

From Grape to Glass: Biodiversity's Impact on Moldovan Wine in a Changing Climate

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ABSTRACT

Moldova, with its rich viticultural heritage and diverse terroir, faces increasing challenges from climate change. This study explores the impact of climate change on Moldovan viticulture and examines traditional practices and successful adaptations. Rising temperatures disrupt traditional grape ripening, affecting wine quality. Understanding the relationship between terroir and climate is crucial for sustainable viticulture. Moldovan winemakers are adapting by exploring indigenous grape varieties, naturally suited to local conditions, enhancing resilience. These varieties not only preserve cultural heritage but also offer unique flavor profiles, contributing to Moldova's distinctive wines. Biodiversity is key, with practices like cover cropping and introducing beneficial insects creating "ecosystem services" that improve soil health, reduce chemical reliance, and contribute to climate change mitigation through carbon sequestration. Integrating traditional knowledge with modern techniques is vital for resilience. Promoting biodiversity ensures the long-term sustainability of Moldovan viticulture, linking economic viability with environmental concerns. Utilizing indigenous varieties and supporting biodiversity strengthens Moldova's wine industry and protects its cultural heritage, offering a valuable resource for adapting to changing climatic conditions.

Keywords: Biodiversity's Impact, Moldova, Wine, Changing Climate, Grape to Glass

Introduction

Moldova, possessing the highest global density of vineyards, has a winemaking history extending back 5,000 years [1,2]. Vineyards constitute 3.8% of the nation's total area and 7% of its arable land, establishing Moldova as a prominent wine-producing country in Eastern Europe, facilitated by its temperate climate and fertile soil [3]. This paper examines the interplay of tradition, innovation, and ecological balance within Moldovan viticulture, emphasizing biodiversity's significance in fostering sustainable ecosystems [2]. Notably, Moldovan wines frequently present outstanding value, delivering high quality at competitive prices relative to wines from more established regions [4].

This research investigates the essential contribution of biodiversity in Moldovan vineyards to strengthening resilience against climate change. It analyzes traditional viticultural methods, the consequences of climate change on Moldovan winemaking, and successful examples of resilient practices in Moldova and the shift to a terroir and local diversity of vineyards.

Sustainable wine production in Moldova marks a significant progression in the country's enduring winemaking heritage [5]. This approach extends beyond environmental considerations, adopting a holistic strategy that merges ecological integrity with economic feasibility and social equity [6]. Such a comprehensive outlook aims to secure the long-term vitality of vineyards, the excellence of wines, and the welfare of communities reliant on this industry. The implementation of sustainable practices

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indicates a dedication to responsible resource management and a forward-thinking approach to the future of Moldovan viticulture.

Materials and Methods

This study involved an extensive secondary data collection and analysis of existing data from industry various sources, such as reports from the Ministry of Agriculture and Food Industry, the National Office of Vine and Wine (ONVV), the Academy of Sciences of Moldova, and UNDP Moldova. Articles from national publications, such as "Fruit growing, Viticulture and Winemaking," and other online resources were also consulted. Materials from various international organizations, including Romanian research, were utilized. The research methodology included a systematic analysis of terms related to biodiversity, climate, and resilience, indigenous or local varieties, and the identification of priorities for future exploration of sustainability in viticulture, particularly within Moldova's grape and wine sector.

Additionally, an online survey was administered to Moldovan winemakers to collect primary data concerning observed climatic shifts, adaptation strategies employed, and biodiversity management techniques. This survey gathered details on vineyard dimensions, sustainable management practices, perceived climate alterations, adaptation measures, impacts on wine quality, agricultural systems, biodiversity enhancement strategies, monitoring protocols, research collaborations, cultivated grape varieties, resilience observations, terroir characteristics, ecosystem comprehension, and challenges encountered during the transition to sustainable practices.

