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Keynote article

Does agricultural abandonment matter? An Italian perspective

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Abstract. Farmland abandonment in Italy is closely linked to rural depopulation; however, the current agricultural policies have proven insufficient to counter it. Research has identified its drivers and effects, but their interconnections and societal impacts remain underexplored. It is essential to evaluate ecosystem services and agricultural externalities to make informed decisions, although applying such assessments in practice is still challenging. The main cause of abandonment is low profitability; ensuring fair incomes is necessary but insufficient without considering local living conditions and quality-of-life factors. Integrated approaches, supported by theoretical frameworks such as Sen's capabilities, can guide context-specific strategies to sustain rural livelihoods. Effective responses require coordinated multi-level governance; territorial zoning; and strategies that combine competitiveness, social well-being, and economic sustainability. Demographic trends, generational turnover, and declining sector appeal heighten the urgency for action. European and national policies increasingly recognise the link between depopulation and agricultural decline, making this a pivotal moment for intervention. Applied and agricultural economists can play a central role, if they are willing to embrace the challenge.

Keywords: land abandonment, depopulation, well-being, profitability, agricultural policy.
JEL codes: R11, R14, R23.

HIGHLIGHTS

- Farmland abandonment in Italy is tied to rural depopulation; the current policies have failed to stop it.
- Low profitability is a serious problem; ensuring adequate levels is necessary but not sufficient.
- An analysis of the determinants of quality of life in marginal areas is essential to promote genuine development paths.
- Coordinated governance and applied economics are essential to turn awareness into concrete, sustainable rural solutions.

1. INTRODUCTION

"Europe offers a unique quality of life. From comprehensive social security to first-class regional food products. Rapeseed fields, vineyards and fruit orchards not only mean good food and drink, they are also part of our homeland. And that is why the future of agriculture is such an important and sensitive issue for us in Europe". The European Commission President Ursula von der Leyen opened her address to the European Parliament on 18 July 2024 with these words, which underline the central role agriculture plays in the European model of development. However, the future of agriculture in Europe is becoming increasingly uncertain, particularly in rural and marginal areas. Over the past decades, the abandonment of agricultural land has become a widespread phenomenon, raising significant economic, environmental, and social concerns (Terres *et al*., 2015; Lasanta *et al*., 2017; Dax *et al*., 2021; Fayet *et al*., 2022). Entire portions of cultivated land have been progressively abandoned, especially where traditional low-input farming systems are no longer sustainable (Plieninger *et al*., 2006; Ustaoglu, Collier, 2018; Quintas-Soriano *et al*., 2022; Cusens *et al*., 2024). In these areas, depopulation often occurs alongside land abandonment. Agriculture is not replaced by other economic activities, and the territory "dies". These two phenomena are closely interconnected, although it is not always clear which is the cause and which the effect. This issue will be explored further throughout the article.

According to a report by the European Commission's Joint Research Centre (JRC), agricultural land abandonment can be defined as "the cessation of agricultural land management, which results in unwanted effects on biodiversity and ecosystem services" (Terres *et al*., 2013: 22). However, other authors have also highlighted the potential for positive environmental impacts (Van der Zanden *et al*., 2017). In reality, it is a highly complex phenomenon in terms of its causes and effects, stemming from a multifaceted interaction of economic, environmental, and demographic factors. Although it is a pan-European issue, the causes and implications of agricultural abandonment vary significantly across regions, reflecting local specificities and the political contexts in which they are embedded (Renwick *et al*., 2013; Pawlewicz, Pawlewicz, 2023).

The growing relevance of the phenomenon has stimulated a rich body of scientific research, ranging from the analysis of future trends (Vacquie *et al*., 2015; Mouchet *et al*., 2017), to the effects on ecosystem services (Plieninger *et al*., 2014; Gabarrón-Galeote *et al*., 2015), to qualitative and quantitative evaluations of the consequences and policy implications of abandonment (Lasanta *et al*., 2015; Keesstra *et al*., 2018). Nevertheless, empirical research has demonstrated the need for a common assessment framework to evaluate impacts and guide policies and land-use planning, while also recognising the need to tailor interventions to specific local realities (Ustaoglu, Collier, 2018).

The strategic importance of the issue is confirmed by the recent vision paper from the European Commission, which anticipates the priorities of the upcoming reform of the Common Agricultural Policy (CAP). The document states: "Agriculture and food are at the heart of the European way of life. Rooted in rich traditions, the ways we produce and consume food have shaped the communities, cultures, and landscapes that define European identity. (...) Rural areas are home to 25% of the EU population and cover 75% of the territory, forming an integral part of Europe's identity. Vibrant rural and coastal communities are essential to counteract depopulation and safeguard the right to remain" (European Commission, 2021).

The document identifies four fundamental priorities for the future of the European agri-food system:

- An attractive and predictable sector, capable of ensuring adequate income for farmers and attracting younger generations.
- A competitive and resilient system, able to withstand global competition and economic shocks.
- Sustainable agriculture that is aligned with planetary boundaries.
- A sector that values food, promotes decent living and working conditions, and supports vibrant and connected rural areas.

At least two of these four priorities clearly reflect concern for an agricultural sector that is showing strong signs of crisis across vast areas of Europe. The goal of creating connected and vibrant rural areas can be pursued by proposing an agricultural, and more broadly territorial, policy that centres on attractiveness for younger generations, achievable only by ensuring adequate profitability along with decent living and working conditions. In this context, several key questions arise: what is the current state of rural areas in Italy? What theoretical and empirical tools does research provide to analyse and address agricultural land abandonment? What economic, institutional, and political levers can be activated to counter this phenomenon? The aim of this paper is to offer some answers to these questions by analysing the current dynamics affecting agriculture and rural areas in Italy. Particular attention will be paid to two central issues for the resilience of agricultural and territorial systems: the profitability of agricultural activity and the

measurement of well-being in rural areas, as achieving adequate levels of both is essential for genuine rural development. Ultimately, the goal is to identify the most promising research paths and the most effective policies to counter agricultural abandonment and foster the sustainable development of rural areas.

The rest of this paper is organised as follows. Section 2 describes the current situation in Italy. Then, Sections 3, 4, and 5 provide an overview of the most relevant scientific contributions on rural abandonment, with a focus on its effects, causes, and possible interventions, respectively. Finally, Section 6 concludes the paper.

2. CURRENT DYNAMICS

The abandonment of agricultural land represents one of the main territorial and economic challenges for Italy and many other European countries, particularly in the Mediterranean area. At the European level, agricultural abandonment has received increasing attention in recent decades, with numerous studies analysing its causes, spatial dynamics, and impacts. Since the 1990s, land use in Europe has followed divergent trajectories: while the North and West have experienced agricultural intensification and growing urbanisation (Plieninger *et al*., 2016; Levers *et al*., 2018), Eastern European countries have seen a significant expansion of forested areas. In contrast, in Southern Europe, particularly in Italy, Spain, Greece, and Portugal, agricultural land abandonment has become the dominant land-use change (Kuemmerle *et al*., 2016).

The quantitative dimensions of the phenomenon are significant: according to Hatna, Bakker (2011), more than 118,000 hectares were abandoned in Southern Europe between 1990 and 2006; Feranec *et al.* (2010) estimated that 88,000 km² was abandoned between 1990 and 2000. Moreover, Kuemmerle *et al.* (2016) identified abandonment of approximately 20,500 km² between 2000 and 2012. This process is often accompanied by spontaneous reforestation (Burrascano *et al*., 2016), which offers ecological benefits but may also result in the loss of traditional agricultural landscapes and cultivated biodiversity.

Among European countries, Italy stands out for the severity of the phenomenon, which primarily affects mountainous and hilly areas characterised by extensive, low-profitability agriculture (Cocca *et al*., 2012; Malavasi *et al*., 2018; Zavalloni *et al*., 2021). The result is a gradual decline in agricultural activity and a loss of socio-economic vitality, often followed by depopulation. At the national level, data from the most recent censuses revealed a highly concerning situation: out of 7,896 municipalities, more than 2,000 showed a reduction in utilised agricultural area (UAA) of over 50% between 1990 and 2020, and another 1,550 recorded a reduction of 30-50%. These municipalities are mainly located in inner areas (Figure 1) characterised by complex hilly and mountainous morphology, poor transport connectivity, and limited access to public services (Salvia *et al*., 2019; Cardillo *et al*., 2022). Some cases of agricultural land expansion, mainly found in Sardinia, are linked to the increase of extensive crops such as pasture meadows, but they do not reverse the trend of depopulation, as shown in Figure 2. The only significant exceptions are found in North-east Italy, where specific socio-economic conditions support the development and retention of younger generations, even in mountain areas. These cases deserve specific studies aimed at examining all the conditions involved and assessing their transferability to other contexts.

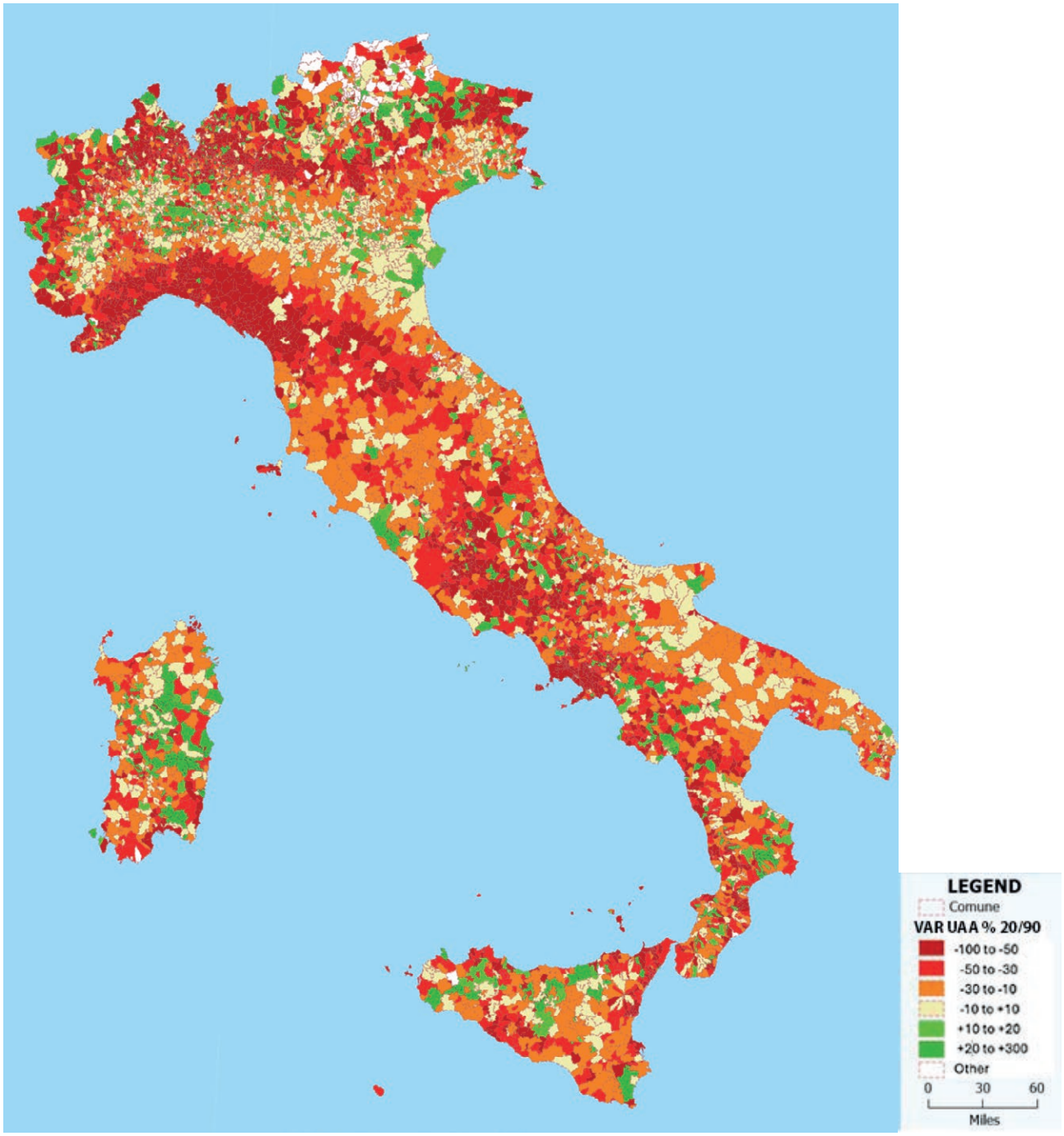
Figure 2 clearly shows the strong interrelation between farmland abandonment and population outmigration. Approximately 2,000 municipalities experienced both a reduction in UAA greater than 30% and a decline in population, with around 1,600 of these located in rural areas. In many inland hilly and mountainous areas, population declines exceeding 10% were recorded between 1991 and 2024. These patterns are particularly evident in Southern Italy, the islands, and Liguria, confirming that depopulation and land abandonment are two facets of the same reality. In many of these territories, agricultural marginality and social marginality coexist, giving rise to a crisis that is difficult to reverse, precisely due to the complexity of its causes and their mutual interactions. As noted by Terres *et al.* (2015), "the reasons for farmland abandonment are multidimensional, and there is no clear-cut division among drivers as it rather depends on the result of their co-occurrence and interactions".

3. THE CAUSES

Numerous international studies have examined the causes of farmland abandonment and the progressive depopulation of inner areas, with particular attention on the European context. However, Italian economists have made a relatively limited contribution to these topics.

Terres *et al.* (2015) provided a key contribution at the European level. The authors emphasised that the causes of land abandonment are multidimensional and arise from the interaction of multiple factors, rather than isolated single variables. The authors also stressed the spatial and temporal specificity of the phenomenon: "The causes of farmland abandonment in Europe are manifold, depending on the area and the period under

Figure 1. The percentage change in utilised agricultural area (UAA) at the municipal level.

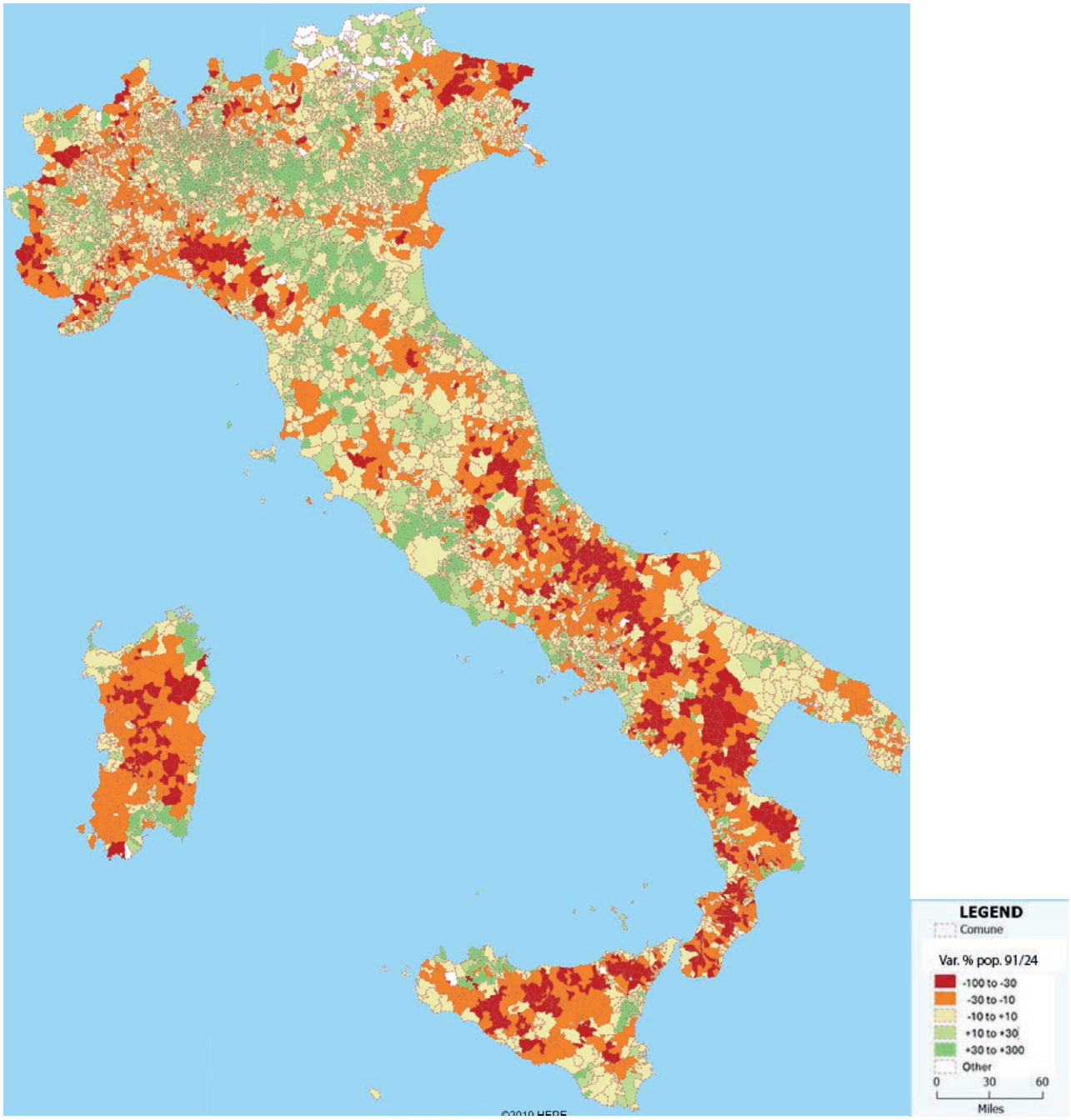


Source: Agricultural Census 1990-2020 (Italian National Institute of Statistics, 2021).

consideration. It is a complex process which can have a wide range of drivers, varying between Member States and sometimes within a single country".

Scholars have identified numerous potential drivers of abandonment, including natural constraints, environmental degradation, socio-economic conditions, demographic changes, and institutional frameworks (Food and Agricultural Organization of the United Nations [FAO], 2006; Lasanta *et al.*, 2017). In areas with poor soil quality or harsh climatic conditions, agriculture becomes

Figure 2. Percentage change in population at municipal level 1991-2024.



Source: Italian National Institute of Statistics (2021).

increasingly unsustainable from an economic standpoint, leading to higher rates of abandonment (Varela Pérez *et al*., 2022). Soil degradation, exacerbated by intensive farming practices and climate change, further undermines the sustainability of agriculture in many regions (Zambon *et al*., 2018; Lucas-Borja *et al*., 2019).

Socio-economic factors are equally important: rising production costs, declining agricultural prices, and the pressure of global competition have reduced farm profitability (Osawa, 2016; Ustaoglu, Collier, 2018; Kumm, Hessle, 2020; Zgłobicki *et al*., 2020), pushing many farmers to seek alternative livelihoods or migrate to urban

areas (Munroe *et al*., 2013; Qianru, Hualin, 2021; Chen *et al*., 2024). This trend is particularly pronounced in regions with ageing populations and where generational renewal in farming is limited (Sroka *et al*., 2019; Zhang *et al*., 2022; Robinson, 2024).

Italy faces particularly complex challenges in line with broader Mediterranean trends. Land abandonment is most severe in mountainous and hilly zones (Cocca *et al*., 2012; Malavasi *et al*., 2018; Zavalloni *et al*., 2021), historically dominated by small-scale subsistence farming. In these areas, competition with farms operating in more productive zones is unfavourable, and the quality of life is often perceived as inadequate, especially by younger generations (Riccioli *et al*., 2016).

Distinctive Italian features include land fragmentation, which hinders farm modernisation and productivity gains (Romano *et al*., 2016; Smiraglia *et al*., 2019; Praticò *et al*., 2022), as well as infrastructural shortcomings and poor accessibility in many territories (Coppola *et al*., 2018 Remondino, Zanin, 2022). Additionally, the declining birth rate exacerbates the challenges outlined above and warrants targeted analysis to understand its causes and implications.

Rizzo (2016) recalled Drudy's (1978) seminal study on the United Kingdon context, which explored the interaction between "push" factors (agricultural unemployment, lack of alternatives) and "pull" factors (job opportunities and better living conditions in industrial cities). Drudy drew on Myrdal's theory of *cumulative causation*, whereby agricultural decline triggers a vicious cycle of migration, withdrawal of public services, and rural population ageing, further reducing the attractiveness of inner areas. In his work on Sicily, Rizzo (2016) proposed a classification of rural areas into three categories: slow, transition, and declining territories. The former show slow but resilient growth thanks to development strategies focused on quality food markets and agritourism (Marsden, 1998). In contrast, declining territories have failed to integrate agriculture with complementary activities and suffer from severe depopulation. Transition territories exhibit mixed characteristics, with advanced rural economies hindered by demographic decline. The key differentiating factors include accessibility and proximity to urban centres, industrial zones, or tourist destinations. The model suggests that diversification, multifunctionality, and adequate connectivity are essential to retain population.

The Organisation for Economic Co-ordination and Development (OECD, 2006) has also emphasised the ongoing relevance of Drudy's theory in explaining contemporary rural depopulation. According to the OECD, the loss of human capital (particularly educated youth) and disinvestment, both public and private in rural areas trigger a regressive spiral that undermines agricultural development prospects.

From an environmental perspective, Antrop (2000, 2004) criticised the CAP for neglecting the specificities of Europe's diverse rural regions. More recently, scholars have called for the development of a rural landscape taxonomy and the use of appropriate analytical scales to better guide European policies (Van Eetvelde, Antrop, 2004).

Finally, several studies have highlighted the role of agricultural policies in producing "induced" abandonment. Between 1988 and 2008, the CAP promoted temporary (set-aside) or permanent (land retirement) withdrawal of farmland from production in an effort to limit surplus output (García-Ruiz, Lana-Renault, 2011; Lasanta *et al*., 2015). These schemes excluded up to 15% of agricultural land from use (Tscharntke *et al*., 2011). Additional policy-related drivers include difficulties in renewing agri-environmental contracts, the introduction of stricter sanitary standards, and the decoupling of direct payments from agricultural production, with significant consequences in Eastern Europe (Pointereau *et al*., 2008). According to Keenleyside, Tucker (2010), even with the uncertainty about the future evolution of some factors, many are expected to intensify due to their deep integration into global agricultural markets (Ustaoglu, Collier, 2018).

3.1. Profitability

To analyse the risk of farmland abandonment, the focus of a recent study (Fantechi *et al*., 2026) is on one of the main determinants of the phenomenon: labour productivity/profitability, measured as the value added per full-time worker. The analysis is based on Farm Accountancy Data Network (FADN) data for three of the main types of farming of Italian agriculture – arable crops, vineyards, and olive groves – considering both gross and net values (with and without subsidies), in nominal and real terms. The study examined farms with an economic size above €25,000 (the European size unit), in order to exclude hobby or part-time farms for which profitability is not necessarily a structural constraint. The findings revealed a worrying situation. A significant number of farms, spread across all macro-regions and all three analysed types of farming, showed a level of value added per worker below the risk threshold for abandonment, defined as 60% of Italian per capita gross domestic product (GDP; €33,000 in 2022), in line with the methodology proposed by Terres *et al.* (2015). For the three types of farming considered, more than one-third of farms are at risk of abandonment,

with olive-growing farms reaching a critical threshold of nearly 60%. Even large olive farms are not fully immune, although small and medium-sized farms are significantly more vulnerable. The severity of the issue increases from north to south, with risk levels exceeding 50% in Southern Italy, as already highlighted in the literature (Streifeneder, 2016; Bonelli *et al*., 2018; Salis *et al*., 2022). In terms of UAA, although the percentage is lower than the share of farms at risk, the data remain alarming: in some macro-areas, particularly in Central and Southern Italy for type of farming 37, the risk affects nearly half of the agricultural surface.

From a farm-size perspective, the analysis confirms a clear gap between large and medium farms. In many cases, medium-sized farms show productivity levels close to or below the abandonment risk threshold, while larger farms, especially in Northern Italy, demonstrate greater adaptability and resilience. Long-term trends are particularly critical: between 2010 and 2022, labour productivity in real terms declined almost across the board, both gross and net of subsidies. The real-term data paint an even more severe picture than nominal values, with negative trends even among larger farms.

These results reinforce and specify, at subnational level and for particular production orientations, what has emerged in other European studies (Lasanta *et al*., 2017; Ferreira *et al*., 2023), underlining the need to place farm profitability at the heart of rural development policies, particularly in marginal areas. They also highlight the urgency of targeted public intervention to rebalance development conditions and promote convergence toward sustainable productivity levels, with specific attention to the economic viability of professional farms.

As stated in the Strategic Dialogue on the Future of EU Agriculture: "Balanced demographic, social, and economic structures are part of the attractiveness of rural areas' appeal. The lack of opportunities in rural areas leads to ageing and rural exodus, which jeopardises the generational renewal of agriculture. These must be countered with rural proofing policy, understood as a coherent set of political measures to preserve and empower rural communities in their diversity and avoid territorial desertification" (European Commission, 2021). This excerpt clearly shows how professional farm profitability is a central issue in avoiding the vicious cycle of low incomes, youth outmigration, declining entrepreneurial capacity, and so on.

3.2. Quality of life

Alongside the well-known economic and productive causes, such as low agricultural profitability, weak competitiveness, and lack of infrastructure, there is a more subtle yet decisive factor: the insufficient quality of life perceived by those living in these areas. Several studies have shown that levels of well-being and rural depopulation are strongly correlated (Peel *et al*., 2016; Casini *et al*., 2019, 2021). A "good" quality of life is, in fact, a precondition for the economic and social vitality of a territory. Where living conditions are not perceived as decent or satisfactory, people tend to leave in search of better opportunities elsewhere. Despite the centrality of this issue, policy interventions aimed at improving quality of life in rural contexts have so far been limited, with rather modest results in many regions. One of the main reasons is the difficulty policymakers face in precisely identifying which dimensions of well-being are truly decisive in different territorial contexts. The concept of "well-being" is broad, multidimensional, and relative, meaning that it strongly depends on the specific socio-cultural, environmental, and economic conditions of each area.

The recent National Strategic Plan for Inner Areas (SNAI; Presidenza del Consiglio dei Ministri, 2025) offers some insights into the main components of well-being. The plan aims to "…provide a strategic framework for the support and development of peripheral and ultra-peripheral areas in decline or at demographic risk, where the active presence of communities is crucial to preserving the hydrogeological, landscape, and identity integrity of the territory". The definition of "inner areas" is primarily based on the classification of Italian municipalities according to access to three categories of public services. Specifically, the key criterion is the travel time required to reach "service centres", meaning municipalities that can simultaneously provide a comprehensive offer of upper secondary education; a hospital with at least a level I emergency department; and a railway station classified as Platinum, Gold, or Silver.

The importance of public services for quality of life in these areas has been widely demonstrated (Casini *et al*., 2021), but in this case the analysis has been rather narrow. Although there has been consideration of three critical service categories, it likely fails to capture all the dimensions that constitute everyday quality of life, and thus the real drivers behind the decision to stay in, or leave, a given territory. The risk here is a misdiagnosis of the problems affecting the selected areas, leading to an inefficient allocation of resources. While this classification serves as a starting point for the selection of intervention areas – through a complex process involving cooperation between regions and municipalities – it may already represent a limitation due to its oversimplified portrayal of well-being components.

