Chapter 18
Impacts of Climate Change on Precipitation and Temperature Climatology in Türkiye from Present to Future Perspective

Beyza Ustaoğlu, Katibe Aslı Tunçat, and Derya Evrim Koç

Abstract Türkiye is located in the Mediterranean Basin, one of the hotspot areas most affected by climate change. Extreme events in weather conditions in the last 10 years are one of the most obvious reflections of global warming. Variations in temperature and precipitation regimes directly affect agriculture, water resources, biodiversity, etc. Climate change is a serious threat, especially in countries such as Türkiye, with a dominant agricultural economy. For this purpose, in this study, (a) examples of extreme events in Türkiye will be given; (b) Türkiye's temperature and precipitation conditions in the period 1929–2020 will be determined by analysing 217 meteorological observation data; (c) areas in Türkiye where the Mediterranean climate is dominant or not, according to the Emberger Bioclimate Classification; (d) future temperature and precipitation conditions will be determined based on 19 bioclimate variables obtained from the WorldClim database for the future 2061-2080 CMIP 5 model and RCP 4.5 and 8.5 scenarios. The results obtained will be shared with public and non-governmental organizations in order to develop adaptation strategies at national, regional and local levels to prevent the serious damage of climate change to humans and the environment and ensure sustainable development in changing climate conditions.

Keywords Climate change · Precipitation · Temperature · Drought · Türkiye

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Introduction

The 6th IPCC report clearly statesd that climate change today is mainly caused by human-induced factors as well as the natural variability of the climate. It is indicated that global warming caused by human activities increased by more than 1 °C between 2010 and 2019 compared to the 1850–1900 period. If we continue to produce fossil-based energy, climate projections indicate that we are rapidly moving towards a hotter and drier future worldwide, where there could be an increase of 4 °C (IPCC 2021).

Fossil fuel use, deforestation, changes in land use and the accumulation of greenhouse gases released into the atmosphere have been increased rapidly since the industrial revolution. This situation has caused the strengthening of the natural greenhouse effect, and an increase in the world's surface temperatures with the impact of urbanization. The severity and intensity of extreme events will determine the future impact and damage of the climate conditions. It is thought that the frequency of extreme events especially will cause severe damage. In this context, climate change is one of the biggest natural environmental problems of today. In the statistical studies on the climate, it has been determined that since the 1990s, there has been a tendency in Türkiye, increase of the daily minimum and maximum temperatures, decrease of snowy and frosty days and increase of the number of hot days and nights in some extreme values (Erlat and Türkeş 2012, 2013).

Model studies on climate change also predict that the global climate will likely change in many parts of the world. According to the statement made by the World Meteorological Organisation (WMO), 2016 was determined as the year with the highest global average temperatures (1880–2020). According to the increase rates in temperatures, 2016 is followed by 2019 and 2020, respectively (WMO 2020). The increase in the variability in the climate shows that, especially in the Mediterranean Basin and most of Türkiye, heavy precipitation, storms, severe floods, floods, mass movements, severe heat waves, droughts and forest fires will be encountered. This situation raises the possibility of a climate in Türkiye and its region in the future where the climate will be stronger, which tends to deviate more frequently from the long-term averages. According to our study to determine the areas where the Mediterranean climate is observed depending on the distribution of annual average temperature and total precipitation amounts for long years 1975–2020 in Türkiye, it is seen that the Mediterranean climate is effective in the regions outside the temperate, semi-terrestrial and terrestrial areas in the north and northeast of Türkiye (Baylan and Ustaoğlu 2020). This change, which has been experienced in the climate for many years, has also shown itself with extreme weather events and effects in recent years. 1024 extreme meteorological events occurred in Türkiye in 2021 (Turkish State Meteorological Service 2021) (Fig. 18.1).

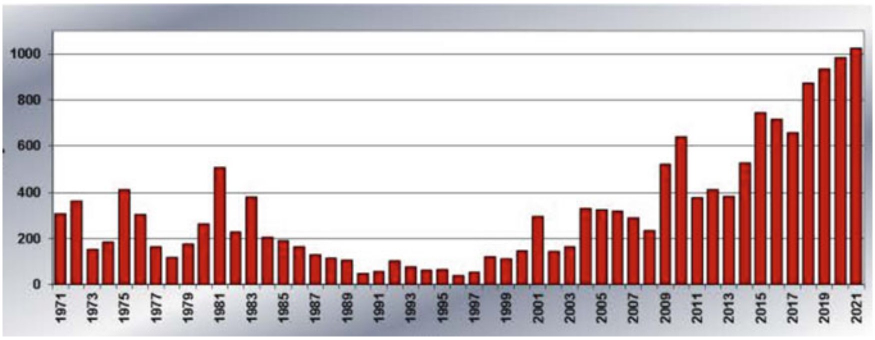

Fig. 18.1 Extreme meteorological events such as heavy rain, storm, tornados event, flood, floods and landslides, heat waves, drought and forest fire are experienced in Türkiye (1971–2021) (Turkish State Meteorological Service 2021)

Study Area

The Mediterranean Basin, including Türkiye, is among the regions most affected by climate change and its global effects (Baltaci and Arslan 2022) (Fig. 18.2).

We have with many natural environmental problems such as crop yield, food supply, food safety, forest fires and changes in land cover, especially the problem to be experienced in accessing clean water resources (Gorji et al. 2017). The most populated region in Türkiye in terms of population density is the Marmara Region, and the most populated province is Kocaeli (İzmit), which ranks second after İstanbul. One of the most critical needs of the population is the need for drinking and utility water. With the start of the water year in October 2020, drought continued until November, December and January and threat to the water requirement of 2021. It has been determined by a drone that the water level in the Yuvacık dam has decreased significantly in recent years and especially in 2020 (June and November) (Fig. 18.3).

According to our study to determine the effects of the change in climatic conditions in the Salda Lake Basin, which is considered an important biodiversity area in Türkiye and has a sensitive ecosystem, it has been determined that there has been a change in the lake surface area and lake water level in the last 48 years. It has been determined that there is a statistically increasing trend in annual average temperatures in the study area. The most critical factor in this change is the degradation of the lake's natural structure due to both the change in climatic conditions and the effect of anthropogenic processes. The lake surface, which had an area of 45.43 km^2 in 1972, decreased to 42.58 km^2 in 2019 (Fig. 18.4). Since Salda Lake is a closed basin, the lake's feeding sources are streams and underground water that show continuous and seasonal flow. According to the findings from field studies, dams and ponds have been built on the main streams feeding the lake in recent years. In addition, groundwater feeding the was used in agricultural activities. In Salda Lake, one of the sensitive lakes with national and international ecological value, located in the Mediterranean Basin, the effects of climate change have been observed in the last 20 years (Fig. 18.5).

