A Case Study for the Environmental Humanities: Climate Change Observed in Kozak Basin (Izmir/Turkey) and Local People's Perception of Global Climate Change

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ABSTRACT

Climate change and its effects, which are increasingly felt in today's world and seen as an important threat to the future, have caused states to produce policies related to the issue, and many scientific studies have been conducted on climate change. However, at this point, more is needed for each research area to deal with climate change unilaterally; It has been seen that a multidimensional and interdisciplinary perspective is necessary. In this sense, this project, with the view of "Environmental Humanities," a multidisciplinary field of study, aimed to determine the effects of climate change observed in Kozak and the global climate change perception of Kozak Plateau Residents. Within the scope of the project, the data of Bergama and Ayvalık meteorological stations and the basin's temperature, precipitation, and humidity values were determined, and flow changes were revealed with the data of the flow observation station of DSI. In addition, precipitation and temperature data from previous years were selected in areas where climate data were insufficient with the dendrochronology method. Finally, a semi-structured interview was conducted to determine the climate change perception of the region's people.

Daily, maximum and minimum temperature and daily total precipitation data of two meteorological stations located in the research area were evaluated. MAKESENS (Mann- Kendall test for trend and Sen's slope estimates) was used to determine the long-term changes and trends in temperature and precipitation and to test their statistical significance. No invasive species or species were found in the area, the number of which increased depending on the temperature.

According to the semi-structured qualitative interview findings, it was found that the people of Kozak Plateau were aware of climate change and had some knowledge about the causes and consequences of climate change. According to the dendrochronological data findings, although there is a parallelism between the annual precipitation amount and the annual ring increments of the trees, this is not direct evidence of climate change.

INTRODUCTION

Climate change is defined as the change in climate patterns caused by greenhouse gas emissions from natural systems and anthropogenic activities (Fawzy et al., 2020). Greenhouse gas emissions cause heat to be trapped by the earth's atmosphere, leading to global warming. Although there are natural systems such as volcanoes, earthquakes, oceans and forest fires that affect climate change, these systems are considered to be self-balancing (Yue and Gao, 2018). In this sense, strong scientific evidence supports the anthropogenic origin of climate change (Masson-Delmotte et al., 2018).

Human activities since the industrial revolution have caused global warming of about 1.0°C above the pre-industrial revolution level, and this is projected to reach 1.5°C between 2030 and 2052 if current emission rates continue. Many people are already affected by climate change, and in 2018, there were 315 climate-related natural disasters in the world. Approximately 68.5 million people were affected by these natural disasters and economic losses amounted to over 131 billion dollars (Fawzy et al., 2020). In addition to its physical impacts, climate change is known to have negative impacts in many areas such as agricultural ecosystem, production, food chain, trade, food security and livelihoods (Uysal and Gürer, 2023).

Due to the alarming concrete consequences of climate change, the nations of the world are organizing different meetings and developing policies under numerous organizations. However, while scientific and political understanding of the existence, causes and methods of combating climate change has evolved, public perception of climate change has not been taken into account. Studies show that the public mostly attributes climate change to natural causes and ignores human actions (Weber and Stern, 2011). This has a negative impact on the willingness to implement national and international policy measures.

Since unconscious practices in agriculture and animal husbandry are effective in greenhouse gas emission, which is the main cause of climate change, among many other factors, the compliance of individuals who provide agricultural production is also important in taking the necessary measures (Şahin and Avcıoğlu, 2016). Farmers have a key role to play in adopting new management practices, with support from coherent and strong climate and agricultural policies. In this context, addressing the perceptions of individuals who live in the village and make their living from the land towards climate change is very important in achieving long- term and sustainable results.

With the environmental humanities approach, it is aimed to provide permanent awareness and behavioral changes by addressing environmental-human relations from the perspective of human sciences, asking the right research questions with the help of educational sciences, and providing trainings. Therefore, climate change, ecological destruction and environmental problems should be addressed through interdisciplinary projects. Understanding that anthropocentric approaches, life views and lifestyles are effective in the emergence and unsolvability of these problems has played an active role in the concept of "anthropocene" being increasingly included in humanities research. In this context, environmental humanities is an approach to help build the climate that will provide a new platform and exciting new opportunities for the work that scientists, students and society are already engaged in.

Research Area

The Kozak basin, which is the research area, is located in the north-northwest of Bergama district of İzmir. The basin is located between Madra Mountain (Maya Hill 1344 m) in the east, Yaylacık Mountain (Yaylacıkdede Hill 1220 m) in the north, Kuzuluk Mountain in the south, and the upper and middle reaches of Kozak Stream. Among these mountains with elevations exceeding 1000 m, the Kozak Stream valley is located between 450-500 m elevation (Figure 1). Due to this geographical location, the circulation conditions prevailing in the region regulate the changes of climatic events during the year and the interrelationships between these events in the research area, which is within the borders of Western Anatolia in a broad sense. In addition, marine influences, aspects related to aspect and relief pattern cause a relative change in the character of circulation conditions (genetic factors). For example, the average annual temperature of 16.9 °C in Ayvalık drops to 14.4 °C in Aşağıcuma, located at an elevation of approximately 500 m, and Yukarıbey, located at an elevation of approximately 460 m. Changes in precipitation amounts are also observed in the same way. The average annual precipitation amounts are 648.6 mm in Ayvalık, 915.93 mm in Aşağıcuma and 946.5 mm in Yukarıbey.

The Kozak basin is one of the largest areas of pistachio pine in Turkey (about 16 000 ha). In the Kozak basin, pines are widely distributed within the borders of 16 villages of Bergama and one village of Ayvalık. Within these borders, pines grow up to 550-600 m on the south-facing slopes behind the villages of Hacıhamzalar, Terzihaliller and Çamavlu in the north and up to 500 m on the north-facing slopes in the south. In the south-

southwest part of the basin, the Kozak Stream forms a natural border for the pistachio pines, with pistachio pines on the south- facing slopes of the valley and red pines on the north-facing slopes. In the east-northeast of the basin towards Tekkeköy, Çamavlu and Kıranlı villages and the plateaus of these villages, pistachio pines continue up to 650-700 m elevations, and in the west around Demircidere village, they descend to Esirlik stream (Bakırlık stream), approximately 200 m elevation. In addition to pistachio pines, red pine, larch and oak forests, juniper, chestnut and shrub communities are observed in the basin. These are *Quercus ithaburensis* subsp. *macrolepis*, *Quercus ce*rris, *Quercus coccifera*, *Quercus frainetto*, *Quercus robus* and *Quercus trojana*. Among these species, *Quercus coccifera*, known as kermes oak, is usually found in shrub form.