To address the complexity of a concept such as quality of life, the most promising and still highly rel-

evant theoretical contribution is the *capability approach* developed by Amartya Sen (1983, 1992, 1993). Unlike traditional economic approaches, such as utilitarian or resource-based models, where well-being is measured in terms of individual utility or material possessions, Sen has proposed a radically different reading: well-being is defined by the real freedoms individuals have to do and to be what they have reason to value.

According to this view, quality of life is not determined solely by access to material resources, but rather by people's actual ability to access a range of essential opportunities, the so-called *capabilities*, that allow them to live meaningful lives. Meghnad Desai (1995) has proposed an applied approach to Sen's theory by defining a list of capabilities that allows for practical evaluation. The main ones include:

- Health and healthcare services;
- Access to education;
- Freedom to work and economic autonomy;
- Freedom of movement;
- Freedom of expression;
- Access to resources such as housing, land, credit, and technologies;
- Absence of discrimination and social recognition;
- A fair balance between work and leisure time.

Clearly, the relevance and assessment of each of these capabilities depends on the specific contexts in which Desai's approach is applied. Nevertheless, according to the author they will always retain importance in determining well-being. Precisely because of the specificity and relativity of the concept of well-being, participatory approaches involving local inhabitants appear to be the most appropriate way to address the issue of abandonment, as they allow for a real understanding of which capabilities are currently unmet in a given area.

Applied to the context of rural areas, the capability approach allows us to interpret abandonment not only as the result of unfavourable economic dynamics, but as the consequence of a systematic deprivation of opportunities and freedoms. In many rural regions, there has been a progressive deterioration in access to basic services (healthcare, education, and mobility), an erosion of the social and cultural fabric, and an increasing perception of isolation and marginalisation. This "capability deprivation" fosters a sense of social exclusion that further fuels abandonment processes. Casini *et al.* (2021) empirically explored these dynamics in Tuscany by adopting Sen's framework to develop a model of *community well-being*, based on subjective measurements referring not to individuals, but to collective perceptions. With this approach, the authors broke down well-being into several dimensions, including health, income, access to goods and services, cultural and recreational opportunities, and the quality of social relationships. They administered a survey to 228 residents of rural areas to evaluate these dimensions and analysed the results with structural equation modelling. Based on the results, the residents perceived that many aspects of collective well-being are unsatisfactory, particularly those related to civic participation, access to services, and perceived opportunities for younger generations. If left unaddressed, these factors risk entrenching the marginality of rural areas and reinforcing the vicious cycle of depopulation and decline. The capability-based approach has two strengths. First, it allows for an integrated and context-sensitive understanding of well-being, overcoming the divide between subjective and objective indicators. Second, it offers a solid theoretical basis for constructing participatory assessment tools, in which communities are not merely recipients of policy but active agents in defining development goals.

In conclusion, addressing rural abandonment requires a paradigm shift: from policies centred exclusively on productivity or economic incentives to strategies focused on well-being, understood as the capacity of individuals to live in environments that offer meaningful opportunities. Being a farmer today is very different from being a farmer in the past. This leads to several questions: how do younger generations perceive this profession today? What are the positive and negative well-being components associated with being a farmer? Profitability is essential, but what are the other components of well-being that are perceived as positive or negative aspects of being a farmer? These questions should be answered to create the conditions for the future development of our rural areas. The capability approach offers a valuable framework for designing interventions aimed at building "an agri-food sector that values food, fosters fair working and living conditions and vibrant and well-connected rural and coastal areas" (European Commission, 2025).

4. THE EFFECTS

Farmland abandonment is a structural phenomenon that affects numerous rural areas across Europe, and it is particularly intense in the Mediterranean and mountainous contexts. Its effects are, in large part, highly negative. In many regions, traditional agricultural practices have historically contributed to the creation of landscapes with high ecological and cultural value, maintaining semi-natural habitats and supporting biodiversity tied to open environments such as pastures and extensive crops. The

abandonment of these practices, along with the withdrawal from land management, results in the loss of biodiversity and ecosystem services as well as increased risks of soil erosion, forest fires, and hydrogeological instability, leading to serious consequences for territorial safety and the quality of life of local populations (Agnoletti *et al*., 2019; Marino *et al*., 2022, Salis *et al*., 2022).

From a socio-economic perspective, agricultural abandonment is closely intertwined with rural depopulation processes. The crisis of agricultural profitability, infrastructural isolation, and the gradual reduction of public services have driven younger generations towards urban centres, triggering a vicious cycle that deepens the marginalisation of entire regions. Population loss, in turn, weakens social networks, disrupts the intergenerational transmission of farming knowledge, and causes cultural and relational impoverishment, undermining both the sense of belonging and community cohesion (Reynaud, Miccoli, 2016, 2021, 2023; Benassi *et al*., 2023).

In this light, abandonment is not merely a land-use transformation; it also entails the loss of human, cultural, and social capital. Furthermore, the decline in cultivated land reduces the national agricultural system's ability to produce essential goods, with consequences for food security and sovereignty. These vulnerabilities were made particularly evident by recent international crises that disrupted global supply chains (FAO, 2017).

Despite these impacts, farmland abandonment is not inherently negative. In some cases, the natural recolonisation of abandoned agricultural areas may produce environmental benefits, such as carbon sequestration, increased forest cover, and the enhancement of ecological processes. However, these benefits are neither automatic nor guaranteed. They depend heavily on the territorial context, the subsequent management of abandoned land, and the capacity of public policies to guide these transitions.

In the absence of active stewardship, abandoned areas risk evolving into ecologically unstable states, characterised by degraded vegetation, high flammability, and low resilience (Chauchard *et al*., 2007; Marquez Torres *et al*., 2023). In addition, rewilding often entails the irreversible loss of complex cultural landscapes shaped by centuries of human-nature interaction, landscapes that communities often perceive as integral to their identity.

Given this complexity, it is clear that agricultural abandonment cannot be addressed through sectoral instruments or monodisciplinary approaches. Instead, a systemic and integrated framework is required, one that can assess trade-offs between agriculture, reforestation, and abandonment by considering the multiple ecosystem services involved and their impacts on human well-being (Van der Zanden *et al*., 2017). In this regard, Zavalloni *et al.* (2021) have offered a valuable modelling attempt, comparing alternative land-use scenarios based on both private agricultural profitability and collective well-being.

A significant contribution to understanding the implications of abandonment is provided by the theoretical framework of Nature's Contributions to People (NCP), developed by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES; Pascual *et al*., 2017). This approach broadens the conventional view of ecosystem services by including non-material dimensions such as landscape aesthetics, collective memory, identity, and perceived well-being. Recent studies have shown that in many rural communities, abandonment is associated with negative emotions, a sense of institutional neglect, and declining quality of life, factors often overlooked in conventional assessments (Van der Zanden *et al*., 2017; Quintas-Soriano *et al*., 2022).

In summary, farmland abandonment presents complex challenges but also strategic opportunities. Addressing it requires a fundamental rethinking of the relationship between agriculture, the environment, and society. This means adopting a territorial approach that values the multifunctionality of rural landscapes, promotes community well-being, and integrates economic, environmental, and cultural instruments within a long-term sustainability framework. Only by doing so can abandonment be transformed from a symptom of decline into an opportunity for a new rural agenda, one that combines ecological resilience, social justice, and territorial regeneration.

5. POLICY INSTRUMENTS

Public policy instruments aimed at tackling farmland abandonment fall within the broader domain of measures to counter rural depopulation, given the strong interconnections between the two phenomena, as previously discussed.

Karcagi-Kovats, Katona-Kovacs (2012) summarised how National Sustainable Development Strategies (NSDS) and National Rural Development Programmes (NRDP) of European Union (EU) Member States address rural depopulation processes. They provided a systematic overview of the main drivers of demographic decline identified in these strategies and programmes, along with the objectives set and the measures proposed. They found that "although most documents recognize the depopulation process and all view it as a negative trend, there is no commonly accepted set of goals or

principles regarding the desired extent of demographic change in rural areas. Objectives vary between 'reducing,' 'halting,' 'stabilizing,' and 'reversing' rural depopulation". According to Karcagi-Kovats, Katona-Kovacs (2012), rural policies require a stronger theoretical foundation to adequately address the wide-ranging, economic, environmental, and social impacts of depopulation. They also call for greater attention to this issue in future national sustainable development strategies.

At the national level, the SNAI represents the most comprehensive framework addressing the challenges of depopulation and poor access to services in Europe. All four European Structural and Investment Funds are combined with national funds to support both local development strategies and innovation in service provision across 72 pilot areas. Approximately €1 billion is being invested through a place-based approach that integrates multiple sectors and levels of governance. Associations of mayors usually lead the process, while LEADER Local Action Groups may support project design or directly implement European Agricultural Fund for Rural Development (EAFRD) measures in the area.

The most recent SNAI (Presidenza del Consiglio dei Ministri, 2025, p. 44-46) for the 2021-2027 period identifies four main strategic goals: (1) reversing population decline; (2) reversing the drop in birth rates; (3) reducing the rate of decline (from sharp to moderate); and (4) managing irreversible depopulation trajectories. Based on these categories, "each municipality must be able to assess which of the four categories it falls into, based on demographic, social, and economic data, and be equipped with appropriate skills and tools to pursue the corresponding specific objectives. Local specificities must be seen as key drivers of endogenous development, capable of producing lasting effects and making these territories attractive for younger generations".

This model frames the municipality as the smallest unit of intervention, a practical approach in the Italian context, though not without limitations. The structural diversity of municipalities may lead to inefficiencies: either because the territories covered are too large, or because they are too small and lack the necessary administrative capacity. The plan's aspiration for "the ability of municipalities to build effective participatory strategies involving all stakeholders living and shaping the territory" (Presidenza del Consiglio dei Ministri, 2025) may not always be easy to achieve. Therefore, the development of adequate multi-level governance mechanisms appears to be essential.

Another critical issue is the absence of a clear theoretical framework guiding operational choices. Resource allocation and priority setting can only be effective if grounded in well-defined guidelines and an integrated vision of the abandonment phenomenon. If funds are distributed based solely on arithmetic criteria, as some aspects of the SNAI suggest, or on simplistic definitions of territorial well-being, the expected outcomes are unlikely to materialise. Similarly, if outcome indicators are not embedded within a comprehensive quality-of-life framework, then this approach may not be sufficient to demonstrate the real effectiveness of implemented actions, opening the door to inefficient solutions. The adoption of a theoretical framework such as the one proposed by Sen and operationalised by Desai could provide significant support both for setting objectives and for evaluating results.

Regarding specific instruments to counter farmland abandonment, Renwick *et al.* (2013) analysed the effects of agricultural and trade reforms on abandonment risk using a modified version of the Common Agricultural Policy Regionalised Impact (CAPRI) model, integrated with the spatial framework Dyna-CLUE. This approach enables a more detailed geographical assessment of policy impacts. One of the study's key findings is the "spatial heterogeneity" of reform effects, highlighting the inadequacy of the CAP, particularly Pillar I, in addressing diverse environmental objectives across varied agricultural and natural contexts. The authors recommended "developing more targeted and territorially differentiated policies" that can selectively prevent undesirable abandonment while allowing beneficial rewilding in other areas. Consistent with FAO (2006) recommendations, the authors concluded that simply maintaining land in agricultural production is neither an effective nor an efficient strategy for managing abandonment. What is needed is a *territorial approach* based on in-depth local analysis and societal preferences regarding public goods. Only in this way can the multiple challenges of farmland abandonment be addressed in a way that enhances agricultural sustainability in Europe.

Today, CAP instruments aimed at supporting rural development are implemented mainly through regional development programmes, which attempt to counter farmland abandonment largely through income support and investment aid. Resource allocation and tool selection are typically based on administrative zoning that rarely exceeds four or five territorial categories at the regional level: (1) areas of intensive agriculture; (2) intermediate rural areas in transition; (3) intermediate rural areas in decline; and (4) rural areas facing development challenges.

Historically, Pillar 2 of the CAP has primarily provided farm support, either in the form of investment grants or income support for low-impact practices, with-

out any specific territorial vision. A territorial logic is found primarily in LEADER-related measures, which represent the most relevant component in terms of place-based development. In several regions, bottom-up planning has triggered significant development pathways. Still, LEADER areas are often large, include multiple municipalities, and suffer from substantial internal heterogeneity. Rarely are tools or strategies developed for more granular territories. This approach appears to conflict with the evidence from both research and the SNAI, which emphasise the need for highly localised, targeted interventions.

Recent documents from the European Commission seem to show greater awareness of the themes of abandonment and the attractiveness of inner areas, particularly for younger generations. The challenge now is to ensure that operational instruments are designed in line with these goals. It is important to recall that various studies have also identified certain CAP instruments themselves as among the causes of abandonment.

In any case, to effectively address the multidimensional effects of rural decline, it is necessary to activate *multi-level governance frameworks* involving coordinated action among European, national, regional, and local institutions, as well as civil society actors. Territorial policies, such as the SNAI, LEADER programmes, or ecosystem services payment schemes, represent examples of integrated approaches that, if properly implemented, can help counter farmland abandonment by enhancing local resources, promoting sustainable agriculture, and strengthening the social fabric of rural communities (Labianca, Navarro, 2019). However, to be effective, such strategies must be built through participatory processes rooted in community needs, tailored to local specificities, and supported by robust theoretical frameworks capable of guiding coherent and sustainable action.

6. CONCLUSIONS

The evidence presented in this paper leads to several final reflections. Farmland abandonment is a highly significant phenomenon in Italy and is strongly correlated with the depopulation of inner areas. It represents a multifaceted phenomenon that poses significant challenges but also opens up strategic opportunities for rethinking the future of rural areas. Addressing it effectively is not just about reclaiming cultivated hectares; it is about rethinking territorial policies in light of a broader concept of rural well-being, one that values the role of communities, local cultures, and intangible ecosystem services as central elements of sustainable rural regeneration. The agricultural policy instruments implemented thus far have not been able to contain this phenomenon across large parts of the country. Research has provided a comprehensive understanding of the drivers behind abandonment and a fairly detailed mapping of its effects. However, these aspects are not always considered in an integrated manner, and the interrelationships between them, and their overall impact on society, remain underexplored.

In this context, the evaluation of ecosystem services and, more broadly, the externalities generated by agricultural activity emerges as a central issue. Whether carried out through direct assessment or negotiated approaches among stakeholders, such evaluation is essential for informed decision-making aimed at enhancing social well-being. Italian agricultural economists have contributed meaningfully to this debate, but the application of these methodologies to real-world cases remains a challenge. It is crucial to bridge this gap to define the appropriate intervention goals.

The European Commission's new vision for CAP reform underlines the need to invest in making rural areas more attractive and in improving working conditions in agriculture. In some areas, it may already be too late, but it is still worth trying. The multiple causes of abandonment are well understood, but they must be contextualised within local realities, including the availability of life conditions that are today offered almost exclusively by urban environments. We must avoid creating binary or exclusive models: agriculture *versus* cities. That said, we cannot overlook the principal cause of abandonment: *insufficient profitability*. As previously discussed, many farming activities fail to generate incomes that are viable in either relative or absolute terms. The current distribution of support payments does not appear adequate to guarantee fair incomes in many situations.

Socially responsible solutions must be based on a comprehensive assessment of the role agriculture plays in different territories and on intervention models that preserve competitiveness while ensuring that agricultural work is satisfying both economically and socially. There are successful examples, especially in Northern Italy, but it is necessary to assess their applicability elsewhere. The path forward must involve ensuring decent income levels wherever agriculture is expected to persist.

As several studies have shown, profitability is a *necessary*, although not *sufficient*, condition to address agricultural abandonment and, even more so, depopulation. It is essential to adopt operational tools grounded in theoretical frameworks capable of explaining the specific elements that, in a given time and place, shape quality of life. Only through an integrated understanding of all

factors affecting life satisfaction can we develop effective measures to limit, if not reverse, abandonment.

Sen's capabilities approach can serve as a useful point of reference, although not necessarily the only one. The fundamental capabilities proposed by Desai (1995), among which work and income are key components, may provide an applicable framework to guide development policies in critical areas. These capabilities should be adapted to specific contexts and while they may vary in their basic elements depending on time and place, they must achieve satisfactory levels of well-being as "perceived" by the inhabitants to enable a future for the territories in question. The development of practical tools to assess these perceptions accurately across the various capabilities, as well as the trade-offs between them, remains an underexplored area that deserves greater attention.

The SNAI represents an important tool that provides a set of guidelines for addressing the crises affecting inner areas. However, it has several limitations, such as its reliance on administrative boundaries, issues related to resource allocation criteria (as evidenced by the distribution for the new inner areas), and, finally, shortcomings in the methods used to identify critical factors. It is essential to develop robust theoretical and methodological tools to guide the process of improving living conditions in these areas, but the scientific literature has offered very limited contributions in this area.

The studies cited in this paper also highlight additional themes that applied economists, especially those working on agriculture, food, and territory, can and perhaps must address. Territorial zoning, which has long been a topic of agrarian economic research, now appears to be indispensable for understanding the dynamics of abandonment and depopulation. The development of tools capable of assessing the varying role of farms in relation to the non-market components of well-being – such as monetary valuations of major externalities and benchmark indicators – represents another key issue for the design of effective support policies for the sector. This is particularly relevant for evaluating the contribution of farms to well-being in both environmental and social terms.

We are approaching a pivotal moment for the agricultural areas of Italy's marginal regions: the majority of the current generation of farmers is nearing retirement; the sector holds little appeal for younger generations; and demographic trends are exacerbating both processes. The risk of widespread depopulation and land abandonment is real.

At both the European and national levels, there is growing awareness of the critical interplay between depopulation and agricultural decline, and vice versa. If we want to ensure a future for the rural world in many of our regions, *the time to act is now*. To do so successfully, we must ensure that the resources likely to become available are used as effectively as possible, through multi-level governance, a shared and theoretically sound development vision, and in-depth analysis of each territorial context. There is substantial room for applied economists, and agricultural economists in particular, to contribute. The question is whether there is sufficient interest and willingness to take up the challenge.

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Research article

Understanding the role of environmental voluntary sustainability standards in the European beef value chain

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Abstract. Beef is a 'deforestation risk' commodity, and its production is environmentally challenging, given its exceptionally high carbon, water and land footprints. Europe is the world's third largest beef producer, following Brazil and the United States. Under European Union law, firms operating along the beef value chain are required to disclose their sustainability-related activities by the regulation on due diligence. The aim of this study was to understand the extent and the factors that shape the adoption of environmental sustainability strategies in the European beef value chain. We collected original data on a sample of companies from Orbis and carried out a content analysis of firm websites and sustainability reports. We created an environmental sustainability index based on a list of 23 environmental practices. We also considered the company characteristics related to the disclosure of particularly interesting practices, such as feed methane control and manure management, and to the adoption of sustainability certifications. We performed a negative binomial hurdle regression analysis on a sample of 263 beef firms. We found that the value chain position of economic actors, firm size and risk identification are some of the firm characteristics related to the adoption of sustainability practices and certifications.

Keywords: voluntary sustainability standards, certifications, beef value chain, hurdle model.
JEL codes: Q01, Q13, Q18.

HIGHLIGHTS:

- Half of our sample do not adopt any sustainability strategy. The most commonly adopted voluntary sustainability standards concern animal welfare, energy use, waste and genetically modified organisms.
- Producers and processors are the key actors that drive the adoption of environmental voluntary sustainability standards. These segments have the power to influence the entire beef value chain, which entails that there is the potential to scale up their efforts.
- Risk awareness and firm size are significant predictors for the adoption of environmental voluntary sustainability standards adoption.

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1. INTRODUCTION

Food systems are responsible for 34% of global greenhouse gas (GHG) emissions (Crippa *et al*., 2021), yet significant reductions are necessary across the entire sector. Livestock production largely contributes to total anthropogenic GHG emissions (Angerer *et al*., 2021; Cusack *et al*., 2021; Gerber *et al*., 2013; Putman *et al*., 2023), and has the highest environmental impact among food products (Clune *et al*., 2017; Gerber *et al*., 2015; Kokemohr *et al*., 2022), which makes it is a key sector in the transition to a more sustainable agrifood system. Based on the literature, the beef value chain (VC) specifically faces severe sustainability challenges (Caccialanza *et al*., 2023; Pashaei Kamali *et al*., 2014). Beef production has higher carbon, water and land footprints than any other livestock system and grain cultivation (Gerber *et al*., 2015). Enteric fermentation, which is linked to the digestive process of ruminant animals, produces methane and is the main cause of beef-related GHG emissions (FAOSTAT, 2025), accounting for 46.5%-62.4% of global warming potential consistently across different beef production systems (Kokemohr *et al*., 2022). In addition, land use change for feed makes up for 40% of beef-related GHG emissions (zu Ermgassen *et al*., 2020), and together with leather, cocoa and soy, beef is considered to be a forest-risk commodity, meaning that its production is deeply damaging the provision of forest ecosystem services (Camargo *et al*., 2019; Parra-Paitan *et al*., 2023). Specifically, beef production is a major driver of deforestation in Brazil, where it has been responsible for around 17% and 41% of all deforestation in the Cerrado and the Amazon, respectively (zu Ermgassen *et al*., 2020), and where it jeopardises the protection of indigenous rights (Nepstad *et al*., 2014).

In Europe, the beef sector holds a prominent position, with a very heterogeneous structure but great relevance in contributing to rural development and shaping gastronomic, social and cultural aspects of European countries (Bernués *et al*., 2011; Hocquette *et al*., 2018). In 2018, the European Union (EU) was the third largest producer of beef after the United States and Brazil, with over 88 million head of cattle (FAOSTAT, 2020). However, the past couple of decades have witnessed a reduction in profitability, with variability dependent on international trade agreements and the policy context (Hocquette, Chatellier, 2011).

Researchers have found that companies operating along the beef VC are adopting an increasing number of voluntary sustainability standards (VSS) to tackle such problems (Lambin, Thorlakson, 2018), and they have examined the variety of strategies adopted. According to Naziri and Bennett (2012), VSS developed by Western companies have become a key element in the governance of meat VCs. In this context, VSS are a requirement related to several sustainability metrics and are expected to be followed by the company itself as well as the other actors operating along its VC (Fernandes Martins *et al*., 2022). VSS can be categorised as collective, if adoption is open to several firms operating on the market, or individual, when its participation is limited to only one firm and its VC (Soregaroli *et al*., 2022). Collective VSS are either public or private and are issued by third party certifiers or by stakeholder associations. An example of collective standards is the Roundtables for Sustainable Beef, which comprise multi-stakeholder initiatives (Buckley *et al*., 2019), and include strategies to develop science-based indicators to measure the environmental footprint of beef production, to engage more stakeholders along the VC and to improve transparency (Maia de Souza *et al*., 2017). Examples of voluntary public standards include the EU organic certification and ISO 14001 from the International Organization for Standardization (ISO) (Gereffi, Lee, 2009). The EU organic label is regulated by the European Commission and is issued to farms that do not use agrochemicals in their production. ISO 14001 is an international standard that sets out a series of requirements regarding environmental management. On the other hand, individual VSS are developed within the companies operating along the beef VC and can either include single sustainability practices or more comprehensive VC programmes (Thorlakson, 2018). Cargill, for example, has demonstrated its commitment towards a 30% reduction in its GHG emissions in North America by 2030 through the BeefUp Sustainability private label. Moreover, retailers are able to influence the entire VC by setting standards thanks to private labels, as in the case of the Italian retailer Coop (Benatti *et al*., 2013). In addition to industry-led initiatives, legislation is also being implemented to improve the overall sustainability of the agrifood chains. EU Directive 2024/1760 on corporate sustainability due diligence aims to hold private companies accountable for environmental impacts that occur along their VCs.

Even with these efforts, producers still perceive the barriers to a sustainable transition in the beef sector to be very high, and an effective transformation of the sector has failed to emerge (Hübel, Schaltegger, 2022). However, Grzelak *et al.* (2022) showed that synergies exist, a finding that challenges the well-established idea that environmental and economical sustainability are conflicting concepts. In the beef sector, Castonguay *et al.* (2023) analysed the trade-offs between climate mitigation and poverty, and estimated that a change in pro-

duction areas and cattle diets would, together with land regeneration, reduce GHG emissions by 34%-85% annually, while keeping production costs constant. A shift in cattle diets and better manure management have been identified as the practices with the highest potential to improve the overall environmental sustainability of the sector (Lowe, Gereffi, 2009).

Consumer preferences surrounding beef purchasing habits are gradually aligning with the environmental sustainability goals set out by international institutions to reduce the negative impacts of climate change. According to previous studies, if the beef is clearly labelled as environmentally friendly, consumers are likely to change their purchasing behaviour in favour of those products (Stranieri *et al*., 2023). Animal welfare and traceability are also important drivers in the decision-making process for beef purchase (Burnier *et al*., 2021). Nevertheless, consumer perceptions can be a barrier for the development of the newest technologies, showing the importance of open and clear communication between companies and their clients (Bullock, van der Ven, 2020; Parmigiani *et al*., 2011; Spada *et al*., 2024). Such a result is validated by similar findings in the European context (Verbeke *et al*., 2010). Therefore, it is essential to consider consumer preferences to identify policy and managerial implications.

Researchers have explored the relationship between firm characteristics and company sustainability (Hahn, Kühnen, 2013; Khaled *et al*., 2021). In the context of beef production, Di Vita *et al.* (2024) found that different farm characteristics across European regions are related to different livestock farming management models, which are in turn related to different levels of sustainability across farms. Among the four management models considered, 'extensive and sustainable livestock farming' is linked to lower water consumption and higher biodiversity. Broom (2021) developed a comprehensive methodology to assess the sustainability of different beef production systems. It is based on nine sustainability components related to the environment, animal welfare and human welfare dimensions. Kokemohr *et al.* (2022) performed a life cycle sustainability assessment of three beef farms in Europe and linked the results to different firm characteristics, such as price, geographic location and vertical integration. To our knowledge, no study has yet linked a wider range of firm characteristics, including VC position and risk identification, to a measure of sustainability that encompasses a larger number of environmental sustainability aspects in the European context. Hence, we aimed to fill this gap by creating a model that considers a wider range of both environmental VSS (Bager, Lambin, 2020; Broom, 2021) and firm characteristics (Marschner *et al*., 2025; Thorlakson *et al*., 2018), by integrating three different theoretical approaches, namely VC theory, stakeholder theory and resource dependence theory. In addition, we considered the company's intentional and strategic communication of environmental VSS to the public to identify interesting managerial and policy implications. Specifically, we attempted to quantitatively assess how much the adoption of sustainability-related practices within the beef VC relates to different firm characteristics in Europe. The focus on Europe is particularly interesting considering the potential of EU legislation to address gaps in sustainability commitment in the sector. Even though beef-related emissions are largely due to diet changes and increasing beef and dairy consumption in rapidly developing countries (Li *et al*., 2023), 15% of methane emissions from enteric fermentation occur in Europe (FAOSTAT, 2025). We constructed an original dataset by matching secondary data on financial characteristics of firms with information on their sustainability strategies collected through a content analysis and then performed hurdle regression analysis.

