Analyzing temporal variation characteristics climate change in crop production of Marmara Region

Funda Dökmen[1*] Ayşe Nur Uzunlar[2] Cansu Aslan[2]

[1]Kocaeli University, Izmit Vocational School, Department of Plant and Animal Production, Arslanbey Campus, Arslanbey-Kartepe, 41285, Kocaeli, Türkiye.
Orcid No: 0000-0002-0615-2887

[2]Kocaeli University, Faculty of Agricultural, Department of Horticulture, Campus of Arslanbey, Arslanbey-Kartepe, 41285, Kocaeli, Türkiye.

ABSTRACT

Climate change is a major global problem, primarily caused by human activities such as industrialisation and urbanisation, which lead to increased greenhouse gas emissions. This phenomenon has far-reaching impacts on the environment, human health, agriculture and ecosystems. Climate change is causing global temperatures to rise, changing precipitation patterns and increasing the frequency of extreme weather events such as hurricanes, droughts and heavy rainstorms.

Changes in temperature, humidity and wind speed affect food security by significantly reducing crop yields in agricultural production. In the Marmara Region, the hydrological cycle, precipitation dynamics and agroecosystem are significantly affected by climate change. Transitions from warm and humid climates to cooler and drier climates also affect the vegetation cover in the region. In this study, 30-year monthly average “temperature”, “precipitation” and “humidity” changes were analysed in Marmara Region, Turkey.

Keywords: Agricultural production, global climate change, humidity, precipitation.

INTRODUCTION

Climate change poses significant challenges for agricultural production, affecting water resources, crop yields and food security. Understanding these impacts and developing strategies for adaptation are crucial for sustaining agricultural productivity and ensuring food security.

Furthermore, climate change affects agricultural production by altering environmental factors such as temperature, precipitation, humidity and wind speed, which in turn affect crop growth cycles, the frequency of extreme weather events and the occurrence of plant diseases. These changes lead to fluctuations in crop yield and quality, affecting food availability and prices (Yuan et al., 2024; Guerriero et al., 2023; Aalijahan et al., 2023; Turan and Gürlek, 2016).

Observational records and climate projections provide ample evidence that freshwater resources are vulnerable and likely to be severely affected by climate change, with far-reaching consequences for human communities and ecosystems (IPCC, 2007).

Temperature, precipitation and humidity are the most important indicators of climate change. We have to take into consideration the increasing temperature values and decreasing precipitation amounts as a result of global warming in our daily lives as well as agricultural production.

Increasing climate changes in recent years have significantly affected the South Marmara Region of Turkey. Significant climate changes have been experienced in temperature, humidity and precipitation regimes (Seter et.al., 2011; Seddiqe et.al., 2023; Hayta and Köksal, 2024).

Studies conducted by scientists report that temperatures will increase as we approach 2030. It is predicted that temperatures will increase by 2 ^{0}C degrees within 20 years (Anonymous, 2024). Therefore, in this study, 30-year monthly average 'temperature', 'precipitation' and 'humidity' changes were analysed. The data obtained from long-term meteorological data, their suitability in terms of drought and agricultural productivity were evaluated with 'Excell Variation Graphs' for the South Marmara Region where agricultural production is intensive in Turkey.

MATERIALS and METHODS

This study was carried out in Bursa, Balıkesir and Yalova provinces where agriculture is intensively practised in the Southern Marmara Region of Turkey. Map of the study area and provinces are shown in Figure 1.

Figure 1. Study area of Marmara region in Türkiye

In the study, 30-year (1994-2024) average temperature, precipitation and humidity values of Bursa, Balıkesir and Yalova Provinces of South Marmara Region were obtained from the Turkish State Directorate General of Meteorology (Table 1), (Anonymous, 2023a).

Table 1. 30-year average temperature, humidity, precipitation, maximum temperature and minimum temperature values of Balıkesir, Bura and Yalova provinces

Meteorological parameters	**Balıkesir**	**Bursa**	**Yalova**
Temperature (^{0}C)	14.9	14.7	14.7
Humidity (%)	60.2	58	76
Precipitation (mm)	603.6	708.1	755.1
Max.Temperature (^{0}C)	43.7	43.8	42.1
Min.Temperature (^{0}C)	-18.8	-20.5	-11

As can be seen in Table 1, the long-term temperature in the study area varies between 14.9 ^{0}C and 14.7 ^{0}C, humidity between 60.2% and 58% and rainfall between 755.1 mm and 603.6 mm.

Excell was used to prepare 12-month change graphs of 30-year average data and the changes were interpreted. According to the change graphs prepared in Excel, long-term data were analysed and the results were evaluated and interpreted at the point of climate change.