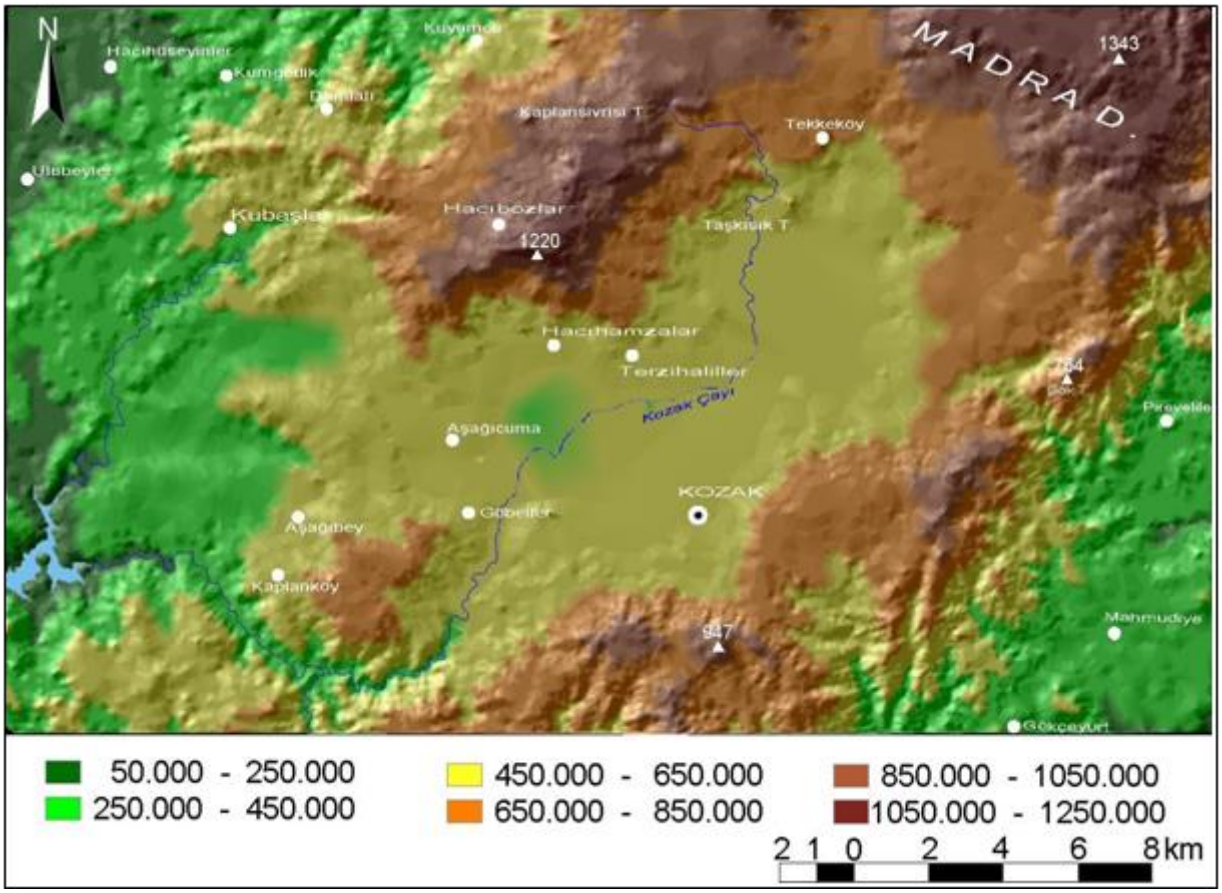

Figure 1. Morphometry map of the study area.

MATERIALS AND METHODS

Climate Data

For the purposes of this study, daily mean, daily maximum, daily minimum temperature and relative humidity values and daily total precipitation values of Ayvalık (1966-2021) and Bergama (1963-2021) meteorological stations were obtained from the General Directorate of State Meteorological Affairs. There is no meteorological station in the Kozak basin except Çamavlu meteorological station, which started measuring in April 2018. As it is known, it is important to use the data of meteorological stations with long observation periods in order to provide healthy results for climate studies. For this reason, the data of Ayvalık and Bergama meteorological stations, which have longer observation periods, were used in our study instead of the data of Çamavlu station, which has a very short observation period, and interpolation was made for the basin.

The non-parametric MAKESENS (Mann-Kendall test for trend and Sen's slope estimates) rank correlation coefficient was used to determine the increasing or decreasing trends in temperature, precipitation and relative humidity values and to test their statistical significance. In order to reveal the rainfall efficiency, "Erinç Rainfall Efficiency Index", which is suitable for Turkey, was applied.

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Dendrochronological Data

Dendrochronology has emerged as a branch of science that can be called "the science of tree aging" with the combination of the Latin words dendro: wood, krono: aging, sorting and loji: science. Dendrochronology, which is subdivided into dendroarchaeology, dendroclimatology, dendrogeomorphology, dendroecology, etc., is based on the analysis of annual rings. In our study, we tried to make dendroclimatological analyzes using tree age rings. For this purpose, samples were taken from trees located at different elevations, aspects and bedrock in the study area (Photo 1). After the necessary preparations, these data were standardized by measuring annual ring thicknesses with the help of Lintap 5 microscope and related software.

Photo 1. Coring pistachio pine in the Kozak basin.

Climate Change Perception Data

In order to reveal the perception of climate change of the local people, a case study, which is a qualitative research approach, was used. Case study is a method that involves in-depth examination of a limited system through systematic information gathering and is frequently used in social sciences (Merriam, 2002; Starman, 2013). In this study, the perception of climate change of local people residing in Kozak Basin was examined through semi-structured interview questions.

One of the ten interviewees was excluded from the study because he refused to be recorded and another one was excluded because he participated in the interview with his son and neighbor. The audio recordings of the interviews were transcribed and turned into text. The data were transferred to the MAXQDA 2022 program and analyzed using the thematic analysis technique. The ages of the participants ranged between 19 and 63, with a mean age of 45 (SD = 14.43). One of the participants was female and the others were male. All participants are engaged in agriculture and animal husbandry activities in the region. In terms of occupation, six are self- employed, one is a student and one is a civil servant.