This paper is organised as follows. The theoretical propositions are presented in section 2. The methodology with data description and the empirical strategy is included in section 3. Section 4 discusses results. Finally, section 5 presents concluding remarks.

2. THEORETICAL FRAMEWORK AND RESEARCH HYPOTHESES

The factors associated with the adoption of sustainability strategies in agrifood VCs have been studied based on different theoretical approaches. According to global value chain (GVC) theory, which was first developed by Gereffi (1994), decisions by firms are influenced by other participants in the VC, and lead firms are likely to stimulate a sustainable change among the broader VC (Ponte, 2020; Ponte *et al*., 2019; Sinkovics, Sinkovics, 2019). However, there has been limited research on the relations between VC positions and the adoption of environmental VSS (Groves *et al*., 2011; Hahn, Kühnen, 2013). Scholars have also employed stakeholder theory, which was initially presented by Freeman (1984), to explain the adoption of sustainability strategies as a response to pressure from stakeholders, including the general public (Darnall *et al*., 2010; Delmas, Toffel, 2004; Freeman, 2010; Khaled *et al*., 2021; Schaltegger *et al*., 2019). Consumer preferences have a great impact on the choices made by firms in terms of sustainability (Bullock, van der Ven, 2020; Parmigiani *et al*., 2011). Recently, scholars have used both

stakeholder theory and GVC theory to create a more comprehensive theoretical foundation (Bager, Lambin, 2020; Thorlakson *et al*., 2018). According to resource dependence theory, first described by Pfeffer and Salancik (1978), companies depend on the environment for the procurement of raw materials, and therefore are constrained by the availability of natural resources for their survival (Chiang, Chuang, 2024; Hillman *et al*., 2009; Jiang *et al*., 2023; Pfeffer, Salancik, 2003). Multiple theoretical perspectives can be integrated to better understand firm behaviour in terms of environmental commitment. For example, resource dependence theory has been integrated with stakeholder theory (Freeman *et al*., 2021; Lourenço, Branco, 2013; Wolf, 2014).

GVC theory is a tool to analyse VCs in terms of power relation and information asymmetries among their actors (Gereffi, Lee, 2012; Ponte *et al*., 2019; Vosooghidizaji *et al*., 2020). Agrifood VCs are often characterised by a high power asymmetry between agricultural producers and the downstream production segments (Abdulsamad *et al*., 2015; Kano, 2018; Pietrzak *et al*., 2020), and the beef sector is no exception (Loomis, Oliveira, 2024). According to Ogundeji and Maré (2020), who examined the price transmission mechanisms in the beef market, the retail prices of beef cuts are significantly higher than the producer price of a beef carcass.

The broad distinction introduced by GVC theory is between buyer- and producer-driven chains, depending on whether the retailer or manufacturing segment, respectively, have the highest market concentration (Lee *et al*., 2012; Ponte *et al*., 2019). This broad distinction is further integrated with more specific models of VC governance depending on the sector and context (Gibbon, 2001; zu Ermgassen *et al*., 2020). Lowe and Gereffi (2009) carried out an extensive study on the U.S. beef and dairy industry and described its structure in detail. They claimed that the market segments with the highest potential to enhance environmental and economic sustainability are those able to control and influence manure management and cattle diets, which are identified in the feed manufacturing companies, feedlots, slaughtering companies and retailers. The authors classified the U.S. beef VC as a bilateral oligopoly, because both the processing and retailing segments are highly concentrated. Zu Ermgassen *et al.* (2020) identified the Brazilian beef VC as buyer-driven when production is export oriented; otherwise, it is a traditional market. They also categorised the Mexican beef VC as a traditional market, meaning that both the manufacturing and retail segments are fragmented.

Based on the existing literature, the EU beef market is considered to be a bilateral oligopoly, with a high concentration in both the manufacturing and retail segments (Maes *et al*., 2019; Nielsen, Jeppesen, 2001). According to Nielsen and Jeppesen (2001), in the European beef market, a highly fragmented primary production segment is confronted with an increasingly concentrated slaughtering industry. Slaughterhouses are concentrated at the national level, whereas concentration of the slaughtering segment is lower at the European level. Simultaneously, large retail chains have gained enough buying power to influence the activities and decisions taken by upstream companies (Nielsen, Jeppesen, 2001). According to Azzam and Andersson (2008), the concentration of the slaughtering industry in Sweden defines the beef market as an oligopoly. Looking at the adoption rates of environmental VSS by VC segments is useful to assess whether there is potential to upscale the sustainability commitment to the entire sector. Based on these theoretical considerations, we hypothesise that the position of companies along the beef VC is related to their choice to adopt sustainability strategies:

H1. The position along the VC is related to the adoption of environmental VSS in the beef sector.

The positive correlation between firm size and the adoption of sustainability strategies has been widely documented in the literature (Artiach *et al*., 2010; Delmas *et al*., 2019; Drempetic *et al*., 2020; Khaled *et al*., 2021), after being initially reported by Ullmann (1985). The relation remains significant across different proxies, including revenue (Gallo, Christensen, 2011; Thorlakson *et al*., 2018), the number of employees (Wolf, 2014), total assets (Khaled *et al*., 2021) and market type, meaning that firms operating on wider markets are more likely to adopt VSS (Sotorrío, Sánchez, 2010; Thorlakson *et al*., 2018). Accordingly, firms with greater financial resources are more able to invest in sustainability activities and disclosure (Drempetic *et al*., 2020). At the same time, according to stakeholder theory, large companies are more exposed to the general public and therefore are more likely to face societal pressure to implement sustainability practices (Artiach *et al*., 2010). Large corporations are key actors in the sustainability transition (Delmas *et al*., 2019; Gray, 2008), and larger manufacturers tend to adopt sustainability standards to differentiate themselves from their competitors (Lee *et al*., 2012). Holley *et al.* (2020) explored the adoption patterns of pasture management and prescribed grazing practices among cattle farmers. Such practices are able to reduce GHG emissions, soil erosion and nutrient runoff, and therefore mitigate the environmental impacts of livestock production (Conant *et al*., 2017). Holley *et al.* (2020) showed that income is a major predictor for adoption of such practices.

In this study, we used turnover and market type as proxies to capture firm size. Based on stakeholder theory and the previous considerations, we propose the following hypothesis:

H2. The likelihood of adopting environmental VSS increases with firm size.

Stakeholder theory predicts that consumers and the general public play a key role in motivating companies to adopt sustainability initiatives. Consumers are effective in positively influencing the adoption of sustainability-oriented innovation (Goodman *et al.*, 2017), and firms respond proactively to consumers' expectations surrounding their environmental performance (Gong *et al.*, 2019; Murillo-Luna *et al.*, 2008). For example, consumers are powerful stakeholder in driving sustainable management of water resources in the hospitality sector (ElShafei, 2020).

Business orientation has been employed as a proxy to measure consumer pressure. Accordingly, business-to-consumer (B2C) firms have a direct relation with consumers and are therefore more exposed to their pressure (Johnson *et al.*, 2018), whereas business-to-business (B2B) companies are less visible to the general public (Wang, Juslin, 2013). B2C firms are more likely to disclose sustainability activities (Goettsche *et al.*, 2016), to adopt a higher number of VSS (Thorlakson *et al.*, 2018) and to adopt more comprehensive and well-designed environmental VSS (Khanna, Anton, 2002).

Firm ownership is a second proxy that is useful for capturing consumer pressure (Garde Sánchez *et al.*, 2017). Specifically, public companies are required to report their financial information and are therefore exposed to stricter scrutiny by the public (Fernandez-Feijoo *et al.*, 2014), which makes them more likely to disclose their non-financial information (Hahn, Kühnen, 2013) and to make stronger sustainability efforts than private firms (Chakrabarti, 2023; Gallo, Christensen, 2011; Kavadis, Thomsen, 2023).

A third proxy for consumer pressure is customer engagement. According to previous research, firms with high consumer engagement are more likely than others to communicate their environmental sustainability practices (Gong *et al.*, 2019; Haddock, 2005). Moreover, in the coffee VC, there is a positive relationship between the number of social media platforms for which a firm has an active presence and the adoption of VSS (Bager, Lambin, 2020). Based on this examination, we employ business orientation, firm ownership and customer engagement as proxies to capture the effect of consumer pressure, and we propose the following hypothesis:

H3. The likelihood of adopting environmental VSS increases with consumer pressure exerted on the beef firm.

According to resource dependence theory, firms that are aware of their dependence on the environment for their success are more likely to commit to environmental sustainability and report their efforts (Giannakis, Papadopoulos, 2016; Lourenço, Branco, 2013; Marschner *et al.*, 2025; Wolf, 2014). Risk-aware and risk-averse firms implement more VSS (Mayer, Gereffi, 2010) – for example, in the context of sustainable management of water resources (ElShafei, 2020). There has been similar findings from studies on the adoption of VSS across the food, textile and wood VCs (Thorlakson *et al.*, 2018) and in the production of coffee (Bager, Lambin, 2020). Gillespie *et al.* (2007) surveyed cattle farmers about the adoption of best management practices, including the ones associated with environmental benefits. They found that risk aversion is one of the predictors of whether practices are adopted. Based on these considerations, we propose the following hypothesis:

H4. There is a positive relation between risk identification by firms and the adoption of environmental VSS along the beef VC.

3. METHODOLOGY

Our target population is European firms operating along the beef VC. To extract a sample of research units, namely European beef firms, from our target population, we operationalised the target population by building as comprehensive of a list of European firms operating along the beef VC as possible (i.e. a sampling frame). We relied on the Orbis database, which contains financial information about over 400 million companies across all continents and economic sectors, covering both publicly listed and private companies (Kalemli-Özcan *et al.*, 2024). In Orbis, we filtered companies to create our sampling frame.

The first filter relates to the NACE Rev.2 codes linked to the production of beef: 0142 (raising of other cattle and buffaloes), 1011 (processing and preserving of meat), 1013 (production of meat and poultry meat products), 1091 (manufacture of prepared feeds for farm animals), 4623 (wholesale of live animals), 4632 (wholesale of meat and meat products) and 4722 (retail sale of meat and meat products in specialised stores). We chose the second filter to include only the businesses operating in the beef industry and excluding the others. Specifically, we selected those firms that reported the term 'beef' in their name or in the description of their activities. This

procedure allowed us to obtain a list of 265,532 companies, from which we further excluded companies that disclosed financial data for <5 years during the 2012-2021 period, with the aim of reducing the effect of yearly variability and providing a more objective representation of firm size. As a result of these procedures, we obtained a sampling frame consisting of 2,596 units. After building our sampling frame, which included almost all individuals in our target population, namely European beef firms, we applied a simple random strategy and to select a random sample of 1,050 companies. This choice was crucial to ensure that we obtained as representative a sample as possible. We later removed the firms with no website or no functional website (n = 550), the ones not significantly involved in the beef VC (n = 179), duplicates (n = 13) and business organisations only involved in retail operations (n = 4), obtaining a final sample of 263 units. Using power calculations, we calculated that a sample of 263 observations would allow for a 6% margin of error and a >95% confidence level (Daniel, Cross, 2018).

We downloaded from Orbis financial data about the sampled companies and complemented them by extracting information about additional firm characteristics and environmental VSS, summarised in Table 1. To obtain said information, we carried out a content analysis on the company websites and sustainability reports, therefore creating an original dataset. We collected the following company characteristics: turnover, computed as the mean turnover in the available years between 2012 and 2021; market type (local, regional or global), ownership status (public or private); consumer engagement (proxied by social media presence); and business orientation (B2B and B2C). Additional variables included VC positions (feed producers, producers, processers or butcher shops) and risk identification, which measured whether firms explicitly recognised environmental risks in their sustainability disclosures. Apart from turnover, all the explanatory variables are dichotomous.

To obtain a unique measure regarding the adoption of environmental VSS, we created a list of 23 environmental practices based on Broom (2021) and coded them as binary variables, before summing them up (Table 2). We also coded whether companies adopted environmental certifications and found the EU Organic and the ISO 14001 to be the relevant ones.

4. EMPIRICAL STRATEGY

To test our hypotheses, we employed the following equation (1):

$$\begin{aligned} \mathrm{y} = {} & \beta_0 + \boldsymbol{\gamma}_\mathrm{j}\mathrm{VC}_\mathrm{ij} + \beta_1 \ln \mathrm{Turnover}_\mathrm{i} \\ & + \boldsymbol{\theta}_\mathrm{j}\mathrm{M}_\mathrm{ij} + \beta_2 \mathrm{B2B}_\mathrm{i} + \beta_3 \mathrm{B2C}_\mathrm{i} + \beta_4 \mathrm{PL}_\mathrm{i} \\ & + \beta_5 \mathrm{CE}_\mathrm{i} + \beta_6 \mathrm{RI}_\mathrm{i} + \beta_7 \ln \mathrm{GDP}_\mathrm{i} \\ & + + \beta_8 \mathrm{SR}_\mathrm{i} + \beta_8 \mathrm{Organic}_\mathrm{i} + \beta_9 \mathrm{ISO}_\mathrm{i} + \varepsilon_\mathrm{i} \end{aligned} \tag{1}$$

Our dependent variable, y, is the adoption of environmental VSS by firms. The first explanatory variables are the stages of the beef chain in which the firm operates (VC_{ij}), which, in the context of the beef VC, are feed producer, producer, processer and butcher shop. The independent variables expressing firm size are the firm's turnover ($Turnover_i$) and the market type (M_{ij}). Market type is a set of three mutually exclusive dummy variables expressing whether the market reach of the company is local, regional or global. To avoid perfect multicollinearity, we omitted from the model the dummy with the lowest number of observations, which was regional. The proxies for consumer pressure are the business orientation of the firm ($B2B_i$ and $B2C_i$, which are not mutually exclusive), the public ownership of the firm (PL_i) and the degree of customer engagement (CE_i). Moreover, the firm's attitude towards risks associated with sustainability-related issues (RI_i) relates to risk dependence theory. We also inserted several control variables: the gross domestic product (GDP) per capita of the country where the company is located (GDP_i), which helped us capture regional differences across firms, whether the company released a sustainability report (SR_i), and the sustainability certifications adopted by the firm ($Organic_i$ and ISO_i).

To estimate equation (1) with the number of environmental VSS as the dependent variable, we performed a hurdle regression model (Cragg, 1971). This model allows one to divide the decision-making process into two steps (Boncinelli *et al.*, 2018). In the first step, we employed logit regression to model whether the firm decided to disclose its environmental sustainability activity. The second step, which is a count model with a truncated component, relates to the number of VSS disclosed by the company only if they are positive. With this approach, we first modelled the choice by companies to adopt at least one environmental VSS, and then the choice to adopt a certain number of said practices. Moreover, the hurdle model is suitable for dependent variables that are nonnegative count variables and take on the value zero in a relevant number of observations (Mullahy, 1986), as in the case of our dependent variable. We performed a regression on the full sample as well as regressions on two parts of the sample, divided along the median turnover (Meemken, 2021), to account for different effects on micro/small and medium/large companies and to discuss more appropriate policy implica-

Table 1. Summary statistics, including frequency analysis, for the dichotomous variables.

	Description	Mean	Standard deviation	Min	Max	Source
Dependent variable						
Adoption of voluntary sustainability standards (VSS)	Number of environmental VSS adopted by each firm	2.350	4.107	0	21	Firm websites
Cardinal explanatory variables						
Turnover (*Turnover*)	Firm turnover (thousands of EUR), computed as the mean turnover in the available years between 2012 and 2021 (at least five)	1.910e+08	7.610e+08	4.326e+03	8.010e+09	Orbis
Consumer engagement (*CE*)	Number of social media platforms on which the firm is active	1.323	1.638	0	6	Firm websites
Gross domestic product per capita (*GDP*)	GDP per capita of the country where firm is located (thousands of USD)	36.930	17.908	1.137	100.172	World Bank
Dichotomous explanatory variables						
Feed producers (VC_1)	Firm produces feed for cattle	32	*10.56%*	0	1	Firm websites
Producers (VC_2)	Firm raises cattle	44	*14.52%*	0	1	Firm websites
Processers (VC_3)	Firm slaughters the animals and processes the meat	224	*73.93%*	0	1	Firm websites
Butcher shops (VC_4)	Firm runs one or more shops	59	*19.47%*	0	1	Firm websites
Market type (*M*)	Local: firm operates in one country	202	*66.67%*	0	1	Firm websites
	Regional: firm operates in more than one country within the same continent	63	*20.79%*	0	1	Firm websites
	Global: Firm operates in at least two countries in two different continents	79	*26.07%*	0	1	Firm websites
Business orientation (*B2B*)	Firm is business facing	247	*81.52%*	0	1	Firm websites
Business orientation (*B2C*)	Firm is consumer facing	162	*53.47%*	0	1	Firm websites
Public listing (*PL*)	Company is publicly traded	10	*3.30%*	0	1	Orbis
Risk identification (*RI*)	Firm mentions risk as part of the sustainability activity	29	*9.57%*	0	1	Firm websites
Sustainability report (SR)	Company has issued at least one sustainability report	15	*4.95%*	0	1	Firm websites
EU organic	Firm adopts the EU organic certification	35	*11.55%*	0	1	Firm websites
ISO 14001	Firm adopts the ISO 14001 certification	27	*8.91%*	0	1	Firm websites

Source: Our content analysis, Orbis and World Bank.

tions. The two subsamples include 131 and 132 observations, respectively, allowing for a statistical power above 90% and a 95% confidence level, based on power calculations (Daniel, Cross, 2018). In all three regressions, we employed the Huber-White estimator to compute robust standard errors.

Concerns about reverse causality could arise regarding the turnover variable. To mitigate them, we used turnover data from the years 2012-2021, which is a previous period with respect to the data collection on sustainability disclosure by companies (i.e. 2022-2024). With this approach, we ensured that our data on sustainability disclosure did not influence our turnover data.

Table 2. List of environmental voluntary sustainability standards.

Environmental practices
Afforestation
Animal welfare programme or policy
Antibiotic use policy
Biodiversity conservation
Building or facility certifications
Energy use target or policy
Feed agricultural and sustainable practices
Feed methane control
Food waste reduction
Greenhouse gas emissions reduction
Genetically modified organism policy
Grazing conservation
Hormone use policy
Life cycle assessment
Manure management
Mobility target or programme
Recycling
Renewable energy
Soil protection
Waste reduction
Water pollution reduction
Water use reduction
Zero deforestation

Source: Our content analysis.

5. RESULTS AND DISCUSSION

Based on descriptive analysis, 55% of firms in the sample have not adopted any environmental VSS, 23% have adopted 1-3 practices, and the remaining portion have adopted ≥4 practices (Figure 1). The environmental practices that are most likely to be adopted by the firms are animal welfare programmes, energy efficiency targets and waste reduction policies (Figure 2). If we consider the issues that are most impactful in terms of GHG emissions, namely enteric fermentation and land-use change, the adoption of practices by the beef industry is not entirely in line with the most urgent problems identified by the scientific community (Figure 2). The negative impacts of enteric fermentation on the environment can be mitigated by managing cattle diets and manure. Although 26 firms have adopted a feed agricultural and sustainable practice, only 6 have declared a more targeted feed methane control, and 16 have adopted a sustainable manure management policy. Notwithstanding the fact that beef is a 'deforestation risk' commodity, only 6 of the companies in our sample have adopted zero deforestation commitments, and only one has declared an afforestation programme. More than 80% of the companies have not adopted any certification; thus, certification adoption is an uncommon strategy among beef firms. Among the 263 companies in our sample, 31 have adopted the organic standard and 26 have adopted the ISO 14001 certification; of these, 7 have adopted both. Figure 3 shows that firms with no sustainability certification perform worse in terms of environmental sustainability disclosure, with few exceptions. Companies adopting either the organic standard or ISO 14001 perform similarly, with a median of 4.5 and 6 VSS, respectively (Figure 3). Several firms that have adopted either of the standards have disclosed only a small number of environmental VSS or have not disclosed any, and are therefore at risk of greenwashing (Figure 3). Figure 3 displays that the seven companies

Figure 1. The number of companies that have adopted a specific number of environmental voluntary sustainability standards (VSS).

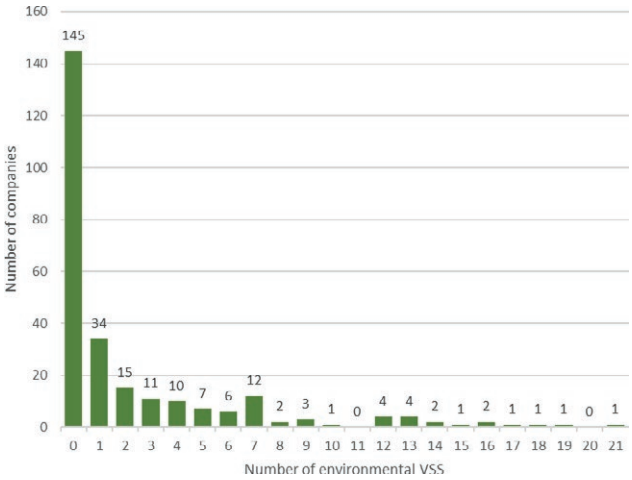


Figure 2. The number of companies that have adopted specific environmental voluntary sustainability standards (VSS).

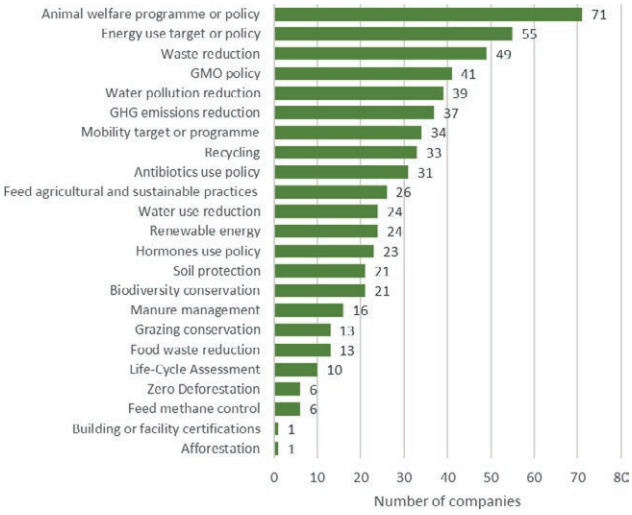
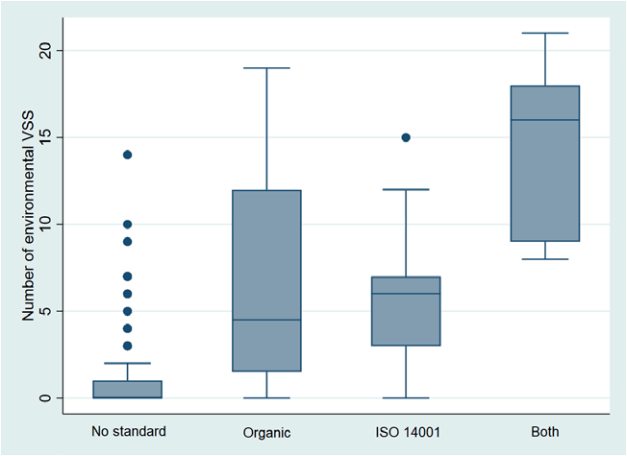


Figure 3. The number of environmental voluntary sustainability standards (VSS) based on the sustainability standard adoption status.



that have adopted both standards have adopted a higher number of environmental VSS (a minimum of eight) than the other firms in the sample.

Table 3 shows the results of the regression models. Model 1 includes the entire sample, model 2 includes the subsample corresponding to the lowest half of the sample in terms of turnover and model 3 includes the subsample with the highest turnover. In model 1, the binary hurdle equation shows that producer, processer, turnover and the organic and ISO 14001 standards are strongly and positively correlated with the adoption of VSS. Based on the count model equation, producer; risk identification; and the control variables GDP per capita, sustainability report and the organic and ISO 14001 standards are strongly and positively correlated with the adoption of VSS. Public listing is weakly and positively correlated with the adoption of VSS, whereas butcher shop and local market have a negative and significant coefficient. Model 2 presents a positive coefficient related to consumer engagement and the organic standard in the binary equation. In the count model, producer, processer, risk identification and the organic and ISO 14001 standards are all strongly positive and significant, whereas feed producer is slightly significant and positive. For model 3, processer, turnover and the ISO 14001 standard are also positively correlated with the adoption of VSS in the binary equation. Looking at the corresponding count model, producer, processer, B2B orientation, B2C orientation, public listing, GDP per capita, sustainability report and the ISO 14001 standard all have positive and significant coefficients, whereas butcher shop and the local and global market types show negative and significant coefficients.

According to our results, VC position seems to have a role in the decision to adopt VSS, which supports H1 and is consistent with the literature (Marschner *et al.*, 2025; Ponte *et al.*, 2019). Specifically, being a feed producer, producer or processer increases the likelihood of adopting VSS. These results suggest that feed producers, animal farmers and manufacturers drive the sustainability transition in the beef VC. Lowe and Gereffi (2009) considered three segments to have a high potential in enhancing environmental sustainability along the VC, because they control manure management and cattle diets. Therefore, according to our results there is an interesting potential for a green transition in the European beef sector.

We identified a positive relationship between firm size and the adoption of environmental VSS, supporting H2. This suggests that as a company's profitability increases, so does its likelihood of implementing individual sustainability standards (Artiach *et al.*, 2010; Drempetic *et al.*, 2020; Khaled *et al.*, 2021). Consistently, larger firms are more likely to disclose their sustainability activities than smaller firms (Bager, Lambin, 2020; Holley *et al.*, 2020). The results regarding market type show that both local companies operating in the national markets and global companies are likely to adopt fewer VSS than others, suggesting that regional firms are the most likely to adopt a higher number of VSS. This finding is in line with Di Vita *et al.* (2024), who found that medium-sized enterprises show great responsiveness to internal or external changes and are therefore more able to adopt sustainability practices than other actors. Our findings partially support H3. Business orientation, public listing and consumer engagement have a role in explaining the variability in VSS adoption, which demonstrates that stakeholder pressure has a consequence in terms of sustainability disclosures by companies (Chakrabarti, 2023; Gallo, Christensen, 2011; Goettsche *et al.*, 2016; Gong *et al.*, 2019; Kavadis, Thomsen, 2023; Murillo-Luna *et al.*, 2008).

According to our models, the firms that identify a sustainability-related risk tend to adopt a higher number of environmental VSS. This finding supports H4 and suggests that firms with a risk-aware attitude perceive the adoption of VSS as a strategic opportunity rather than just a compliance cost (Bager, Lambin, 2020; ElShafei, 2020; Thorlakson *et al.*, 2018). This result aligns with the findings by Swaim *et al.* (2016) and Williams and Schaefer (2013), who highlighted the importance of firms' attitudes, values and environmental concerns in driving their commitment to sustainability practices and certifications. Indeed, having well-developed risk awareness related to existing environmental

Table 3. Cragg hurdle regression coefficients with robust standard errors.