Fig. 18.2 Location map of Türkiye

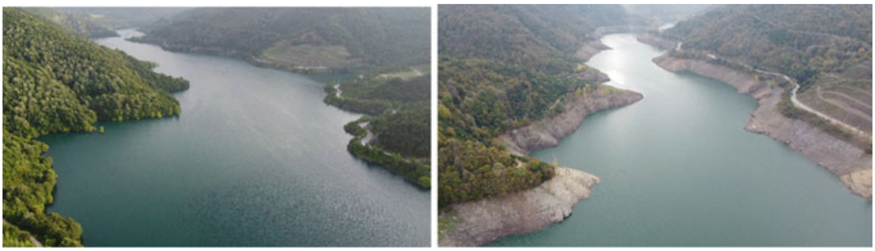

Fig. 18.3 Drone images of Yuvacık Dam in June and November 2020

For sustainable wetland management, adaptation process to climate change should be initiated by the decision-makers in Salda Lake.

With the effect of the global temperature increase, the temperature differences between rural and urban areas have increased due to industrialisation in many cities in Türkiye today (Aykır 2017). In the Marmara Region, where the population density is high in Türkiye, especially in İstanbul, Kocaeli and Sakarya, located on the Çatalca-Kocaeli Peninsula, the effect of the urban heat island has been determined statistically.

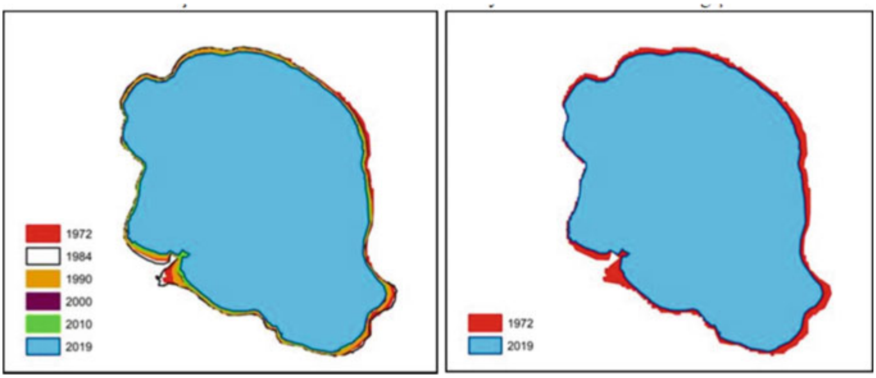

Fig. 18.4 Spatio-temporal change of Salda Lake between 1972 and 2019 (Arıtürk and Ustaoğlu 2020)

Fig. 18.5 Terraces of the Old Lake level containing huntite mineral located on Beyaz Adalar Beach in Salda Lake

Daily minimum temperatures have increased in cities. Especially in Sakarya, where agricultural production is intense, daily minimum temperatures tend to increase (Fig. 18.6) (Ustaoğlu 2018). This situation also affects the phenological periods and yield of crops with high economic value, such as quince, cherries, and grapes.

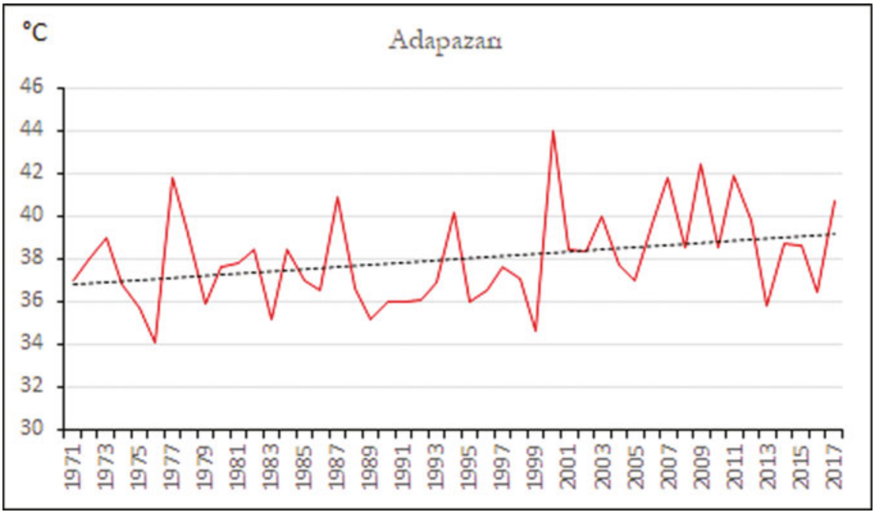

Fig. 18.6 Linear trend of the highest maximum temperatures in Adapazarı

Hazelnut (*Corylus avellena*), which has an important value in exports in Türkiye and ranks first in the world with a yield of 610,200 tons in the last 5 years average Turkish Statistical Institute data, is grown in optimum climatic conditions in the Black Sea Region. However, depending on the changing climatic conditions, there are fluctuations in its yield over the years, and this situation concerns many groups from production to the market, especially many producers who make their living from hazelnut farming. For this purpose temperature increases of up to 6 °C are predicted in the next 80 years depending on the climate projections according to the worst scenario, and it is predicted that the change in temperature conditions may cause the hazelnut planting areas to change horizontally and vertically. Depending on the rising temperature values, it may adversely affect hazelnut cultivation in the coastal zone between 0-250 meters. On the other hand, the cultivated areas will also change in the vertical direction and the areas above 1500 m, will become suitable lands (Ustaoğlu and Karaca 2014). The fact that the olive, which is a bioindicator species in the Mediterranean Region, could not fulfil its chilling requirement in the phenological period, especially due to increasing temperatures (Fig. 18.7), has caused a decrease in its yield recent years (Uzun and Ustaoğlu 2021).

Changes in climatic conditions from year to year in arid and semi-arid regions of developing countries greatly affect the yield and cause financial losses in societies whose economy is based on agriculture. When evaluating the impact of extreme climatic conditions on agricultural activities, it should not be perceived as only a decrease in yield. Because this situation brings together socio-economic phenomena such as economic crisis, food insecurity, hunger, and migration. According to the map in which the distribution of hunger is determined by the World Food Program