Photo 2. In order to reveal the global climate change perception of the local people living in the Kozak basin, visits were organized to the area at different times and interviews were conducted with local people.

FINDINGS AND CONCLUSION

Changes and Trends in Temperature Conditions

When the time series plots of annual average temperatures in Kozak basin are analyzed, it is seen that there is an increase in temperatures at both Bergama and Ayvalık stations, although they have been changing over the years. This upward trend is significant with a probability of 99% (α=0.01) according to the MAKESENS test (Figure 2). The changes and trends of the annual average maximum and annual average minimum temperatures over time are largely similar to the changes and trends of the annual average temperatures. There is an increasing trend in both annual average maximum temperatures and annual average minimum temperatures in both stations. These increasing trends were found to be significant with a probability of 99% (α=0.01) according to the MAKESENS test, just like the annual mean temperatures (Figure 3).

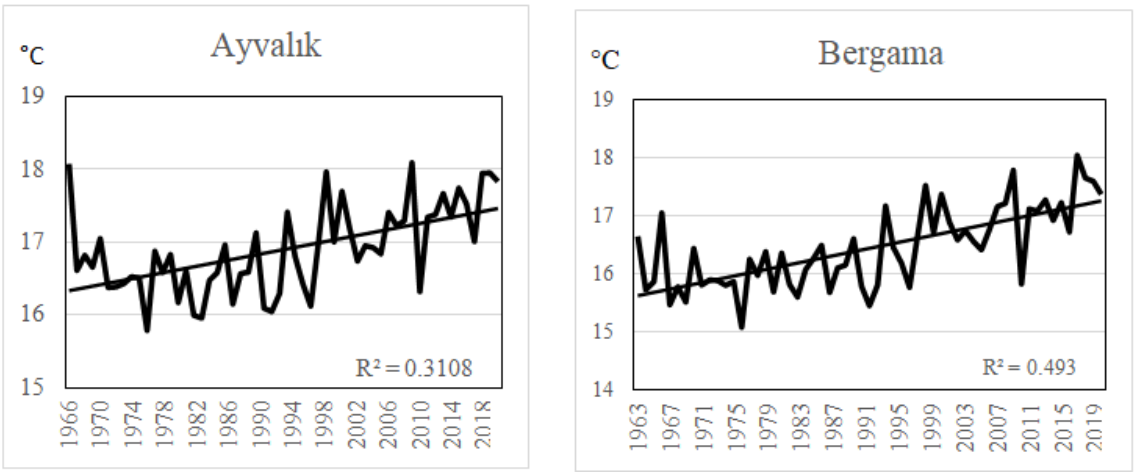


Figure 2. Long-term average temperatures and trends for Ayvalık and Bergama meteorological stations.

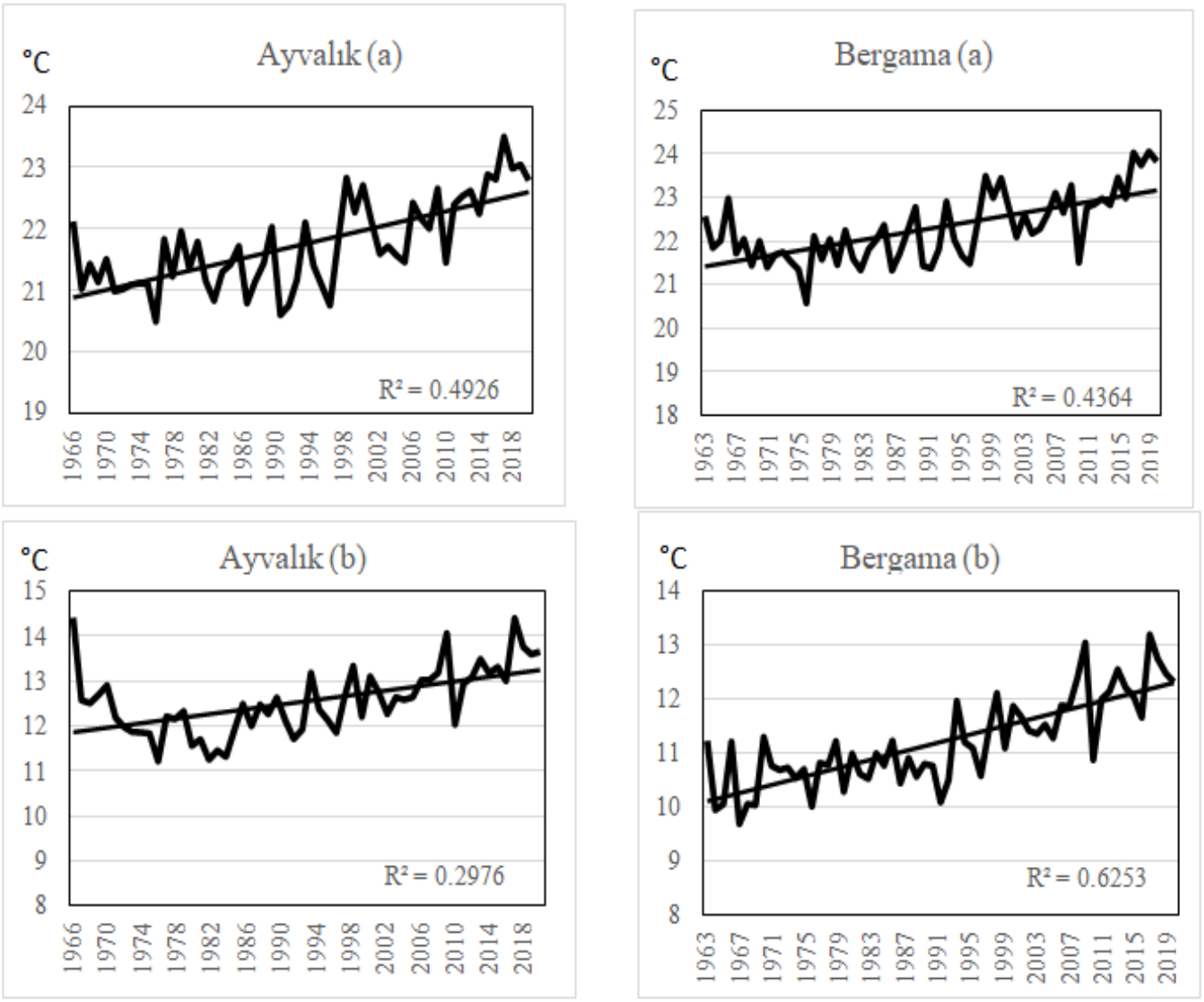
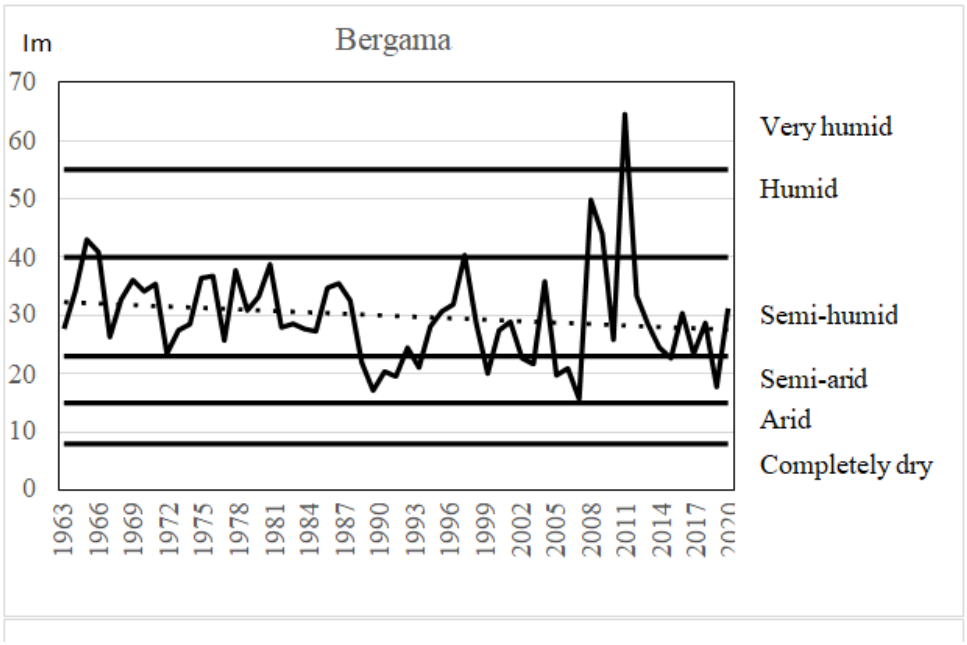