Results and Discussion

Impact of Climate Change on Moldovan Viticulture

Climate change profoundly impacts Moldova's grape and wine sector, which contributes significantly to the national economy—approximately 20% of its GDP—and employs, directly or indirectly, 10% of the population [6]. Rising temperatures are influencing vine dormancy and frost resistance, altering the critical balance of sugars and acids necessary for high-quality wine production [6]. Warmer winters and hotter growing seasons disrupt traditional grape ripening schedules and challenge the maintenance of ideal fruit composition [4]. This climatic shift has expanded areas suitable for wine production in Moldova, with an increasing suitability for red wine varieties [7,8]. Also, previous studies suggested that higher temperatures could shift grapes cultivation towards the country's northern border and may improve grape quality, by increasing sugar content, which could significantly boost wine quality [8]. Temperature fluctuations, changes in precipitation patterns, and extreme weather events like heatwaves, frost, floods, and droughts heighten Moldova's vulnerability [8].

Moldova is predominantly threatened by increased greenhouse gases leading to drier conditions and an increasing, over the last decade, of multiannual climate average of air temperatures [4,9].

In the context of climate change, the wine regions are changing significantly, which leads to important consequences: changes in the phenology of wines, early maturation of grapes, higher alcoholic potential and lower total acidity of grape must, color changes appear and aromatic and sensory profile of wines [7].

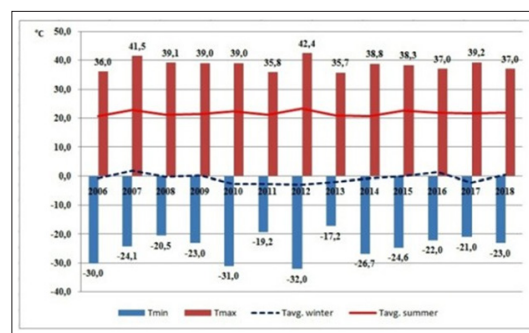


Figure 1: Extreme temperatures during the summer and winter between 2006–2018 in Moldova (Source: Savin et al, 2019)

Winemaker Observations on Climate Change

Survey responses from Moldovan producers offer practical insights into climate change impacts at the vineyard level. Gogu Winery, that produces certified organic wine in Causeni region, reported "drought and high temperatures," as primary recent climate changes. These conditions affect wine quality, as the producer noted that "sometimes sugar rises too quickly and phenolic ripening isn't achieved in red varieties. For white varieties, pH increases in the grapes". This highlights the complexities winemakers face due to disrupted ripening patterns as noted in several researches that indicates that climate change, particularly rising temperatures, leads to higher sugar and extract accumulation in musts and wines from Moldova [7].

EcoWine from Molovata Nouă, identified "reduced precipitation" as its main climate challenge. Interestingly, recent droughts positively affected older vines. Producer noted that the last 3 years have been quite dry, with droughts in 2023. Using traditional varieties and due to the age of the vines, which are 30 years old, "the heat has positively influenced the vineyard, as droughts don't allow the development of diseases", according to EcoWine. In 2021 – a year with many rains, has affected the vineyards more, increasing the diseases rate. These observations confirm scientific data on temperature increases and shifting precipitation, offering nuanced insights into vineyard-specific manifestations [7, 9]. Adaptation differences often relate to wine type. Older vineyards with traditional varieties demonstrate greater drought resilience. EcoWine noted, "the vines have deep roots, that sometime can reach 15 meters, making them more resistant to increased temperatures".

Terroir and Climate

Topography, biodiversity, and geology contribute to Moldovan wine diversity and quality, creating an intricate patchwork of terroirs [10]. Soils range from black chernozem to iron-rich loams and heavy clays, yielding varied wine characters and expressions of each variety [11]. These elements critically shape wine character. Moldova's varied landscape—hills, valleys, and Black Sea proximity—creates a mosaic of terroirs, each unique [11].

Understanding the terroir-climate relationship is vital for sustainable viticulture. As climate change brings warmer, drier conditions, Moldovan winemakers must adapt practices to ensure continued quality and yield [6]. This includes exploring indigenous varieties, often better adapted to local conditions and

more resilient to climate impacts [9, 11]. Terroir is critical in determining wine characteristics and similarity with regional wine traits. Soil, alongside climate, geography, and grape varieties, is a key terroir component, nourishing vines with water and essential nutrients [13]. The fertile soil and suitable climatic conditions in the Moldova, the size of vineyard areas, traditions, low input and operating costs are advantageous factors compared to many other wine- growing countries [13].