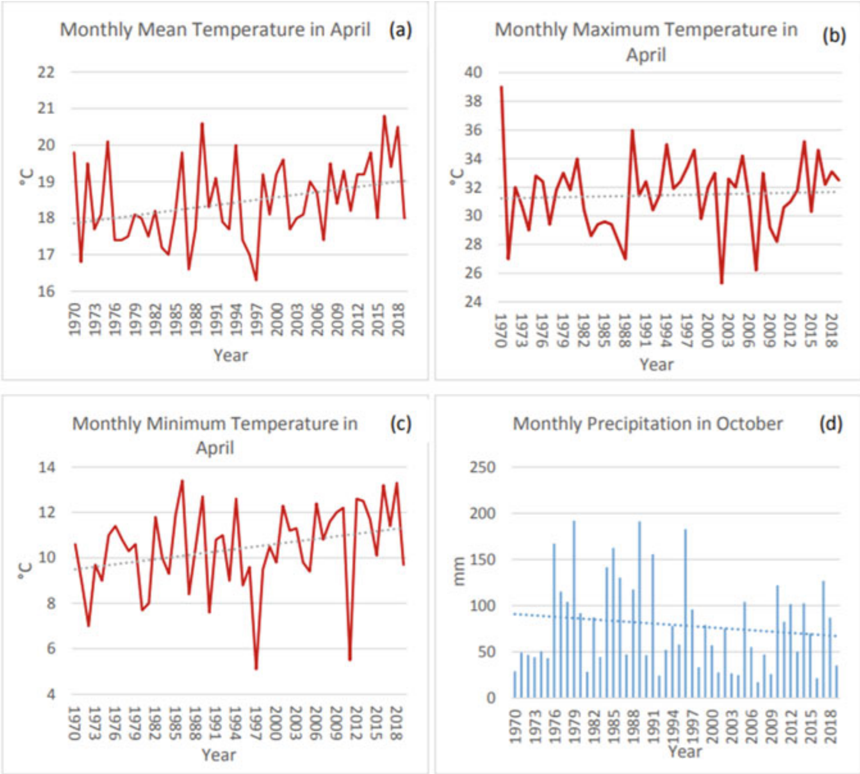

Fig. 18.7 Distribution of average, maximum and minimum temperatures and precipitation during the flowering period of olive in Hatay

(WFP), it is predicted that by 2030, 840 million people will face hunger due to climate change and the negative impact of the COVID-19 epidemic.

On the other hand, heat waves caused by climate change have been effective in Türkiye, especially in the countries located in the Mediterranean Basin in recent years, and have caused the loss of biodiversity (Ustaoğlu 2022) (Fig. 18.8).

Rationale of the Study

The purpose of this study is (a) to determine the present temperature and precipitation conditions in Türkiye (1929–2018), (b) to identify the stations that are arid and non-arid in Türkiye, (c) to predict of the temperature and precipitation conditions depending on the future climate scenarios within the scope of climate change (2061–2080), (d) to determine the arid areas that will be effective in Türkiye in the future.

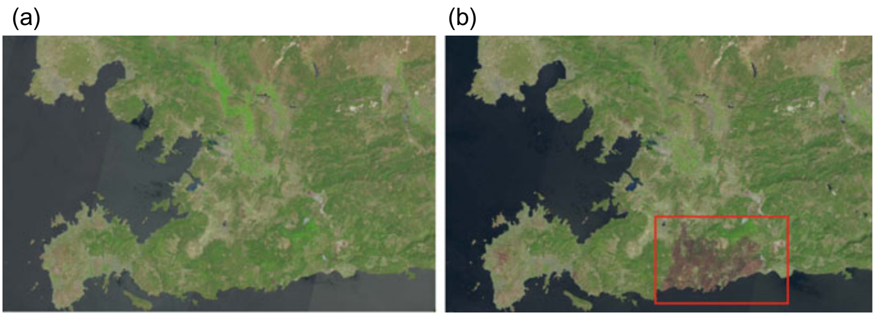

Fig. 18.8 **a** Landsat 8 OLI image of Bodrum and its surroundings in 26 July 2021. **b** Landsat 8 OLI image of Bodrum and its surroundings in 30 July 2021

Materials and Methods

In the study, firstly, Emberger Bioclimate Classification was applied to determine the climatic conditions of Türkiye. The areas where the Mediterranean climate is effective in Türkiye have been selected. Accordingly, humid, arid, continental and semi-continental areas in Türkiye were determined with equations. Especially in Türkiye, the stations with summer drought were determined with ombrothermic diagrams. Afterwards, the temperature and precipitation values of 217 meteorological stations in Türkiye were analysed, temperature and precipitation distribution maps were obtained. To determine the temperature, precipitation and drought condition of Türkiye in the future, climate projection maps created according to the CMIP5 model, WorldClim data, and RCP 4.5 and 8.5 scenarios were applied.

Determining I*, the Mediterranean Climatic Border*

Emberger developed the following equation for the purpose of determining the boundaries of the Mediterranean climate (Akman 2011).

$$I = 2P/(M + m)(M - m) \tag{18.1}$$

where

P the amount of precipitation on rainy days within a year
M The maximum average temperature of the hottest month
m The minimum average temperature of the coldest month.

As a result of the equation, a station that calculates $I < 10$ is understood to be within the boundaries of Mediterranean climate, and the monthly aridity index is understood to be between 1 and 10.

Determination of Seasonal Precipitation Regimes and Determination of Areas with Summer Precipitation > 200 mm and < 200 mm

Türkiye is located in the Mediterranean climate area, but regional and local climate characteristics occur as a result of dynamic and thermal modifications that occur depending on geographical factors (elevation, orography, continentality, etc.). The most distinctive feature of the Mediterranean climate is that the summer precipitation is below 200 mm and there is a distinct summer drought (Akman 2011). The average seasonal precipitation regimes of the 217 meteorological stations that make up the database for many years were checked, and the oceanic, continental or semi-continental conditions of the stations outside the summer season of the driest season were examined.

Determining Continentality (C)

The seasonal precipitations from the meteorological stations have been calculated in the scope of the study. According to this, in areas where the value of $S < 5$ and the lowest season for precipitation is not summer, Coutagne's precipitation equation is used. The precipitation is calculated according to the value obtained as a result of the total precipitation from the hottest 6 months of the year (April, May, June, July, August, September) being divided into the total rainfall from the coldest 6 months (October, November, December, January, February, March) of the year. As a result of the equation, the following values emerge (Daget 1977):

- $C > 1.75$ shows continental climate
- $1 \leq C \leq 1.75$ shows semi-continental climate
- $C < 1$ shows non-continental climate.

Determining Aridity (S)

In the Mediterranean climate, the summers are dry and hot, and the winters are warm and rainy. The most effective factor in determining the Mediterranean climate is the determination of summer drought (Kaymaz and İkiel 2007; Atalay 2013; Kurt 2014). Many criteria have been developed for the determination of the dry period. According to this, the hottest three months of the year are the driest. According to the researchers, the driest 3 months are June, July, August in the interior of the countries located in the Northern Hemisphere, and July, August and September for the countries located in the coastal regions in the Mediterranean climate. Emberger developed the following equation to detect the dry season in the Mediterranean climate (Akman 2011; Daget 1977).

Equation for determining the Emberger Aridity Index (Daget 1977):

$$S = \mathrm{PE}/M \tag{18.2}$$

where

S Aridity
PE Total precipitation for June–July–August (September) months
M Average maximum temperature for the hottest month.

According to the results of the equation, the S:

- $S < 5$ = Mediterranean
- $S = 5 - 7$ = Sub-Mediterranean
- $S > 7$ = Non-Mediterranean.

Gaussen Method (Ombrothermic Diagram)

After dealing with climate problems for many years, Gaussen developed a new classification in 1955 to specify the distribution of vegetation units that he used to name biological climates. According to Gaussen, when the precipitation (P) in any month is equal to or less than twice the temperature in that month, that month is considered a dry month.