	Adoption of environmental voluntary sustainability standards					
	Model 1		Model 2		Model 3	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Parameters of the binary hurdle equation						
Constant	-7.193***	(1.969)	-2.403	(2.909)	-10.888***	(3.976)
Value chain position						
Feed producer	0.451	(0.419)	-0.151	(0.730)	0.662	(0.587)
Producer	0.653***	(0.317)	0.655	(0.540)	0.608	(0.421)
Processer	0.725**	(0.290)	0.739	(0.465)	0.911*	(0.421)
Butcher shop	-0.156	(0.301)	-0.570	(0.459)	-0.181	(0.461)
Turnover	0.214***	(0.075)	-0.069	(0.111)	0.450**	(0.190)
Market type						
Local	-0.008	(0.261)	-0.030	(0.421)	0.139	(0.355)
Global	0.091	(0.315)	0.167	(0.534)	-0.070	(0.425)
Business orientation						
B2B	0.074	(0.313)	-0.041	(0.481)	0.199	(0.454)
B2C	-0.258	(0.239)	-0.291	(0.347)	-0.245	(0.353)
Public listing	-4.630	(181.954)	0.000	(omitted)	-4.963	(149.647)
Consumer engagement	0.381	(0.236)	0.761**	(0.364)	0.224	(0.365)
Risk identification	8.694	(265.708)	6.394	(293.123)	7.966	(232.428)
Gross domestic product per capita	0.233	(0.171)	0.201	(0.256)	0.171	(0.251)
Sustainability report	8.857	(399.937)	0.000	(omitted)	8.291	(275.644)
Organic standard	1.703***	(0.448)	1.558***	(0.573)	5.646	(228.252)
ISO14001 standard	1.841***	(0.520)	6.662	(330.545)	1.151*	(0.625)
Parameters of the count model equation						
Constant	-33.541	(10.327)	-31.199	(22.807)	-38.662	(12.464)
Value chain position						
Feed producer	0.636	(1.562)	8.737*	(5.053)	1.618	(1.924)
Producer	5.533***	(1.226)	7.058***	(1.583)	2.762*	(1.517)
Processer	2.258	(1.505)	3.732***	(1.451)	5.050**	(2.384)
Butcher shop	-6.482***	(1.875)	-2.904	(1.917)	-6.110***	(2.110)
Turnover	-0.104	(0.266)	0.787	(0.898)	0.349	(0.384)
Market type *Local*	-2.509**	(1.201)	0.250	(1.886)	-3.708***	(1.377)
Global	-1.971	(1.301)	-0.489	(1.830)	-2.513*	(1.487)
Business orientation						
B2B	2.448	(1.541)	3.089	(2.118)	2.924*	(1.762)
B2C	0.454	(1.019)	-0.535	(1.359)	2.601***	(1.265)
Public listing	3.790*	(2.108)	2.804	(omitted)	4.143*	(2.165)
Consumer engagement	1.025	(1.038)	1.913	(1.282)	0.385	(1.288)
Risk identification	2.640**	(1.096)	6.161***	(1.440)	0.018	(1.326)
GDP per capita	3.139***	(0.959)	1.005	(1.611)	2.671**	(1.081)
Sustainability report	4.761***	(1.542)	3.857	(omitted)	4.659***	(1.541)
Organic standard	3.620***	(0.979)	6.351***	(1.592)	1.541	(1.1787)
ISO 14001 standard	4.780***	(1.104)	8.579***	(2.251)	5.234***	(1.272)
Observations	263		131		132	
Log likelihood	-367.054		-113.458		-227.209	

Note: Model 1 includes the entire sample. Model 2 includes the subsample corresponding to the lowest half of the sample in terms of turnover. Model 3 includes the subsample with the higher turnover. Robust standard errors are presented in parentheses. 'Regional' is the reference level for market type and was omitted from the models. *p < 0.1; **p < 0.05; ***p < 0.01.

uncertainty can help firms be more sensitive towards the management of uncertainties that could possibly hinder business activities. For example, the adoption of VSS could allow businesses to anticipate future regulations rather than having to comply with mandatory policies when they are implemented. This is especially important for firms that may encounter difficulties in adapting to new regulatory frameworks and market rules due to their limited financial availability. In these cases, the adoption of standards can help such firms to progressively adapt to changing regulatory conditions and to be updated about new market trends.

Beef firms tend to adopt a higher number of VSS when they are in countries with a high GDP per capita and when they issue a sustainability report. It is interesting to note the results about the certifications implemented by firms, suggesting a sort of path dependency in the firms' attitude towards the adoption of sustainable practices. Specifically, the higher the structural dimension of the firms, the higher the probability to adopt different types of sustainability practices (Drempetic *et al*., 2020). There are several reasons for this phenomenon. First, large firms have the financial possibility to invest in sustainable programmes for their business. Second, larger firm is affected by a higher risk of reputation loss compared with smaller firms. Consequently, the need to implement sustainability-certified activities becomes strategic. Third, the implementation of sustainability practices often creates interdependencies between certification and practice adoption. Once a firm has invested in one sustainability certification, it incurs fixed costs related to compliance, reporting and monitoring. These investments can lower the marginal cost of adopting additional VSS. Fourth, in buyer-driven supply chains, large corporations and retailers often require multiple certifications from suppliers. Consequently, the larger the firms are, the higher the number of sustainability-related requests by large retailers.

6. CONCLUSIONS

We explored the mechanisms driving beef companies to adopt different sustainability strategies, emphasising the role of firm characteristics and VC positions. We found that a large proportion of beef firms have not adopted any sustainability strategies. The most commonly adopted VSS concern animal welfare, energy use, waste and genetically modified organisms (GMOs), which are notable topics in the public discourse. These policies do not align entirely with the priorities identified by the scientific community in terms of GHG emissions (Caccialanza *et al*., 2023; Putman *et al*., 2023). Manure management, cattle diet practices and feed methane control are more urgent and relevant to mitigate beef production's negative impact on the environment (Kokemohr *et al*., 2022; Lowe, Gereffi, 2009), but those are not among the most commonly adopted in our sample of European companies. The regression analysis results demonstrate that GVC theory, stakeholder theory and resource dependence theory complement each other in explaining the pattern of the adoption of environmental VSS by European beef firms. Specifically, producers and processers tend to communicate their sustainability efforts more than other firms. Firm size and stakeholder pressure are also partially relevant in explaining the adoption of VSS. We found a positive correlation between risk identification and environmental disclosure, which implies that risk-aware firms adopt VSS strategically to improve the business.

These results can provide both policymakers and companies with information about how the beef sector addresses environmental issues, and inform their policy choices. Overall, our results should stimulate policymakers to implement stronger regulation to give beef firms incentives to act more sustainably. We identified producers and processors as key actors driving the adoption of environmental VSS. These two segments have the power to influence the entire beef VC and to control manure management and cattle diets, which are two of the most impactful practices in terms of reducing GHG emissions (Lowe, Gereffi, 2009). This entails the potential to scale up their efforts. Policymakers should focus on regulations and incentives on these segments to strengthen sustainability impacts across the VC. This could involve, for example, mandatory reporting requirements for large processors or targeted methane-reduction standards in feed and manure practices. According to Lowe and Gereffi (2009), feed producers also have the potential to drive the environmental sustainability transition along the beef VC because they can influence cattle diets, but our results show that this potential is only exploited in the small and medium-sized enterprises (SMEs). This result highlights the importance of putting feed manufacturers under the spotlight and targeting that VC segment with awareness campaigns and tailored policy, which could effectively lower the methane emissions from enteric fermentation.

We found that firm size is a significant predictor for environmental-sustainability-related strategies, and SMEs are less likely to commit to sustainability. A potential policy implication of this finding is the need for policymakers to focus on SMEs, and to provide them with a normative path to reduce the barriers they face by introducing,

for example, specific technical assistance programmes to implement practices and certifications, or easing the access to sustainability consultants. The results also show that firms with high awareness towards environmental risks tend to adopt more VSS. Policies could provide effective communication strategies to increase environmental risk literacy, to share industry best practices and to increase the availability of sector-specific tools, such as environmental risk assessment templates.

Our data collection revealed that there are not many beef-specific third-party sustainability certifications. However, there are inconsistencies in the literature regarding the actual effectiveness of sustainability activities by third-party certifiers in agri-food VCs (Meemken *et al*., 2021). Therefore, the lack of beef-specific ones creates a somewhat favourable opportunity for policymakers to focus their efforts on regulating beef firms directly, which could allow for a direct sustainability effort scale-up along the beef VC.

From a managerial perspective, our results provide a framework to help firms select suitable sustainability strategies and to understand their competitors' approaches. Larger firms and those operating in regional markets tend to adopt more VSS, both for reputational benefits and differentiation. Therefore, adopting and communicating sustainability strategies and environmental VSS offers an opportunity for beef producers and actors along the VC to strengthen their reputation of their brands and firms, and therefore to improve their market positioning and competitive advantage. In addition, the positive role of consumer engagement in the sustainability path of firms reveals that investments in transparent communication channels and traceability systems that align with consumer values can be effective solutions to leverage consumer engagement. Moreover, our analysis revealed a sustainability path dependency. Hence, firms should consider initial investments in sustainability as a useful step to lower the marginal cost of future compliance.

It is essential to acknowledge that our methodology presents some limitations and carries risks of selection bias, information loss and coverage gaps. First, our reliance on Orbis data implies potential data gaps, especially concerning small and micro firms. Nevertheless, we decided to rely on Orbis because it includes financial information of both private and public companies, differently from other databases (Kalemli-Özcan *et al*., 2024). The presence of the word 'beef' in the company name or activity description as one of our criteria to filter companies may have excluded from the sample actors operating in the beef VC that do not report the word 'beef' explicitly, such as vertically or horizontally integrated food firms, or multinational processors. Moreover, our study design required an online presence by firms to build our database, which may have led to an underrepresentation of small and micro firms that do not have the means to maintain a website. These limitations create a risk of overrepresenting larger and more formalised firms, and thus only partially replicating the actual European beef VC structure, in which the presence of SMEs is important. Additionally, the reliance on voluntary sustainability reporting raises concerns about greenwashing and data accuracy. In this regard, we decided to focus on sustainability disclosure rather than effectiveness and factual impact of the sustainability initiatives we considered. Another challenge is the potential endogeneity between firm turnover and environmental VSS adoption. Whether financial success enables sustainability efforts or vice versa remains unclear, but we mitigated this issue by employing turnover data referring to a previous point in time rather than the sustainability disclosure data. Similarly, measuring consumer engagement through social media activity may conflate sustainability communication with actual consumer interaction.

The scientific implications of this study include the effectiveness of integrating different research approaches. Future studies should consider the generalisability of our findings by investigating other agrifood VCs. An additional indication for future research is to develop a methodology to identify possibly misleading information on firm websites and sustainability reports, and to address potential greenwashing in firms' sustainability disclosures. This would enrich the literature by allowing for an even deeper comprehension of the adoption patterns of sustainability strategies along the agrifood VC.

AUTHOR CONTRIBUTIONS

Conceptualization: S.M., S.S.; Methodology: S.M., L.O., S.S.; Writing - Original draft preparation: S.M.; Writing - Reviewing and Editing: S.M., S.S.

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Research article

A spatial analysis of geographical indication: the case of the relevant geographical market centred on the production zone

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Abstract. This study proposes a methodology for defining the relevant geographical market (RGM) for a geographical indication (GI) centred on its production zone. The model is inspired by von Thünen's spatial model of land rent and assumes that various consumer-related variables decline as the distance from the production area increases. The model is applied to an Italian GI product, *Prosciutto Veneto Berico-Euganeo*, using data from a survey of 563 consumers located at varying distances from its production zone. Eight hypotheses are formulated and tested using the Cochran-Mantel-Haenszel test for categorical variables and linear regression for continuous variables. The results substantiate the model's validity, demonstrating a gradient for the tested variables (product familiarity, first consumption experience, purchasing frequency, relative consumption, willingness to pay, and price premium) in relation to the distance from the GI production zone. This study provides evidence of non-homogeneous spatial trends for these variables, suggesting that the shape of the RGM deviates from a circular pattern. The main contribution of this research is its novel approach to define the RGM for a GI with a market centred on the production zone. It provides valuable insights for producers and operators to develop effective marketing strategies tailored to different distances and directions from the production zone.

Keywords: geographical indication, distance, relevant geographical market, willingness to pay.
JEL codes: Q10, Q13, M31.

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HIGHLIGHTS

- A new methodology for defining the relevant geographical market of a geographical indication centred on production zone is presented.
- A type of geographical indication distinguished from other geographical indications is proposed.
- The background relies on von Thünen's spatial model of land rent.
- This study is the first comprehensive examination of how consumer-related variables correlate with the distance from a geographical indication origin.

1. INTRODUCTION

Geographical indications (GIs) are widely adopted in the European Union (EU) and are gradually proliferating in other countries. Italy leads the EU with the highest number (888) of agri-food products linked to specific origins and geographical areas (Qualivita, 2023). Production and turnover vary significantly among these GIs. While some, such as Grana Padano cheese or Prosecco sparkling wine, exhibit high values for these variables, a large proportion demonstrates relatively small values. Because these differences may largely depend on the geographical size and features of their markets, a spatial analysis of these markets presents an intriguing research opportunity.

This study deals with a specific type of GI whose relevant geographical market (RGM) is centred in the area of origin. According to the EU Commission (1997), an RGM 'comprises the area in which the undertakings concerned are involved in the supply and demand of products or services, in which the conditions of competition are sufficiently homogeneous and which can be distinguished from neighbouring areas because the conditions of competition are appreciably different in those areas'. Although this concept, originally defined for antitrust purposes, is not easily operationalised (Nevo-Ilan, 2007), it appears to be useful for understanding the territorial dimension of a market and providing GI producers with a sound basis for developing effective marketing strategies. More specifically, attention is focused on a group of GIs that only appear competitive when their supply meets demand within or near the production area. As the distance from this area increases, more powerful GIs gradually diminish and ultimately eliminate their competitiveness.

The literature on the economic and social value of GIs is extensive. Numerous researchers have elucidated the characteristics and benefits of GIs for producers and consumers. Livat (2019) emphasises the function of GIs as quality signals for food products linked to specific territories, capable of increasing consumer utility and serving as vehicles for the collective reputation of producer groups associated with specific regions. Josling (2006) underlines that GIs are also associated with natural and human factors such as climate, soil quality, or specific skills developed through tradition. Choi *et al.* (1995) posit that GIs can generate attachment and loyalty, similarly to other brands. Charters, Spielmann (2014) demonstrate that GIs should be managed as brands for products with a natural connection to a place, resulting in goods that cannot be produced elsewhere. Other authors have highlighted the importance of product origin in consumer evaluations as a guarantee of safety. In this regard, Stasi *et al.* (2008) show that GIs tend to decrease consumer price sensitivity and reduce the risk of substitution in the market of a GI product with another. Additional studies have focused on the crucial role of GI labelling in influencing purchasing decisions, demonstrating that the origin and safety of food products are considered the most relevant (Baker, Mazzocco, 2005; Banterle *et al.*, 2012; Bruwer, Johnson, 2010; Veale, Quester, 2009). Cardinale *et al.* (2016) argue that the production of a good in a geographical area creates a competitive advantage for that product, as the origin area is inimitable by competitors. Several studies indicate that consumers show a willingness to pay a price premium for products with GIs compared with those without this designation (Cappelli *et al.*, 2014; Menapace *et al.*, 2011). This is a consequence of a monopolistic market effect that can relate to some GIs, primarily due to quality regulations and production scarcity (Thiedig, Sylvander, 2000).

However, few studies have focused on distance from a product's origin as a factor influencing market features. Some of these studies do not refer to GIs but simply to products being purchased locally. Scarpa *et al.* (2005) argue that the value of a GI depends on both the product and the market segment, suggesting an exploration of the effect of geographic size on consumer attitudes towards a GI. GIs facilitate information transmission, replacing traditional quality assurance methods, which weaken as the distance between producers and consumers increases (Bardají *et al.*, 2009). An examination of Spanish consumers' preferences for beef revealed a higher utility and preference for locally produced beef compared with products from other regions (Mesias *et al.*, 2005). According to Hempel, Hamm (2016), German consumers show a notable preference for local conventional products over organic options from different regions or countries.

Other research has focused on the correlation between willingness to pay and distance, showing a higher willingness to pay for local or GI products. Resano-Ezcaray *et al.* (2010) discuss the geographic location of consumers in terms of variations in willingness to pay for GI products. An investigation of food origins in the United States illustrates that local strawberries command a significantly higher willingness to pay than those from other sources (Darby *et al.*, 2008). In Arizona, consumers demonstrate a willingness to pay a premium for locally branded spinach compared with non-branded options (Nganje *et al.*, 2011). Similarly, Carpio, Isengildina-Massa (2009) find that South Carolina consumers are willing to pay a price premium for both

plant and animal products from local farms. Moulard *et al.* (2015) demonstrate that origin impacts consumers' perceptions of wine authenticity and their willingness to pay, especially for Old World wines. Giraud (2016) emphasises that quality regulations and production scarcity significantly contribute to a monopolistic market effect for a GI cheese, whereby local consumers and connoisseurs are willing to pay a price premium due to their familiarity or expertise. However, that beyond the production area, the monopolistic effect diminishes due to lower knowledge and familiarity.

Conversely, some studies suggest that distance from the production area can positively influence willingness to pay. For example, Garavaglia, Marcoz (2014) note that consumers' price expectations for Fontina Valdostana cheese differs based on their residence, with residents of Valle d'Aosta displaying a lower willingness to pay compared with consumers in Milan. Garavaglia, Mariani (2017) report that willingness to pay for Prosciutto di Parma is lower in Parma than in Monza, which is approximately 100 km away from the production site. Similarly, Rabadán *et al.* (2021) report a higher willingness to pay outside the area of influence of a GI for cherry consumers.

The aforementioned studies indicate divergent trends for willingness to pay in relation to distance from the production site. This suggests a dichotomy between two types of GIs: those whose competitiveness is only effective within their production area, and those that establish a strong presence in distant markets without showing increased competitiveness in their local production area. Our primary objective is to highlight and examine the former type. Garavaglia, Mariani (2017) conclude their article by stating that 'it would be interesting to develop a relationship between consumers' willingness to pay for a Protected Designation of Origin (PDO) label of a certified product and their distance from the place of production'. We adopt this suggestion and extends it beyond merely demonstrating significant territorial differences in willingness to pay based on consumers' place of residence. We go beyond simply comparing consumer behaviour in the production zone with that in distant locations; instead, we treat distance as the key variable.

In pursuing our research objective, we draw upon von Thünen's (1966) spatial model of land rent, applying the fundamental concept of a progressive decline in key variables, particularly consumption levels and willingness to pay, as distance from the production site increases. Our two specific aims are to propose a methodology for verifying the RGM for a GI centred on its production zone based on consumer characteristics and to provide producers and market operators with an informational framework to enhance their marketing strategies starting from the production zone.

We apply our model an Italian PDO product, Prosciutto Veneto Berico-Euganeo (PVBE), a type of raw ham. We selected this GI from a group of PDOs that primarily enjoy local recognition. Based on a sample of 563 interviews, we formulated eight hypotheses to validate our model. This endeavour involves the development of an innovative methodology that combines linear trend tests and regression analyses, with the choice between them depending on the nature of the variable that is being examined.

This study is pioneering in its explicit focus on the role of distance in determining willingness to pay as well as other significant market indicators. It proposes a conceptual framework applicable to other GIs whose relevant market is centred on their production zone, thus defining a typology or a sub-group within the GI range. To our knowledge, no previous research has explicitly investigated this GI typology or examined how various consumer-related variables correlate with the distance from the origin of an agri-food product. Our results substantiate the model's validity, demonstrating a gradient for the tested variables in relation to the distance from the PVBE production zone. Despite certain limitations, our work appears to open new avenues for investigating the RGM of a GI similar to our case study, while simultaneously providing operators with valuable information for business improvement.

The remainder of this paper is organised as follows: Section 2 provides a brief overview of PVBE. Then, we detail the reference model and hypotheses in Section 3, describe the methodology and data in Section 4, and present the results and discuss them in Section 5. Finally, in Section 6 we describe the research limitations, highlight the key findings, and provide practical implications for operators and suggestions for further areas of investigation.

2. THE GI UNDER STUDY: PROSCIUTTO VENETO BERICO-EUGANEO

In Italy, the mean annual production of raw ham from 2018 to 2022 was approximately 282,000 tonnes, constituting 25% of the country's total cured meat production (ISMEA Mercati, 2023). Currently, 10 raw hams with PDO labels are available on the national market. Among these, Prosciutto di Parma and Prosciutto di San Daniele are the most significant in terms of revenue and national distribution. Among raw ham with a GI, Prosciutto di Parma shows the highest production, approxi-

mately 8 million hams annually, while Prosciutto di San Daniele follows with around 2 million hams (Assica, 2021). These two products represent the primary competitors for PVBE from the perspective of product substitutability in an RGM (EU Commission, 1997), assuming no other GI ham is produced in the neighbouring area. Although small quantities of PVBE are marketed in various regions of Italy and abroad, the majority of its sales remain closely linked to its production area, which consequently represents the focal point of its RGM.

PVBE has a designated processing and ageing area spanning 356 km², encompassing 16 municipalities situated near the border between the provinces of Padua, Vicenza, and Verona in the foothills of the Berici and Euganean Hills. This area is approximately equidistant from the production zones of Prosciutto di San Daniele and Prosciutto di Parma, located about 20 km from the Venetian Prealps, 40 km from Lake Garda, and 50 km from the Adriatic Sea. The topography of the two hilly regions influences the sub-Mediterranean climate, particularly the wind pattern dynamics. Fresh thighs are sourced from specific Italian regions known for robust pig farming, including Veneto, Lombardy, Emilia-Romagna, Umbria, and Lazio. This sourcing area is nearly identical to that of Prosciutto di Parma.

PVBE is a small-scale PDO that has been recognised since 1981. From 2017 to 2022, the mean annual certified production totalled 844 tonnes (about 100,000 hams), with a net company value of approximately 9 million euros. Exports comprise only 1% of total production and are limited to a few European countries. While the presence of PVBE is sporadic across the national territory, consumption remains predominantly concentrated in the Veneto region, particularly in areas adjacent to the production zone. The primary distribution channel in the national market is large-scale retail, accounting for 70% of production in 2022. The remainder is distributed through specialised retail (12%), wholesalers (8%), on-trade (8%), and direct sales (2%). The Protection Consortium includes ten producers, four of whom are located in the municipality of Montagnana, establishing it as the hub of the designation.

3. REFERENCE MODEL AND HYPOTHESES

The EU Commission (1997) suggests that the analysis of demand characteristics is a valuable tool to ascertain and delineate an RGM thereby distinguishing the RGM area 'from neighbouring areas because the conditions of competition are appreciably different in those areas' based on the values of specific market indicators. Consequently, to define a GI's RGM centred in the production zone, it is necessary to delineate a territorial area where key market demand variables are significant. In 1875, von Thünen proposed a framework derived from economic geography (based on the dynamics of land rent) that can be useful for this purpose. This model identifies distance from a settlement as the primary factor in determining land rent value (von Thünen, 1966). While this model has primarily been utilised to understand GIs from the supply side (Aveni, 2020), in this study we apply it from the demand perspective.

Wiegant, Parey Sinclair (1967) provide a useful discussion on the variants and limitations of this model. Our focus is on the central concept of von Thünen's model, and we relate it to market demand characteristics. The fundamental premise is that as the distance from the production zone increases, there is a gradual reduction in consumer contact with the production site, which in turn results in lower involvement and motivation to purchase the GI product.

Both involvement and motivation towards GIs in the zone of origin or in proximity can be attributed to several factors, including the product's organoleptic quality, freshness, health benefits, tradition, consumer ethnocentrism (Fernández-Ferrín *et al*., 2019); support for the local economy and personal interaction with producers (Hand, Martinez, 2010); and environmental sustainability (Dwi, Nyoman, 2020). These factors can also be related to other local non-GI products, although the GI label can provide additional assurance regarding these attributes. The key proposition of our model is that most variables representing these factors and defining consumer behaviour decrease with distance from the production zone, a trend that is similar to that which land rent exhibits with increasing distance from a settlement, although the rationale of von Thünen's model is fundamentally different. Rejection of this proposition would indicate that the RGM is not centred in the production zone and can be defined differently.

The proposed model assumes that the total utility (the benefit derived from per capita total consumption) as well as the differential utility (the benefit derived from consuming the GI product relative to substitutes) peaks near the production area and progressively declines with increasing distance, approaching zero consumption at some point. Considering various directions, the market for the GI can be spatially represented through 'iso-utility' or 'differential iso-utility' curves, with the outermost curve potentially outlining the boundary of the catchment area.

As with other goods, a GI product's brand value relates to quality perception and aspects such as aware-

ness, image, and loyalty (Calderon *et al*., 1997). If the RGM is centred in the production zone, one can expect that at least some of these aspects will decline as the distance from the production area increases. Thus, analogously to what can be defined for land rent in von Thünen's model, we can conceptualise 'iso-value' curves for specific marketing variables. These curves may deviate from a circular shape based on the geomorphological and anthropogenic features of the territory (e.g., mountains, lakes, and roads) as well as the presence of competing GIs for similar products, situated in different directions and at varying distances from the area of origin. The area defined by the outermost curve can be assimilated to the notion of 'chorotype' applied in biology, where it is defined as a type of geographic distribution that characterises a group of species with similar features (Fattorini, 2015), paralleling the concept of competition among similar products in the RGM. The forms displayed by the iso-value curves can provide information on the topology of the relevant market in the space focused on the production zone, which can aid in calibrating *ad hoc* marketing actions for specific target areas.

Excluding willingness to pay, the literature on GIs and distance does not suggest market variables for the purpose of our model. Therefore, we selected a set of variables related to consumer behaviour, which can be useful for defining the RGM and/or developing appropriate marketing strategies. For these variables, with reference to PVBE, we formulated the following partially interconnected hypotheses.

H1: Knowledge (i.e., familiarity with PVBE) decreases with distance from the area of origin.

Brand familiarity and knowledge play a crucial role in influencing consumer behaviour (perception and attitude) and purchase decisions, impacting perceived value (Aaker, 2010). This aspect is fundamental to the potential market, driving repeated purchases and enabling effective communication (Ateke, Nwulu, 2017). Support for H1 is necessary to define the RGM for a GI primarily sold in proximity to the production zone. Knowledge and information are expected to decrease as distance increases (Bardají *et al*., 2009), reducing product search probability and decreasing purchase likelihood.

H2: The incidence of having tasted PVBE at least once decreases with distance from the area of origin.

Initial consumption experience significantly influences subsequent consumer behaviour towards the product based on both cognitive processes and affective reactions (Chaney *et al*., 2018). This hypothesis is strongly related to H1, as the first consumption experience of a food product typically depends on knowledge. Additionally, this variable is affected by the diminishing number of retail outlets offering the product as distance from the origin increases.

H3: Frequent purchasing of PVBE decreases with distance from the area of origin.

Frequent purchasing of a branded product is a key indicator of market penetration and consumer loyalty (Jindal, 2022). This trend is supported by a decline in purchase opportunities, general product familiarity, and consumer engagement with traditions and events surrounding the GI. Such engagement, including knowledge of recipes and pairings, enhances the product's gastronomic value and highlights its cultural heritage (Duncan *et al*., 2020). This can potentially lead to strong consumer-product identification, with the GI serving as a symbolic 'flag' of the territory and a source of pride for local residents.

H4: The share of consumers purchasing PVBE at different points of sale is affected by distance from the area of origin.