In addition, the distribution of fruit, vegetable and field areas and production amounts of the agricultural areas of Bursa, Balıkesir and Yalova Provinces, the types and amounts of land use in these Provinces were obtained from the data of Bursa, Balıkesir and Yalova Provincial Directorate of Agriculture and the Ministry of Agriculture (Tables 2 and 3), (Anonymous, 2023b).

Table 2. Agricultural potential and product pattern of Balıkesir province

Forest area (%)	Agricultural area (%)	Non-agricultural land (%)	Meadow-Maereland (%)
43	28	23	6

Production area Balıkesir province (ha)	Fruit 970.024	Vegetable 264.570	Field 1790.923
Share in Turkey (%)	6.9	3.7	11.4

As indicated in Table 2, agricultural production area in Balıkesir province is in the leading position as field cultivation.

Table 3. Agricultural potential and crop patterns of Bursa and Yalova provinces

Agricultural potential	**Products**
Field crops	Wheat, barley, vetch
Fruit Growing	Olive, apple, peach, cherry, kiwi, pear
Vegetable production	Cabbage, tomatoes, lettuce, cucumber, beans
Ornamental Plants	Outdoor and indoor ornamental plants, cut flowers

Since the climatic characteristics of Bursa and Yalova are close to each other, they have common agricultural products (Tablo 3). Fruit production is carried out on an area of 60,975 decares in Yalova. In 2023, 49,107 tonnes of fruit was produced on 59,757 decares of land, while 50,697 tonnes of fruit was harvested on 60,975 decares of land in the first 6 months of 2024.

RESULTS and DISCUSSION

When the effects of global climate change on precipitation, temperature and humidity meteorological parameter variables in the research area are examined, it is seen that the studies and meteorological data show a trend/trend at certain rates on average in the 30-year period between 1994-2024 (Figures 2, 3 and 4). When the change graphs are analysed; there is not much deviation from the average temperature, precipitation and relative humidity data of the Marmara Region. Average values are compatible with the general characteristics of the climate of the region. Average temperature increased in May-August in accordance with the season. The average precipitation decreased in May-August and then increased. Average relative humidity decreased in June-July and increased in other months.

Within the scope of the research, the change/variation graphs of long-term meteorological data (precipitation, temperature and humidity) of Balıkesir, Bursa and Yalova provinces located in the Marmara Region using 30-year monthly average values over 12 months are shown in Figures 2, 3 and 4.

Balıkesir Province

Balıkesir Province has a semi-arid climate, cool in winters, hot in summers, water surplus in winter and a climate close to maritime influence. The dominant wind direction is North, and depending on seasonal changes, the secondary dominant wind direction is North-Northeast.

According to Balıkesir Meteorological Station data; the long years average temperature is 14,5 ^{0}C and has an increasing trend. The daily maximum temperature is 43.7 ^{0}C and the minimum temperature is -21.8 ^{0}C.

The long-term average annual total precipitation is 550.9 mm. The maximum precipitation measured in 24 hours is 126.8 mm. The maximum precipitation falls in November, December and January. The least rainy months are July and August.

