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CLIMATE CHANGE PROBLEMS IN AGRICULTURAL LANDSCAPE AREAS: EASTERN THRACE VINEYARDS

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Abstract. Hurricanes, heat waves, torrential rain, flooding and other extremes of weather are being reported every year around the world. Each of these weather events is unusual, and are held in growing consensus as early indications of global climate change. It is now widely agreed that changes in land use, deforestation, and especially burning fossil fuels have already caused and will continue to cause substantial releases of greenhouse gases into the atmosphere, which directly affects global climate change. One of the largest contributors to this phenomenon is the agriculture sector, and, paradoxically, this sector is also one of the most affected by climate change. That is, because agriculture depends directly on predictable climate conditions, and suffers when environmental variables fluctuate unpredictably. The impacts of climate change on agriculture come about through changes in variability, seasonality, mean precipitation and water availability, as well as the emergence of new pathogens and diseases. The importance of understanding climate change impacts on agriculture is especially evident within viticulture. Direct or indirect effects of climate change in viticulture were monitored on vegetative and generative development, crop quality, yield, harvest time, irrigation, fertilisation, crop preservation and marketing. The climate not only influences the production of quality grapes, but it also affects the quality of the resulting products, including wine. In the scope of this study, a representative survey was done within Eastern Thrace Wine Producers, Turkey, to reveal the effects of climate change on wine grape production and the produced wines. The results were examined in order to present suggestions for future climate projections.

Keywords: climate change, viticulture, Thrace Region, agricultural landscapes.

AIMS AND BACKGROUND

Extreme and unpredictable weather events are being reported every year around the world. Each of these weather events is unusual and all are talked about as early indications of global climate change or global warming[1]. Such events are not only destructive to the world's ecosystems by altering average seasonal temperature and precipitation, but could also be life-threatening to humans[2].

It is now widely agreed that changes in land use, deforestation and especially burning fossil fuels have already caused and will continue to cause substantial releases of greenhouse gases into the atmosphere. These emissions stay in the atmosphere for long periods such that concentrations of greenhouse gases have been rising sharply over recent decades[3]. Human activities have modified atmospheric

constituents that absorb and scatter radiant energy within the thermal infrared range, thereby contributing to increased greenhouse gas concentrations[2].

Notably, 20th-century industrialisation increased human-mediated greenhouse gas levels in the atmosphere. In this sense, sectors like agriculture, food production, industry, tourism and healthcare have contributed to and been affected by this phenomenon. Although global climate change has robust and direct causality linked with the greenhouse gases produced by the agriculture sector, paradoxically, this sector is one of the most affected by this change. This is because agriculture depends on predictable climate conditions and, as such, is inextricably linked to economic, environmental and social fluctuation[4].

Climate change impact is likely to have a significant influence on the growth and productivity of plants and the spread of pests[5]. Fischlin *et al*. show that the impacts of climate change on agriculture come about through changes in variability, seasonality, mean precipitation and water availability, and the emergence of new pathogens and diseases[6]. However, the overall impacts of climate change on agriculture will ultimately depend on the timing of plant physiological requirements and the spatial variations, seasonality, and magnitude of the warming. The importance of understanding climate change impacts on agriculture is especially poignant for viticulture[7].

While we can access historic global climate change data for a range of sectors, there are limited data available on the effects of this change on viticulture. Direct or indirect effects of climate change in viticulture can impact on vegetative and generative development, crop quality, yield, harvest time, irrigation, fertilisation, crop preservation, and marketing[8]. Climate change impacts on viticulture have been, and are likely to continue to be highly variable, both geographically and varietally[7]. Impacts that may be considered negative for some geographical regions may affect another part positively. Temperature trends of the recent past, focusing on viticultural regions, show that the growing-season mean temperatures have increased in Europe. Contrastingly, some of the southern Europe viticultural regions reported impacts such as shortening of the growing season, earlier phenological events, increased risks of pests and diseases, and reduced grape colour[9].

The climate not only influences the production of quality grapes; it also affects the quality of the wine. The major influences on the grapes are optimum levels of sugar, acid, alcohol, and flavour to maximise a given style of wine and its taste, balance, and quality[7].