When examining local GI product purchases across various points of sale, a general decrease with distance cannot be assumed. As distance increases, reliance on certain points of sale may diminish while others become more relevant. This hypothesis comprises four sub-hypotheses based on the type of point of sale.

H4a: Purchases at company stores decrease with distance, reducing accessibility and increasing travel costs for consumers (Fox *et al*., 2004).

H4b: Purchases at small, specialised shops decrease with distance, as they offer limited assortment depth and stock only the most in-demand brands, reducing GI availability. These shops can attract consumers living close to the production zone who show a higher willingness to pay (Toporowsky, Lademan, 2004) and usually imply proximate interactions between producers and retailers (Enthoven, Van den Broeck, 2021).

H4c: Purchases at supermarkets remain constant even at considerable distances from the production zone. Several large-scale retailers have shown interest in regional and local food (Martinez *et al*., 2010). By displaying a broad selection of similar and substitute products, they can sustain GI purchases even in more distant areas, making supermarkets a preferred location.

H4d: Purchases at restaurants are expected to remain constant or even increase with distance, due to the decreasing availability of the GI product in oth-

er retail outlets, which limits purchase opportunities. These operators see opportunities in selling regional products as a way to differentiate themselves (Dannek *et al.*, 2020).

H5: PVBE consumption relative to total raw ham consumption decreases with distance from the area of origin.

This hypothesis is supported by the expected shrinkage of all GI market segments (potential, available, served, and penetrated) as distance from the production area increases. GI spatial availability and consumer preference compared with substitute products are important aspects in determining this trend. Distance from the production area likely negatively impacts both the product's presence in retail venues and the value consumers assign to it in comparison to substitutes. This hypothesis, along with H7, is important to define the boundaries of an RGM centred in a GI production zone. Relative consumption can be assumed as a proxy of GI market share, providing a useful indication of collective brand potential (EU Commission, 1997). Consequently, the geographical border of the RGM could be set where this variable falls below a pre-defined percentage.

H6: Willingness to pay for PVBE decreases with distance from the area of origin.

This hypothesis suggests that the perceived value of the collective brand diminishes as distance from the production area increases. The factors that contribute to willingness to pay (identity, image, reputation, and loyalty) are expected to decrease with distance (Mesias *et al.*, 2005). This hypothesis is critical for testing H7. As previously noted (Garavaglia, Marcoz, 2014; Garavaglia, Mariani, 2017), this hypothesis may not hold true for some GIs. Rejection of H6 would indicate that the RGM is likely not centred in the GI production zone.

H7: A willingness to pay a price premium for PVBE compared with Prosciutto di Parma decreases with distance from the area of origin.

Support for this hypothesis would reflect the dominance of the GI product over similar products from other origins, contributing to defining the RGM centred in the production zone from the perspective of possible market monopolization (Nevo-Ilan, 2007). However, the outcome may not be clear cut, as local consumers might prefer GI products but hesitate to pay a higher price for them compared with substitutes, seeking better value for their money due to their familiarity with the product.

H8: The effects of distance are not spatially homogeneous for all variables examined in H1-H7.

This hypothesis posits that the variables may exhibit different intensities in their trends depending on the direction from the GI production zone and reveals other phenomena that are not reducible to distance. It implies that the areas defined by iso-value curves for these variables are not circular.

4. METHODOLOGY AND DATA

To test the aforementioned hypotheses, we employed contingency analysis and the Cochran-Mantel-Haenszel test to identify linear trends for categorical variables (Rayner, Livingston, 2023), while utilising linear regression for continuous variables. The analysis was conducted at both a multidirectional level, encompassing the entire sample, and in relation to specified directions. To our knowledge, no other studies have proposed alternative techniques to estimate a gradient of dependent variables in relation to spatial distance while simultaneously accounting for both numerical and categorical variables.

For categorical variables, where only the frequencies of respondents were available, linear regression analysis was not feasible. Consequently, we tested the null hypotheses of independence and non-linearity against the alternative hypotheses of dependence (contingency analysis) and linearity (Cochran-Mantel-Haenszel test) concerning distance, both based on the χ^2 statistic. We categorised distance into 10-km intervals (bands) radiating from the centre of the PDO production area. To effectively illustrate the outcome of the linearity test, we calculated the percentage effect per kilometre by dividing the difference between the percentages of the first and last bands by the total number of kilometres separating them.

For continuous dependent variables, the analysis proceeded in two phases.

1. Simple regression analysis: This phase evaluated the value and significance of the coefficient associated with distance. We used dichotomous variables for directions to test H8.
2. Multiple regression analysis: This phase aimed to obtain a more precise estimate of the distance (Dist) coefficient by introducing additional independent variables, such as consumers' sociodemographic characteristics (SD_i) and merit evaluations (EV_i), which could potentially influence the dependent variables (D_{Hi}) as described by H5-H7.

The regression model can be formally defined by Equation 1 for each of the three dependent variables:

$$D_{Hi} = a + b(Dist) + \sum c_i(SD)_i + \sum d_i(EV)_i + e, \quad (1)$$

where a is the intercept; b, c_i, and d_i, are the coefficients; and e is the error term.

It is important to note that these multiple regressions should not be interpreted as exhaustive models for the dependent variables examined in H5-H7; rather, they aim to provide a refined estimate of the distance coefficient while controlling for the effects of other independent variables.

Calculating the distance from the production area is a critical component of this study. According to the GI's features, various methods may be adopted (e.g., from the perimeter of the zone or from the producers' barycentre). For our analysis, we calculated the distance from the centre of Montagnana, considering that most producers are located within Montagnana or its immediate vicinity and this town has historically engaged in extensive promotional efforts for PVBE, and is recognised primarily for this product. We opted not to pursue alternative distance calculations from the boundary of the production area or the municipality of Montagnana, as these could introduce measurement inaccuracies.

Data were collected through a questionnaire administered directly to consumers, following a multi-phase process:

1. The area surrounding Montagnana was divided into concentric bands, each spaced 10 km apart.
2. Four directional paths were chosen for questionnaire collection.
3. Within each band, a data collection point was identified along each direction, consisting of a supermarket.
4. At each data collection point, approximately 30 questionnaires were gathered to ensure equal sample sizes within each band.
5. Data collection in each direction concluded when fewer than 10% of the respondents in the band reported having consumed PVBE.

The selected directions employed to test H8 do not strictly follow the four cardinal points; instead, they align with significant pathways related to demographic distribution and the prevalence of competing products with a GI status. The south-east direction includes Rovigo, which has a notable influence from the cured meats from Emilia-Romagna. The eastward direction primarily leads towards the Euganean Hills and the Adriatic coast, as well as the Prosciutto di San Daniele production area. The north-west direction targets Verona and an area likely more influenced by Prosciutto di Parma. Finally, the northward direction points towards the Berici Hills and the city of Vicenza (Figure 1).

Figure 1. Geographical distribution of data collection points.

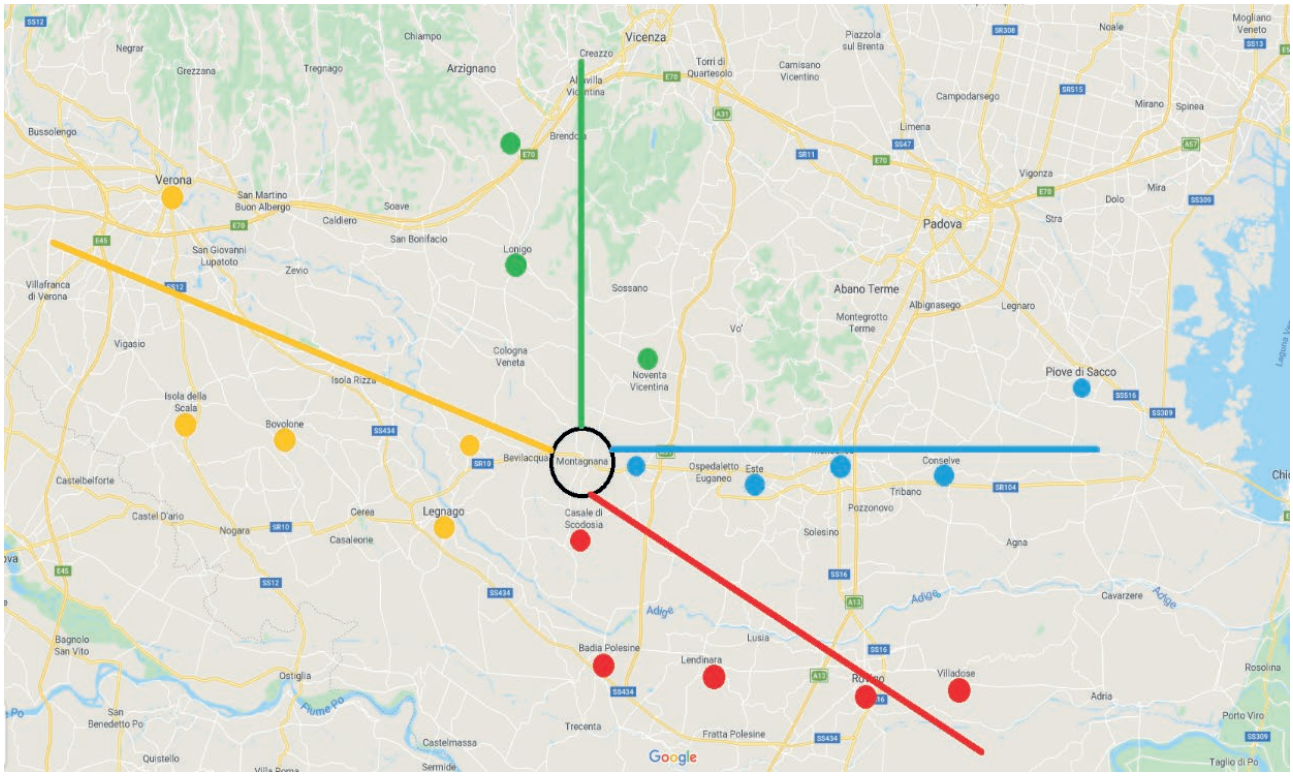

Table 1. Socio-demographic characteristics of the sample.

	Value
Age in years (mean)	52.5
Men	*29.0%*
Women	*71.0%*
Low to medium educational level	*39.9%*
Medium to high educational level	*61.1%*
Employed worker	*42.8%*
Self-employed worker	*17.9%*
Retired	*22.9%*
Housewife	*14.7%*
Other occupation	*1.7%*
Monthly household income ≤ 2000€	*68.4%*
Monthly household income > 2000€	*31.6%*

The administered questionnaire comprised two sections: the first focused on familiarity and consumption of PVBE, while the second collected common sociodemographic data, summarised in Table 1. The initial questions assessed the respondent's general acquaintance with raw hams, specifically PVBE. We did not use specific constructs to investigate familiarity and first consumption experience with the GI; instead, the respondent was asked two simple dichotomous questions: (1) 'Do you know PVBE ham?' and (2) 'Have you tasted it at least once?' If the respondent indicated no knowledge of PVBE, then the interviewer proceeded directly to the final section. Otherwise, the inquiry continued with questions about PVBE consumer behaviour, including purchasing locations, purchase frequency, and the proportion of PVBE in overall raw ham consumption (see Table 3).

Assessing the percentage consumption of PVBE in relation to other types of raw ham, rather than individual consumption, is more feasible when conducting a survey at retail points. It also allows for an assessment of the importance of PVBE in the diet, irrespective of individual preferences for raw ham. Additionally, we evaluated subjective perceptions of PVBE, such as hedonic liking ('How do like PVBE?') and overall satisfaction from the purchase ('How satisfied were you with buying PVBE?'), both rated on a 5-point Likert scale. The former ranges from 1 (*no taste*) to 5 (*very good*), while the latter ranges from 1 (*not satisfied*) to 5 (*extremely satisfied*).

Finally, the respondents were asked about their willingness to pay for both PVBE and Prosciutto di Parma, which can be considered the most likely alternative for PVBE among high-quality raw hams in the surrounding area and is the best-selling ham in Italy. We deemed it appropriate to evaluate the difference in willingness to pay for generic non-GI raw ham, as such products represent a secondary option for consumers seeking medium-to-high quality goods. Moreover, producers of generic raw ham are not present in the PVBE production zone or its proximity. However, in certain cases, non-GI products may be important to consider, particularly those with strong reputational potential. Because we were interested only in a rough indication of the willingness to pay trend with distance, we did not employ a particular estimation scheme; we simply asked for the maximum amount that the respondent would be willing to pay for a hectogram of the two hams.

A single interviewer collected data in 2019. Each respondent provided informed consent after the interviewer explained the research objectives. A total of 563 responses were collected. We calculated both linear and road distances between each respondent's municipality of residence and the centre of Montagnana. For the definition of road distance, we used the shortest route in terms of time, as calculated by Google Maps.

5. RESULTS AND DISCUSSION

This section presents the results in accordance with the hypotheses outlined earlier, beginning with descriptive statistics of the main variables. We present the findings regarding H8 after dealing with H1-H7. Given the novelty of this study, the discussion focuses primarily on the interpretation of results rather than comparisons with previous outcomes reported in the literature.

5.1. General aspects

The survey did not extend beyond the 40-50 km band in three directions because the proportion of PVBE consumers within that band dropped to < 10%. In the northern direction, the survey was terminated at the 20-30 km band for the same reason (see Table 2). This outcome is somewhat unexpected and warrants further investigation, particularly considering that the Berici Hills, whose name is partially included in the PDO, lies directly to the north. This may be attributed to the production of the Soppressa Vicentina PDO in Vicenza province, where the Berici Hills are located. This cured meat product (similar to a thicker and more seasoned salami) may have local brand recognition and reputation, potentially substituting PVBE in high-quality cured meat consumption. The necessity to terminate the survey in one direction provides strong evidence that the RGM 'chorotype' for PVBE deviates from a circular shape.

Based on the survey, 91% of the respondents consume raw ham, albeit some only occasionally. Knowl-

Table 2. Distribution of the sample cases by kilometric bands and directions.

	Percentage
Up to 10 km	*22.2*
From 10 to 20 km	*23.4*
From 20 to 30 km	*21.7*
From 30 to 40 km	*16.2*
From 40 to 50 km	*16.5*
North	*16.4*
East	*27.5*
South-east	*29.1*
North-west	*27.0*

edge of the most renowned Italian PDO hams – Prosciutto di Parma and Prosciutto di San Daniele – is nearly universal, with 96% and 92% of the respondents recognising them, respectively. This suggests that their reputation is not affected by distance from Montagnana; it is relatively evenly distributed throughout the Veneto region. PVBE is recognised by 83% of the respondents (i.e., 470 respondents); however, only 66% of this group have actually consumed it at least once. These data reduce the number of cases available for testing H3-H7 to 308, representing 55% of the sample. Furthermore, the relatively low market penetration across the entire sample raises concerns about the effectiveness regarding the communication strategies for PVBE beyond its production zone.

Supermarkets are the primary point of purchase, followed by restaurants and other retail outlets (Table 3). While the supermarket share may be somewhat overestimated because the interviews were conducted outside supermarkets, it aligns with a global trend of supermarkets offering local and regional food (Caraballo-Cueto, 2021). This indicates that PVBE retains the characteristics of a convenience good in proximity to its production zone. Its absence from shelves could potentially create customer loyalty challenges for large-scale retailers. More than 60% of the respondents reported purchasing PVBE at least once a month. On average, PVBE accounts for nearly 50% of total raw ham consumption, highlighting its significance to local consumers compared with nationally distributed GIs and other hams (either lacking a GI or holding a less recognised one). This is supported by high satisfaction levels from purchases (4.66) and strong hedonic liking (4.62) revealed in our sample. We noted an average premium of 7% for PVBE over Prosciutto di Parma. Similarities in thigh procurement sources and production methods between the two hams, both considered high-quality cured pork meat, may con-

Table 3. Consumer behaviour and evaluations of Prosciutto Veneto Berico-Euganeo.

	Value
Place of purchase and frequency (percentage of respondents)	
Purchase at restaurant	*19.2%*
Purchase at supermarket	*61.0%*
Purchase at a specialised shop	*15.6%*
Direct purchase from company store	*14.9%*
Purchase once or more a month	*63.1%*
Purchase less than once a month	*36.9%*
Raw ham consumption (percentage of respondents)	
Prosciutto Veneto Berico-Euganeo	*49.2%*
Prosciutto di Parma	*21.4%*
Prosciutto di San Daniele	*10.0%*
Other raw hams	*19.4%*
Hedonic liking based on the 5-point Likert scale (mean)	
Prosciutto Veneto Berico-Euganeo	4.62
Prosciutto di Parma	4.21
Satisfaction from the purchase of Prosciutto Veneto Berico-Euganeo based on the 5-point Likert scale (mean)	4.66
Willingness to pay for Prosciutto Veneto Berico-Euganeo, €/hg (mean)	3.08
Willingness to pay for Prosciutto di Parma, €/hg (mean)	2.87
Difference in willingness to pay, €/hg (mean)	0.21

Note: The number of cases is 308 except for willingness to pay for Prosciutto Veneto Berico-Euganeo (n = 294) and willingness to pay for Prosciutto di Parma and difference in willingness to pay (n = 289) due to missing data.

tribute to explaining such a limited gap and confirm Prosciutto di Parma as the closest substitute for PVBE. Although PVBE tends to have a more intense flavour and a softer texture, while Prosciutto di Parma is known for its sweetness and more compact structure, the difference in willingness to pay appears to be more attributable to a gap in intangible features embedded in the perception of the value of the two PDOs (Gusman, Sundry, 2022). These features may include consumers' willingness to support local production and their sense of pride in consuming regional specialties.

5.2. Familiarity and first consumption experience

Table 4 presents the results of hypothesis testing for categorical variables, covering the entire sample. Appendix A provides separate results for each direction (subsample) to highlight differences from the overall findings.

The data strongly support H1 and H2. At a distance of approximately 40-50 km from Montagnana, nearly 60% of the respondents declared familiarity with PVBE, and this variable decreases by over 1% for each kilometre away from the centre, confirming the decline noted by Giraud (2016) for a GI cheese. The impact of distance is even more pronounced for the first consumption experience: the percentage of the respondents who have consumed PVBE at least once decreases by more than 2% per kilometre. In the 20-30 km distance band, this percentage drops to 50%. Consequently, the gap between familiarity and first consumption experience widens as distance from the production area increases. A range of initiatives, such as tastings, promotional gifts at the point of sale, and participation in local fairs, may enhance the PVBE experience and significantly contribute to reducing this gap.

Tests conducted on the directional sub-samples confirm the general trends, although some differences in the percentage reductions per kilometre and the final percentages emerge, supporting H8 for these variables. For example, familiarity falls to just 47% in the last kilometre band heading north-west, likely due to urban consumers in Verona paying less attention to GI food produced far from the city. The most significant reductions in both familiarity and first consumption experience occur in the northern direction, particularly within 30 km of Montagnana. Given the 3.88% decline per kilometre among those who have consumed PVBE at least once, we hypothesise that the Berici Hills not only represent a geographical barrier but also influence consumer approach to PVBE. The largest discrepancy between familiarity and consumption occurs when traveling east: at distances greater than 40 km from Montagnana, 70% of the respondents recognise PVBE, while only 9% have actually consumed it. By contrast, we noted the smallest gap in the north-west (familiarity 47%, consumption 21%), suggesting a potential communication deficit in this direction.

5.3. Purchase frequency and locations

The data also support H3, which posits that the percentage of individuals purchasing PVBE at least once a month decreases with distance, implying a decline in loyalty to the GI. This percentage nearly halves from the first to the last distance band, indicating a decline of approximately 1% per kilometre. There are variations across the four directions, likely due to differences in product accessibility and consumer preferences for PVBE. Notably, in the north-west, purchasing frequency remains stable, with two-thirds of the respondents continuing to buy PVBE at least once a month even more

Table 4. The effect of distance from Montagnana on variables related to Prosciutto Veneto Berico-Euganeo (all directions).

	N	χ^2 conting.	p	χ^2 linear	p	Initial %	Final %	% difference/ km
Familiarity	563	75.07	<0.001	71.89	<0.001	*100.0*	*61.3*	*-1.11*
Consumption (at least one time)	470	98.61	<0.001	88.70	<0.001	*88.0*	*15.8*	*-2.06*
Place of purchase								
Restaurant	308	50.15	<0.001	22.34	<0.001	*15.50*	*77.8*	*1.78*
Supermarket	308	6.80	0.147	0.72	0.395	*52.70*	*55.60*	-
Specialised shop	308	11.71	0.020	9.37	0.002	*24.50*	*11.1*	*-0.38*
Company store	308	19.18	<0.001	17.59	<0.001	*25.50*	*0.00*	*-0.73*
Frequency of purchase								
Once or more a month	309	34.85	<0.001	31.41	<0.001	*80.00*	*44.40*	*-1.02*

Note: Initial % is the percentage in the first band (the closest to Montagnana), Final % is the percentage in the last band (the furthest to Montagnana), and % difference/km is the percentage difference between the first and last band per kilometre.

than 40 km from Montagnana (the Verona urban area). A hypothesis that requires further investigation is that some Verona consumers who appreciate PVBE exhibit notable loyalty to the product, effectively 'adopting' PVBE as their typical ham, despite the fact that it is produced in the south-eastern boundary of their province.

Regarding purchase locations, the percentage of individuals who consume PVBE in restaurants significantly increases with distance, confirming H4d. Restaurants appear to become the preferred purchasing channel for distant consumers; they tend to buy PVBE when dining out, while those closer to Montagnana may reserve PVBE purchases at restaurants for special occasions. Detailed analysis shows that within 30 km of the town, the percentage of PVBE purchases at restaurants remains nearly constant (around 15%) but sharply increases beyond this distance. Although this trend applies to all directions, the linearity test is not significant for some of them, possibly due to sub-sample limitations and/or uneven distribution of PVBE in certain restaurant locations. A direct survey of restaurant operators would be needed to clarify this issue. We hypothesise that, in the absence of other hams with strong regional characteristics, restaurants – especially those located 40-50 km from Montagnana – offer PVBE as an appetizer, allowing consumers from more distant areas to experience it. Similarly to how Italian restaurants abroad often serve as 'trailblazers' for various Italian GI products, regional cuisine restaurants act as 'ambassadors' for local small-scale GI products, particularly if they represent a symbol of cultural identity or accumulated regional history (Pieniak *et al*., 2009).

The lack of significant findings regarding supermarket purchases seems to support the hypothesis that the use of these outlets remains relatively stable, both near the production zone and in more remote areas, reinforcing the notion that supermarkets offer a broad assortment of local products with good reputation (Martinez *et al*., 2010). This finding should be considered in light of H4a and H4b: while supermarkets operate alongside other retail points near Montagnana, they tend to become the primary source of PVBE for domestic consumption as distance from the production area increases. This is partially confirmed by the significant rise in the purchasing percentage at supermarkets in the north and south-east directions. We did not examine PVBE purchases across different types of organised retail outlets by size, but it is likely that as distance from the production site increases, contrasting trends emerge – such as a decrease in purchases at smaller outlets and an increase at larger ones, particularly concerning PVBE availability in their assortments.

Stability or growth of the PVBE purchase percentage at supermarkets and restaurants as distance from Montagnana increases does not contradict the concept of an RGM centred on the production area. Rather, these findings indicate that producers should primarily rely on these points of sale if they aim to expand their business outside the current RGM boundaries.

H4a and H4b, which address declines in purchases at the other two retail points, are strongly supported by the data. Consumers in the farthest distance band report no purchases at the company store, with zero occurrences as early as 20-30 km from Montagnana in all directions, likely due to rising travel costs (Fox *et al*., 2004). There are similar patterns for purchases at specialised shops, where the limited selection means that only the most popular products are supplied. Differentiated distribution strategies and the size of sub-samples may explain the non-significant results from the linearity test in some directions. Purchases at specialised shops in the north are limited to within 10 km of Montagnana, while in the east and south-east, they do not extend beyond the third distance band. However, purchases at these outlets continue beyond 40 km in the north-west direction. We hypothesise that demand for typical Veneto products from moderately affluent consumers in Verona may explain the persistence of PVBE purchases at these retail outlets. The information on points of sale can be highly valuable to producers for two purposes: they can use it to restructure their marketing channels and to promote PVBE more effectively. This endeavour allows for more precise targeting of specific geographical areas.

5.4. Relative consumption, willingness to pay, and price premium

We initially tested H5, H6, and H7 by using simple regressions, as summarised in Table 5. We considered the road distance between Montagnana and the buyer's residence as the independent variable; it proved more explanatory than the straight-line distance calculated on a map. This finding aligns with the notion that consumers perceive the market in terms of accessibility and travel time (Toporowsky, Lademan, 2004), rather than just physical distance. Alternative non-linear trends were also examined but consistently proved less explanatory.

H5, H6, and H7 are largely supported by the significance of the coefficients. Starting with a PVBE consumption share of 72% in Montagnana, this proportion decreases to 27% after 40 km. Similarly, willingness to pay decreases from €3.26 per hectogram to €2.90, and the price premium over Prosciutto di Parma drops from €0.33 to just under €0.10, becoming zero at 55 km from

Table 5. The effect of distance from Montagnana on variables related to Prosciutto Veneto Berico-Euganeo (simple regressions, all directions).

	Relative Consumption of Prosciutto Veneto Berico-Euganeo		Willingness to pay for Prosciutto Veneto Berico-Euganeo		Difference in willingness to pay	
	Costant	Road distance	Costant	Road distance	Costant	Road distance
Coefficient	72.115	-1.119	3.263	-0.009	0.334	-0.006
Standard error	3.46	0.145	0.052	0.002	0.042	0.002
t	20.845	-7.708	62.192	-4.026	7.865	-3.576
p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
F	59.41		16.207		12.787	
R^2	0.160		0.049		0.039	
Number	308		294		289	

Montagnana. The spatial trend of this last variable is attributable solely to the dynamics of willingness to pay for PVBE, not due to an increase in willingness to pay for Prosciutto di Parma. In fact, regression analysis of Prosciutto di Parma willingness to pay demonstrates complete distance invariance for this indicator because the perceived value is uniformly widespread at the territorial level for this PDO ham.

These outcomes confirm for PVBE both a GI value trend according to that suggested by the von Thünen model and the existence of an RGM centred on the production zone, where competition with other GI raw hams is evident. The consideration of Prosciutto di Parma as the main competitor for PVBE is based on its relative consumption data from our survey (Table 3) and its highly comparable quality to PVBE. However, we cannot exclude that further investigation might identify Prosciutto di San Daniele and generic raw ham as important substitutes. While for the former we can hypothesise a PVBE price premium similar to that of Prosciutto di Parma, for the latter it is likely to be considerably higher.