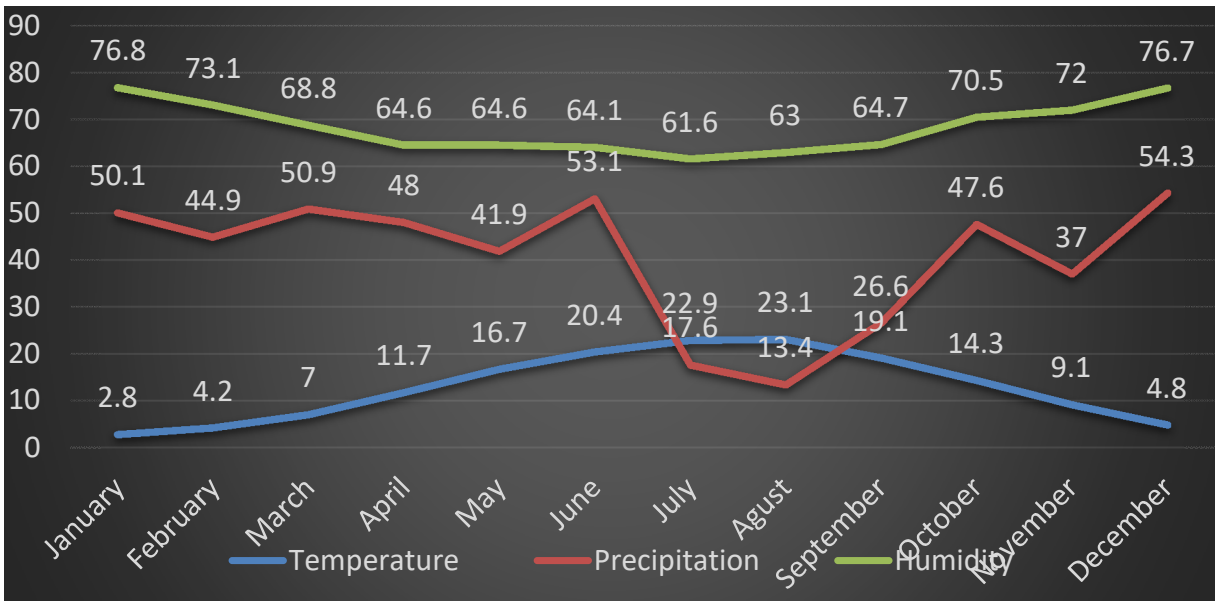

Figure 2. 30-year monthly average precipitation, temperature and humidity change/variation graphs of Balıkesir Province (1994-2024)

When we examine the monthly average values for 30 years in Figure 2, we see that the temperature values vary between 22.9-26.6 ^{0}C at the highest and 2.8-4.8 ^{0}C at the lowest. Precipitation ranged between 41.9-26.6 mm in summer and the lowest was 13.4 mm in August. Humidity values varied between 76.8 and 76.7 % with the lowest value being 61.6 % in July.

Bursa Province

Located in a transition area between Marmara and Aegean regions, Bursa's climate shows a complex structure. While the type of Mediterranean climate specific to the Marmara coasts is effective in the northern part, the continental climate of Central Western Anatolia is observed in the southern and inner parts. Accordingly, the natural vegetation consists of Mediterranean origin plants in the lowlands and moist forests characterised by the Black Sea plant community on the slopes facing north in the highlands. Most of the precipitation is in the form of rain, but where the elevation increases, the precipitation turns into snow. In general, the hottest months are July-August and the coldest months are January and February. The months with high rainfall intensity are April, September and December.

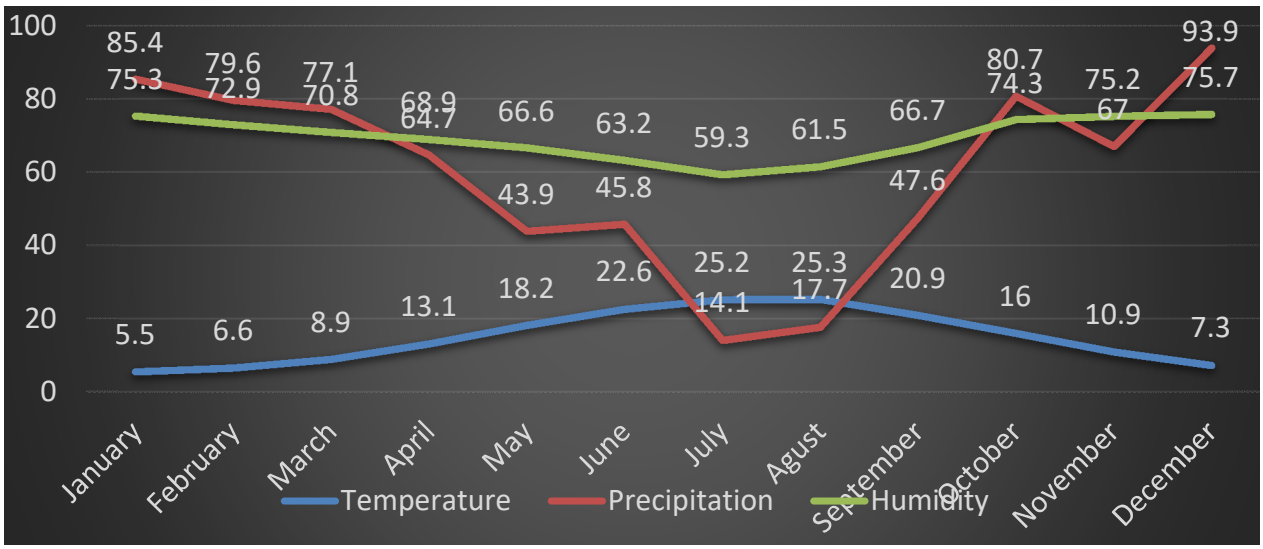

Figure 3. 30-year monthly average precipitation, temperature and humidity change/variation graphs of Bursa Province (1994-2024)

When we examine the monthly average values for 30 years in Figure 3, we see that the temperature values vary between 18.2-25.3 ^{0}C at the highest and 5.5-7.3 ^{0}C at the lowest. Precipitation ranged between 45.8-17.7 mm in summer and the lowest was 14.1 mm in July. Humidity values varied between 75.3 and 75.7 % with the lowest value being 59.3 % in July.