Divided in 4 soil-climatic areas in the 1960s, Moldovan scientists identified 23 production areas and united them into 4 regions [13], which are now included in the Protected Geographical Indication (PGI) : Codru, Ștefan Vodă, Valul lui Traian and Divin [14].

The fertile soil and suitable climatic conditions in the country, the size of vineyard areas, traditions, low input and operating costs are advantageous factors compared to many other wine-growing countries. For instance, the award-winning wines from the Purcari microzone owe their quality primarily to local soil properties [12]. Carbonate chernozem combined with sandy loam, rubidium traces, and Tertiary red deposits rich in iron group trace elements give Purcari red grape wines their distinctive high quality [12].

Climatically, southern vineyards are very favorable. The Dniester River's proximity and floodplains ensure climatic stability, protecting vineyards from severe frosts and summer heat [12]. Grapes ripen gradually, absorbing necessary elements without destructive temperature changes [12]. As such, different regions in the country are suitable to different types of grapes: red in the southern regions and white predominantly in the central part of the country [14]. The southern area is warm with rich soils, suitable for full-bodied red wines with ripe fruit flavors and smooth tannins [12,14]. Conversely, Ștefan Voda in southeastern Moldova, with a continental climate and varied soils, produces more white wines known for bright acidity and rich aromas [14].

Understanding the relationship between terroir and climate is essential for sustainable viticulture. This includes exploring the potential of indigenous varieties, which are often better adapted to local conditions and more resilient to climate change impacts [11].

Moldova's regional diversity, with a varied topography and climate, supports a rich diversity of grape species. While Moldova has a large variety of grapes registered and cultivated, there are 109 varieties of basic and 161 varieties of cloned grapes registered and cultivated [15]. According to Timbrus, in winemaking, including households, only 44 varieties are used to the maximum, of which 13 are white and 31 red grapes. Simultaneously, industrial producers prefer fewer varieties—about 9 red and 12 white.

Currently, the Catalog of Plant Varieties [15] includes six old local grape varieties, of which five are wine varieties: Tămîioasa Românească (Muscat Frontignan or White Muscat), Fetească Alba, Fetească Regală, Fetească Neagră, and Rară Neagră, from which high-quality wines are already being produced. However, the evolution of Moldova's wine industry in the past has restricted the use of indigenous varieties of grape and caused the extinction of some altogether [16]. Nevertheless,

more recently, the rediscovery of indigenous grapes, as well as the exploration of the country's ability to deliver world-class examples of international varieties [17], has taken place hand-in-hand with a better understanding of Moldova's landscape and the implementation of viticultural best practices [12].

Terroir Perspectives from Producers

Survey responses provide insights into terroir characteristics and their influence on adaptation. Gogu Winery described their terroir with "sandy chernozem and sandy clay soils that don't retain water in drought years". They implemented cover cropping "to retain water in surface soils," illustrating how specific terroir understanding informs targeted adaptation.

Eco Wine emphasized their connection to traditional varieties: "Local grape varieties deeply rooted in this terroir for generations. Viorica, Crească, Târasă, Zaibar, and Castel are among the cherished grape varieties thriving in the sandy loam soil, in Moldovata Noua. This focus on historically adapted varieties is an important climate resilience approach.

Biodiversity in Moldovan Vineyards

These indigenous varieties are not only integral to Moldova's viticultural heritage but also play a crucial role in maintaining biodiversity and resilience in the face of a changing climate [16, 17]. They possess unique characteristics that enable them to flourish in adverse conditions and resist diseases, contributing to the overall health and stability of the vineyard ecosystem. Preserving these local grape varieties is essential for safeguarding Moldova's biological history, traditional knowledge, and cultural identity [17]. Moreover, research identified the potential of indigenous varieties to contribute to the resilience of Moldova's viticulture. Feteasca Neagră exhibits resistance to both cold temperatures and drought conditions. Rara Neagră is capable of tolerating temperatures as low as -18°C, demonstrating winter hardiness [16]. These characteristics suggest that indigenous varieties can play a crucial role in adapting to the challenges posed by climate change, such as temperature extremes and altered precipitation patterns. Hence the significance of its indigenous varieties, and the ongoing efforts to enhance the industry's resilience and sustainability.