The hypothesis that consumers living farther from the product's origin would value the GI product more, resulting in higher willingness to pay – as suggested by Garavaglia, Marcoz (2014) – is not supported in this case. In the case of Fontina Valdostana PDO cheese, the RGM is not the production area and its proximities; rather, it may be that of large cities, where the GI value is 'exported' by a specific tourist typology. In Val d'Aosta, urban tourists coming for residential vacations have the opportunity to experience the local GI directly, being deeply involved in both its tangible and intangible features. This results in a higher GI value in areas far from its origin, implying a higher willingness to pay compared with that shown by local residents. Additionally, in highly touristic areas, GIs can provide a guarantee of authenticity in a local product offer that may include many imitations and usurpations of local names, for which GIs would provide a reassuring benchmark. Conversely, in the Montagnana area, tourism is not residential but rather mostly short term, focused on a small historical town, which scarcely allows visitors to establish a sound involvement with the local GI food, creating the premise of a relevant market outside the production zone. Therefore, our results do not contradict Garavaglia, Mariani's (2017) findings regarding willingness to pay, as the markets examined are fundamentally different: the dimension of the relevant market for Prosciutto di Parma is markedly national and international, while that of PVBE is primarily local and regional.

If producers aim to expand sales beyond the production zone, a practical implication can be drawn from the previous considerations. Specifically, both producers and stakeholders should plan a series of interventions that enable tourists visiting historical monuments to also engage with PVBE. These could include organizing tasting events near monuments and offering tours of ham production facilities.

The regressions used to determine whether there is significant homogeneity among the explored directions reveal moderate effects for certain directions (Appendix B). Notably, there are no significant coefficients beyond the baseline (south-east) for willingness to pay, indicating directional homogeneity for this indicator. Conversely, the relative consumption of PVBE declines more slowly in the north-west direction compared with the south-east direction (0.93% per km vs 1.23% per km). In the north-west direction, there is also a less pronounced reduction in the price premium, aligning with previous findings for purchase frequency and purchases at specialised stores. This is likely linked to higher appreciation for PVBE or higher purchasing power in the urban area of Verona.

Although the sample size and the incompleteness of directional data prevent a conclusive assessment of

the spatial dynamics across the continuous variables, it seems likely that the iso-value curves may also deviate from a circular pattern for relative consumption and price premium. This suggests that it may be beneficial to consider direction-specific sub-strategies, particularly when communicating about PVBE.

The simultaneous inclusion of all other independent variables considered in our survey resulted in numerous non-significant coefficients and a considerable degree of collinearity. Consequently, we employed a stepwise variable selection method, yielding the findings reported in Table 6. The coefficients of determination are either improved or remain comparable to those of simple regression, and the degree of collinearity among the independent variables is reduced.

Distance remains a more influential factor than sociodemographic variables, which contribute modest or negligible explanatory power to the three dependent variables. In contrast, the subjective assessments (hedonic liking and purchase satisfaction) have a significant impact. For example, having a medium-to-high income increases PVBE's consumption share by over 8%. However, income seems unrelated to willingness to pay, as reported by Martinez *et al.* (2010). Consistent with other studies showing a higher willingness to pay among women (Enthoven, van den Broeck, 2021), the status of being a housewife is associated with a higher willingness to pay compared with other occupational categories, likely due to heightened sensitivity to gastronomic characteristics among those who spend more time preparing meals (Zepeda, Li, 2006). Purchase satisfaction, presumably incorporating elements of sensory appreciation, affecting both willingness to pay and relative consumption, whereas hedonic liking primarily influences the difference in willingness to pay between PVBE and Prosciutto di Parma. While the coefficients of distance in Table 6 are somewhat lower than those in the corresponding simple regressions, their significance remains unchanged, further validating H5-H7.

These findings highlight key aspects for pricing and promoting PVBE, which need to be balanced with distance considerations. Specifically, they suggest that particular attention should be given to emphasizing PVBE's organoleptic characteristics while providing consumers with an excellent purchasing experience.

6. CONCLUSIONS

This study is the first to comprehensively investigate the spatial diffusion of specific marketing variables for a GI whose RGM is centred on the area of production and thus inevitably presents certain limitations. The impact of competing GIs was not sufficiently analysed. While Soppressa Vicentina might pose some market competition to PVBE in the north, it can only be considered a

Table 6. The effect of distance from Montagnana on variables related to Prosciutto Veneto Berico-Euganeo (multiple regressions).

	Coefficient	Standard error	t	p
Relative Consumption of Prosciutto Veneto Berico-Euganeo				
Constant	-78.803	14.405	-5.47	<0.001
Road distance	-0.952	0.126	-7.534	<0.001
Satisfaction from the purchase of Prosciutto Veneto Berico-Euganeo	22.807	4.682	4.871	<0.001
Monthly household income > €2000	8.641	3.191	2.708	0.007
Hedonic liking for Prosciutto Veneto Berico-Euganeo	8.324	4.604	1.808	0.072
R^2 = 0.385; F = 48.666; n = 308				
Willingness to pay for Prosciutto Veneto Berico-Euganeo				
Constant	1.341	0.228	5.869	<0.001
Satisfaction from the purchase of Prosciutto Veneto Berico-Euganeo	0.261	0.074	3.53	<0.001
Road distance	-0.007	0.002	-3.379	<0.001
Occupation: housewife	0.14	0.066	2.119	0.035
Hedonic liking for Prosciutto Veneto Berico-Euganeo	0.138	0.072	1.908	0.057
R^2 = 0.240; F = 24.138; number = 294				
Difference in willingness to pay				
Constant	-1.327	0.165	-8.036	<0.001
Hedonic liking for Prosciutto Veneto Berico-Euganeo	0.353	0.034	10.31	<0.001
Road distance	-0.005	0.002	-3.304	0.001
R^2 = 0.297; F = 61.89; number = 289				

partial substitute given that it lacks the specific traits of raw ham. Similarly, internationally recognised hams such as Prosciutto di Parma and Prosciutto di San Daniele do not appear to significantly disrupt PVBE's local market.

Some methodological weaknesses can be identified in the survey management. The decision to cease the investigation where PVBE consumers constitute less than 10% of the sample, due to budget constraints, hindered the precise delineation of the 'chorotype' for this PDO. Additionally, the exploration of only four directions made it impossible to create comprehensive iso-value maps for the analysed variables. Expanding the analysis could have better captured consumer familiarity dynamics, which, as demonstrated, do not drop below 60% in our sample. An *ad hoc* web survey covering a broader area surrounding the production zone could help address these limitations.

The survey did not explicitly consider some important marketing variables, such as brand image, identity, loyalty, and the reputation of the collective brand, which can inform communication strategies or strengthen market penetration. Likewise, the definition of other variables (e.g., familiarity and difference in willingness to pay) could have been enhanced. Moreover, while consumer preferences for points of sale were taken into account, the spatial distribution of PVBE sales remains unknown, necessitating further investigation on the supply side.

Our paper concludes with an unanswered question about the PVBE market situation, particularly whether its RGM is a deliberate choice by the GI operators or a situation forced upon them by major competitors. This inquiry extends beyond our primary objective, which was to offer a new framework for understanding 'dominated' GIs in sectors where competition with 'dominant' GIs is only possible and successful in the production area and its vicinity, by taking advantage in terms of local reputation and consumer attachment. In fact, our approach provides a concrete criterion for identifying GIs that fit this model. Despite the aforementioned shortcomings, this research significantly highlights the relationship between distance from a GI production zone and a set of important market variables, as well as contributes to better identifying a particular type of GI, with an RGM is centred on its production area where the role of the gastronomic dimension of tourism is relatively limited.

The findings provide broad support for the proposed interpretative model inspired by von Thünen's spatial trend for land rent. Our findings support H1-H7, and there is also evidence that iso-value curves for most variables deviate from a circular pattern (H8). Consequently, we posit that this model can be applicable to other GIs when the RGM is centred in the production area. This is an important conceptual advance that needs to be confirmed in contrasting cases.

The model appears not applicable to GIs whose RGM is national or international (e.g., Asiago cheese, Prosciutto di Parma, or Prosecco) or for those where tourism 'export' reputation far from the production zone (e.g., Fontina Valdostana or Südtiroler Speck). While the latter must address the challenge of retaining their local significance, facing the risk of losing their cultural basis shared with local society, the former may need to consolidate their RGM within current boundaries or expand beyond them by finding new opportunities.

The validity of an RGM centred in the production zone for PVBE, coupled with the increasing number of GIs in the EU and other countries, suggests that this model could be confirmed for numerous GIs. Once this typology has been well investigated and its properties determined, it could become a tool to discriminate between GIs that fit the model and those that do not, potentially contributing to the political debate on GIs and specifically on their role in supporting food producers. Institutions may decide to recognise new GIs or to subsidise existing ones according to the features of their RGM.

From an operational perspective, our innovative approach can aid in formulating effective marketing strategies to improve the performance of producers. Strategies can be adapted to different distances from the production area, aiming to defend market share against competitors, to penetrate new markets, and to cultivate consumer loyalty. Moreover, they can be concentrated in subzones or targeted directions with greater profit potential, taking advantage of the space-varying values of key marketing variables.

Our research has implications not only for producers and Protection Consortia of GIs showing an RGM similar to that of PVBE, but also for other stakeholders such as local administrations and institutions. Their engagement in impactful information and promotional campaigns to raise consumer awareness and reputation of GIs can be crucial. For PVBE, a targeted strategy could be developed to enhance opportunities to bridge the gap between familiarity and first consumption experience, such as through supermarket tastings, participation in regional fairs and events, on-trade promotions, and expanding distribution to specialized food shops. As examples of considering differences in specific directions, these actions may initially focus on the north, where familiarity and consumption are lower despite the presence of three ham producers, while in the north-west, producers' profitability may be increased by promoting purchases from specialised stores,

capitalising on the higher willingness to pay in this side of the market 'chorotype'.

GIs that show an RGM centred in the production area are likely to be well represented both in Italy and the EU, providing an ample base to examine the applicability of our model. Moreover, our results appear to be quite satisfactory. Nevertheless, we must advise caution regarding the adoption of our model for other GIs due to the specific characteristics of PVBE. Further investigation is required to extend the validity of out model. Specifically, it should be validated with other GIs, which may differ in terms of economic size, export share, reputation, competition with other GIs or non-GI products, and the impact of tourism. In particular, it would be interesting to apply our model to some wine GIs for which the possibility of product differentiation is higher than in the case of the ham industry. Moreover, research could determine whether our model can be extended to producer's brands when their RGM is centred in the production site, as can happen for some small-scale agrifood industries.

Another research issue could be the relationship between the proposed model and product life cycle, by combining spatial and temporal models. An intriguing hypothesis is that GI sales are in a maturity or near-saturation phase within or very close to the production zone, in a growth phase in surrounding areas, and in an introductory phase in areas farther away. However, undertaking such an investigation may prove quite challenging because testing this hypothesis would require temporal data at least from the time the GI was first recognised or even longer, as well as sound historical information.

Finally, because we utilised a consumer survey to collect data, it would be interesting to apply the model from the supply side by directly surveying points of sale such as restaurants and supermarkets, with the aim of investigating how much and how far the GI is sold. Furthermore, we should consider other stakeholders such as tourist offices, local decision-makers, and media outlets. Their contributions in terms of communication, territorial image construction, and reputation building will interact with and influence the actions of GI producers. This research would not only add information to that obtained from consumers, but could also confirm or refute some interpretations based on the demand-side survey.

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Appendix A. The effect of distance from Montagnana on variables related to PVBE in the four directions.

North	No.	χ^2 conting.	p	χ^2 linear	p	Initial %	Final %	% difference/ km
Familiarity	92	12.74	0.002	12.23	<0.001	*100.00*	*70.00*	*-1.77*
Consumption	80	25.45	<0.001	21.98	<0.001	*84.80*	*19.00*	*-3.88*
Place of purchase								
Restaurant	50	2.11	0.349	1.45	0.229	*17.90*	*50.00*	-
Supermarket	50	5.51	0.064	3.95	0.047	*50.00*	*75.00*	*1.47*
Specialised shop	50	5.36	0.069	4.41	0.036	*21.40*	*0.00*	*-1.26*
Company store	50	3.91	0.142	3.56	0.059	*25.00*	*0.00*	-
Frequency of purchase								
Once or more a month	50	8.43	0.015	4.89	0.027	*71.40*	*50.00*	*1.47*
East								
Familiarity	155	17.32	0.002	13.44	<0.001	*100.00*	*70.00*	*-0.74*
Consumption	139	33.35	<0.001	21.49	<0.001	*81.30*	*9.50*	*-1.78*
Place of purchase								
Restaurant	88	38.23	<0.001	15.45	<0.001	*11.50*	*50.00*	*0.95*
Supermarket	88	5.94	0.204	1.93	0.164	*69.20*	*50.00*	-
Specialised shop	88	8.08	0.089	6.51	0.011	*26.90*	*0.00*	*-0.67*
Company store	88	6.36	0.174	1.51	0.218	*19.20*	*0.00*	-
Frequency of purchase:								
Once or more a month	88	39.90	<0.001	31.13	<0.001	*92.30*	*50.00*	*-1.05*
South-east								
Familiarity	164	20.83	<0.001	19.05	<0.001	*100.00*	*66.70*	*-1.02*
Consumption	143	58.99	<0.001	52.76	<0.001	*96.60*	*18.20*	*-2.40*
Place of purchase								
Restaurant	101	34.36	<0.001	6.12	0.013	*17.90*	*100.00*	*2.51*
Supermarket	101	12.18	0.016	4.13	0.042	*32.10*	*50.00*	*0.55*
Specialised shop	101	7.35	0.119	6.61	0.010	*25.00*	*0.00*	*-0.77*
Company store	101	9.09	0.059	8.03	0.005	*28.60*	*0.00*	*-0.88*
Frequency of purchase								
Once or more a month	101	9.80	0.044	8.26	0.004	*75.00*	*25.00*	*-1.53*
North-west								
Familiarity	152	34.56	<0.001	31.58	<0.001	*100.00*	*46.70*	*-1.59*
Consumption	108	21.34	<0.001	13.78	<0.001	*90.30*	*21.40*	*-2.06*
Place of purchase								
Restaurant	69	8.75	0.068	4.91	0.027	*14.30*	*66.70*	*1.56*
Supermarket	69	5.90	0.207	0.10	0.922	*60.70*	*66.70*	-
Specialised shop	69	0.66	0.956	0.00	0.955	*25.00*	*33.30*	-
Company store	69	8.34	0.080	6.97	0.008	*28.60*	*0.00*	*-0.85*
Frequency of purchase								
Once or more a month	69	4.61	0.330	2.41	0.121	*82.10*	*66.70*	-

Note: Initial % is the percentage in the first band (the closest to Montagnana), Final % is the percentage in the last band (the furthest to Montagnana), and % difference/km is the percentage difference between the first and last band per kilometre.

Appendix B. The effect of distance from Montagnana on variables related to Prosciutto Veneto Berico-Euganeo with reference to different directions.

	Coefficient	Standard error	t	p
Dependent variable: relative consumption of Prosciutto Veneto Berico-Euganeo				
Constant	74.042	3.529	20.98	<0.001
Road distance	-1.229	0.154	-7.964	<0.001
North-west	0.297	0.167	1.777	0.077
North	-0.451	0.266	-1.696	0.091
R^2 = 0.174; F = 17.04; n = 308				
Dependent variable: difference in willingness to pay				
Constant	0.342	0.043	8.039	<0.001
Road distance	-0.008	0.002	-3.999	<0.001
North-west	0.004	0.002	1.776	0.077
R^2 = 0.046; F = 8.039; n = 289				

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Research article

Enhancing food accessibility and affordability in rural Mali through mobile money

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Abstract. This study examines how mobile money adoption influences food accessibility in rural Mali, a context marked by limited financial infrastructure and persistent food insecurity. Using household-level survey data from Koulikoro and a composite food insecurity index – the Household Food Insecurity Access Scale (HFIAS) – we apply censored Tobit regression to identify the effect of mobile money use on household food access. The results show that mobile money significantly reduces food insecurity, with users reporting lower HFIAS scores than non-users. Other key determinants include income, land ownership, and education, particularly at the university level. However, gender disparities and land tenure insecurity constrain the full benefits of digital finance. Policy responses should prioritise financial inclusion for women, formalise land rights, and expand digital remittance platforms to enhance rural resilience. Aligning mobile money expansion with broader institutional reforms can strengthen food security outcomes in Mali's rural communities.

Keywords: mobile money, food accessibility, rural digitisation, financial inclusion, Mali.
JEL codes: Q18, O33, G21, R20, R51.

HIGHLIGHTS

- Mobile money usage significantly reduces household food insecurity in rural Mali.
- Households receiving mobile money remittances report higher food access and lower Household Food Insecurity Access Scale scores.
- Contextual factors such as village location are crucial, revealing significant geographic heterogeneity in food security outcomes that must be accounted for in analysis.

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1. INTRODUCTION

There has been a growing interest in the convergence of technology and agricultural sustainability (Kabbiri *et al*., 2018). Mobile money (MM) – a digital financial service that enables transactions through basic mobile phones without requiring internet access or bank accounts – has emerged as a tool that can enhance food accessibility in rural areas (David-West *et al*., 2019; Wieser *et al*., 2019). Ensuring food security is paramount, especially in remote areas where limited resources, long distances from markets, and a lack of banking access increase vulnerability (Piaskoski *et al*., 2020; Rural Health Information Hub, 2023). Food security in Mali remains a major issue: although consistent access to nutritious food is required to live an active, healthy life (Zenk *et al*., 2022), rural households face systemic challenges such as financial inclusion gaps compared with urban areas (Piaskoski *et al*., 2020). Financial inclusion fosters inclusive growth and improves food security (Ashrad, 2022), as has been shown by studies linking financial access to household resilience (Huang, Nik Azman, 2023). However, the relationship between financial inclusion and food security remains underexplored, particularly in developing contexts.

Rural areas, such as what can be found in Mali, are often financially excluded (Amadou, 2018). MM operates via local agent networks (Guérin *et al*., 2014) to facilitate secure transfers, bill payments, and savings via simple SMS or USSD technology (Wantchekon, Riaz, 2019). Its low-cost, real-time transaction capabilities have proven especially valuable for rural populations, farmers, and women who have traditionally lacked access to formal banking services. There is evidence from Uganda which shows the potential of MM to reduce food insecurity (Bruhn, 2019; Dunne, Kasekende, 2017; Wantchekon, Riaz, 2019). Additional evidence suggests the potential of MM systems to revolutionise participation in rural markets (Menekse, 2011; Murendo, Wollni, 2016; O'Hara, Toussaint, 2021).

In this study, we examine how MM adoption influences access to food in rural Mali by analysing key socio-economic factors including gender, education, and land ownership. We address three central questions: (1) how does MM technology affect household food security? (2) Through what mechanisms does it improve food security? (3) Which socio-economic variables have the most significant impact on its effectiveness? Our investigation of these relationships contributes to an understanding of how digital financial tools can enhance rural resilience while providing actionable insights for policies aimed at strengthening food security in vulnerable communities. This study lays the foundation for exploring innovative solutions to address food accessibility issues in rural regions, including local development and capacity-building initiatives. This interdisciplinary endeavour requires the integration of elements from economics, technology, agriculture, sociology, and food safety, making it a stimulating and challenging research topic. The outcomes of this study could directly inform the design of development policies and programmes aimed at bolstering food resilience in rural communities.

1.1. Literature review

The relationship between MM, financial inclusion, and food security has been widely studied in development economics, rural studies, and research of food systems. Scholars argue that mobile financial services can reduce economic vulnerabilities by facilitating access to remittances, reducing transaction costs, and improve a household's ability to cope with shocks. However, it is important to distinguish between financial circulation and access to food to understand the specific routes through which MM affects food security. While financial circulation refers to the flow of monetary resources enhanced by mobile platforms, food access entails the physical and economic capacity to get adequate and nutritious food.

The literature rooted in financial inclusion theory, particularly the entitlement approach (Sen, 1999) and financial access theory (Morduch, 1999), provides a foundation to understand how MM increases the access of food. Sen's (1999) approach emphasises the individual's ability to transform resources into well-being, where financial tools are essential for expanding personal freedoms and choices. In this context, MM acts as a facilitator that broadens economic capabilities by offering a household the means to secure food. Morduch's (1999) financial access principle suggests that financial services increase economic participation, which can translate into better domestic welfare and consumption patterns. These theoretical perspectives have inspired empirical studies examining the effects of MM services on rural livelihoods.

Empirical evidence shows that MM enables households to face food insecurity by increasing liquidity and smoothing consumption. Remittance flow through mobile platforms acts as informal form of insurance against a lack of food, especially in agricultural settings where income is unstable. Wantchekon, Riaz (2019) reported that MM remittance helps rural families manage seasonal shortage and price spikes. Marando, Volni (2016) found that MM increases the expenditure and

dietary diversity related to food between farming houses in Zimbabwe. These findings suggest that MM improves the economic access pillar of food security by boosting the household's purchasing power.

Moreover, MM contributes to food security by enabling participation in regional markets. As shown in the study of Uganda and Tanzania (Naito *et al.*, 2021; Weiser *et al.*, 2019; Yao *et al.*, 2022), mobile platforms reduce the cost of sending and receiving funds, which facilitates trade and improves supply chains. These benefits, in turn, support the availability of food by improving access to more diverse and reliable sources of food. Yao *et al.* (2023) further emphasised that MM enables market access and also strengthens the ability of rural families to respond to the shock, including value volatility and climate disruptions.

Other scholars have emphasised the importance of contextual variables such as income, the education level, household composition, and infrastructural reach. For example, Diallo *et al.* (2021) demonstrated that higher education and income increase the likelihood of MM adoption, which correlates with improved food access. Conversely, Aron (2018) found that structural barriers such as poor mobile coverage in remote regions limit the effectiveness of MM in enhancing food security. These studies highlight the importance of differentiating between the potential and realised impacts of financial tools.

According to food security frameworks (Barrett, 2002; Sassi *et al.*, 2018), availability, access, stability, and utilisation are distinct pillars. MM primarily affects the access dimension by improving financial resources and market connectivity. However, it may also influence utilisation by enabling purchases of higher-quality food and health-related goods and services. These dynamics are especially relevant in settings like Mali, where food insecurity is closely tied to both economic constraints and limited infrastructure. Hence, our focus is on access and utilisation. We adopt the Household Food Insecurity Access Scale (HFIAS) proposed by Food and Agricultural Organization of the United Nations (FAO) (FAO, 2007) to explore these factors.

Based on our literature review, we hypothesise that MM plays a dual role in reducing rural vulnerability. First, it serves as a financial instrument that facilitates monetary flows. Second, it is a mechanism that enhances food security through better access and adaptive capacity. This duality is shaped by socio-economic inequalities and institutional factors, which may amplify or constrain the potential benefits of digital finance. By engaging with both theoretical and empirical work, we seek to clarify how MM impacts food access in the specific context of rural Mali.

2. METHODOLOGY

2.1. Study area

Koulikoro, a strategically important region in southwestern Mali, serves as a key administrative and transportation hub in West Africa. Situated along the Niger River, it connects major routes, including the Bamako-Dakar railway and hosts the vital Koulikoro Training Centre (Figure 1). The region features a blend of urban centres and rural landscapes, with agriculture driving its economy. Its diverse population includes Bambara, Malinke, and Soninke ethnic groups, creating a rich cultural mosaic.

2.2. Data collection and sampling procedure

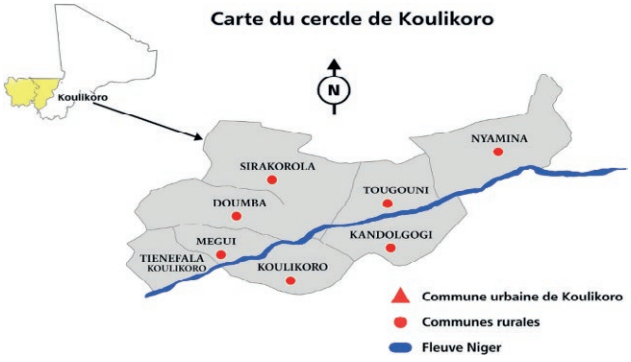
Researchers from the Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR/IFRA) in Katibougou conducted the survey across three rural Malian villages between August and September 2023. Twenty trained university students collected data through face-to-face interviews using Kobotoolbox and a customised questionnaire, with preliminary testing to ensure question clarity.

Using the Newbold (1995) formula (Equation 1) with 2010 population data (United Nations, 2021), we selected 328 households from a sampling frame of 1,047 through random sampling with local stakeholder assistance. We evaluated the impact of MM on rural food accessibility.

$$n = \frac{Np(1-p)}{(N-1)\sigma_{p^x}^2 + p\left(1-p\right)} \quad (1)$$

Where:
n = sample volume.

Figure 1. Prefectures of the Koulikoro region.



N = number of rural households in the study area.
p = 0.5 (for the maximum sample size, the estimated proportion of households aware of MM use).
p = the ratio variance (calculated as 1.645 × σp = 0.05 for a 90% confidence interval [CI] with a margin of error of 0.03; p = 0.03039).

We randomly sampled 328 households across three Koulikoro villages: Diakitébougou (n = 101), Mamibougou (n = 110), and Katibougou (n = 109). With a 95% confidence level and 5% margin of error, the sample size ranged from 307 to 382 from a population of 1,047 households. After data cleaning, 298 valid responses were retained for analysis.

Data collection used simple random sampling. IBM SPSS Statistics Version 24 was used to calculate descriptive statistics. R was used to construct the HFIAS and for Tobit regression analysis.

2.3. Assessing food insecurity in Mali's MM context

The survey assessed five major areas: (1) demographics, (2) MM use, (3) food insecurity, (4) ease of MM use, and (5) affordability and food access. We adapted the HFIAS to the Malian context: we maintained the main dimensions (anxiety, quantity, quality, and coping strategies) but used a 5-point Likert scale (from 1 [*never*] to 5 [*always*]) instead of the original 4-point scale. This modification better captures Mali's food insecurity and thus improves the accuracy of the responses. We calculated the severity threshold (secure/mild/moderate/severe) using the Mali-specific nutrition benchmarks to ensure our findings are relevant to the local context and amendable to global comparisons. Our 5-point scale provides the following important benefits:

- Better identification of respondents at risk (4 [*often*]) versus in chronic hunger (5 [*always*]).
- Captures seasonal variations in food insecurity.
- Provides more accurate data to evaluate the effect of MM on food access.

This cultural adaptation of HFIAS enables more targeted food security interventions by maintaining strict measurement standards for the Mali's MM context (Harknes *et al.,* 2010).

2.4. Generating an HFIAS indicator

The six key questions (Q27-Q32) described in Table 1 were scored from 1 (*never*) to 5 (*always*). Then, the score for each question was added together to obtain a composite index (Equation 2).

$$HFIAS_m = Q_{27} + Q_{28} + Q_{29} + Q_{30} + Q_{31} + Q_{32} \qquad (2)$$

Each question received equal weighting because these six questions collectively capture food access challenges. The total score ranges from 6 (food secure) to 30 (severely food insecure), with higher scores indicating greater food insecurity. We categorised this score into four levels:

- Food secure (6-10): no meaningful food access limitations.
- Mild insecurity (11-15): occasional worries about food supply without reduced intake.
- Moderate insecurity (16-20): regular reductions in food quality and/or quantity.
- Severe insecurity (>20): frequent hunger experiences including skipped meals

This approach followed the standard HFIAS methodology (Kotts *et al.*, 2007) while adapting it to the Malian context.