Yalova Province

The climate of Yalova province, as a micro-climate type, is a transition between the Mediterranean and Black Sea climates. In some periods, the province has continental climate characteristics, summers are quite dry and hot, winters are cool and rainy. Snowfall is common in the high parts of the district in winter and snow can stay on the ground for weeks. Almost every winter, it snows several times in the coastal areas.

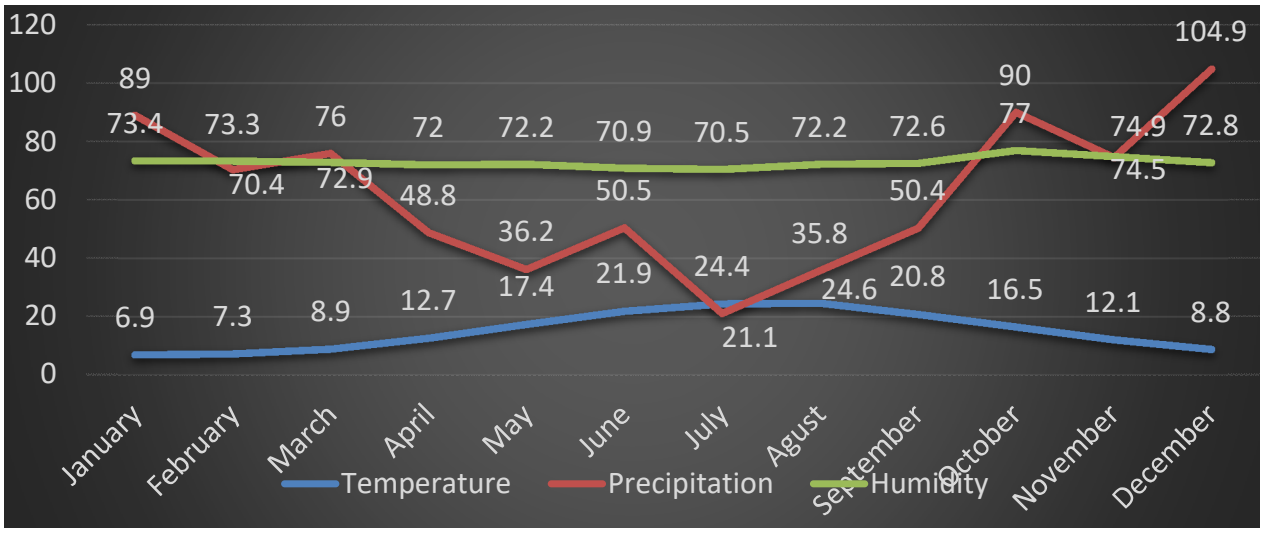

Figure 4. 30-year monthly average precipitation, temperature and humidity change/variation graphs of Yalova Province (1994-2024)

When we examine the monthly average values for 30 years in Figure 4, we see that the temperature values vary between 17.4-24.6 ^{0}C at the highest and 6.9-8.8 ^{0}C at the lowest. Precipitation ranged between 36.2-35.8 mm in summer and the lowest was 35.8 mm in August. Humidity values varied between 73.4 and 72.8 % with the lowest value being 70.5 % in July.

Yalova has a micro climate characteristic in terms of agriculture. For this reason, in order for any plant to be able to grow, cultivation can be carried out all year round even in very narrow climatic conditions. Due to the microclimate characteristic of this region, climatic conditions in this region show an effect in the horizontal and vertical direction, that is, in a width of a few meters.

CONCLUSION

The Marmara Region is under the stress of climate change. In the Southern Marmara Region, climate models predict significant variability in precipitation. While Balıkesir region shows resilience, other regions are expected to experience significant decreases in precipitation.

According to the research, heat wave duration, summer days, tropical nights and warm days have increased in the region, while cold wave duration and icy days have decreased (Abbasnia and Toros 2018; Baltacı, 2019). This warming trend is more evident in night temperature indices than in daytime indices (Başdurak, 2023; Yetik and Candoğan, 2024; Oksal, 2023). Precipitation patterns are also changing, and annual precipitation amount and precipitation intensity are increasing, especially in urban areas with rapid urbanization such as Bursa.