Figure 3. Long-term average maximum (a) and minimum (b) temperatures and trends for Ayvalık and Bergama meteorological stations.

Many studies on temperature changes and extreme temperatures in Turkey show that temperatures are in a tendency to rise and extreme values are in a tendency to change, as we found in the temperatures in our research area (Erlat and Yavaşlı 2009, 2011;Türkeş 2012; Turp et al. 2014; Sütgibi 2015, 2016).

Precipitation and Humidity

According to the data of the meteorological stations examined in the research area, the average annual precipitation is 647.9 mm in Ayvalık and 666.5 mm in Bergama. However, as we have stated before, when we go up to the basin at 450-500 m elevations, these precipitation values increase above 900 mm. When we look at the changes in the precipitation of Ayvalık and Bergama meteorological stations over the years, it is found that the average values show significant differences from year to year within the observation periods. In Ayvalık, maximum annual precipitation was recorded as 992.3 mm (1998) and minimum annual precipitation was recorded as 304.6 mm (1989) in 56 years (1966-2021) of precipitation observations, and maximum annual precipitation was recorded as 1470.2 mm (2012) and minimum annual precipitation was recorded as 362.6 mm (2008) in 59 years (1963-2021) of precipitation observations in Bergama. Based on this variability in annual precipitation amounts, it can be said that short-term humid and dry periods alternate in the study area over time. As a matter of fact, this variability in precipitation can be observed from the graphs prepared to reveal the precipitation efficiency (Figure 4).



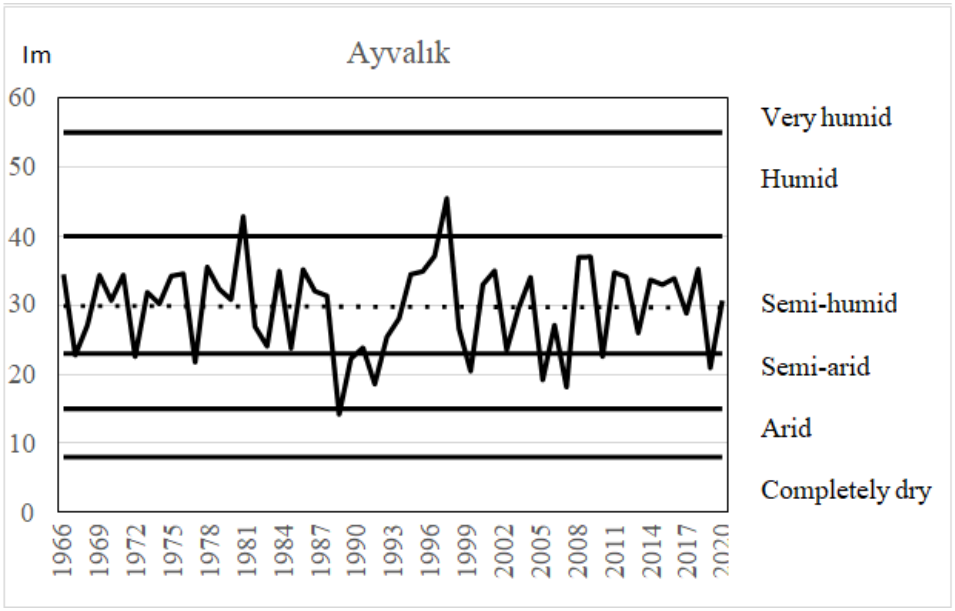


Figure 4. Climate characteristics of Ayvalık and Bergama according to Erinç precipitation efficiency index.

When Figure 4 is examined, it is seen that semi-humid climatic conditions are dominant in both stations, but in some years, semi-arid or humid and even very humid conditions were effective in Bergama as in 2012. This difference in precipitation from year to year, especially in below- average years, is important for plant life and plant development. Since water cannot accumulate sufficiently in the soil in years with low precipitation, the wilting point is reached with the high temperature and evaporation in the summer months and this affects plant life.

Changes and Trends in Precipitation and Moisture Characteristics

For the changes observed in the precipitation in the research area in the form of inter-annual variations and long-term trends, the inter-annual variations and trends in total precipitation, the number of rainy days, precipitation anomalies, precipitation intensity and the frequency of certain amounts of precipitation for the two stations examined were analyzed. Accordingly, when the long-term precipitation series are analyzed, a non-strong increasing trend is observed in Ayvalık and a decreasing trend is observed in Bergama. However, neither the upward nor downward trend was statistically significant (Figure 5). In the number of rainy days, an increasing trend, which is not statistically significant, is observed in both stations.