From the initial 310 respondents, we obtained complete HFIAS data for 298 households (96.3% completion rate). The adapted scale demonstrated strong reliability, with Cronbach's alpha of 0.89 and an average inter-item correlation of 0.58. Sensitivity analysis confirmed the importance of each question, as removing any single item would not improve reliability. These results validate our adapted scale as a robust measure of food insecurity in rural Mali.

Table 1. Comparison between the original Household Food Insecurity Access Scale (HFIAS) and the HFIAS adapted for this study.

HFIAS domain	Our questions	Response scale	Comparison
Anxiety about food supply	Q31 (worry about running out)	5-point Likert	Measures the psychological aspect of food insecurity
Reduced food quantity	Q28 (ate less)	5-point Likert	Measures the 'quantity' dimension of the HFIAS
	Q32 (went to bed hungry)	5-point Likert	Measures the severe food deprivation indicator of the HFIAS
Reduced food quality	Q29 (ate less healthy)	5-point Likert	Measures 'quality' compromise due to affordability
Coping strategies	Q30 (borrowed money)	5-point Likert	Measuring financial coping mechanisms, which aligns with the HFIAS: 'reliance on less preferred foods'
Access barriers	Q27 (difficulty accessing)	5-point Likert	Capture general access barriers (e.g., the HFIAS 'food shortage' items)

To investigate the effect of MM use on HFIAS, we utilised censored Tobit regression (Equation 3):

$$\begin{aligned} \mathrm{HFIAS}_i^* &= \beta_o + \beta_1 \mathrm{Age}_i + \beta_2 \mathrm{Gender}_i \\ &+ \beta_3 \mathrm{Log(Income)}_i + \beta_4 \mathrm{Landownership}_i \\ &+ \beta_5 \mathrm{UseMM}_i + \ldots \beta_{10} (\mathrm{UseMM}^* \log(\mathrm{Income}))_i + \epsilon_i \end{aligned} \quad (3)$$

$$HFIAS_i \begin{cases} 6 & if \leq HFIAS_i^* \quad 6 \\ HFIAS_i^* & if < HFIAS_i^* \quad < 30 \\ 30 & if \geq HFIAS_i^* \quad 30 \end{cases}$$

$$\epsilon_i \; is \sim N(0\ \sigma^2)$$

where:
$HFIAS_i^*$ is the latent (unobserved) household food insecurity score.
$HFIAS_i$ is the observed score, censored at 6 (lower limit) and 30 (upper limit).
X_i is the vector of explanatory variables.

The use of censored Tobit regression is justified because the HFIAS variable is a bounded variable; using ordinary least squares regression would yield biased estimates (Greene, 1983). Censored Tobit regression estimates both the probability of censoring and the conditional mean of the uncensored observations (Greene, 1983).

We must emphasise that, while this study provides useful information about how MM can help improve food security in rural Mali, it has limitations. We utilise self-reported data for both MM use and food insecurity (HFIAS), which could lead to recall or social desirability bias. Second, the cross-sectional design makes it difficult to draw conclusions about cause and effect. Longitudinal studies could better show how MM adoption and food security change over time. Third, the study is limited to Koulikoro, which is typical of rural Mali but may not be true for areas that have been affected by conflict or have different climates. Finally, we did not consider how food access or MM use patterns change with the seasons, which could have an effect on the results.

3. RESULTS

3.1. Cross tabulations

We used cross tabulation to explore the relationship between socio-economic factors (e.g. gender, education, age, occupation, and MM usage). Based on the results presented in Table 2, household food security status is significantly associated with several key factors. Geographical location exhibits a strong association ($p < 0.001$), with the food security rate, which varies widely from 27.8% in Mamibougou to 70.3% in Diakitébougou, indicating the crucial role of local context. Land ownership is also a significant differentiator ($p = 0.009$), with landowners experiencing markedly higher food security (62.4%) than non-landowners (43.0%), underscoring land's role as a critical productive asset. The education level is also significant ($p = 0.007$), as a university education correlates with improved food security, likely by enhancing livelihood opportunities and access to information.

Most notably, the use of MM services demonstrates a powerful positive relationship with food security ($p < 0.001$). MM users are substantially more food secure (61.8%) and experience a far lower rate of severe food insecurity (6.6%) compared with non-users. This suggests that financial inclusion via digital platforms may bolster resilience by facilitating access to financial resources. In contrast, factors such as gender, marital status, and specific MM service attributes show no significant associations. Overall, the results underscore the multifaceted nature of food security, highlighting the critical importance of geography, asset ownership, education, and financial inclusion in shaping household-level outcomes.

Table 3 explores the relationship between how the respondents rate the effects of MM on food access and their level of food insecurity. Both the Pearson chi-square test ($\chi^2 = 20.013$, degrees of freedom [df] = 12, $p = 0.067$) and the likelihood ratio test (likelihood ratio = 20.849, df = 12, $p = 0.053$) show a trend for statistical significance, suggesting a weak association. The majority across all food insecurity groups rated the MM impact as 4, indicating a perceived strong benefit. This is especially pronounced among the severely food insecure group, where 60.9% selected this rating. The food secure respondents were more likely to rate MM impact as 5 (33.3%), in contrast to just 6.5% in the severe group. These results imply that while MM is widely perceived as beneficial for food access, the strength of this perception varies across food security levels, with some indication that those with higher insecurity are more cautious in assigning the highest benefit rating.

Table 4 examines how self-rated perceptions of MM benefits vary by household food insecurity status. The Pearson chi-square test indicates there is not a significant association ($\chi^2 = 27.806$, df = 20, $p = 0.114$), but the likelihood ratio test suggests a marginal association (likelihood ratio = 31.576, df = 20, $p = 0.048$). The distribution shows that individuals experiencing mild or moderate food insecurity report stronger perceived benefits from MM. For example, 18.8% of the respondents in the mild food insecurity category rated the benefits of MM as 4, and 6.0% rated it as 5. In comparison, the

Table 2. Association between socio-economic factors and household food security in rural Mali.

Variable	Category	Food secure (n = 154)	Mild insecurity (n = 46)	Moderate insecurity (n = 43)	Severe insecurity (n = 55)	p-value	Significant?
Location	Diakitébougou	64 (*70.3%*)	1 (*1.1%*)	0 (*0%*)	26 (*28.6%*)	<0.001***	Yes
	Katibougou	60 (*60.6%*)	5 (*5.1%*)	17 (*17.2%*)	17 (*17.2%*)		
	Mamibougou	30 (*27.8%*)	40 (*37.0%*)	26 (*24.1%*)	12 (*11.1%*)		
Gender	Female	60 (*48.8%*)	18 (*14.6%*)	17 (*13.8%*)	28 (*22.8%*)	0.460	No
	Male	94 (*53.7%*)	28 (*16.0%*)	26 (*14.9%*)	27 (*15.4%*)		
Marital status	Married	102 (*51.5%*)	32 (*16.2%*)	33 (*16.7%*)	31 (*15.7%*)	0.380	No
	Single	49 (*52.7%*)	12 (*12.9%*)	9 (*9.7%*)	23 (*24.7%*)		
	Widow/widower	3 (*42.9%*)	2 (*28.6%*)	1 (*14.3%*)	1 (*14.3%*)		
Land ownership	No	71 (*43.0%*)	29 (*17.6%*)	27 (*16.4%*)	38 (*23.0%*)	0.009**	Yes
	Yes	83 (*62.4%*)	17 (*12.8%*)	16 (*12.0%*)	17 (*12.8%*)		
Education level	Primary	33 (*37.1%*)	15 (*16.9%*)	18 (*20.2%*)	23 (*25.8%*)	0.007**	Yes
	Secondary	46 (*52.3%*)	18 (*20.5%*)	13 (*14.8%*)	11 (*12.5%*)		
	University	75 (*62.0%*)	13 (*10.7%*)	12 (*9.9%*)	21 (*17.4%*)		
Occupation	Farmer	28 (*46.7%*)	11 (*18.3%*)	12 (*20.0%*)	9 (*15.0%*)	0.769	No
	Trader	23 (*41.8%*)	11 (*20.0%*)	7 (*12.7%*)	14 (*25.5%*)		
	Other	94 (*57.0%*)	20 (*12.1%*)	22 (*13.3%*)	29 (*17.6%*)		
Mobile money usage	No	13 (*18.6%*)	8 (*11.4%*)	9 (*12.9%*)	40 (*57.1%*)	<0.001***	Yes
	Yes	141 (*61.8%*)	38 (*16.7%*)	34 (*14.9%*)	15 (*6.6%*)		
Mobile money use duration	<3 months	10 (*58.8%*)	2 (*11.8%*)	3 (*17.6%*)	2 (11.8%)	0.862	No
	>6 months	130 (*50.0%*)	42 (*16.2%*)	40 (*15.4%*)	48 (*18.5%*)		
Mobile money acceptance	No	7 (*50.0%*)	3 (*21.4%*)	3 (*21.4%*)	1 (*7.1%*)	0.600	No
	Yes	147 (*51.8%*)	43 (*15.1%*)	40 (*14.1%*)	54 (*19.0%*)		
MM reliability	No	90 (*49.5%*)	31 (*17.0%*)	27 (*14.8%*)	34 (*18.7%*)	0.732	No
	Yes	64 (*55.2%*)	15 (*12.9%*)	16 (*13.8%*)	21 (*18.1%*)		
Continue to use mobile money	No	5 (*38.5%*)	2 (*15.4%*)	4 (*30.8%*)	2 (*15.4%*)	0.112	No
	Yes	142 (*52.0%*)	44 (*16.1%*)	39 (*14.3%*)	48 (*17.6%*)		
Mobile money cultural perception	Yes	148 (*52.3%*)	43 (*15.2%*)	43 (*15.2%*)	49 (*17.3%*)	0.076	Yes
	No	6 (*40.0%*)	3 (*20.0%*)	0 (*0.0%*)	6 (*40.0%*)		

Note: ***p < 0.01; **p < 0.05.

respondents in the food secure category were more likely to report either no benefit or minimal impact, with 10 out of 12 assigning a rating below 4. These patterns may indicate that those facing food-related challenges perceive digital financial services as helpful tools in accessing or securing food, though the association is not uniformly strong across all groups.

Table 5 presents the relationship between household food insecurity status and preference for MM relative to physical cash. The Pearson chi-square test ($\chi^2 = 59.63$, df = 20, $p < 0.001$) and the likelihood ratio test (likelihood ratio = 62.85, df = 20, $p < 0.001$) indicate a significant association between the two variables. A substantial proportion of the respondents in the mild, moderate, and severe food insecurity categories expressed a greater preference for MM. Specifically, 75.7% of the respondents in the mild food insecurity category rated their preference as 4 or 5, indicating a clear shift towards MM usage. In contrast, the respondents in the food secure category predominantly prefer cash, with 10 out of 12 assigning the lowest possible score of 0. The trend suggests that food insecure households may view MM as a more reliable or accessible option for managing food needs, possibly due to its flexibility, speed, or reduced transaction barriers. This pattern supports the argument that digital financial tools may play a role in mitigating food insecurity by improving access to resources.

Table 6 presents the results of post hoc pairwise comparisons following a statistically significant Kruskal-Wallis H test, which we conducted to assess the differences in household income distributions across the four HFIAS categories. The analysis revealed a significant effect of the food security category on household income ($p < .001$). Next, we conducted Dunn's pairwise

Table 3. Self-rated impact of mobile money on food access by household food security category.

Self-rated mobile money effect on food access	Food secure	Mild insecurity	Moderate insecurity	Severe insecurity	Total	Row %
0 (No benefit)	0 (*0.0%*)	0 (*0.0%*)	0 (*0.0%*)	0 (*0.0%*)	0	*0.0*
1	0 (*0.0%*)	0 (*0.0%*)	0 (*0.0%*)	0 (*0.0%*)	0	*0.0*
2	0 (*0.0%*)	35 (*24.3%*)	10 (*22.7%*)	9 (*19.6%*)	54	*22.0*
3	2 (*16.7%*)	21 (*14.6%*)	5 (*11.4%*)	6 (*13.0%*)	34	*13.8*
4	6 (*50.0%*)	76 (*52.8%*)	19 (*43.2%*)	28 (*60.9%*)	129	*52.4*
5 (Max benefit)	4 (*33.3%*)	12 (*8.3%*)	10 (*22.7%*)	3 (*6.5%*)	29	*11.8*
Total	12 (*100.0%*)	144 (*100.0%*)	44 (*100.0%*)	46 (*100.0%*)	246*	*100*

Note: *The total number is less than 298 due to missing observations.

Table 4. Association between the dichotomised perception of the benefits of mobile money and food insecurity levels.

Perceived mobile money benefit	Food secure	Mild insecurity	Moderate insecurity	Severe insecurity	Total
0 (No benefit)	2 (*0.7%*)	0 (*0.0%*)	1 (*0.3%*)	0 (*0.0%*)	3
1	1 (*0.3%*)	26 (*8.7%*)	8 (*2.7%*)	6 (*2.0%*)	42
2	0 (*0.0%*)	20 (*6.7%*)	5 (*1.7%*)	9 (*3.0%*)	41
3	1 (*0.3%*)	30 (*10.1%*)	6 (*2.0%*)	8 (*2.7%*)	55
4	10 (*3.4%*)	56 (*18.8%*)	14 (*4.7%*)	22 (*7.4%*)	119
5 (Max benefit)	0 (*0.0%*)	18 (*6.0%*)	11 (*3.7%*)	4 (*1.3%*)	38
Total	12	152	44	41	298

Table 5. Preference for mobile money over physical cash by household food security status.

Mobile money rating	Food secure	Mild insecurity	Moderate insecurity	Severe insecurity	Total	Row %
0 (prefer cash)	10 (*3.4%*)	0	0	5 (*1.7%*)	15	*5.0%*
1	0	11 (*3.7%*)	3 (*1.0%*)	2 (*0.7%*)	16	*5.4%*
2	0	18 (*6.0%*)	3 (*1.0%*)	5 (*1.7%*)	26	*8.7%*
3	0	8 (*2.7%*)	1 (*0.3%*)	4 (*1.3%*)	13	*4.4%*
4	0	74 (*24.8%*)	16 (*5.4%*)	27 (*9.1%*)	117	*39.3%*
5 (prefer mobile money)	2 (*0.7%*)	41 (*13.8%*)	21 (*7.1%*)	6 (*2.0%*)	70	*23.5%*
Total	12 (*4.0%*)	152 (*51.0%*)	44 (*14.8%*)	49 (*16.4%*)	298	*100%*

tests with the Bonferroni adjustment to identify specific group differences. The mean rank differences indicate the direction and magnitude of the disparities in household income between groups. We observed a consistent and statistically significant effect between food security status and household income. The households in the food secure category have a significantly higher median household income than the mild food insecurity category (mean rank difference = 2.69, $p = 0.007$), the moderate food insecurity category (mean rank difference = 3.60, $p = 0.001$), and the severe food insecurity category (mean rank difference = 9.01, $p < .001$). The magnitude of this difference is most pronounced between the food secure and severe food insecurity categories. Furthermore, the households in the severe food insecurity category have a significantly lower median household income than those in the mild food insecurity category (mean rank difference = 4.82, $p < 0.001$) and the moderate food insecurity category (mean rank difference = 3.90, $p < 0.001$). However, there is not a significant difference in household income between the mild and moderate food insecurity categories (mean rank difference = 0.79, $p = 0.214$).

Table 6. Kruskal-Wallis test of household income by the Household Food Insecurity Access Scale food security category

Category comparison	Mean rank difference	Adjusted p-value	Significant?
Food secure vs mild food insecurity	2.694	0.007	Yes
Food secure vs moderate food insecurity	3.601	0.001	Yes
Food secure vs severe food insecurity	9.009	< 0.001	Yes
Mild vs moderate food insecurity	0.794	0.214	No
Mild vs severe food insecurity	4.817	< 0.001	Yes
Moderate vs severe food insecurity	3.900	< 0.001	Yes

Note: The mean rank is the average position that all the observations from a particular group (e.g., food secure) occupy when all the data from all groups are combined and sorted from lowest to highest.

Table 7. Mean comparison by income and remittance between MM Users and frequency of MM remittance

Variable	Frequency_ MM_Remitt	Number	Mean Rank	Kruskal-Wallis H
MM_Remittance	Daily	115	126.61	9.909 (p = 0.042)
	Weekly	68	158.12	
	Monthly	77	155.79	
	Quarterly	17	156.79	
	Annually	9	118.56	
	Total	286		
Family_Income	Daily	115	142.21	10.090 (p = 0.039)
	Weekly	68	167.74	
	Monthly	77	130.68	
	Quarterly	17	134.65	
	Annually	9	103.28	
	Total	286		

Table 7 shows the results of the Kruskal-Wallis test assessing differences in a variable by the frequency of MM remittances and family income. There are significant differences across the categories for both variables. For MM remittances, respondents who receive funds weekly, monthly, or quarterly have higher mean ranks compared with those receiving daily or annual remittances (H = 9.909, p = 0.042). Similarly, family income varies significantly by remittance frequency, with weekly recipients showing the highest mean rank, followed by quarterly and monthly recipients (H = 10.090, p = 0.039). These results suggest that the frequency of MM remittances is associated with variations in the measured variable and the family income levels.

3.2. Censored Tobit regression findings

Table 8 provides the descriptive statistics for the variables used in the censored Tobit regression analysis. The sample consists of 298 households with no missing data.

We employed censored Tobit regression to analyse the factors influencing rural household food insecurity, operationalized by the HFIAS score – a bounded dependent variable ranging from 6 to 30. The initial model was highly significant (Wald $\chi^2(10) = 298.2$, *p* < 0.001), indicating that the collective set of predictors effectively explains variation in food insecurity. The initial model without clustered standard errors (Table 9) underestimated the precision of these estimates. Therefore, the bootstrapped average marginal effects (AMEs) from the village-clustered specification form the definitive basis for our conclusions.

Recognising that households within the same village share unobserved characteristics, we accounted for this clustering to obtain robust standard errors. The results from this preferred specification are presented as AMEs in Tables 10 and 11, derived from the village-clustered model using bootstrapped standard errors (500 replications) to ensure robust inference. These AMEs represent the average expected change in the observed HFIAS score for a unit change in each predictor, holding all other variables constant.

MM use is a potent driver of food security. The AME indicates that, on average, the HFIAS score of MM users is 6.08 points lower (95% CI -8.61, -3.55) than non-users, a highly significant effect (*p* < 0.001). This represents a shift of nearly one full category on the HFIAS severity scale (e.g., from severe to moderate food insecurity).

Household income is another critical factor. A 1% increase in family income is associated with a 1.84 unit decrease in the HFIAS score (95% CI -2.54, -1.14; *p* < 0.001). The education level also confers a significant protective effect. Attaining a university education is associated with a 1.67-point reduction in food insecurity (95% CI -3.30, -0.05; *p* < 0.05), while the effect of secondary education, though negative, is not statistically significant (AME = -1.22, *p* = 0.140). Land ownership remains an important asset, associated with a 1.93-point improvement in food security (95% CI -3.22, -0.64; *p* < 0.01).

Table 8. Descriptive statistics of the censored Tobit regression variables.

Variable	Mean	Median	Standard deviation	Minimum	Maximum	Valid
Hhsize	9.21	8.00	7.11	1	31	298
Age	35.4	30.0	15.8	17	95	298
Gender				0	1	298
Marital_status				1	3	298
Land_ownership				0	1	298
Education_leve				1	3	298
MM_Use				0	1	298
Family_Income	191,716	50,000	577,757	2,000	7200,000	298
HFIAS_Score	12.37	10.00	6.220	6	25	298

Table 9. The result of censored Tobit regression with robust standard errors accounting for heteroscedasticity but no village clustering.

Variable	Estimate	Robust standard error	Average marginal effect	z-value	p-value
Intercept	51.30	7.69			0.00***
Age (cont)	-0.02	0.03	-0.023	-0.640	0.52
Gender (Male)	-0.36	0.73	-0.063	-0.490	0.62
Marital Status (Single/)	-1.21	0.92	-1.101	-1.320	0.19
Marital Status (Widow/Widower)	-0.41	2.25	0.918	-0.180	0.86
Land Ownership (Yes)	-2.81	0.76	-1.888	-3.700	0.00***
MM Use (Yes)	-15.43	8.73	-4.280	-1.770	0.08*
Log of Family Income	-2.99	0.78	-1.745	-3.850	0.00***
Education Level (Secondary)	-2.73	0.89	-2.034	-3.040	0.00***
Education Level (University)	-3.11	0.84	-2.449	-3.710	0.00***
MM × Log Income	1.07	0.85	1.070	1.250	0.21
log (Sigma)	1.734	0.05			

Note: The Tobit model fit the data well (log-likelihood = -771.6, Wald $\chi^2(10) = 298.2$, $p < 0.001$). The model converged after 5 iterations. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

A key finding from the interaction coefficient is that the beneficial effect of MM is moderately stronger for households with lower incomes (MM × log income coefficient = 1.065, *p* < 0.1). This suggests digital financial services play a crucial role in enhancing resilience specifically for the most economically vulnerable.

Conversely, the AMEs for demographic factors such as age, gender, and marital status are not statistically significant, with CIs straddling zero. This likely reflects the strength of communal support systems and collective household strategies that mitigate individual-level vulnerabilities in this context.

4. DISCUSSION

The findings from this study reveal significant diversity in food security outcomes across geographical locations, demographic groups, and socio-economic characteristics, with MM usage emerging as a particularly significant determinant of food security. We found that MM usage has a robust and statistically significant relationship with food security based on several analyses. The preferred Tobit model, accounting for village-level clustering, revealed a strong negative association between MM usage and food insecurity (AME = -6.08, 95% CI -8.61, -3.55, *p* < 0.001). This relationship is corroborated by the descriptive statistics: 141 MM users were food secure compared with only 15 who were severely food insecure. In contrast, 40 non-users reported severe food insecurity. This suggests that MM plays a critical role in enhancing household resilience by facilitating timely financial transactions, reducing transaction costs, and enabling access to remittances and savings. The strength of this effect may be amplified by Mali's unique MM ecosystem, where services such

Table 10. Robustness analysis with village-clustered standard errors.

Variable	Main model	No education	No main income	Village fixed effects
Mobile money user	-17.810*** (5.385)	-18.608*** (5.505)	-17.810*** (5.385)	-17.807** (6.915)
Mobile money × log income	1.065* (0.614)	1.125* (0.632)	1.065* (0.614)	1.018 (0.749)
Log family income	-2.628*** (0.545)	-2.752*** (0.521)	-2.634*** (0.578)	–
Secondary education	-1.224* (0.670)	–	-1.224* (0.670)	-1.086 (0.717)
University education	-1.675*** (0.405)	–	-1.675*** (0.405)	-1.341*** (0.459)
Age	-0.019 (0.018)	-0.007 (0.021)	-0.019 (0.018)	-0.007 (0.015)
Male head of household	0.546 (0.854)	0.537 (0.882)	0.546 (0.854)	0.555 (0.915)
Single	-0.715 (0.677)	-0.778* (0.446)	-0.715 (0.677)	-0.162 (0.966)
Widow/widower	3.131 (2.053)	3.320* (1.890)	3.131 (2.053)	1.509 (1.997)
Farmland owner	-1.934 (1.676)	-1.925 (1.671)	-1.934 (1.676)	-1.354 (1.643)
Katibougou (village)	–	–	–	-0.128 (0.088)
Mamibougou (village)	–	–	–	2.623*** (0.218)
Constant	47.305*** (4.687)	47.319*** (4.337)	47.305*** (4.687)	45.966*** (4.798)
Village clustering	Yes	Yes	Yes	Yes
Village fixed effects	No	No	No	Yes
Observations	298	298	298	298
Log-likelihood	-771.626	-774.137	-771.626	-763.096

Note: Standard errors clustered at the village level are presented in parentheses. ***p < 0.01; **p < 0.05; *p < 0.1.

Table 11. Average marginal effects of the main model.

Variable	Average marginal effect	Standard error	95% confidence interval	p-value
Mobile money user	-6.08	1.29	[-8.61, -3.55]	< 0.001***
Log family income	-1.84	0.36	[-2.54, -1.14]	< 0.001***
Age	-0.02	0.03	[-0.07, 0.03]	0.478
Male head of household	0.55	0.69	[-0.80, 1.89]	0.426
Single	-0.72	0.79	[-2.26, 0.83]	0.365
Widow/widower	3.13	1.95	[-0.68, 6.95]	0.108
Farmland owner	-1.93	0.66	[-3.22, -0.64]	0.003***
Secondary education	-1.22	0.83	[-2.85, 0.40]	0.140
University education	-1.67	0.83	[-3.30, -0.05]	0.044*

Note: Marginal effects were computed from the Tobit estimates. Bootstrapped standard errors (500 replications) were calculated to ensure robust inference given the relatively small sample size. ***p < 0.01; **p < 0.05; *p < 0.1.

as Orange Money and Wave dominate rural areas with extensive agent networks, bridging gaps left by scarce traditional banking infrastructure. Our findings align with the study by Murendo, Wollni (2016), who showed that MM adoption significantly affects food security in Uganda. Our analysis also revealed that households that perceived a strong effect of MM on food security showed a clear improvement in food security outcomes. On the other hand, households that perceived no effect of MM on food security experienced the highest rates of severe food insecurity. The 'yes effect' group, which included households acknowledging the positive influence of MM, reported fewer severe cases compared with the 'no effect' group, highlighting the importance of both actual and perceived financial inclusion in driving behaviour and access to resources.

Contrary to the findings of some studies (e.g., Atta-Aidoo *et al*., 2024; Aliyu *et al*., 2022), we did not find a significant independent association between gender or marital status and food security outcomes in our robust model (the 95% CIs for the AMEs included zero), despite some apparent differences in the descriptive data. This suggests that, in this specific context, the potential effects of these demographic factors may be mitigated by other variables in the model, such as income, land ownership, and MM use. The lack of a significant gender

effect could be attributed to the strong communal and kinship support systems noted earlier, where food provisioning responsibilities are often shared regardless of the gender of the head of household (Allotey *et al*., 2022). Similarly, the nonsignificant effect of marital status may reflect the social safety nets that absorb widowed or unmarried individuals into broader family units, reducing their economic vulnerability (Diamoutene, Jatoe, 2024). This shows the critical role of the local cultural context in shaping food security determinants, suggesting that the disparities observed in other regions may not be as prevalent in the studied communities of Mali due to these protective social structures.

Our findings highlighted that owning land is an important factor in food security (AME = -1.93, 95% CI -3.22, -0.64, *p* < 0.01). Households without land were more likely to experience food insecurity compared with landowners. The positive correlation between land ownership and food security has been well documented in the literature. For example, the ownership of land has consistently been shown to correlate with improved food security outcomes, as land ownership enables more reliable agricultural production and income generation (Sidibé *et al*., 2018). Owning land is a critical factor in ensuring access to food in rural areas because it affects household nutrition and food security. Research conducted in India (Goli *et al*., 2021; Pritchard *et al*., 2017) and Nicaragua (Schmook *et al*., 2021) has demonstrated the significant impact of agricultural landholding on food insecurity levels, with households that own land having better access to essential food items. Furthermore, the connection between smallholder food insecurity and land access and tenure reveals the persistent issue of hunger among rural populations, regardless of political alignments or land tenure arrangements. The importance of land ownership is emphasised because secure access to land can enhance welfare; income; and investment in food, health, and education, ultimately contributing to reduce poverty and to spur economic development.