Biodiversity is fundamental to vineyard resilience, particularly against climate change. Moldovan vineyards, especially those practicing organic or regenerative viticulture, are increasingly recognizing the value of biodiversity, as noted in the survey. Practices such as cover cropping, maintaining natural vegetation around vineyards, and introducing beneficial insects create "ecosystem services" that enhance soil health, reduce reliance on chemical inputs, and can contribute to climate change mitigation through carbon sequestration [4,6]. Research indicates that biodiversity in vineyards can improve soil structure, water retention, and nutrient cycling, while also promoting natural pest control [18]. Moldova's diverse flora and fauna offer a rich resource for enhancing vineyard ecosystems, contributing to the unique character of its wines. Vineyards managed with biodiversity in mind often exhibit greater resilience to pests, diseases, and climatic stresses [17].

On the other hand, the same research suggests that the relationship between organic certification and biodiversity benefits reveal

important nuances [18]. While European studies present conflicting evidence—from increased predatory mite diversity in Italian organic vineyards to reduced grasshopper populations in Swiss counterparts' Moldovan producers demonstrate that deliberate practices outweigh certification alone [18].

When examined through Moldova's unique viticultural traditions and practices, the study finds that several winegrowers are aware of the benefits of plant cover for the vines and the vineyard ecosystem.

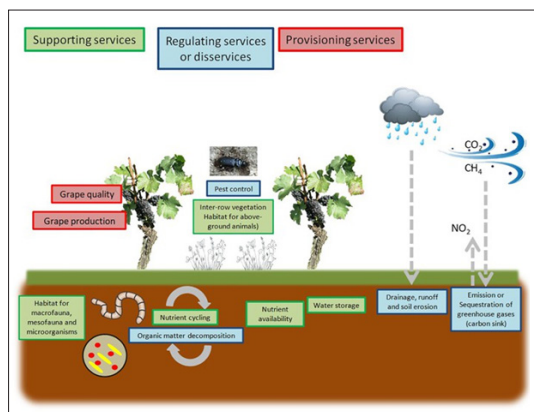


Figure 2: Ecosystem services provided by vineyard soils. Biodiversity is strongly linked to habitats availability in this agroecosystem: soil and plant cover (Source [18])

For example, Crama Mircești's permanent vegetative cover between vine rows, planting in symbiosis with nature, creates habitats that support diverse insect populations more effectively than some certified organic vineyards abroad, while Carlevana's herbicide-free management of native Rară Neagră vines aligns with research confirming that chemical exclusion benefits soil biota [18-20]. The study also identified that Moldova's older vine rootstocks (averaging 14–15 years at Carlevana ; 30 years at EcoWine) is naturally drought resistant and represents a powerful and environmentally friendly adaptation to increased drought as once planted, do not increase production costs. Novak Wineries' old-vine parcels (planted 1977-2004) with deep root systems support soil microbiomes, while traditional mixed plantings foster stable ecosystems that may explain why its vineyards often surpass the biodiversity outcomes observed in European studies [21]. As noted, Novak wineries cultivate rare native grapes like Kaz Ayá (Gagauz "goosefoot" vine), preserved through generations despite Soviet collectivization and managed to revive nearly lost Moldovan varieties: Alb de Onițcani, Floricica [21].

The country's Soviet-era zoning, though designed for production efficiency, inadvertently preserved genetic diversity through structured vineyard blocks [20,21]. This historical advantage combined with modern organic protocols, could strengthen by mandating ground cover and documenting traditional practices like Equinox's hand-harvesting or Novak's woven-basket techniques, which maintain arthropod habitats more effectively than mechanized organic systems. This evidence positions Moldova as a compelling case where traditional knowledge, when consciously applied, achieves biodiversity outcomes that resolve the contradictions seen in global organic viticulture

research. This ecological approach also supports broader conservation goals and can enhance the appeal of Moldovan wines to environmentally conscious consumers [10].

Biodiversity Practices by Producers

Winegrowers' surveys reveal active biodiversity management, particularly focused on organic practices and as well as applying regenerative agriculture. The UNDP's regenerative viticulture platform demonstrates how technology can scale climate resilience. Small wineries like Carpe Diem use its biodiversity dashboards to validate that wildflower corridors boost beneficial insects by 40%, while carbon tracking confirms agroforestry sequesters 1.8 t CO₂/ha/year [6].