Drought is a critical issue as temperature increases could lead to longer and more severe droughts in the region. The variability of extreme climate events, such as hot days and nights, is evident across the Marmara Region and significant trends are observed in many areas. These changes require new adaptive strategies for water resources used in agricultural production.

In this context, policy support will be needed in Europe in the near and distant future for the development of agri-environmental programs that integrate adaptation and mitigation strategies, as well as the promotion of flexible land use and crop production systems.

Acknowledgements

This study was prepared within the scope of The Scientific and Technological Research Council of Turkey (TÜBİTAK) 2209-A Project No. 1919B012301811/2023 and is supported by TÜBİTAK. Authors would like to thank to TÜBİTAK for financial support.

Ethics declarations

Conflict of interest

The authors have no competing interests to declare that are relevant to the content of this article.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

REFERENCES

Abbasnia, M., & Toros, H. (2018). Analysis of long-term changes in extreme climatic indices: a case study of the Mediterranean climate, Marmara Region, Turkey. *Pure and Applied Geophysics*, 175, 3861-3873. https://doi.org/10.1007/s00024-018-1888-8.

Aalijahan, M., Karataş, A., Lupo, A., Efe, B., & Khosravichenar, A. (2023). Analyzing and Modeling the Spatial-Temporal Changes and the Impact of GLOTI Index on Precipitation in the Marmara Region of Türkiye. *Atmosphere*. https://doi.org/10.3390/atmos14030489.

Anonymous, 2023a. MGM, Turkish State Directorate General of Meteorology, Ankara, Türkiye.

Anonymous, 2023b. Recorder of Bursa, Balıkesir and Yalova Provincial Directorate of Agriculture and the Ministry of Agriculture, Ankara, Türkiye.

Anonymous, 2024. https://sentrum.com-iklim-değişikliğinin-türkiyeye-etkileri (The effects of climate change on Turkey), (access date: 11.03.2025).

Basdurak, B. (2023). Climate change impacts on river discharge to the Sea of Marmara. *Frontiers in Marine Science*. https://doi.org/10.3389/fmars.2023.1278136.

Baltaci, H. (2019). Spatiotemporal variability of climate extremes in the Marmara Region (NW Turkey). *International Journal of Global Warming*. https://doi.org/10.1504/IJGW.2019.101085.

Guerriero, V., Scorzini, A., Di Lena, B., Iulianella, S., Di Bacco, M., & Tallini, M. (2023). Impact of Climate Change on Crop Yields: Insights from the Abruzzo Region, Central Italy. *Sustainability*. https://doi.org/10.3390/su151914235

Hayta, B., & Köksal, M. (2024). Forecasting Wind Power Plant Electricity Generation at the Marmara Basin Based on Climate Change Projections. *2024 International Conference on Renewable Energies and Smart Technologies (REST)*, 1-5. https://doi.org/10.1109/REST59987.2024.10645370.

IPCC. (2007). *Impacts, Adaptation, and Vulnerability (Eds. ML Parry, OF Canziani, JP Palutikof, PJ van der Linden, CE Hanson)* (Vol. 4): Cambridge University Press, UK.

Oksal, N. (2023). Comparative analysis of the influence of temperature and precipitation on drought assessment in the Marmara region of Turkey: an examination of SPI and SPEI indices. *Journal of Water and Climate Change*. https://doi.org/10.2166/wcc.2023.179.

Turan, C., & Gürlek, M. (2016). Climate Change and Biodiversity Effects in Turkish Seas. , 1, 15-24. https://doi.org/10.28978/NESCIENCES.286240.

Sertel, E., Ormeci, C., & Robock, A. (2011). Modelling land cover change impact on the summer climate of the Marmara Region, Turkey. *International Journal of Global Warming*, 3, 194. https://doi.org/10.1504/IJGW.2011.038379.

Seddiqe, K., Sediqi, R., Yildiz, O., Akturk, G., Kostecki, J., & Gortych, M. (2023). Effects of Climate Change on Streamflow in the Ayazma River Basin in the Marmara Region of Turkey. *Water*. https://doi.org/10.3390/w15040763.

Yetik, A., & Candoğan, B. (2024). Climate Change Impacts on Precipitation Dynamics in the South Marmara Region of Turkey. *Bursa Uludağ Üniversitesi Ziraat Fakültesi Dergisi*. https://doi.org/10.20479/bursauludagziraat.1442146.

Yuan, X., Li, S., Chen, J., Yu, H., Yang, T., Wang, C., Huang, S., Chen, H., & Ao, X. (2024). Impacts of Global Climate Change on Agricultural Production: A Comprehensive Review. *Agronomy*. https://doi.org/10.3390/agronomy14071360