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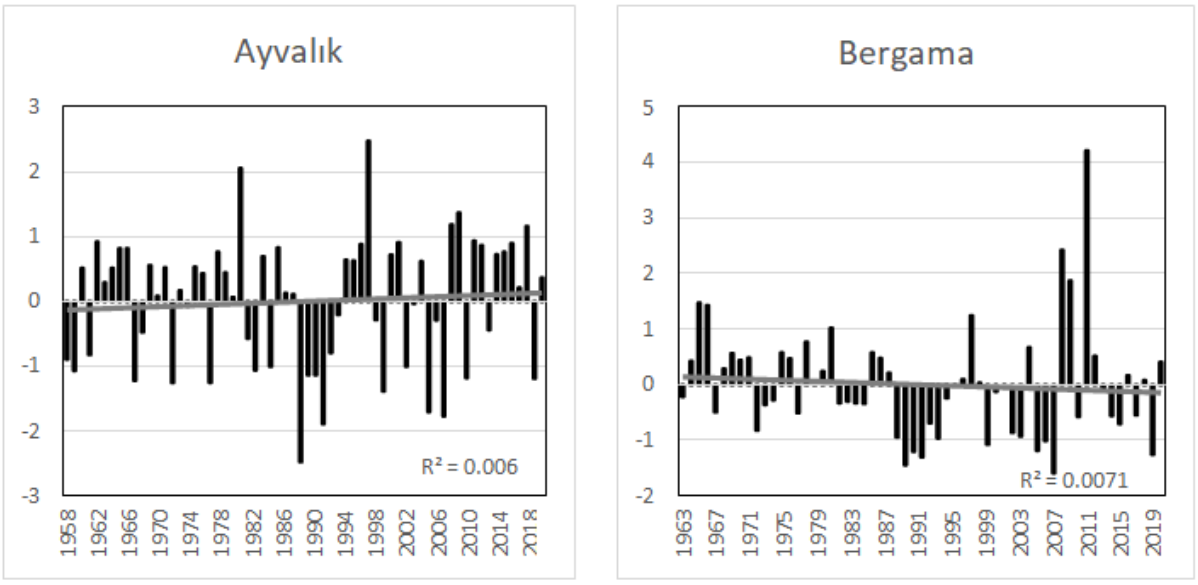

Figure 5. Standardized total precipitation of Ayvalık and Bergama meteorological stations.

Another important criterion for precipitation is the intensity, duration and frequency of a certain amount of precipitation. Generally, as an average value in the Mediterranean climate zone, daily precipitation above 25 mm is considered to be torrential precipitation, while daily precipitation below 25 mm is considered to be normal precipitation (Dönmez, 1984). These values can be classified as follows:

Daily rainfall of 10 mm or less is light/normal

Daily rainfall between 10.1-25 mm is moderate

Daily rainfall between 25.1-50 mm with light showers

50.1-100 mm daily rainfall with heavy downpours

Daily rainfall of more than 100.1 mm are very heavy downpours (Erlat, 1996).

Accordingly, when we look at the distribution of the number of rainy days in the study area according to the intensity of precipitation, it is seen that approximately 93% of the rainy days in both stations consist of light/normal and moderate precipitation (25 mm and below) and approximately 7% of the rainy days consist of showers (25.1 mm and above). Therefore, it would not be wrong to say that light/normal and moderate rainfall of 25 mm or less per day is dominant in the study area. On the other hand, heavy and very heavy downpours occurred 61 days in Ayvalık (1966-2021) and 48 days in Bergama (1963-2021) during the observation periods. The highest daily precipitation in Ayvalık was 215.2 mm on November 29, 2016 and in Bergama was 423.5 mm on April 30, 2012.

When we look at the seasonal distribution of precipitation in the research area, we observe a statistically insignificant increase in fall, winter and summer precipitation in Ayvalık and a statistically insignificant decrease in spring. In Bergama, a tendency of decrease in fall, winter and spring precipitation and an increase in summer precipitation was detected, and it was observed that these changes in the direction of increase or decrease were not statistically significant.

The average relative humidity values in the research area varied between 63.2% (Bergama) and 68.2% (Ayvalık) and it was determined that the average relative humidity values were in a decreasing trend in both meteorological stations during the observation period and this decreasing trend was found to be 99% significant according to the MAKESENS test.

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Dendrochronology

Samples (cores) taken from forest trees reflecting different environmental conditions (such as different elevation, aspect, bedrock, locality) from the study area were analyzed dendrocoronologically (Table 1, Photo 3).

Table 1: Sample locations and general information

DENDROCHRONOLOGICAL DATA TABLE						
Sample no	Species	Location	Age	Tall	Elevation	Plant Sociology
1	**Pinus pinea**	YukarıCuma-Güneşli	28	19,5	440	*P. pinea, Quercus sp.*
2	**Pinus pinea**	Güneşli	21	10	762	*Quercus sp., Juniperus sp.,*
3	**Pinus nigra**	Güneşli -Tekkeköy	85	12	856	*Astragalus,* eğrelti,
4	**Pinus nigra**	Güneşli kuzeyi	100	19,5	857	Eğrelti, böğürtlen
5	**Pinus nigra**	Güneşli kuzeyi	100	20,5	885	Eğrelti, böğürtlen, kuşburnu
6	**Pinus pinea**	Demircidere Bergama	75	19	240	*P. pinea, Quercus sp.*
7	**Pinus pinea**	Çamavlu	31	16	489	*P. pinea, Quercus sp.*
8	**Pinus pinea**	Göbeller	22	13	480	*Pinus pinea*
9	**Pinus pinea**	Kaplanköy	60	26	540	*Pinus pinea*