The dry season is formed by the succession of dry months. There are two curves in the ombrothermic (precipitation–temperature) diagram. One of these curves shows monthly average temperatures (°C), and the other shows monthly precipitation averages (mm). The precipitation curve begins with January in the Northern Hemisphere. In these graphs, the dry period starts where the precipitation curve cuts the temperature curve and passes under it and ends where the two curves intersect for the second time. Thus, the dry period and the duration of the dry period can be easily read on the graph very clearly (Akman 2011; Pina et al. 2016; Pesce et al. 2020; Loucif et al. 2020).

Spatial Analysis with Kriging Interpolation Method in Geographic Information Systems

Kriging is one of the statistical interpolation methods that is used more than other estimation methods and gives extremely accurate results, as well as allowing the calculation of the standard deviation of the estimation and minimum variance (Johnston et al. 2004; Yaprak and Arslan 2008; Ustaoğlu 2012; Kahraman and Ünsal 2014). The data network is quite large in the study area, the distance between this data is calculated with mathematical functions, and a continuous surface is created. The maps were analysed in ArcGIS 10.5 software; Annual Average Temperature Distribution Map in Türkiye (Fig. 18.9), Annual Average Precipitation Distribution Map in Türkiye (Fig. 18.10), Distribution of Areas with Summer Precipitation > 200 mm and < 200 mm (Fig. 18.11), Distribution of Continental and Semi-Continental Areas (Fig. 18.13), Distribution of Summer Drought and Continental-Semi-Continental Areas in Türkiye (Fig. 18.15).

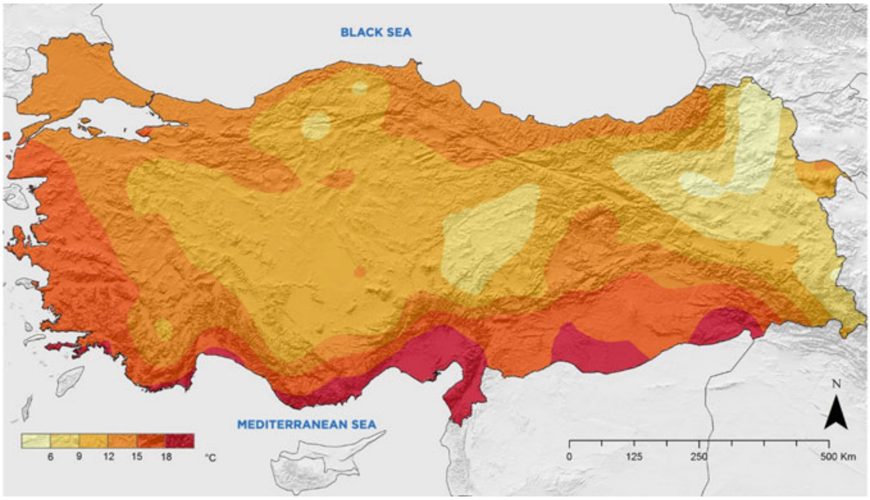

Fig. 18.9 Annual average temperature distribution map in Türkiye (1929–2018)

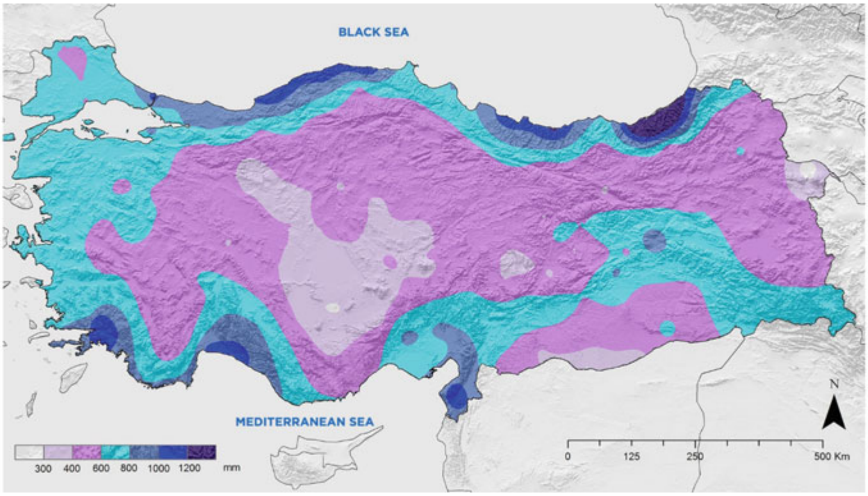

Fig. 18.10 Annual total precipitation distribution map in Türkiye (1929–2018)

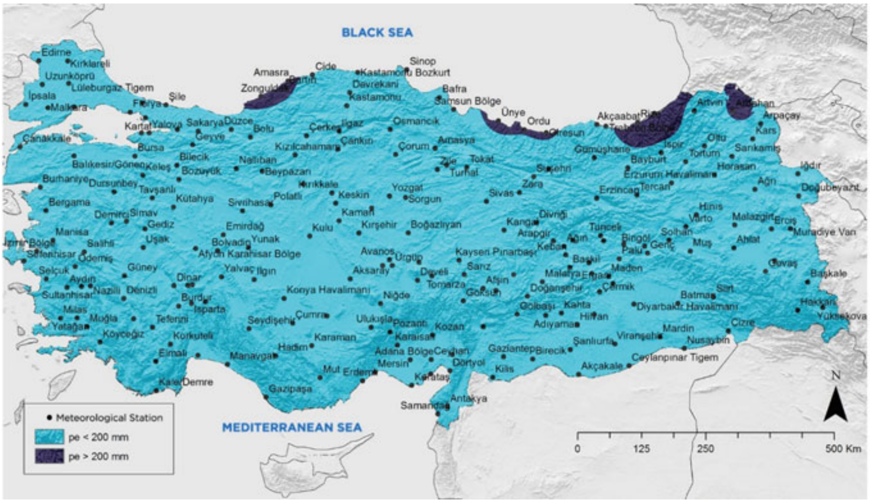

Fig. 18.11 Distribution of Summer Precipitation (June-July-August) with > 200 mm and < 200 mm in Türkiye

Results and Discussion

Temperature and Precipitation Conditions of Türkiye

Annual average temperature values in Türkiye decrease from south to north and from west to east, depending on altitude, geographical latitude and distance from the sea (Koçman 1993). When the annual average temperature values of the 217 meteorology stations used in the study are examined, it is seen that there are significant differences (Fig. 18.9). Temperature values are higher in all coastal regions of the country than inland areas surrounded by high mountain ranges.