VITICULTURE AND CLIMATE IN EASTERN THRACE

According to the International Organisation of Vineyards and Wine's 2018 Statistical Report on World Vitiviniculture, 7 534 000 ha of the global area is under vine cropping and the total global grape production was 73.3 million t in 2017. In Turkey, the grape is cultivated approximately 450 000 ha area and the production

was 4.2 million t in 2017 (Ref. 10). Turkey is ranked 6th out of all the world's countries in grape production. Eastern Thrace is the region where grapes are cultivated mostly for wine production.

Eastern Thrace, also known as Turkish Thrace or European Turkey can be defined as a peninsula bounded by three seas: the Black, Marmara and Aegean. The region contains Edirne, Kirklareli and Tekirdag provinces as well as parts of Istanbul and Canakkale. With its land and water resources, the region is one of the significant agricultural regions of Turkey[11]. The Thrace region has major agricultural areas that can grow a variety of products due to the variable climate, soil and topographic features[12]. Today, the main agricultural products of the region are sunflower, wheat, grapes, rice, canola and sugar beet[13]. Agricultural lands of Thrace cover an area of 12 398 km^2, and the total area of vineyards is 113 km^2. As for the wine grapes which have an essential place among the agricultural products across the region, production is carried out in an area of about 61 km^2 (Ref. 14).

Eastern Thrace is topographically, climatically and biologically heterogeneous. The climate of the region is typically the Mediterranean near the southern coast. Mild, wet winters and long, hot, dry summers are characteristic. The drought period is usually from May to September. There is a clear difference from west to east Thrace. The climate is more humid and cooler going towards the Black Sea coast or toward the north of the area[15].

Candar et al.[16] examined the changes in viticulture climate indicators in Thrace Region for the last six years (2013–2018). The study shows that temperatures have tended to increase overall throughout the region. Mean temperature rises cause an increase in night temperatures, albeit slowly, and this affects the degree and rate of grape colouration and quality parameters. It is stated that the precipitation regime has tended to destabilise, especially in the vegetation period, and the number and frequency of unusual climatic events will likely increase. All of these climate indicators point out that the temperature increases and the amount of precipitation are not yet much changed, but the period of rainfall has. The impacts of climate change have become more livable than envisaged.

EXPERIMENTAL

In the scope of this study, a representative face-to-face survey was done with Eastern Thrace Wine Producers to reveal the effects of climate change on wine grape production and also on the wine. The member companies of the Thrace Vineyard Route Project selected to participate in the survey. These companies have a high contribution to the rural development of the Thrace Region in both the agricultural and tourism sectors. During the study, returned data were obtained from 11 out of 15 member companies. These companies are from Kirklareli (36%), Tekirdag (36%), Canakkale (19%) and Edirne (9%).

According to the information obtained from personal interview surveys conducted with the 11 companies, 18% of these companies (2 companies from Tekirdag) have less than 10 ha of vineyards, 18% (Tekirdag (2)) have 11–25 ha, 18% (Kirklareli (1), Canakkale (1)) have 26–50 ha, only one company (10%) from Canakkale had 51–75 ha of vineyards, 18% (Kirklareli (2)) have 76–100 ha and 18% (Kirklareli (1), Edirne (1)) have more than 101 ha.

The oldest two companies are in Tekirdag, and they are operating their vineyards for more than 21 years. 46% (Kirklareli (3), Tekirdag (1), Canakkale (1)) of the companies have been operating vineyards for 11–15 years, 18% (Kirklareli (1), Edirne (1)) for 6–10 years and 18% (Tekirdag (1), Canakkale (1)) for 16–20 years.

In most of the companies (64%), the grape production is 1–250 t per year, 18% of them produce 501–1000 t, and 18% produce 251–500 t annually.

Cabernet Sauvignon is the most common grape grown in all of these vineyards. This is followed by Merlot, which is the second most common type of grape grown in 91% of these vineyards and Sauvignon Blanc and Cabernet Franc are the third grape types grown in 64% of these vineyards. The other types of grapes, which are grown in these vineyards, are Okuzgozu (46%), Chardonnay, Papazkarasi, Petit Verdot, Pinot Noir and Syrah (36%), Narince (27%), Alverinho, Muscat, Riesling, Sangiovese, Shiraz and Viognier (18%), Barbera, Cinsault, Gamay, Karasakiz, Malbec, Sauvignon Gris, Semillon, Tempranillo and Zinfandel (9%).

