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THE IMPACT OF CLIMATE CHANGE ON THE WINE SECTOR

ABSTRACT

Climate change is a major challenge for the wine sector, affecting both grape production and wine characteristics. The paper analyses the effects of climate change on grape and wine production at national and global level, highlighting how rising temperatures, variations in precipitation and extreme events influence this industry. The paper provides an integrated perspective on how wine industry can overcome climate obstacles while maintaining both sustainability and product quality. Future research should focus on assessing the economic impact of widely implemented climate change adaptation strategies in the wine sector. These studies could look at the costs and benefits associated with efficient irrigation technologies, use of resistant varieties, changing agricultural practices and modernising wineries. In addition, it would be essential to investigate the return on investment required to reduce vulnerability to extreme phenomena and to maintain the competitiveness of the wine market. Such an approach could support the strategic decisions of producers and policy makers, facilitating a sustainable and economically viable transition for the global and local wine industry.

Key words: climate change, grapes, wine, production, impact.

JEL Classification: Q10, Q11, Q18.

1. INTRODUCTION

In recent years, climate change has been more and more clearly highlighted, having an increasing impact on agriculture. Grapevine is one of the crops most affected by these changes. While weather patterns are constantly changing, vineyards are subject to variations and challenges in spring due to significant weather conditions. This season is crucial for vine development, and temperature variations and heavy rainfall have negative effects on budding, flowering, ripening, etc. of grapes, affecting the production and quality of wine. Another challenge is the increase in temperatures that causes the proliferation of diseases and pests and implicitly the use of pesticides and fungicides, with a negative impact on soil and production (Faralli *et al*., 2024).

Agricultural producers can adapt to these changes by using modern technologies with effective monitoring and management of vineyards, with smart irrigation systems, weather sensors, pest prediction methods, all of which are tools

to respond more effectively to climate change. By adopting these modern practices, farmers help to improve the biodiversity and resilience of the viticultural ecosystem. Moreover, by using technical methods such as conservation agriculture and economic irrigation systems, wine farmers can protect soil erosion and use natural resources more efficiently. Wine growers are involved and concerned about the impact on the environment and are increasingly moving towards regenerative agriculture with the use of sustainable farming techniques with resistant varieties and hybrids (Izquierdo-Bueno *et al*., 2024).

Climate change has changed the viticultural potential of wine-growing regions, their specific wine styles, and even the boundaries of the world's wine-growing area. The significant impact of climate change on viticulture requires in-depth studies of its consequences, in order to identify adaptation measures (Irimia *et al*., 2018).

Collaboration between researchers and wine farmers is important to find innovative solutions, investment in the discovery of new varieties adapted to climate change and effective, sustainable technologies and methods to combat pests. In addition to strategies in the field, these actions are not only for food safety or the protection of natural resources, but also for the wine industry. Wine-growers, through joint research and innovation activity, will be able to produce varieties adapted to climatic realities, quality wines and environmental protection for a better life.

2. STATE OF KNOWLEDGE

Climate change is having profound and lasting effects on global agriculture, with viticulture – grape and wine production – among the most vulnerable sectors. Rising temperatures, shifting precipitation patterns, more frequent and intense heatwaves, and elevated CO_2 levels are negatively impacting grapevine development and the overall quality of wine. A key issue is the disruption of the grape ripening process, where technological ripening (sugar accumulation) and phenolic ripening (flavor and color development) no longer occur simultaneously. This imbalance leads to grapes with higher sugar and alcohol levels but reduced sensory qualities, such as aroma and taste. Main issues regarding the climate change as a major challenge for the wine sector, affecting both grape production and wine characteristics was identified on *www.infoclima.ro*. The study has taken into consideration recent references regarding the impact of climate change on viticulture (Irimia *et al*., 2018), the sustainable farming techniques with resistant varieties and hybrids (Izquierdo-Bueno *et al*., 2024), as well as the negative impact the use of pesticides and fungicides have on soil and production (Faralli *et al*., 2024). OIV Statistics Database has proven extremelly usefull in gathering data for this paper. A series of specialised materials with rich information content were studied.

3. MATERIAL AND METHOD

The paper aims at capturing the main aspects related to climate factors in wine production in Romania and the EU in the period 2018–2023. The paper analysed several sector-specific indicators at global and national level, such as: wine production; imports and exports; average annual wine consumption. The data presented and analysed were taken from various specialized sites, such as: FAOSTAT, IPCC, NIS and MARD. For the purpose of this paper, representative data were graphically illustrated in the "Results and Discussions" section.

