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Editorial

Editorial for the special issue: Innovation for sustainable agri-food systems in the Mediterranean region: Drivers and challenges

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1. Introduction

The Mediterranean agri-food system is currently facing a critical juncture, characterised by a profound and structural paradox. On the one hand, the area is a cradle of biodiversity, a repository of millennia-old traditional knowledge and the source of the famous Mediterranean diet, globally recognised for its health benefits and intangible cultural value. On the other hand, the Mediterranean basin is a climate change hotspot, subject to accelerated warming, endemic water scarcity and extreme weather events that threaten the very stability of agricultural production [1]. This environmental fragility is compounded by historical structural challenges, including land fragmentation, an ageing agricultural population and a persistent digital divide between rural and urban areas [2]. The convergence of these pressures calls for transformative innovation aimed at changing current sociotechnical regimes [3], which renders linear production models obsolete, requiring a radical transformation towards circular, knowledge-based and resilient systems. In this context, European policies, in particular the Green Deal and the Farm to Fork (F2F) strategy, outline a necessary but ambitious path: drastically reducing the use of chemical inputs, increasing the area dedicated to organic farming and ensuring food security. This Special Issue lays the foundations for a debate on this issue, bringing together multidisciplinary contributions that integrate technical, economic and social aspects, always with an eye on the political implications. The five articles published in this collection offer a varied perspective and address both the supply and demand sides. As far as the supply side is concerned, the three papers offer insights from precision agriculture, robotics, blockchain to rural development strategies. As far as the demand side is concerned, the focus is on the consumer's acceptance of

products embracing circular economy (CE) principles, and on the role of blockchain technologies in securing consumers on the quality of the products.

2. Background

The modernisation of Mediterranean agriculture involves the adoption of advanced technologies that allow us to "do more with less", managing natural variability and ensuring the authenticity of production. Precision farming tools boost sustainable agriculture relying on specialized equipment, software and IT services, engendering multiple benefits from both economic and environmental points of view [4].

Viticulture is one of the key sectors for the Mediterranean agricultural economy, but it is also one of the most exposed to climate change [5]. Precision Viticulture (PV) is emerging as a strategic response to mitigate these impacts. As highlighted in the review by Comparetti et al. [6], PV is based on the management of spatial and temporal variability within the vineyard. The use of remote sensing technologies allows for the monitoring of vegetative vigour indices and water stress. This approach is able to identify differentiated "management zones", enabling the variable rate application of inputs (e.g. fertilisation, irrigation) and the practice of selective harvesting, which is essential for ensuring wine quality in climatically difficult vintages. At the same time, automation is redefining field operations. Comparetti et al. [7] offer a review of field robots, illustrating how robotics can respond to labour shortages and the need to reduce chemical impact. Unmanned ground vehicles are now capable of precision sowing and mechanical weeding, eliminating the need for herbicides. In addition, robots equipped with artificial intelligence for weed recognition allow for targeted treatments, generating savings of up to 60% in crop protection products and significantly reducing the environmental footprint of high value-added crops typical of the Mediterranean.

The adoption of these innovations does not take place in a vacuum, but within specific business and territorial contexts. De Rosa et al. [8] propose an analysis on the role of the digitalisation for sustainable rural development among Italian farms. Using data from the latest census of agriculture, the study identifies a "three-pronged approach" in a specific cluster of farms (approximately 13.6%), located mainly in remote rural areas. These farms combine the adoption of technological innovations with diversification strategies, demonstrating how digitalisation can be a driver for "smart rurality" and resilience in inland areas, bridging the digital divide and contributing to sustainable local development.

Innovation does not stop in the field but continues along the supply chain to ensure product traceability and consumers' trust. The study by Staffolani et al. [9] analyses the application of blockchain to the Extra Virgin Olive Oil (EVOO) supply chain, a product of excellence often threatened by counterfeiting. Through a discrete choice experiment conducted on young Italian consumers, the study shows that blockchain is perceived as a powerful guaranteed tool. The results indicate a willingness to pay a significant price premium for EVOO tracked on blockchain (€11.12/L additional for the blockchain attribute), especially when combined with the Italian origin attribute (€23.68/L for the blockchain + 100% Italian combination). This highlights how digital innovation can act as a value multiplier for traditional products, strengthening the Made in Italy brand.

Consumers play a key role in identifying the "direction" of innovation towards more sustainable solutions. Actually, the transition to sustainable systems also requires a change in consumption patterns [10]. The study by Dolfi et al. [11] addresses the issue of "indirect

entomophagy", which is the consumer acceptance of fish farmed with insect-based feed. In a context where aquaculture needs to reduce its dependence on wild fish meal, insects could represent a promising CE solution. The research is conducted in Italy and highlights that, although there is widespread indifference or neophobia towards new feeds, information plays a key role: providing consumers with details on the sustainability benefits of insect-based feeds increases their willingness to purchase by an average of 15%. This suggests that product innovation may support a CE transition in production and consumption models. Transfer of innovation, knowledge and information (e.g., educational campaigns) are increasingly necessary to bridge the gap between "declared" sustainability and actual purchasing choices.

3. Conclusions

This Special Issue highlights how the Mediterranean agri-food system is a living laboratory for innovation. Climate and market challenges are addressed through a mix of technological (robotics, remote sensing), digital (blockchain) and organisational (multifunctional strategies) solutions. However, the success of this transition depends on the ability to integrate these innovations into a systemic framework that includes all the actors, including consumers, as active participants and values the heterogeneity of rural areas. The adoption of innovation is not uniform. There is a polarisation between technologically advanced farms, integrated into value chains, and small marginal farms that risk being left behind. Nonetheless, the high percentage of farms in the Mediterranean agriculture raises non-neutrality issues, linked to digital and spatial affordance [12]. Consequently, the "Twin Transition" risks exacerbating these inequalities, if it is not accompanied by targeted cohesion policies. Furthermore, for Mediterranean products, technology should not be understood as a substitute for tradition, but rather as a means to safeguard and enhance it. The price premium that consumers are willing to pay for traceable extra virgin olive oil indicates that transparency can function as a concrete economic asset, particularly when it is firmly anchored to territorial identity. Sustainability, in this perspective, extends beyond input efficiency to include openness to alternative sustainable production models (e.g., the use of insects in aquafeeds) and the social vitality of rural areas (e.g., smart villages). At the same time, the cultural acceptance of novel foods in Southern Europe remains a gradual process, requiring time as well as carefully designed and context-sensitive communication strategies [13].

In light of the findings reported in this special issue, several suggestions emerge for work in the near future. There is an urgent need to develop business models that make capital-intensive technologies accessible to small businesses, for instance through user consortia, shared investment arrangements, or Robot-as-a-Service solutions. While economic constraints remain the primary barrier [14], the digital transition also depends on effective knowledge transfer and a deeper understanding of social-capital dynamics. Further research is therefore needed on the social processes shaping technology adoption in the Mediterranean context. In particular, unpacking cultural resistance is crucial for designing innovations that are not only technically and economically viable, but also socially sustainable.

In conclusion, the future of Mediterranean agriculture depends on its ability to become "smart" without compromising its identity. By combining precision farming techniques to safeguard heritage productions, leveraging blockchain to enhance traceability and protect traditional products, and restoring connectivity to rural areas to revitalise villages and services, the Mediterranean can turn long-standing structural constraints into drivers of resilience and sustainable growth.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflict of interest.

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