Distribution of Precipitation in Türkiye

The most important factor in the distribution of precipitation in Türkiye is geographical factors. In particular, the extent of the mountains, the position of the slopes (aspect effect) against the frontal activities and the effect of the pressure regimes that change according to the seasons are among the most important geographical factors. When the annual average precipitation distribution map (Fig. 18.10) is examined, it is seen that the highest precipitation falls on the seafaced slopes of the mountain ranges in our northern and southern regions and on the coastal zone in front of these mountain. Decrease in temperature is also seen in precipitation towards the inner parts. This is due to the sea effect in the north, south and west of the country. At the same time, the humidity air masses affecting the coastal regions rise on the outer slopes of the Taurus Mountains and the North Anatolian mountains, causing a lot of precipitation to fall between the coastal belt and these mountains. As these air masses, which cause a lot of precipitation in the coastal zone, move inland, they contain less humidity, as they leave most of the humidity they carry in the coastal areas and are heated adiabatically as they cross the mountains. For this reason, precipitation in the interior regions is less than in the coastal regions (İkiel 2005).

Distribution of Areas with Summer Precipitation > 200 mm and < 200 mm

In the Mediterranean climate, summers are hot and dry, and winters are warm and rainy. The most effective factor in determining the Mediterranean climate is the determination of summer drought. For this reason, in addition to the calculation of the drought index (S), the seasonal distribution of precipitation during the year was examined and the areas with the least precipitation in summer were accepted as Mediterranean climate. Another criteria, summer precipitation not exceeding 200 mm, was also mapped (Fig. 18.11). Areas with a drought index of $S > 7$, the lowest precipitation seasonally in spring, and the summer precipitation totals above 200 mm were considered oceanic. As it can be understood from the ombrothermic diagrams, in the stations characterising the oceanic climate, it is rainy all year and there is no dry period. The most precipitation falls in these areas in the autumn season and the least in the spring season (Fig. 18.12).

Distribution of Continentality (C)

According to the result of the precipitation continentality equation, three stations were determined as continental and 13 stations as semi-continental out of 217 stations. In regions where continentality is evident, summer precipitation is generally higher than winter precipitation. These regions are located in the northeast of Türkiye. Semi-continental zones are located around the continental zone. In areas with continental climate, the total annual precipitation is between 500 and 561 mm, M value; 26.7–24.7, m value; It varies between − 16.5 and − 14.1 (Fig. 18.13). When the precipitation temperature diagram of some stations representing the continental climate is examined, it is seen that the precipitation is extremely low in the winter season, the precipitation increases especially in the spring and summer months, and the temperatures reach the highest level while the precipitation decreases again in September at the end of the summer season at the beginning of the autumn season drought is observed. In the areas with semi-continental climate, the annual precipitation total is 634–262 mm. When the precipitation-temperature

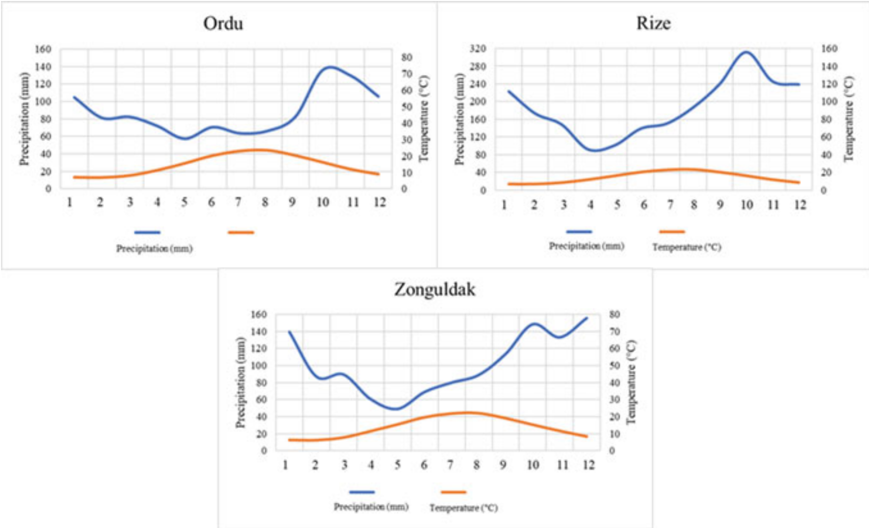

Fig. 18.12 Ombrothermic diagram of oceanic stations in Türkiye

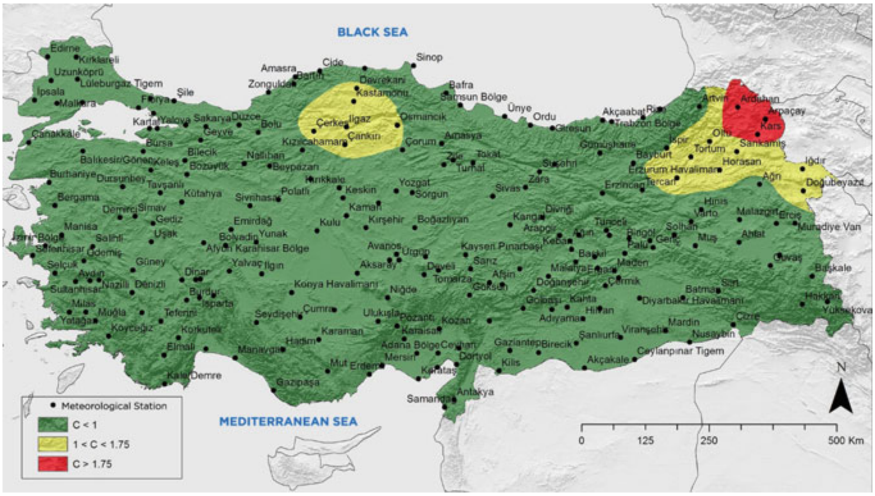

Fig. 18.13 Distribution of continental and semi-continental areas in Türkiye

diagram of some stations representing the semi-continental climate is examined, it is understood that it shows similarities with the stations representing the continental climate, but the dry period observed in the continental stations in September, including the end of August at the semi-continental stations, continues throughout September (Fig. 18.14). An insignificant summer drought is observed in these areas.

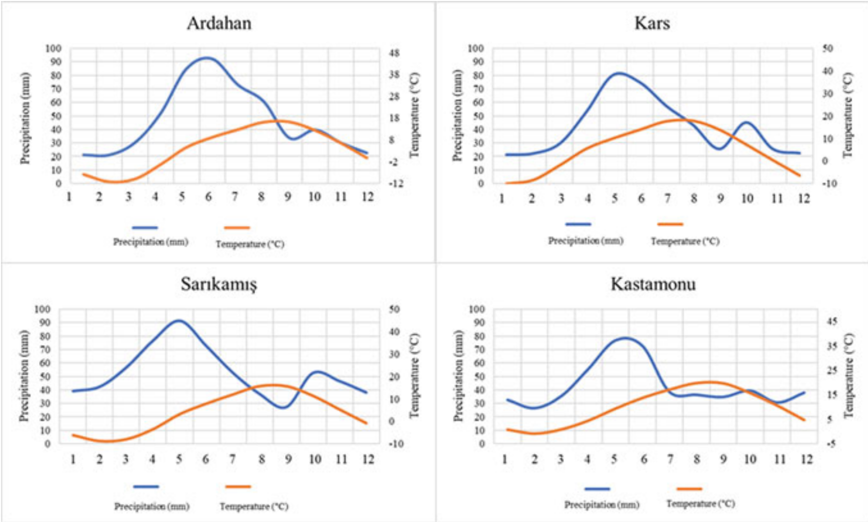

Fig. 18.14 Ombrothermic (precipitation–temperature) diagram of continental and semi-continental stations in Türkiye