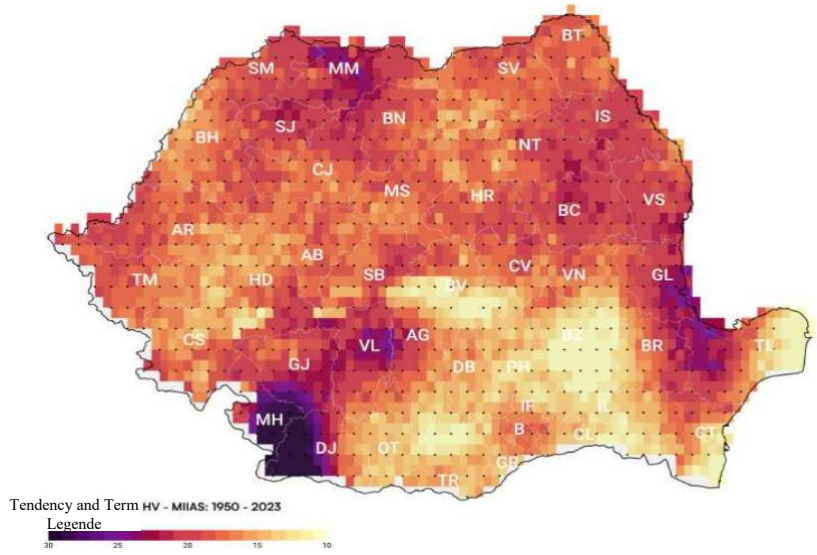
4. RESULTS AND DISCUSSIONS

The irreversible damage of the effects of climate change affects the agricultural sector, including vineyards. High temperatures, reduced precipitation and increased CO_2 have led to negative consequences on grape ripening, i.e. technological and phenolic ripening do not occur at the same time and result in thermal stress with diminished organoleptic properties. The increase in the percentage of alcohol and the accumulation of sugars in grape production can be called a decompensation process. Romania has recorded a significant increase in average temperatures in recent decades, with an increase by approximately 2.11°C.

1. *Evolution of heat waves*. Romania has registered a significant increase in average temperatures in recent decades, with an increase by approximately +2.11°C between 1958 and 2023, exceeding the global and European increase. The regions in the north of the country were the most affected. This warming has led to more frequent and more intense heat waves, with negative effects on human health, agriculture and water resources, amplifying drought and fire risks. These changes underline the need for urgent measures to protect the population and the environment (Figure 1).

In recent years, Romania has been hit by the longest and most intense heat wave in recent history – in the year 2024, representing 75% of the entire period.

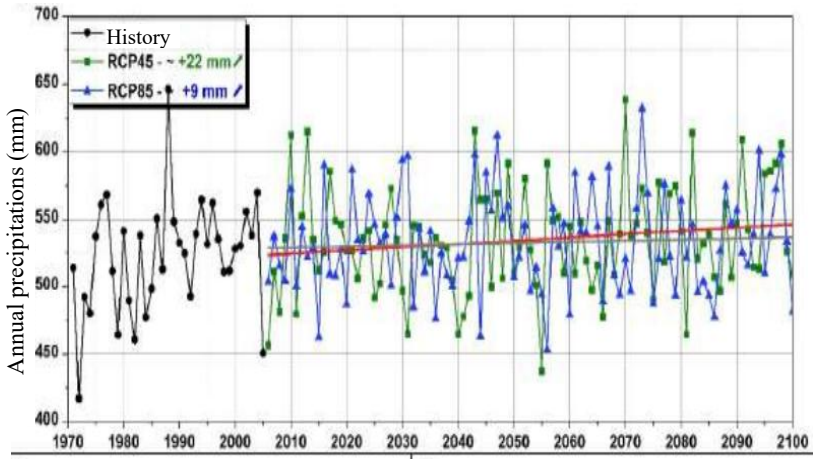
2. *Drought.* According to meteorological data, Romania has registered a significant increase in the area affected by drought, with the largest expansions in the last two decades, especially in the periods 2018–2020 and 2021–2023. The longest drought occurred between October 2018 and March 2021, peaking in May 2020, and the second worst event occurred between March 2022 and December 2023, with a peak in August 2022. In 2024, climate data shows that drought is still present, and this event could become the longest and most intense in the last 124 years.



Source: IRCC, ANM.

Figure 1. Evolution of the duration and frequency of heat waves at country level, in the period 1951–2023.

3. *Rainfall*. The recent signal of global warming plays a critical role in how we define and understand drought. Traditionally, drought has been mainly linked to a lack of precipitation, but rising temperatures caused by climate change are amplifying drought by increasing evaporation and reducing soil moisture, even when precipitation remains relatively constant. Thus, certain regions may experience drought-like conditions without a significant decrease in precipitation (Figure 2).