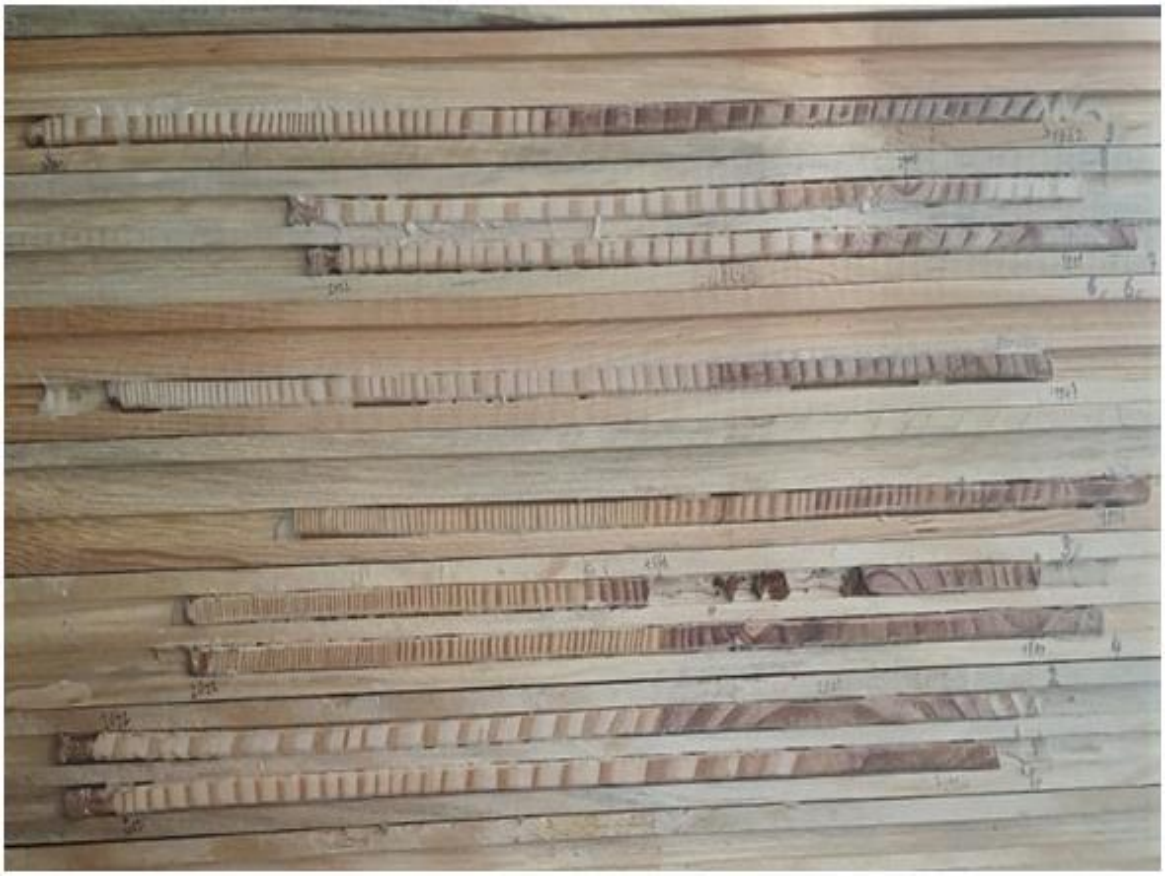

Photo 3. The samples taken from the presses with the increment auger are slatted and cleaned by sanding process and made ready for evaluation.

The samples collected from the field were evaluated with the help of the Lintab 5 age ring measuring device (microscope) (Figure 6). For the evaluation of the data with this device, the Dendrochronology Lab at Ege University, Faculty of Letters, Department of Geography was used. This device can measure with an accuracy of 1/100 of a mm.

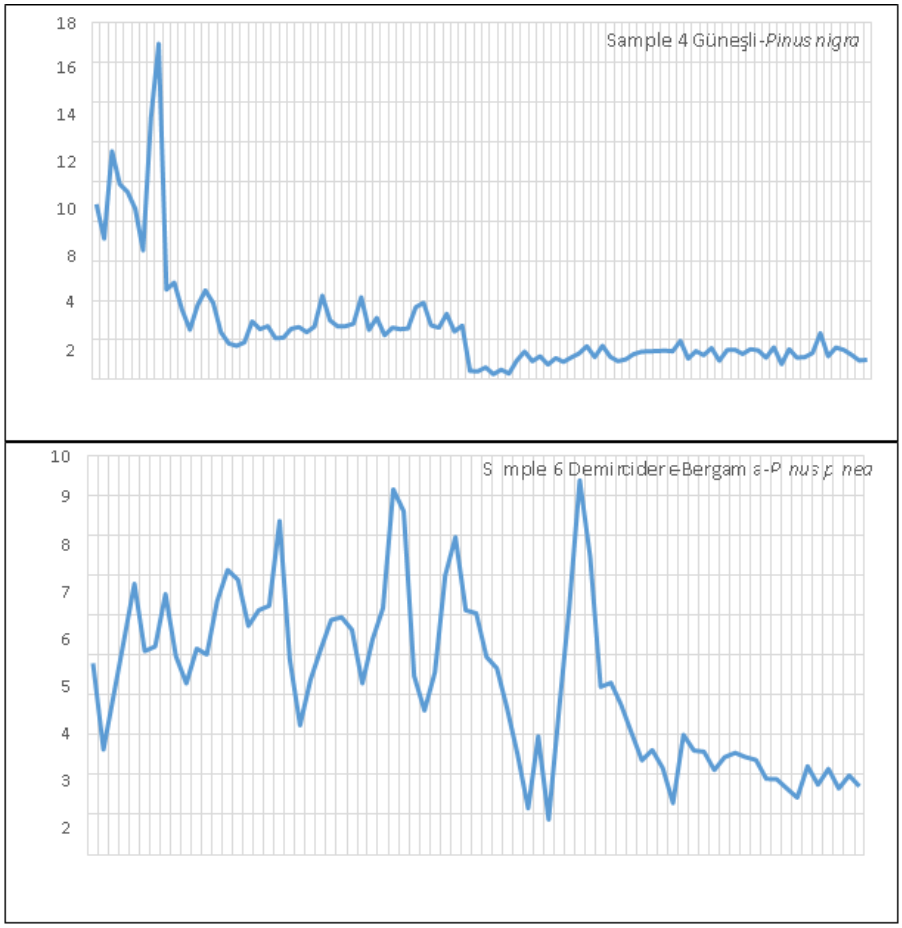

Figure 6. Graphs plotted according to the data obtained in Lintab 5.

This data then needs to be standardized. The rationale for this process is that the diameter of the inner diameter and the diameter of the outermost annual age ring of nested annual rings are not the same, giving the illusion that the annual increment of the outermost age ring is less than that of the innermost ring. However, there is a huge difference between the circumference of the outer diameter and the inner one. To avoid this illusion, standardization is used (Figure 7).