According to the information received about the crop damage by climatic events, most of the vineyards (70%) are affected by hail. Drought is the most significant event for crop damage affecting 40% of vineyards. Late spring frosts, high temperatures and heavy rain contributed to severe floods at 30% of vineyards. Reduction in precipitation and a decrease in snowfall affects 20% of vineyards and cyclones and high humidity are reported to cause crop damage at 10% of vineyards.

Vineyard owners stated that the most significant biotic changes that occurred due to climate change are increased diseases (82%) such as powdery mildew, fungal infections, aphids, and Pierce's disease. They stated that the most significant secondary impacts on vineyards were a reduction in the length of growing season (36%), an increase in maintenance works (36%), earlier harvests (36%), and rising alcohol and sugar levels in wine (36%). In 27% of vineyards, these impacts have increased irrigation demands. In addition, some changes reported as lower yields, were caused by an increase in pest activities and intensity, higher canopy density and pigmentation problems (18%), increases in the length of the growing season, decreased irrigation demands, smaller grapes, high-quality wines, unbalanced wines, increased pH levels, and change in wine's flavour, aroma, and colour (9%).

In Eastern Thrace vineyards, harvests are generally occurring in the second half of August (55%), the first half of September (36%) and the second half of September (9%). Since they were founded, the harvest starts approximately one week earlier in 64% of these vineyards. In 18% of these vineyards, harvest starts

two weeks earlier, and in 9%, it starts three weeks earlier. There is no change in 9% of these vineyards. There is a meteorological station in 60% of these vineyards.

RESULTS AND DISCUSSION

Although climate change can have similar effects on viticulture across a region, in the provinces of Thrace, a variety of problems have been encountered due to its variable geology and topography[17]. In general, though temperature increase, precipitation and frost days are decreasing across the entire region[16,18].

In conducting a separate review for the provinces of Thrace, it was observed that the climate of Kirklareli, which has an arid climate, has shifted from temperate warm to the warm climate class. It is noteworthy that night-time temperatures have increased in the province too[16]. Vineyards in Kirklareli suffer crop damage due to later spring frosts and hail. Heavy rain, a decrease in snowfall, drought and cyclones are other climatic events that contribute to this damage. In all vineyards of the province, diseases were observed. In addition to this, other problems stated include an increase in pest activities and intensity, higher canopy density, pigmentation problems, changes in the length of the growing season, increase in maintenance works, earlier harvests and increases in the sugar and alcohol level of the wine. The harvest occurs in the second half of August, in all of the Kirklareli vineyards; indeed, 75% of the vineyards reported that the harvest starts one week earlier since they were established. Some of the company owners mentioned that the harvest time changes every year according to the climate conditions; depending on the earlier or late start of the growing season it can be 10–15 days earlier or later.

Tekirdag, which is generally in the arid and temperate warm climate class, switched to the very warm climate class in 2013 and 2015 and warm climate class in 2016 and 2018. Night-time temperatures are considered as warm in Tekirdag. The hydrothermal index was calculated to be unusually high in 2014, and this has caused extraordinary damage in terms of yield and quality (such as downy mildew) throughout the province[16,19]. Fluctuation in the climate indicator values refers to difficulties in cultivation, especially in terms of quality. Drought and hail are the most frequently-mentioned climatic events for the crop damage in Tekirdag. High temperatures, a reduction in precipitation, and a decrease in snowfall are also negatively impacting the crops there. Reduction in the length of the growing season, increased irrigation demands, diseases, rising alcohol levels in wine are reported as the main effects of climate change in Tekirdag. Other changes include decreased irrigation demands, lower yields, higher canopy density, smaller grapes, increase in maintenance works, earlier harvests, high-quality wines, an increase in the sugar level of the wine, increased pH levels, and change in wine's flavour, aroma and colour. Harvest occurs in the first half of September in 75% of the Tekirdag's vineyards and is reported to be earlier by about 1–2 weeks. Only one

vineyard's harvest is in the second half of September, and they reported that there is no change since they established.