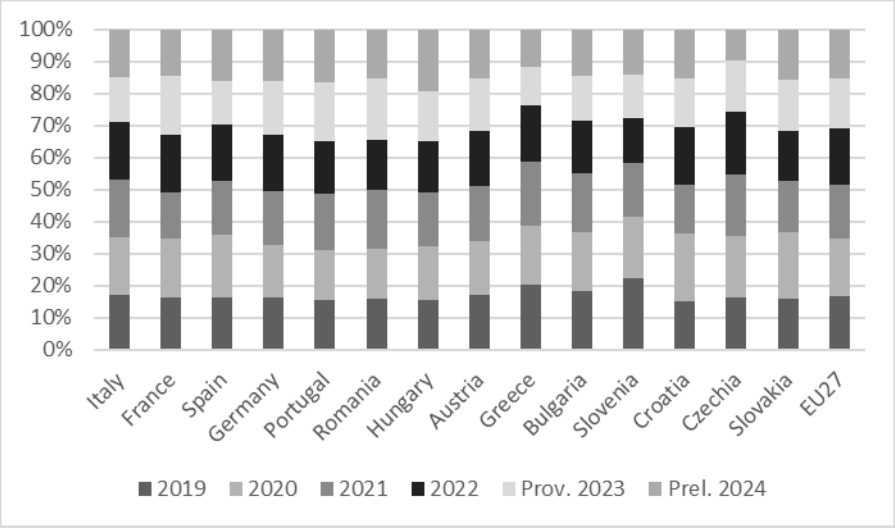


Source: IRCC, ANM.

Figure 2. Precipitation evolution and trend in the period 1970–2100.

- *Global production*

Climate change is changing the viticultural potential of wine-growing regions, their specific wine styles, and even the boundaries of the world's wine-growing area. The significant impact of climate change on viticulture requires in-depth studies of its consequences, in order to identify adaptation measures. Based on complete data from 29 countries, representing 85% of global production in 2023, global wine production for 2024 is estimated at 227–235 million hectolitres, with an average projection of 231 million hl. This forecast signals a 2% decline from the already low 2023 volume and a 13% reduction from the ten-year average. This places the 2024 production at possibly the lowest global production level since 1961 (220 million hl) (Figure 3).



Source: OIV, 2024.
Figure 3. Evolution of wine production in the European Union.

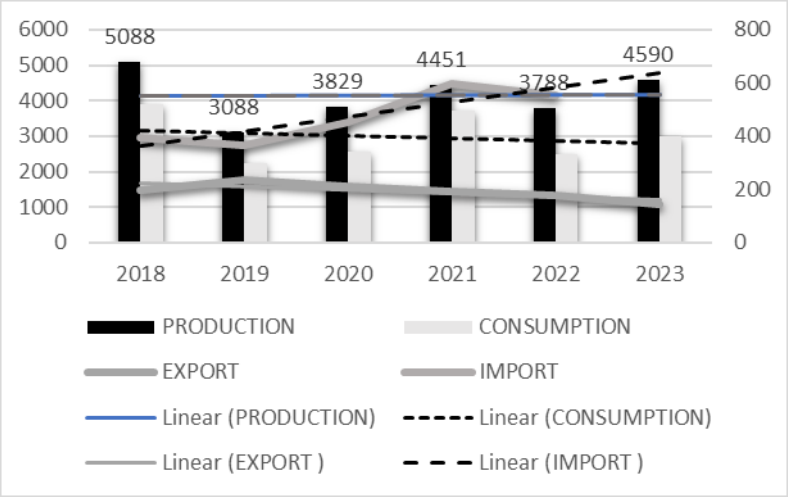
- *Production, consumption, export and import at national level, 2018–2023*

Between 2018 and 2023, wine production in Romania experienced significant fluctuations. In 2018, production was very high (5,09 million hectolitres [mhl]), but fell sharply in 2019 (3,09 mhl). Later on, in 2020 and 2021, a slight increase was noticed, reaching 3,83 mhl and 4.45 mhl, respectively. In 2022, production fell again (3,79 mhl), but in 2023 it increased to 4.59 mhl, signalling a better harvest.

The production of table grapes had a similar trend, with decreases in 2019 and 2020, but a slight recovery in 2021 (46.35 thousand tonnes). Fresh grape production was similarly variable, with a peak in 2018 and significant declines in subsequent years, but a slight increase in 2021.

These fluctuations were mainly caused by weather conditions, which influenced harvests and the overall production of grapes and wine.