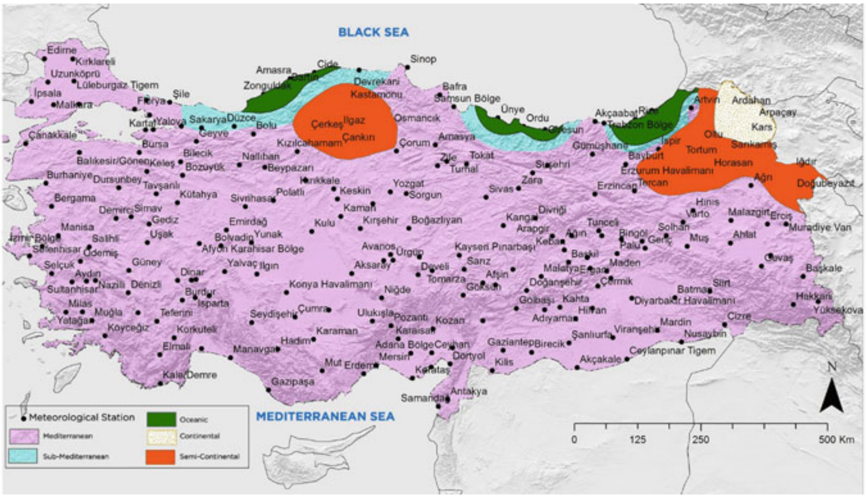

Fig. 18.15 Distribution of summer drought and continental/semi-continental areas in Türkiye according to the Emberger bioclimate classification

Distribution of Drought Conditions of Selected Cities (S)

Drought, which is the most important factor in determining the Mediterranean climate, was determined using Emberger's (S = PE/M) equation. As a result of the equation, the S value of three stations determined as continental from 217 meteorology stations is greater than 7, and the S value of 10 of 13 stations determined as semi-continental is less than 5, but these 16 stations do not have Mediterranean climate characteristics. Except for continental and semi-continental stations, the S value of 187 of 201 meteorology stations was less than 5, the S value of 5 stations was between 5 and 7, and the other 9 stations were greater than 7 (Fig. 18.15). According to the result of the equation, 187 stations with an S value less than 5 are Mediterranean (Fig. 18.17), 5 stations with an S value between 5 and 7 are Sub-Mediterranean, and 9 stations with an S value greater than 7 are not Mediterranean (Oceanic). Stations with an S value greater than 7 are located on the Black Sea coastline in northern Türkiye, these regions are characterised by not having a dry season and summer precipitation was above 200 mm (Fig. 18.16). In the eastern part of this region, tea plants are grown in places where humid and mild climate conditions are suitable. Hazelnut (*Corylus avellana*) (Ustaoğlu and Karaca 2010, 2014), chestnut (*Castanea sativa*) and spruce (*Picea*) are common in the Black Sea region (Atalay 2015). In addition to the Oceanic climate, it is seen that the rainy Mediterranean climate is also effective on the Black Sea coastline.

Projected Changes in Temperature and Precipitation Climatology in Türkiye

The CMIP 5 model with RCP 4.5 and RCP 8.5 emission scenario outputs is used for future (2061–2080) in order to possible changes in temperature and precipitation climatology, and drought conditions. According to model results of future projections, there will be an increase in average temperature (BIO1) and a decrease in total precipitation (BIO 12) over almost all parts of Türkiye (Fig. 18.18). More arid conditions are likely to occur in most of Türkiye (Figs. 18.19, 18.20 and 18.21).

According to the obtained results, an increase in the annual average temperatures (BIO1) is predicted in the Black Sea coasts where the oceanic climate is observed in Türkiye. A decrease is predicted in the annual total precipitation (BIO 12) (Fig. 18.18) and precipitation of the driest three months (BIO 17) (Fig. 18.23). This situation shows that partially dry conditions can be observed in the areas where oceanic climate prevails on the northern coasts of Türkiye, particularly in summer (Figs. 18.18, 18.19, 18.23 and 18.24). According to the change detection map, in the areas of Türkiye defined as Central and Eastern Anatolia, projected changes in minimum temperature of coldest months (Fig. 18.22) and projected changes in maximum temperature of warmest months (Fig. 18.24) are increase, and annual total precipitation (Fig. 18.18) is projected to decrease according to the both RCP scenarios. Anomaly values are

Fig. 18.16 Ombrothermic (precipitation–temperature) diagram of Sub-Mediterranean stations in Türkiye

about 6–7 °C in RCP 4.5 and 8–9 °C in RCP 8.5 scenario. This situation shows that the existing drought in terrestrial and semi-continental areas will become more severe.

Türkiye is in the impact area of the Mediterranean Climate. Sub-Mediterranean climate is seen in the transition from Mediterranean climate to continental, semi-continental and oceanic climate regions. It is seen that the different temperature and precipitation characteristics (BIO1-BIO5-BIO6-BIO12-BIO17) included in the bioclimatic variables of the areas dominated by the Mediterranean climate will

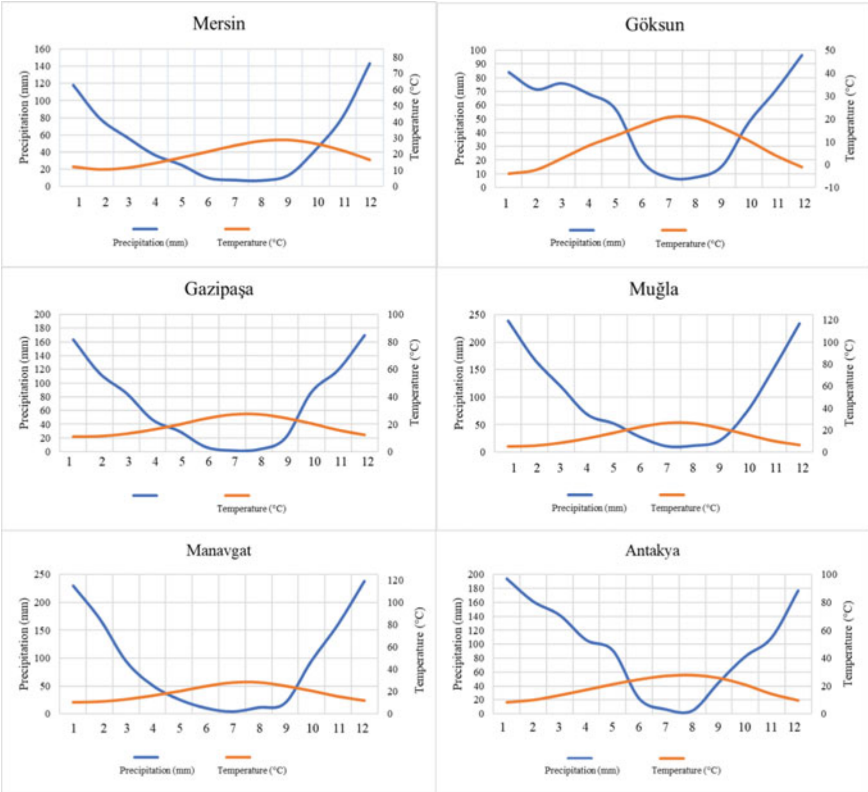

Fig. 18.17 Ombrothermic (precipitation–temperature) diagram of Mediterranean stations in Türkiye