One of Moldova's first fully certified organic wine producer, with its inaugural certified vintage released in 2013, is Equinox Wines. While not technically the first Moldovan organic wine, Equinox became the first complete organic winery operation, establishing a model for sustainable viticulture in the country [22].

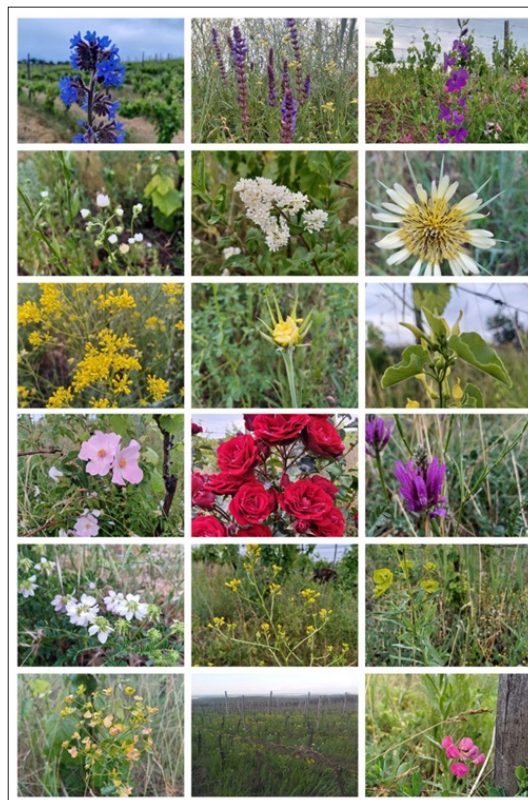


Figure 3: Floral diversity between rows in Crama Domneasca (Equinox wines) [Source: Equinox Facebook page]

Equinox's wine journey began in 2002 when they planted the first two hectares of vines near Olănești, Ștefan Vodă, driven by viticulture education and desire to implement environmentally conscious practices. Organic conversion started in 2010, when Mr Stratan "wanted to be part of that future and believed organic methods could produce superior quality" [22,23]. Additionally, Mr Stratan maintains biodiversity by planting flowers between the rows, as noted in several social media posts of the Equinox wine, observing over 20 different flowers (Fig 2). Promoting flower presence in vineyard inter-rows and conserving native vegetation can support wild pollinators that enhance the ecosystem services and soil fertility.

As found in a research, biodiversity conservation, including floral-rich vegetation in inter-rows contributes to improvement of biological control of pests by enhancing the diversity of flower-visitors, thus supporting the abundance and diversity of predators and parasitoids [24].

Survey also revealed that Gogu Winery employs cover crops to enhance soil health and water retention and fertilize soil naturally. Such practices reduce mechanical intervention and chemical use, fostering a healthier ecosystem. This winery is an organic certified [25].

EcoWine applies mulch of crushed grapevines prunings under the vineyards to protect them from extreme droughts and help preserve soil moisture. Research also shows that this is an effective technique to control excessive weed cover, which was also the aim of the produce— to reduce the workload of weeding. According to the survey, the winegrower believes that “returning to land what nature offers us and living in this symbiosis is very important”. He also applied horse dung some 3 years ago as a natural fertilizer [24]. Additionally, the winemaker has a strong focus on local varieties, inherently supporting genetic biodiversity. Their minimal intervention approach – no mechanisation in the past 3 years - allows natural flora and fauna to thrive, creating a balanced vineyard ecosystem. Survey revealed that the EcoWine is surrounded by a small Acacia Forest, supporting the diversity of birds, such as pheasants that made a nest in their vineyard. There are acacia strips around, hedgrows that attract many bees. The winemaker only has walnuts for shade, an apricot in the vineyards.

Timbrus Estate also implements practices to preserve and enhance biodiversity, recognizing its role in sustainable viticulture and wine quality [12].