Canakkale is in the warm and arid climate class and generally has warm night temperatures. Night-time temperatures have increased since 2013 and reached higher values in 2015 and 2018. The hydrothermal index values have a fluctuating trend, and this shows the instability of the precipitation regime in recent years, and especially the unwanted precipitation taken during the vegetation period[16]. High temperatures, drought and a reduction in precipitation and hail are the main climatic events for crop damage in the province. According to these changes in climate, diseases, increased maintenance works and earlier harvests are the most seen impacts on the timing of works in the vineyards of Canakkale. Additional changes reported were a reduction in the length of the growing season, increased irrigation demands, an increase in pest activities and intensity, pigmentation problems, an increase in the sugar and alcohol level of wine, and unbalanced wines. The vineyards of Canakkale used to make their vintage in the second half of September, but are now harvesting their crop 1–3 weeks earlier.

In Edirne, which is in the arid climate class, it has observed that both mean temperatures and rainfall during the vegetation period increased. Climatic projections show that Edirne, which is still in the warm climate class, will shift to a very warm climate class. Night-time temperatures are cool in the province, but in recent years, warm nights have become more frequent, and this can cause an increase in pigmentation and quality problems. Hail, extreme temperatures and precipitation have caused damages in Edirne vineyards. Most frequently-observed changes in the province are reported as lower yields and diseases. Harvest starts one week earlier and occurs in the second half of August.

It is observed that the growing-season mean temperatures and night-time temperatures have increased throughout the region. According to the meteorological data for Kirklareli (223 mm) and Edirne (238.7 mm), the average rainfall amount in the vegetation period is higher than the average of the region[16]. Along with this, the producers in these provinces also reported that they experienced product damage due to excessive rainfall. Conversely, Tekirdag (185.2 mm) and Canakkale (139 mm)[16] have faced crop damage due to a decrease in precipitation. Drought has damaged 50% of the vineyards in both these provinces. The most significant injuries in the region were caused by hail. Depending on climate change, diseases have also started to be encountered, mostly powdery mildew. Reduction in the length of the growing season, increased maintenance works, and an increase in the alcohol level of wine is the other most commonly seen problem in Thrace vineyards. In all vineyards, except for one, harvesting began to occur 1–3 weeks earlier.

These results emphasise some of the consequences of climatic change in the agricultural sector using the specific context of viticulture. Viticulture is not only an essential part of Thrace's agricultural activities, but it also has a special place in

terms of contributing to the rural landscape value of the region and thus creating an alternative for tourism activities such as enotourism. Depending on climate change, changes in the patterns of agricultural land-use will naturally lead to changes in the rural landscape, and over time may have a side effect on tourism activities.

CONCLUSIONS

Agricultural landscape areas, which are an essential component of the rural landscape, comprise 30% of Turkey's total land area. Agriculture is one of the primary income sources of the Thrace region, and 5% of the country's agricultural land is located here. Turkey is one of the world's leading grape producers and 10% of the total production area is in Thrace. Wine grapes are grown in more than half of these areas.

Agricultural areas are under pressure by increasing industrialisation and urbanisation movements in Thrace. Reduced support in the context of changing agricultural policies is also negatively affecting these areas, and to cap it all, climate change impacts, which, as we have seen, are quite evident in the region put producers in a challenging situation to profit from the viticulture industry.

Climate change is a concern for viticulture in Thrace, with pronounced impacts already being observed from the effects of drought and hail, causing product damage and the spread of diseases causing loss of plants. Harvests have started to occur earlier, and sugar and alcohol levels of the wines have increased. Jones et al.[6] mention that the exact magnitude and rate of future climate change are uncertain. However, any change can significantly impact the narrow geographical limits of high-quality production viability in viticulture and will likely bring about subsequent changes in suitable grape varieties, regional wine styles, and regional cultures. Therefore, it is crucial that Thrace producers, who produce 25 varieties of wine in total, regularly share the data obtained from their meteorological stations, and the negative and positive effects encountered in their vineyards with the authorities, in order to prepare for the future.

Even though agriculture is both subject to and partly responsible for climate change, it is also part of the solution. When developing climate-related measures and determining strategies, the accurate identification of potential impacts and consequences is imperative. Thrace, which is the wine capital of Turkey, has significant value not only in the context of agriculture but also in tourism. It is necessary to pay attention to these determinations in order to ensure the sustainability of agriculture and tourism activities in the future.

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