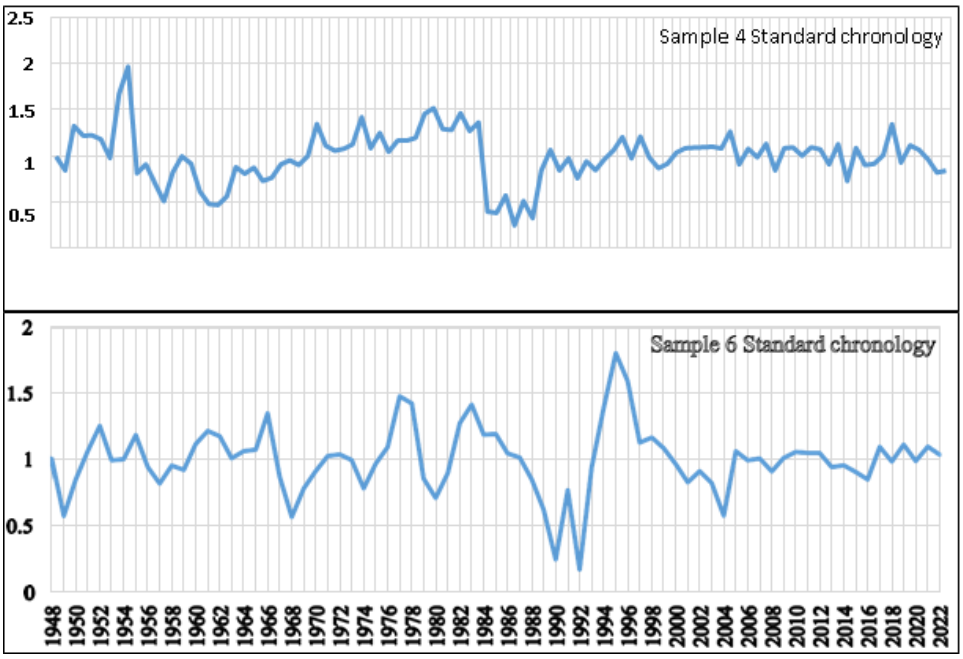

Figure 7. The graphs of sample 4 and sample 6 after standardization.

Without human intervention, annual ring development and height increase in trees are directly affected by factors and processes in the natural environment. It is affected by static features such as slope, elevation and aspect, as well as changes in climatic elements such as temperature and precipitation from year to year. Due to the fact that temperature values are generally sufficient under Mediterranean climatic conditions and frosty days are rare; precipitation values play an important role in associating the values of annual ring development with the environment. Because the variation of precipitation from year to year and season to season has an important role in annual ring increments. Therefore, we tried to evaluate the relationship between annual ring increments and annual precipitation changes (Figure 8). Spearman correlation was applied to determine the relationship between annual ring increments and annual rainfall. Spearman rho was found to be 0.215. Accordingly, there is a low positive correlation between annual ring increment and annual precipitation (Figure 9). Similarly, there is a low positive correlation between annual ring increments and annual average temperature and relative humidity values.

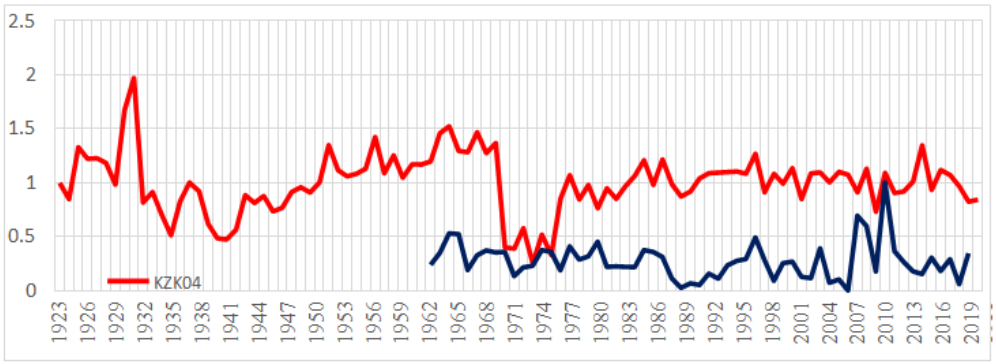

Figure 8. Reduced values graph of sample 4 annual increment and Bergama annual total precipitation data. Here, a harmony is observed between the annual total precipitation and the annual age ring increment.

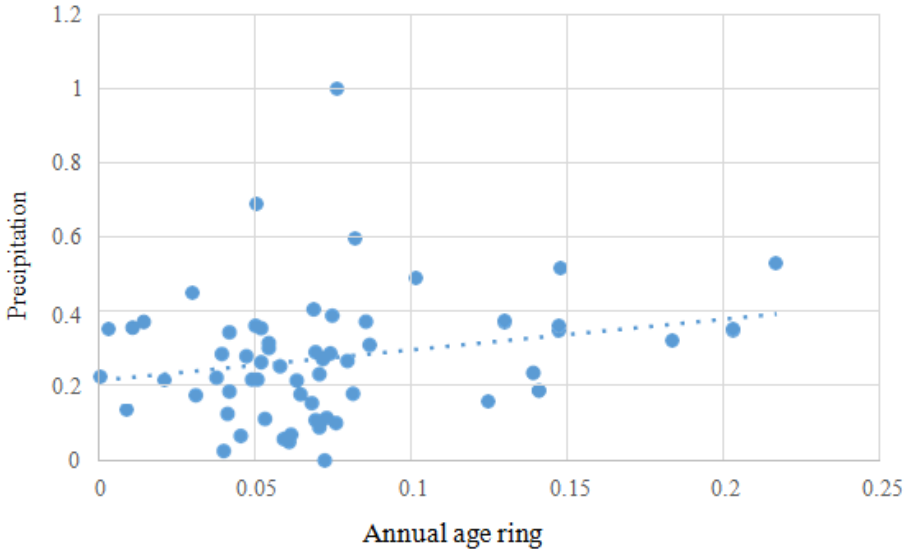

Figure 9. Correlation between annual precipitation and age ring in the study area.