Cricova Winery's also started producing organic wines since 2017 [25], to align to their sustainability goals. These organic viticulture practices enhance biodiversity, using exclusively natural fertilizers and manual labor, avoiding GMOs and systemic treatments. Emphasis is placed on natural ground cover, which fosters a balanced ecosystem, mitigates moisture deficits, and reduces reliance on chemicals. Post-harvest materials (stems, pomace) are recycled as organic fertilizer. Advanced drone technology is employed for precise, eco-efficient vine treatment, minimizing waste while supporting soil, plant health [26]. These examples show a growing commitment to biodiversity as a cornerstone of resilient and sustainable viticulture in Moldova.

Traditional Knowledge and Modern Techniques

The integration of traditional Moldovan viticultural knowledge with modern scientific understanding is crucial for developing effective climate change adaptation strategies. Traditional practices, refined over centuries, often embody principles of sustainability and resilience that remain relevant. For instance, the selection and propagation of indigenous grape varieties, well-suited to local climatic and soil conditions, is a testament to ancestral wisdom [19,20,21]. Modern research can validate and enhance these practices, such as by identifying specific genetic traits in local varieties that confer drought or disease resistance [16]. Combining empirical knowledge with data-driven approaches, like precision viticulture and advanced

climate modeling [6], can optimize vineyard management for a changing environment [21]. This synergy allows for innovation rooted in heritage, ensuring that adaptation strategies are both effective and culturally resonant [Source 355].

Carlevana Winery exemplifies how Moldova's viticultural heritage can merge with modern innovation to address contemporary challenges. Established in 1959 within the Moldvinprom collective system, its Soviet-era infrastructure—including structured vineyard zoning— unintentionally preserved genetic diversity [20]. Today, Carlevana repurposes this foundation for climate-smart viticulture, adopting precision irrigation and pioneering Moldova's first Ice Wine production through temperature- controlled fermentation [20]. This duality extends to plantings: industrial-scale parcels of Rară Neagră (a drought-resistant native) coexist with experimental blocks of Sauvignon Gris, blending ancestral resilience with modern market adaptability [20]. By bridging collective- era discipline with 21st-century technology, Carlevana demonstrates how historical assets can catalyze sustainable innovation—a model increasingly replicated across Moldova's wine sector.

Another example is Novak Winery's century-old legacy that illustrates how traditional knowledge and modern innovation can co-evolve. The winery's revival of near-extinct indigenous varieties like Kaz Ayá — preserved through Soviet-era collectivization in home gardens—showcases ancestral understanding of drought- resistant cultivars [21]. Additionally, Novak managed to revive Alb de Onitcani and Floricica, forgotten varieties that some experts considered lost in history. Today, Novak pairs these heritage grapes with modern precision viticulture in Valul lui Traian's sun-drenched slopes, leveraging 300+ annual sunlight days to reduce fungal treatments [21]. Their transition from bulk production to award-winning bottled wines (2017 onward) reflects a deliberate fusion: traditional hand-harvesting with woven baskets (a Codru-region practice) meets data-driven export strategies. This model, where genetic diversity and cultural memory inform climate adaptation, offers a template for sustainable transitions across Moldova's wine industry.

Similarly, traditional soil management techniques, such as organic matter incorporation, as seen at EcoWine can be augmented by scientific understanding of soil microbiology and carbon sequestration to enhance soil health and vineyard resilience. This blending of old and new ensures that Moldova's viticultural heritage continues to evolve and thrive [27].

Case Studies and Best Practices

Moldova's wine industry offers several examples of successful adaptation and resilience. Asociația Micilor Producători de Vinuri din Moldova [28] plays a key role in promoting quality and sustainable practices among its members, fostering a collaborative approach to tackling challenges like climate change. Smaller producers, such as those highlighted in the surveys (Gogu Winery, Eco Wine), also contribute significantly by championing organic farming, indigenous varieties, and minimal intervention winemaking [19,20,21,23]. Their experiences provide valuable lessons in agility and adaptation at a different scale. International collaborations and knowledge exchange, facilitated by organizations like the National Office

of Vine and Wine (ONVV), UNDP further support the adoption of best practices across the sector [1,6]. Learning from regions with similar climatic challenges, such as parts of Romania or other Eastern European countries, can also provide insights into effective adaptation strategies, for example, in vineyard management techniques or the use of specific rootstocks [24, Source 366; Source 367]. Regenerative viticulture, focusing on soil health and ecosystem restoration, is gaining traction globally and offers a promising pathway for Moldovan vineyards to enhance resilience and sustainability [6].