Wine consumption in Romania fluctuated significantly. In 2018, consumption reached 3.9 mhl, but decreased considerably in 2019 (2.24 mhl). In 2020, consumption increased slightly to 2.5 mhl, to reach 3.71 mhl in 2021, a significant peak. However, in 2022 consumption fell again to 2.5 mhl, and in 2023 it increased to 3.0 mhl. Production and consumption of table grapes followed a similar trend, with declines in 2019 and 2020, but a slight recovery in 2021 and 2022. The production of dried grapes was more constant, with a significant decrease in 2022 (3731 tonnes) compared to previous years, when it was around 6000 tonnes. These fluctuations in wine and grape consumption may reflect changes in consumer preferences and the impact of economic or climate conditions on the market.



Source: graphic representation, OIV data, 2024.
Figure 4. Production, consumption, export and import at national level, 2018-2023

Between 2018 and 2023, wine exports from Romania registered a general decrease. In 2018, wine export was 199 thousand hectolitres, and in 2019 it slightly increased to 236 thousand hl. However, since 2020 exports have declined, reaching 210 thousand hl and continuing to decline to 146 thousand hl in 2023, which is a significant decrease from 2018.

Exports of fresh grapes were variable. In 2018, 580 tonnes were exported, and in 2019 and 2020 exports decreased, to reach 271 and 299 tonnes, respectively. However, in 2022, the export increased significantly to 1089 tonnes. Exports of dried grapes fluctuated less, but saw a significant decrease in 2020 (49 tonnes), followed by an increase in 2021 (133 tonnes) and a slight decrease in 2022 (106 tonnes).

These changes in exports can be attributed to several factors such as foreign market demands, economic conditions and climate changes that can influence production.

Between 2018 and 2023, Romania's imports had the following trends:

- Dried grapes import registered a significant decrease, from 6168 tonnes in 2018 to 4000 tonnes in 2023. This reflects a considerable decrease in imports, especially after 2022, when only 3837 tonnes were imported.
- Wine import: In 2018, Romania imported 395 thousand hectolitres (mhl) of wine, and the import fluctuated in the following years, reaching 451 thousand hl in 2020 and 597 thousand hl in 2021. In 2022 and 2023, imports decreased to 555 thousand hl, but remained relatively stable.
- Import of fresh grapes: Recorded steady growth over the period, from 42138 tonnes in 2018 to 57408 tonnes in 2023, which indicates an increased demand for fresh grapes on the Romanian market.

These trends suggest a fluctuation of supply and demand on the domestic market, with a significant decrease in imports of dried grapes and a constant increase in imports of fresh grapes and wine, probably due to market demands and economic conditions.

5. CONCLUSIONS

In conclusion, the inclusion of temperature in drought definitions is essential for correctly assessing its severity and impact and for developing effective adaptation and mitigation strategies.

In Romania, the projected changes in annual and monthly precipitation until the end of the 21st century fluctuate, with significant decreases and increases, depending on the region.

Climate change is changing the viticultural potential of wine-growing regions, their specific wine styles, and even the boundaries of the world's wine-growing area. The significant impact of climate change on viticulture requires in-depth studies of its consequences, in order to identify adaptation measures.

Collaboration between researchers and wine farmers is important to find innovative solutions, investment in the discovery of new varieties adapted to climate change and effective, sustainable technologies and methods for pest control.

Determinants: Climate change and global economic conditions have had a significant impact on the wine sector in Romania. Declining domestic production and rising imports suggest an increasing dependence on foreign markets and the need for more effective coping strategies.

Overall, these data underline the importance of adapting the Romanian wine sector to climate change and the dynamics of internal and external demand, in order to ensure the industry's long-term stability and development.

REFERENCES

1. Michele Faralli, Stefano Mallucci, Alessandro Bignardi, Mauro Varner, Massimo Bertamini, (2024). *Four decades in the vineyard: the impact of climate change on grapevine phenology and wine quality in northern Italy*, Vol. 58 No. 3 (2024): OENO One, https://doi.org/10.20870/oeno-one.2024.58.3.8083.
2. Irimia L. M., Patriche C. V., Murariu O. C., (2018). *The impact of climate change on viticultural potential and wine grape varieties of a temperate wine growing region*, 2018, Applied Ecology and Environmental Research 16(3), DOI: 10.15666/aeer/1603_26632680.
3. Izquierdo-Bueno I., Moraga Javier, Jesús M. Cantoral, María Carbú, Carlos Garrido, Victoria E. González-Rodríguez, (2024). *Smart Viniculture: Applying Artificial Intelligence for Improved Winemaking and Risk Management*, Appl. Sci. 2024, 14(22), 10277; https://doi.org/10.3390/app142210277.
4. *** OIV Statistics Database, accessed on December 10, 2024.
5. *** www.infoclima.ro, accessed on November 30, 2024.