terms and conditions used in the tests.

The results obtained from these methods can be promising as well as could guide engineers' to new studies. Besides, studies can be performed along with some conclusions by considering water resources management strategies as well as trend analysis results in the agricultural sector for the region.

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CONGRESS

Nacaroğlu, S. (2021, Ağustos). Aksaray, Kulu, Keskin, Yozgat, Kayseri, Nevsehir And Çiçekdaği Precipitation-Temperature Interactions. 11. Uluslararası Bilimsel Araştırmalar Kongresi (UBAK) 11th International Scientific Research Congress. Uluslararası Balkan Üniversitesi. Ankara.