On the other side, bigger wineries like Castel Mimi, Cricova and Purcari have invested in modern technologies and sustainable practices while preserving their historical legacy, demonstrating that innovation and tradition can coexist [2].

Conclusion

Moldova's viticultural sector, a cornerstone of its economy and cultural heritage, stands at a critical juncture due to climate change. This research underscores the profound impacts of rising temperatures and altered precipitation patterns on traditional grape growing and winemaking practices. The disruption in grape ripening, affecting sugar-acid balance and phenolic development, poses a significant challenge to wine quality. However, the study also highlights the proactive and adaptive spirit of Moldovan winemakers.

A key finding is the growing recognition and implementation of biodiversity as a critical tool for enhancing vineyard resilience. Practices such as cover cropping, mulching, preserving natural vegetation, and focusing on indigenous grape varieties are not merely ecological choices but strategic imperatives for sustainability. The genetic reservoir of indigenous Moldovan grape varieties, shaped by centuries of adaptation to local conditions, provides unique sensory profiles, disease resistance, and drought tolerance that can differentiate Moldovan wines in the global market. The case studies of Gogu Winery and Eco Wine, among others, demonstrate practical applications of these principles, showcasing how understanding specific terroir characteristics informs targeted adaptation strategies.

The synergy between traditional ecological knowledge and modern scientific innovation is vital. While ancestral wisdom in variety selection and site management provides a robust foundation, contemporary research and technology offer tools to refine and scale these practices effectively. Sustainable wine production in Moldova, therefore, is evolving into a holistic approach that integrates ecological health, economic viability, and the preservation of cultural identity.

The findings confirm that by championing biodiversity, investing in research on local varieties, and fostering collaboration between producers, research institutions, and governmental bodies, Moldova can navigate the challenges of climate change. This approach will not only safeguard its ancient winemaking tradition but also enhance its competitiveness and solidify its reputation as a producer of distinctive, high-quality wines that reflect a profound respect for nature.

Recommendations

Based on the findings of this research, the following recommendations are proposed to enhance the resilience and sustainability of Moldovan viticulture in the face of climate change:

Promote and Invest in Indigenous Grape Varieties

Researchers should prioritize further research, cataloging, and promotion of Moldova's indigenous grape varieties (e.g., Fetească Neagră, Rară Neagră, Viorica) [16]. Investment in clonal selection and vineyard trials can identify optimal matches for specific terroirs and resilience traits. Support schemes for planting and marketing wines from these varieties should be enhanced.

Enhance Biodiversity in Vineyards

Develop and disseminate guidelines for biodiversity enhancement practices, such as tailored cover crop mixes, establishment of ecological corridors, and integrated pest management programs that reduce chemical inputs. Offer incentives for wineries adopting certified organic, biodynamic, regenerative viticulture or other high- biodiversity viticultural systems. Support research on the specific ecosystem services provided by local flora and fauna in vineyard settings.

Strengthen Research and Knowledge Transfer

Foster collaboration between research institutions (e.g., Academy of Sciences, National Office of Vine and Wine) and wine producers to co-create and implement adaptation strategies. Support long-term studies on climate change impacts on various terroirs and grape varieties. Establish demonstration farms and facilitate peer-to-peer learning networks for sharing best practices in sustainable viticulture.

Support Water Management and Soil Health Initiatives

Promote water-efficient irrigation techniques where necessary, alongside strategies to improve soil water retention capacity (e.g., organic matter addition, reduced tillage). Support initiatives focused on regenerative agriculture principles to build soil health, enhance carbon sequestration, and improve drought resilience.

Develop Climate-Resilient Terroir Mapping

Utilize GIS and climate modeling to update terroir maps, identifying areas that will remain suitable or become newly suitable for specific grape varieties under future climate scenarios. This can guide new vineyard plantings and adaptation planning for existing ones.

Enhance Policy Support and Market Access

Advocate for national policies that support sustainable viticulture and climate change adaptation. Assist producers, especially small and medium-sized enterprises, in accessing markets for sustainably produced wines and in communicating their environmental credentials to consumers.

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