Perception of Climate Change

At the beginning of the qualitative interviews, everyone (n = 8) responded positively to the question "Have you ever heard of climate change?". All participants were familiar with this concept. It was observed that

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familiarity with and knowledge about climate change was acquired through the media (n = 4), direct experience as a result of agriculture and animal husbandry (n = 4), volunteering with the Turkish Foundation for Combating Erosion, Reforestation and Protection of Natural Habitats (TEMA) (n = 1) and postgraduate education (n = 1). In response to the question of what local people understand by climate change, the participants mentioned themes such as temperature change (14 times), drought (10 times), decrease in pine nut yield (3 times) and the appearance of new species (1 time). For example, participant 5 (P5) said, "The weather is suddenly variable, for example, we experience winter like summer. There used to be years when there was knee-deep snow here, but now we don't experience that. We also experience abnormal weather in winter. There is also a changeable weather in midsummer, this year, for example, the crops are not even growing, it's like a winter wind. There is variability in the weather, there is a very strange variability in the climate." However, in addition to these changes they felt or experienced locally, participants also mentioned the phenomenon of global warming and the melting of glaciers. In the interviews, the answers to the question "How is the level of knowledge/awareness of the people around you about climate change?" formed the theme of local people's awareness of climate change. According to the participants, although the public perceives climate change in some way, they said that they could not name it or that awareness was not at a sufficient level. For example, P8: "Everyone says there is. Especially the elderly. Everyone above a certain age says this." while P4: "They have no level of knowledge. But they know that the amount of heat is increasing every year, the amount of precipitation is decreasing and they say that while the grass used to grow at the end of August, now it grows before the middle of June. So they experience it in a concrete way, but they cannot define it." he made the following statement.

Participants also mentioned human activities such as lifestyle, mining, environmental pollution, cutting down oak trees, dam construction, wrong agricultural practices, wind turbines and global impacts (gas emissions, changes in the ozone layer) as causes of climate change. It is noteworthy that the activities of the quarries that have been going on in the region for many years and the gold mine operation in Bergama Ovacık are particularly emphasized here (the mining code was encountered 28 times in the interviews). Some participant statements on this issue are as follows:

P4: "For example, in quarries, after the quarries start to operate, the bees there die."

P7: "I mean, this water has an end, it is not infinite, it is the water under the earth. It will do something at some point, that's the biggest thing, that's the damage anyway, how much of the water it uses is separated and returned to the soil, how much is separated, even if it is separated, what is left in it, what is not left, I am against mining. I mean, there are more sources of income until mining."

The following themes emerge in participants' perceptions of the impacts and consequences of climate change: consequences on nature, emotional consequences and consequences on human beings. For example, the following statement appears in the results on nature;

P3: "Imagine what beautiful pines we had, for example. Imagine that the mountains are bare, it's horrible, it will lead to desertification over time."

Participants stated that their livelihoods had to change as a result of climate change, as a result of which people became alienated from each other and migration occurred. In addition, according to participants, conflicts of interest and friction arise as a result of the decline in livelihoods due to climate change. For example, P8 used the following statements about this issue: "There is migration, that is, our friends leave, someone from the family migrates and settles in the city. Or at work, children are more attracted to the city. I mean, it wasn't like this before, at least when you earned better, it was different."

Participants mentioned both individual and social/political struggles to combat climate change. In the individual struggle category, they mentioned saving energy and water, changing consumption habits, and stopping the use of chemicals in agriculture and animal husbandry as well as in household cleaning, while in the social/political struggle category, they mentioned state support in agriculture and animal husbandry and

state control in mining. The majority of the participants consider the contribution of individuals to climate change as insignificant and state that the measures to be taken should be on a larger scale. Participants who attach importance to individual efforts, on the other hand, think that others do not do their part and therefore say that individual efforts will be insufficient.

DISCUSSION AND CONCLUSION

According to the evaluations made regarding temperature, precipitation and humidity in the research area, it was observed that there were statistically significant increases in temperatures and this finding was in accordance with many studies conducted in Turkey (Acar and Gönençgil 2024; Aydın and Karabulut 2022; Erlat and Yavaşlı 2009, 2011;Türkeş 2012; Turp et al. 2014; Sütgibi 2015, 2016). For example, according to the study of Aydın and Karabulut (2022), an increasing trend in extreme maximum temperature indices and a decreasing trend in extreme minimum temperature indices were determined in Konya. As for precipitation, it was observed that there was a decreasing trend in Bergama and an increasing trend in Ayvalık, but this was not statistically significant. Seasonally, there is a non-significant increase in autumn, winter and summer precipitation and a decrease in spring precipitation in Ayvalık, a decrease in autumn, winter and spring precipitation and a non-significant increase in summer precipitation in Bergama. In the study of Türkeş et al. (2007), it was stated that there is a general tendency of decrease in precipitation in Turkey and these findings are similar to the results of previous studies on Turkey and the Mediterranean basin. When the relationship between dendrochronological data and annual total precipitation data was evaluated, it was observed that the positive and/or negative trends in precipitation over the years were almost parallel to the changes in annual diameter increment. However, these changes are not changes that can be a reference to climate change. As a matter of fact, Spearman's correlation to see the correlation between annual wet ring increments and precipitation, temperature and relative humidity showed a weak positive correlation for all three values.

In the interviews with the local people, when asked what climate change means to them, the fact that they generally talk about agricultural production, especially the decrease in yield and economic loss in pine nuts, creates an opinion that the link between them and climate change is formed on the anthropocentric axis. However, when they were asked to answer questions such as "Have you ever heard of climate change?" or "Where did you hear about it?", it was observed that they could mention physical changes such as temperature, precipitation, drought, wind, seasonal changes related to climate change. They state that they learnt this information mostly through mass media. As a result, climate change is evaluated together with the values in this dimension in terms of its effects on socioeconomic and cultural life such as livelihood, lifestyle and migration in individual and social dimensions.

It is noteworthy that the decline in the yield of pistachio pines, which is an important economic resource for the local people, is associated with climate change, but we did not find any findings to support this belief in our field studies. For example, drought, which is accepted as a consequence of global climate change, and drying out of trees due to drought were not observed in the area. Again, invasive plant species or species expressed as a result of climate change were not encountered. Therefore, the decreases in peanut yields expressed by the local people suggest that the increase in microorganism and insect activities with increasing temperatures may be the result of increased microorganism and insect activities or fungal formations. Nitekim Batur'un (2015) çalışması bizim bu kanımız destekler niteliktedir. According to this study, it was stated that there is a relationship between peanut yield and average and maximum temperatures and that changing precipitation, humidity and temperature conditions cause an increase in microorganism and insect activities. As a result, the subject needs a more comprehensive research.

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