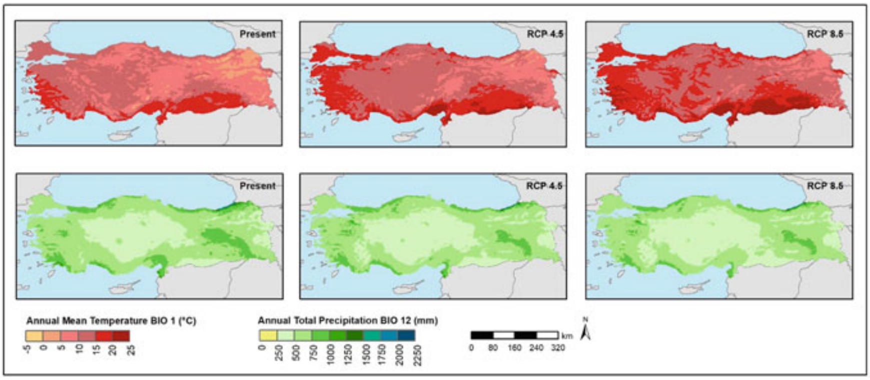

Fig. 18.18 Annual average temperature (°C) and annual total precipitation (mm) distribution for the period of present (1960–1990) and future (2061–2080) according to RCP 4.5 and RCP 8.5 in Türkiye

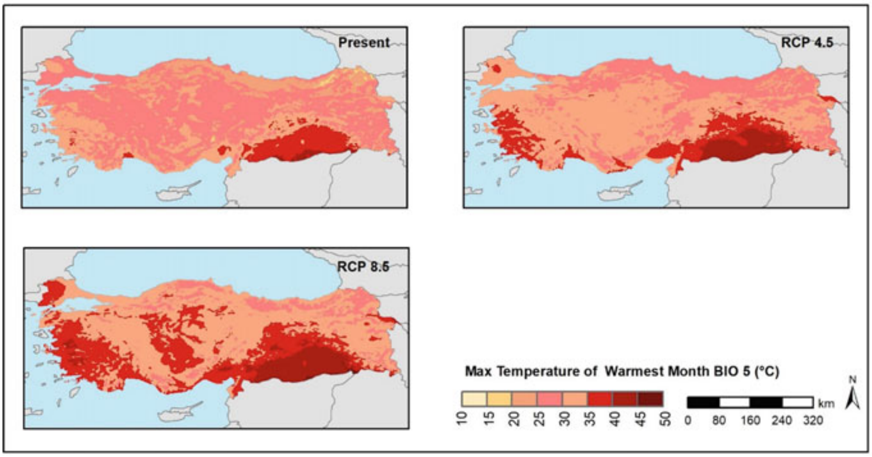

Fig. 18.19 Maximum temperature of warmest months distribution for the period of present (1960–1990) and future (2061–2080) according to RCP 4.5 and RCP 8.5 in Türkiye

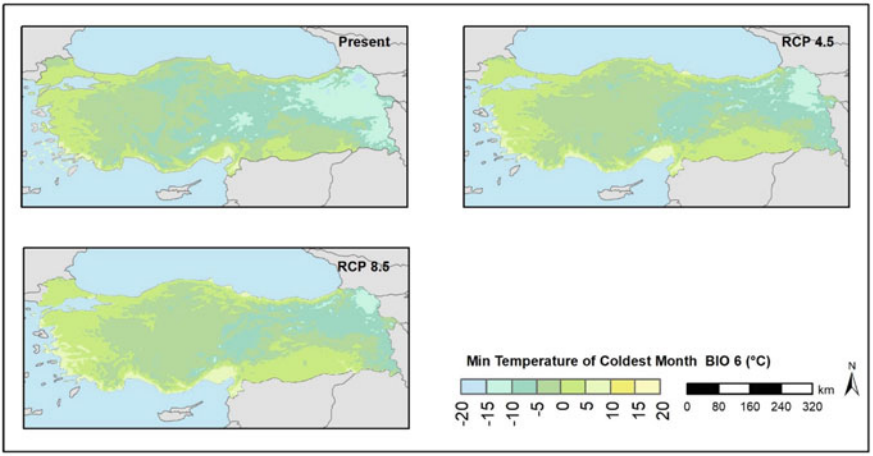

Fig. 18.20 Minimum temperature of coldest months distribution for the period of present (1960–1990) and future (2061–2080) according to RCP 4.5 and RCP 8.5 in Türkiye

change in the future. In general, increases in temperatures and decreases in precipitation will trigger drought and affect the duration and severity of drought (Figs. 18.18, 18.19, 18.20, 18.21, 18.22, 18.23 and 18.24). When other studies related to the study area were discussed, it was observed that similar results were obtained in different time and space scales in the Mediterranean Basin (Dabanlı et al. 2017; Demircan et al. 2017; Türkeş et al. 2020; Bağçacı et al. 2021). According to the results of the study examining possible future changes in mean air temperature, precipitation climatology and inter-year variability over the Mediterranean, the frequency and

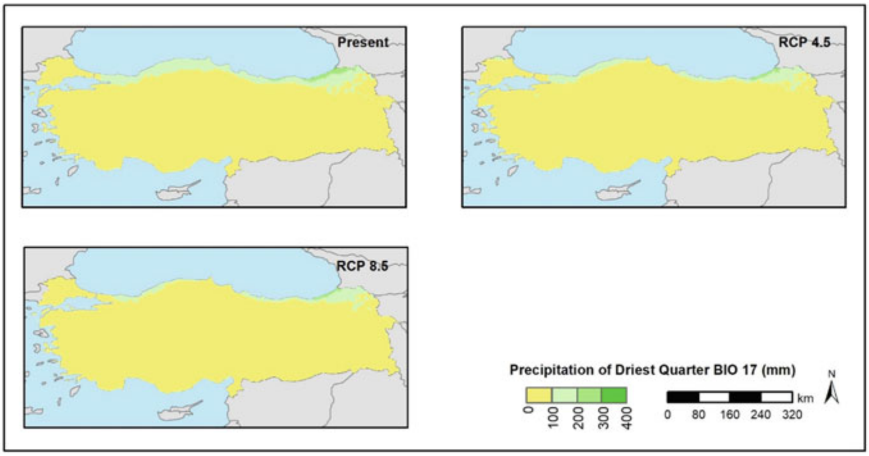

Fig. 18.21 Precipitation of the driest quarter distribution for the period of present (1960–1990) and future (2061–2080) according to RCP 4.5 and RCP 8.5 in Türkiye

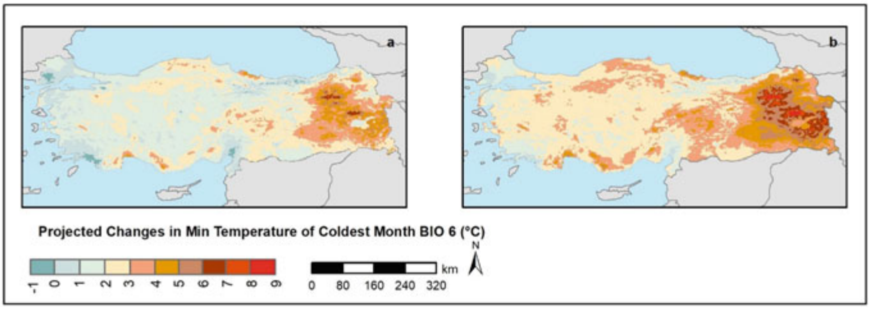

Fig. 18.22 Projected change detection map in minimum temperature of coldest month distribution for the period of present (1960–1990) and future (2061–2080) according to **a** RCP 4.5 and **b** RCP 8.5 in Türkiye

intensity of high temperatures and extreme precipitation events will likely increase in the future (Öztürk et al. 2015). Giorgi and Lionello (2008) examined climate change projections over the Mediterranean region, based on comprehensive global and regional climate change simulations. The results suggest that the Mediterranean may be a particularly vulnerable region to global change. Görgüner et al. (2017) examined temperature and precipitation changes in the Gediz Basin according to the RCP4.5 and RCP 8.5 scenarios. According to the trend analyses obtained, a decrease in annual average precipitation and an increase in annual temperatures are predicted. On the other hand, the changes in seasonal precipitation climatology, extreme weather conditions and drought conditions in Türkiye for the 2021–2050 period are evaluated according to the 1971–2000 reference period using regional climate model simulations. According to the results obtained, drier conditions are expected in Türkiye

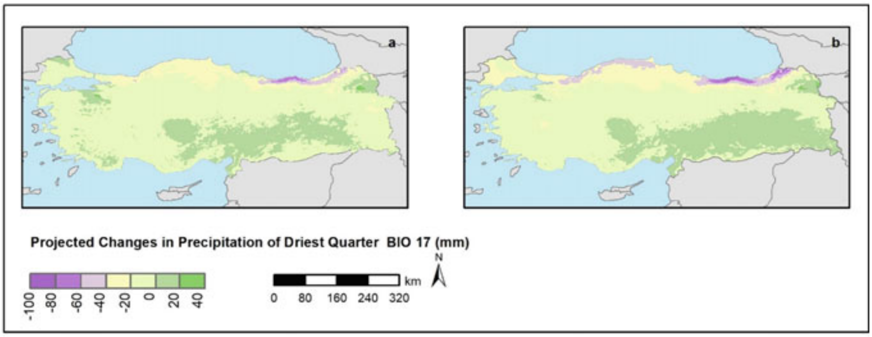

Fig. 18.23 Projected change detection map in precipitation of the driest quarter distribution for the period of present (1960–1990) and future (2061–2080) according to **a** RCP 4.5 and **b** RCP 8.5 in Türkiye

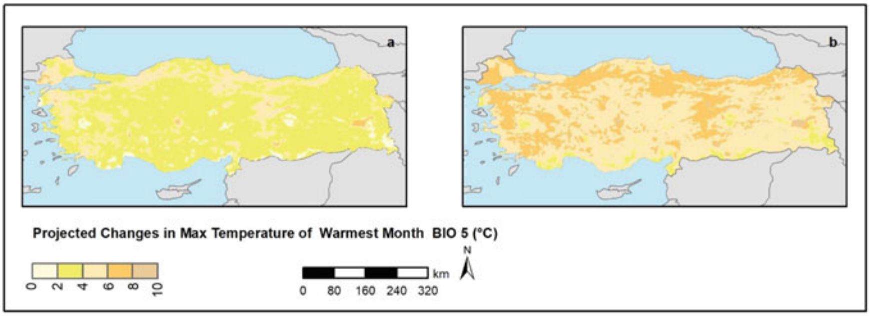

Fig. 18.24 Projected change detection map in maximum temperature of warmest months distribution for the period of present (1960–1990) and future (2061–2080) according to **a** RCP 4.5 and **b** RCP 8.5 in Türkiye

in the near future (Türkeş et al. 2020). Lionello and Scarascia (2018) analysed the recent (twentieth century) and future (twentieth century) climate in the Mediterranean region in relation to the annual average global surface temperature change. According to the results obtained, as the average global temperature increases in the twenty-first century, precipitation will decrease in the Mediterranean region, and warming will be more especially in summer. The decrease in precipitation will affect all seasons in the central and southern Mediterranean regions, and the maximum decrease in winter precipitation will be seen. For areas along the northern border of the Mediterranean region, the decrease will be greatest during the summer months, with no significant precipitation decrease during the winter months. Bucchignani et al. (2018) investigated the predicted changes in future climatic conditions for the Middle East-North Africa region in the twenty-first century. Climate projections have shown a significant warming of the entire area under consideration by the end of the twenty-first century, as well as a reduction in precipitation, which is particularly evident in the western part of the region. Zittis et al. (2022) conducted a study based on a revised analysis of recent observations and projections and a comprehensive review of the latest scientific literature on the causes and effects of regional climate change. Cos et al. (2022) compared CMIP5 and CMIP6 and projections of historical and future scenario simulations to measure the effects of changing climate in the Mediterranean region. The results showed strong and significant warming in the Mediterranean region during all seasons, populations and experiments in the twenty-first century.

Conclusion

Human-induced climate change has had significant impacts on the environment, human health and various segments of society, and these impacts are expected to continue. For this reason, in addition to taking measures, the society needs to be prepared for and adapt to some inevitable consequences of climate change. Adaptation strategies at national, regional and local levels are required in order to prevent the serious damage of climate change to humans and the environment and to ensure sustainable development in changing climatic conditions. Early warning systems are useful in informing long-time-scale forecasts in climate change impact assessment. The catastrophic effect of climate change can be eliminated by irrigation and determining appropriate planting dates. In order to adapt to climate change, product types that are resistant to very high and very low temperatures and drought should be developed or existing species can be improved. In order to reduce and prevent the effects of climate change, we must first reduce the use of fossil fuels. We should implement the principles of energy saving and energy efficiency in all sectors (agriculture, transportation, housing, industry) and turn to the use of renewable energy sources.

In conclusion, considering the future 2061–2080 projections, drought conditions are very likely to affect Türkiye, making it extremely vulnerable to climate change.

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