We found that the education level, particularly a university education, significantly improves food access (AME = -1.67, 95% CI -3.30, -0.05, *p* < 0.05). The respondents with a university education had higher food security outcomes, likely due to better access to formal employment, information on nutrition and health, and financial literacy. The results of this study are similar to the findings of Ishfaq*et al.* (2022) in Pakistan: the education level positively affects the food security status. The higher the education of the family head, the better the household food security will be.

From an occupational viewpoint, households classified under 'others' and those involved in trade showed higher food security, whereas farmers were distributed across all food security categories, including severe insecurity. According to Atta-Aidoo *et al.* (2024), households with diverse occupations other than farming are not exposed to the seasonal fluctuations associated with agriculture and on-farm income. Such households are therefore able to secure adequate food throughout the year with little or no difficulty. The findings of this study are in line with that of Dzanku (2019) and Regmi, Paudel (2016), who indicated that off-farm income has a positive correlation with household food security.

The comparison between MM and cash revealed that households attributing stronger effects to MM over physical cash were significantly more likely to be food secure, highlighting the potential of digital finance as a major instrument for promoting rural food resilience. This result is consistent with the findings of Munyegera, Matsumoto (2016) and Yao *et al.* (2023), who showed that households that adopt MM have an advantage compared with non-adopters, mostly in terms of remittances, which gives them the capacity to withstand food security during shocks.

According to the findings of the study, family income positively increases the probability of a household to be food secure. The Kruskal-Wallis test results support the importance of income in determining food security. We observed statistically significant differences across all but one category comparison (i.e., mild vs moderate food insecurity). Food secure households had higher income than all other categories. Consistently, Achilana *et al.* (2020) and Abdallahh *et al.* (2024) have shown that lower-income households struggle to afford healthy foods, which affects their food security status.

5. CONCLUSION AND RECOMMENDATIONS

This study has revealed the vital role of MM in enhancing food accessibility and affordability in rural Mali, where digital remittances and land ownership emerge as key determinants of household resilience. By facilitating timely income streams, reducing transaction costs, and bridging gaps in formal financial access, particularly in underserved regions such as Koulikoro, MM services such as Orange Money have demonstrated measurable impacts on food security. Our findings from Koulikoro are scalable and can be replicated in the larger Malian context, including areas plagued with conflicts and climate stress. Moreover, the full potential of these tools cannot be fully exploited without addressing systemic barriers, from gender-based resource disparities to land tenure insecurity and climate vulnerabilities.

Based on our findings, we propose several recommendations to policymakers and stakeholders aiming to enhance food access and reduce food insecurity in rural areas. We recommend policies that promote income generation and secure property rights.

Mali, like many rural regions in sub-Saharan Africa, has seen growth in mobile phone usage and MM services, particularly in urban areas. However, many rural households still lack consistent access to income opportunities. Expanding digital remittance platforms can help connect migrant workers with their families in rural Mali, providing them with a frequent income that can be used for food, health, and education. This would be particularly beneficial given the high reliance on remittances in rural areas.

Access to financial services in rural Mali is limited, particularly for women and smallholder farmers. Expanding financial services, such as microcredit, savings groups, and insurance, would give Malian households the tools to invest in agricultural improvements and to manage financial risks. This is crucial in a country where many are vulnerable to environmental and economic shocks. Improving financial inclusion could lead to greater stability and security for households, enhancing their ability to access food.

Gender inequality in Mali is a significant issue, with women often having limited access to resources such as land, credit, and education. By adopting gender-transformative policies in agriculture, Mali could address this imbalance. Empowering women with equal access to agricultural resources would not only enhance their productivity but also improve household food security. Ensuring women's participation in decision-making processes related to agriculture and food systems could result in more sustainable and inclusive food security outcomes.

In Mali, land tenure insecurity is a key factor limiting agricultural investment and productivity. Smallholder farmers, particularly in rural areas, face difficulties in securing land rights due to historic and legal challenges. Reforming land tenure systems to provide clearer, more secure land rights would encourage farmers to invest in long-term agricultural improvements, leading to increased productivity and food availability. Secure land tenure could also reduce land conflicts, particularly in areas affected by displacement due to conflict.

Malian farmers face challenges from climate change, drought, and soil degradation. Diversifying agricultural practices and promoting innovations such as drought-resistant crops, improved irrigation, and climate-smart agriculture could help buffer against these challenges. Policies that support agricultural diversification can also reduce the dependency on a single crop (e.g., millet or cotton) and improve household income stability, leading to better food access and improved resilience to shocks. Traditional markets are often disrupted in certain parts of Mali due to insecurity, leading to higher food prices and reduced access to essential goods. Strengthening local markets and supply chains, especially in rural areas, could help reduce the reliance on external food sources and ensure that food is more readily available. By improving rural infrastructure and market access, local food systems can be made more resilient to external shocks, like conflicts or price volatility.

To build upon this work, future research should move beyond observational data to establish causal evidence, perhaps through experimental designs such as a randomised rollout of MM services. This would allow for a clearer understanding of its true impact. Furthermore, it is critical to investigate not just if MM works, but for whom and under what conditions. This endeavour entails an examination of how its benefits are distributed across different segments of society, particularly along the lines of gender, age, and vulnerability, to ensure that it does not inadvertently widen existing inequalities. The local ecosystem is also paramount; studies should explore how the effects of MM are amplified or constrained by factors like network coverage, agent density, and access to markets. Finally, given the increasing pressures of climate change, a vital avenue for research is to determine whether MM can serve as a real-time financial cushion against shocks such as droughts, and how it can be most effectively integrated with broader support systems, such as agricultural extension programmes or social protection schemes, to create a more resilient food security framework for the future.

AUTHOR CONTRIBUTIONS

OAO.: Writing, Conceptualization, Methodology, Statistical analysis. P.S.: Data curation, Writing- Original draft preparation. TD: Data collection, Editing, and Proof reading. NLN: Writing, Proof reading, conceptualization. ID: Data cleaning, and Statistical analysis.

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Entrepreneurial profiles of Italian professional farms

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Abstract. This paper analyses the prevailing entrepreneurial profiles within Italy's professional agricultural sector, using data from the 7th Italian National Institute of Statistics (ISTAT) Agricultural Census, 2020. Access to micro-data from the complete spectrum of Italian farms allowed us to perform to an extensive analysis of the entrepreneurial profiles. Moving from market-oriented farms with stable market relationships and a minimum threshold of economic production, we identified nine distinct profiles by using hierarchical cluster analysis and a set of structural and managerial indicators supported by the current literature. These profiles vary significantly in terms of the age of farmers, the economic size of farms, the type of farming, human capital, and strategic orientation. The age of farmers is a particularly powerful variable to discriminate among the entrepreneurial profiles. Although young farmers are often more innovative than older ones, the spectrum of entrepreneurship is wide and diverse, especially regarding the diversification of activities. Our results confirm a complex picture of farm management in Italy, where corporate businesses integrated into the agro-food system coexist with small farms and part-time farmers. Such representation calls for more targeted public support policies that address specific needs and potential role of different types of farmers.

Keywords: Italian agriculture, census, entrepreneurial profiles, market-oriented farms, cluster analysis.
JEL codes: Q10, Q12, Q13.

HIGHLIGHTS:

- We identified nine distinct entrepreneurial profiles, ranging from innovative to more traditional farmers.
- Some profiles have a greater propensity for innovation and diversification, but the prevalent profile in Italian agriculture shows a low to medium entrepreneurial attitude.
- Generational renewal does not automatically lead to innovation; some young farmers appear to align with less innovative agricultural businesses.
- The findings confirm that there is a diverse array of farm types in Italy and suggest there is a potential mismatch with current public support policies.

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1. INTRODUCTION

Entrepreneurship in agriculture is a complex issue that encompasses multiple theoretical definitions. It moves from the standard definition given by non-economists and includes empirical aspects related to the behaviour, knowledge, skills, and ability of entrepreneurs to interact with society. The central element is a subject who identifies and evaluates business development opportunities and makes the appropriate decisions to pursue them (Lans *et al*., 2013). Unlike the classic objectives of profit maximisation and production efficiency, contemporary agricultural entrepreneurs have broadened their decision-making set of choices by adapting resources to respond effectively to growing socio-economic and environmental pressures and challenges. While this is evident in contemporary farm organisation, the objectives of entrepreneurs depend on the type of entrepreneur who manages the on-farm activities (McElwee, 2008; McElwee *et al*., 2012; Milone, 2024).

Recent theoretical frameworks of new entrepreneurship in agriculture have emphasised changes and strategies that have emerged as a response to integrated production systems which primarily support global value chains. These frameworks have identified a wide spectrum of strategies and production factors that reflect the role of agricultural activities in rural areas, the physical and economic sizes of farms, the range of income diversification in favour of on-farm activities, and the perspective of a generational renewal of farm holders (Herman, 2025; Salvioni *et al*., 2020). Moreover, social and environmental concerns are becoming a key part of decision-making, so economic returns are no longer the only driver in the entrepreneurial approach to agriculture (Seuneke *et al*., 2013; Poponi *et al*., 2021; Passaro, Randelli, 2022). This new entrepreneurship aims to create novel production modes based on product differentiation, activity diversification, collective action, and proximity relationships (Dias *et al*., 2019; Condor, 2020). This theoretical framework is consistent with Italian agriculture, which is characterised by great diversity in terms of the form and scope: from self-consuming micro-farms to corporate businesses integrated into the agri-food system. This is also consistent with the European model of agriculture, which features the coexistence of business models based on diversified farms, mostly family-run and part time, producing a wide range of differentiated products (Cardwell, 2004; Korkeaoja, 2006). However, in our view the prevailing and coexisting entrepreneurial models in Italian agriculture have been long neglected and need to be better explored in the light of the deep changes occurring in the primary sector and in rural areas, as demonstrated by long-term changes reported by several authors (Fabiani, Scarano, 1995; Fanfani, 2008; Sardone, 2012; Sotte, Arzeni, 2014; Henke, Sardone, 2020). The 7th Italian National Institute of Statistics (ISTAT) Agricultural Census, 2020, has provided an updated and detailed picture of the agricultural sector in Italy, allowing for a deeper analysis of its complex entrepreneurial landscape (Dias *et al*., 2019).

As highlighted in a systematic review of entrepreneurship in agriculture (Condor, 2020), there are different streams of the literature based on the concepts of structural changes and business diversification. Since the 1990s, many researchers have shown how small family farms have the same entrepreneurial skills as other larger businesses. Other studies have focused on the external factors affecting farm entrepreneurship, such as the diversification of activities and the supply of services, which became a challenge for farmers and their families. In Italy, we can identify three main waves of studies focusing on the issue of agricultural entrepreneurship. The first wave has used the ISTAT Agricultural Census to investigate how Italian agriculture has transformed over time, with specific attention to its structural and entrepreneurial changes (Barbero, 1982; Fabiani, Scarano, 1995; Russo, Sabbatini, 2005). Most of these studies explained the differences in farm structures and entrepreneurial behaviours in terms of physical and economic sizes, labour, product specialisation. The second wave focused on specific structural dynamics of Italian farms, especially on innovation, multifunctionality; and the relationships between primary productions and production of public goods and eco-services, and relative support policies (Rete Rurale Nazionale, 2011; Devitiis, Maietta, 2013; Salvioni *et al*., 2013; Vanni, 2013; Arzeni, Sotte, 2014). The inclusion of new economic, social, and environmental variables from the census has enriched our understanding of territorial differences, particularly concerning market relationships and the functional diversification of on-farm activities. These expanded datasets, whether policy driven or focused on territorial disparities, have recently spurred numerous studies on agricultural entrepreneurship, representing the third wave of studies (Mantino, Vanni, 2018; Salvioni *et al*., 2020; Henke, Sardone, 2022).

The 7th ISTAT Agricultural Census from 2020 has further broadened the spectrum of data, introducing new information which helps to complete the picture of changes in Italian agriculture. These new relevant elements include diversification, generational change, and the level of sustainability in agriculture (Henke, Sardone, 2022; Licciardo *et al*., 2023; Gismondi, 2024).

In Italy, 93% of farms are run by individual families. Their activity is linked to a diverse array of demographic, structural, economic, environmental, and social factors. It is crucial to investigate the diversity of agricultural entrepreneurs operating in Italian farms (based on these factors) and the actions they take to produce both private and public goods. Therefore, this study aimed to identify and discuss the prevailing entrepreneurship profiles in professional Italian agriculture, utilising the new elements offered by the 7th ISTAT Agricultural Census, adopting selective criteria to focus on farms with stable market relationships. The identification of prevailing and emerging entrepreneurial profiles in market-oriented (or professional) agriculture is relevant not only for scientific purposes, but also for a better understanding of the structural changes occurring in the Italian agricultural sector, following the main dynamics of the European model of agriculture. This in-depth analysis is relevant to connect the main features of contemporary professional agriculture, decisions about on-farm activities, and management, providing comprehensive data on on-going evolution, and targeting agricultural policies. It is worth noting that the identification of main entrepreneurial profiles moving from micro-data collected by the 7th ISTAT Agricultural Census rather than from *ad hoc* surveys or interviews is rather innovative and requires extensive preliminary work regarding data selection, elaboration, and stratification. Nevertheless, we think that the results are meaningful and contribute to advance the knowledge in the field and support analysis for policy design and implementation.

2. DATA AND METHODOLOGY

Before describing the methodology used in this study, it is necessary to describe the two concepts on which this analysis is based: market-oriented farms (MOFs) and the level of entrepreneurship. MOFs have a prevalent economic objective: to obtain from product and service sales[1] an income that is adequate to support at least the farm manager. We can therefore assume that these farmers have an entrepreneurial approach to business management, which involves strategic decisions to achieve the economic objective. The level of entrepreneurship increases as the complexity and risk related to these choices increase. For example, those who make innovative investments have a greater propensity to take risks in their business. Based on this consideration and our review of the literature (see citations in Section 2.2 and Table 1), we identified several variables associated with different levels of entrepreneurship. They are shown in the last column of Table A.1.

Differently from other contributions (e.g. Weltin *et al.*, 2017; Graskemper, 2021a), we applied our methodology to the entire agricultural farm population based on the micro-data collected by the 7th ISTAT Agricultural Census. Our combination of micro-data and a multivariate approach allowed us to examine entrepreneurial diversity of Italian agriculture in depth. These insights could inform future research that uses more sophisticated methodologies.

Figure 1 illustrates our methodological approach and the data flow followed in this study. We identified and classified MOFs by using a set of indicators of entrepreneurial characteristics and behaviours and then associated each group with a distinct entrepreneurial profile. Finally, we compared the profiles were compared to each other to highlight their similarities and differences.

2.1. Data

The analysis is based on the micro-data[2] of the 7th ISTAT Agricultural Census, which includes 1,133,006 farms nationwide. The census questionnaire consists of eight sections to collect information on land use, the type and size of livestock farms and their management, environmental considerations, the presence and type of other gainful activities, the characteristics of the farm manager, generational renewal, marketing of farm products, workforce, digitalisation, and innovation, among others. Therefore, the collected data are mainly structural in nature, but the census also provides valuable classifications of farms based on economic size and farming type.

We selected the specific variables used in this study from more than 600 items in the census questionnaire. Of these, approximately 400 items are strictly agronomic, relating to the species cultivated and the breeds raised, as well as to certain purely technical aspects. Many values are missing among the remaining variables: only about 150 items remained effectively usable, including the various response modalities, such as over 20 options for farm diversification activities.

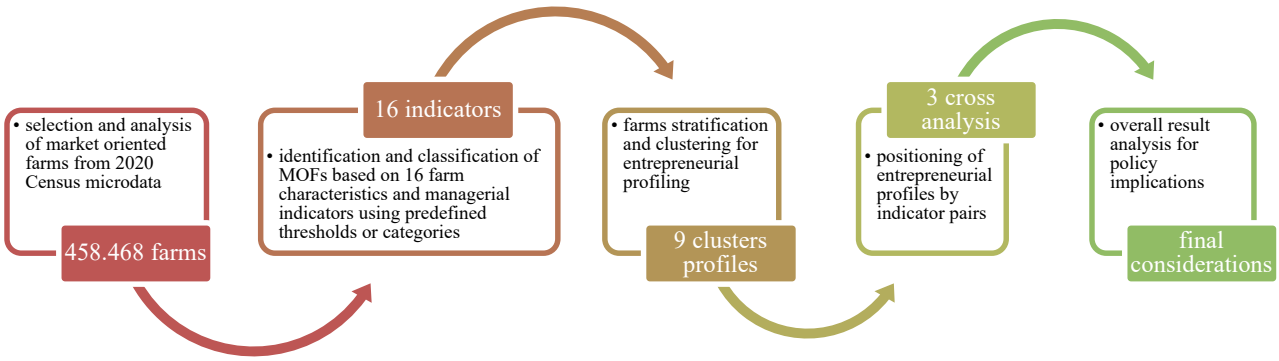
2.2. Methodology

We excluded farms with a standard output (SO) of <8,000 euros, as these are considered non-commercial holdings (non-market-oriented) and mainly oriented towards social strategies (Rete Rurale Nazionale, 2011;

[1] Where sales cover all possible commercial channels used for income generation.

[2] To extract and organise the census data we used SAS version 9.4.

Figure 1. The methodological steps followed in this study and the flow of data.



Source: developed by the authors.

Condor, 2020). Thus, we focused on MOFs which (i) sell their products/services on the market, including each possible channel; (ii) consume less than 100% of their products; and (iii) have a minimum SO of 8,000 euros (Figure 1). While only 40.5% of the farms recorded by the census are MOFs, they represent a larger share of the utilised agricultural area (UAA) and economic output.

We characterised the MOFs by selecting a smaller set of variables from the census data (Table 1) to identify groups based on farm characteristics and activities. We selected these variables by cross-referencing them with the scientific literature published since the early 2000s. They are associated with key characteristics of various entrepreneurial profiles in agriculture (van der Ploeg, 2009; Carelsen *et al.*, 2021; Pappa *et al.*, 2021; Schnebelin, 2022), or have been used in the literature to analyse the behaviours of farmers (Köbrich *et al.*, 2002; van der Ploeg, 2009; Salvioni *et al.*, 2013; Weltin *et al.*, 2017; Bartkowski *et al.*, 2022 López-Felices *et al.*, 2023; Gómez-Limón *et al.*, 2024) or to identify the determinants driving farm management choices (Vandermersch, Mathijs, 2002; Seuneke *et al.*, 2013; Kuswardhani *et al.*, 2014; Pindado, Sánchez, 2017; Bartkowski, Bartke, 2018; Daxini *et al.*, 2019; Corsi *et al.*, 2021; Graskemper *et al.*, 2021a, 2021b).

We grouped the variables into five thematic areas which reflect key entrepreneurial operational contexts for the farm managers: market relations, human capital, economic size and production orientation, work organisation, and strategic entrepreneurial orientation. We used these thematic areas to provide information about the types of entrepreneurial behaviour and choices.

We chose the hierarchical cluster analysis method[3] to classify farms because it has been widely used in the literature to group similar observations for some common characteristics. Due to the large number of MOF observations (>450,000), we first stratified them by three key variables considered in the literature as the most significant in discriminating the main entrepreneurial characteristics of farms: age[4] (3 classes), economic size (3 classes) and type of farming (4 classes).

We applied the cluster method to the frequency distribution of farms across these three classes with those of the other selected variables. The resulting matrix dimensions are 36 rows by 31 columns, a portion of which is shown in Table A.2. Each row of the matrix identifies a unique age/size/type data combination (observation unit), used by the cluster method to measure the similarity. This approach aggregates groups formed by combinations of the three classes, rather than single farms. Regarding the main stratification, we can assume that demographic, economic and managerial affinities constrain possible management choices and therefore also entrepreneurial behaviours. The results of the cluster analysis highlighted nine groups, each of which represents an entrepreneurial profile. We characterised these profiles using specific indicators such as propensity for innovation, work commitment, and environmental sustainability.

[3] We used the Complete linkage algorithm with Euclidean distance calculated using the Hclust procedure in R (version 4.4.1).

[4] In particular, age is one of the most analysed entrepreneurial factors in the agricultural literature and often considered as crucial for farms development (Graskemper *et al.*, 2021b). Furthermore, farmers under 40 years old can access European contributions specifically for young agricultural entrepreneurs, as a target of specific policies within the Common Agricultural Policy (CAP).

Table 1. The thematic areas and variables selected within the 7th ISTAT Agricultural Census, 2020, and the related scientific literature.

Thematic areas	Variables	Relevant references
Market relations	Sales revenue (%) Self-consumption (%)	Fabiani, Scarano, 1993; Salvioni *et al*., 2013; Carelsen *et al*., 2021; Schnebelin, 2022
Human capital	Age of the farm manager	Vandermersch, Mathijs, 2002; Kuswardhani *et al*., 2014; Pindado, Sánchez, 2017; Bartkowski, Bartke, 2018; Daxini *et al*., 2019; Bartkowski *et al*., 2022; Corsi *et al*., 2021; Graskemper *et al*., 2021a, 2021b; Pappa *et al*., 2021; Schnebelin, 2022; López-Felices *et al*., 2023; Gómez-Limón *et al*., 2024
	Management experience	Köbrich *et al*., 2002; Vandermersch, Mathijs, 2002; Kuswardhani *et al*., 2014; Pindado, Sánchez, 2017; Bartkowski, Bartke, 2018; Pappa *et al*., 2021; López-Felices *et al*., 2023
	Education level	Vandermersch, Mathijs, 2002; Seuneke *et al*., 2013; Kuswardhani *et al*., 2014; Weltin *et al*., 2017; Pindado, Sánchez, 2017; Bartkowski, Bartke, 2018; Daxini *et al*., 2019; Bartkowski *et al*., 2022; Corsi *et al*., 2021; Graskemper *et al*., 2021a, 2021b; Pappa et al., 2021; Schnebelin, 2022; López-Felices *et al*., 2023
Economic size and production orientation	Standard output	van der Ploeg, 2009; Daxini *et al*., 2019; Schnebelin, 2022
	Type of farming	Salvioni *et al*., 2013; Seuneke *et al*., 2013; Weltin *et al*., 2017; Daxini *et al*., 2019; Bartkowski, Bartke, 2018; Bartkowski *et al*., 2022; Corsi *et al*., 2021; Graskemper *et al*., 2021b; Schnebelin, 2022
	Organic certification	Salvioni *et al*., 2013; Weltin *et al*., 2017; Graskemper *et al*., 2021b; Schnebelin, 2022; López-Felices *et al*., 2023
Work organisation	Extra-family work force	Weltin *et al*., 2017; Carelsen *et al*., 2021; Schnebelin, 2022; López-Felices *et al*., 2023
	Outsourcing services	Vandermersch, Mathijs, 2002; Schnebelin, 2022; Gómez-Limón *et al*., 2024
	Off-farm work commitment of manager	Köbrich *et al*., 2002; Weltin *et al*., 2017; Daxini *et al*., 2019; Bartkowski *et al*., 2022; Graskemper *et al*., 2021a, 2021b; Gómez-Limón *et al*., 2024
Strategic entrepreneurial orientation	Participation in associations	Vandermersch, Mathijs, 2002; Bartkowski, Bartke, 2018; Graskemper *et al*., 2021a; Graskemper *et al*., 2021b; Pappa *et al*., 2021; Schnebelin, 2022
	Other gainful activities (diversification)	Vandermersch, Mathijs, 2002; Salvioni et al., 2013; Seuneke *et al*., 2013; Weltin *et al*., 2017; Bartkowski, Bartke, 2018; Graskemper *et al*., 2021a, 2021b; Schnebelin, 2022
	Innovation investments	Bartkowski, Bartke, 2018
	Information technology tools	Vandermersch, Mathijs, 2002; Bartkowski, Bartke, 2018; Bartkowski *et al*., 2022; Carelsen *et al*., 2021; Schnebelin, 2022; López-Felices *et al*., 2023
	Leased land	Gomez-Limon *et al*., 2024

Note: each variable was categorised following the classification shown in Table A.1.
Source: developed by the authors.

3. RESULTS AND DISCUSSION

3.1. Farm characteristics

Before presenting the results, we show the stratification of farms in Table 2. After a short description of their main characteristics, we associate these features with distinct entrepreneurial profiles resulting from the cluster analysis.

Young farmers (≤40 years old) represent 15% of MOFs, a higher share than the total population (9%). Intermediate farmers (between 41 and 67 years old) are the largest group (57%), while 28% of farmers of over 67 years of age are still active, despite being well above retirement age.

MOFs are concentrated in the two lower economic size classes, which together represent nearly 80% of the total. There are significant differences in SO across the age groups. Among young farmers, the intermediate SO class (25,000-100,000 euros) is the most common (45%), with an equal distribution for the other two SO classes. For the older farmers, the lowest SO class is most common. Finally, the middle-aged farmers have a more balanced distribution regarding the SO classes. The most common agricultural type among the MOFs is permanent crops, which includes almost 40% of the production units. The mixed type is the least common (12%), indicating that 88% of MOFs are involved in specialised production. Regarding the age groups, livestock orienta-

Table 2. Distribution of market-oriented farms by age group, economic size, and type of farming.

Age (years)	Type of farming	Standard output (thousands of euros)			Total
		8-25	25-100	≥100	
		Number of farms (units)			
	Field crops	6,285	8,310	4,785	19,380
	Permanent crops	7,397	11,253	4,790	23,440
≤40	Livestock	2,541	6,895	6,627	16,063
	Mixed	3,395	4,523	1,822	9,740
	Total	19,618	30,981	18,024	68,623
	Field crops	33,089	30,310	18,071	81,470
	Permanent crops	39,017	41,042	17,648	97,707
41-67	Livestock	9,195	20,230	22,140	51,565
	Mixed	12,783	12,925	5,976	31,684
	Total	94,084	104,507	63,835	262,426
	Field crops	25,512	13,780	5,063	44,355
	Permanent crops	29,119	20,109	5,353	54,581
>67	Livestock	4,051	5,350	4,659	14,060
	Mixed	7,887	4,976	1,560	14,423
	Total	66,569	44,215	16,635	127,419
Grand total		180,271	179,703	98,494	458,468
		Share of grand total (%)			
	Field crops	*1.4*	*1.8*	*1.0*	*4.2*
	Permanent crops	*1.6*	*2.5*	*1.0*	*5.1*
≤40	Livestock	*0.6*	*1.5*	*1.4*	*3.5*
	Mixed	*0.7*	*1.0*	*0.4*	*2.1*
	Total	*4.3*	*6.8*	*3.9*	*15.0*
	Field crops	*7.2*	*6.6*	*3.9*	*17.8*
	Permanent crops	*8.5*	*9.0*	*3.8*	*21.3*
41-67	Livestock	*2.0*	*4.4*	*4.8*	*11.2*
	Mixed	*2.8*	*2.8*	*1.3*	*6.9*
	Total	*20.5*	*22.8*	*13.9*	*57.2*
	Field crops	*5.6*	*3.0*	*1.1*	*9.7*
	Permanent crops	*6.4*	*4.4*	*1.2*	*11.9*
>67	Livestock	*0.9*	*1.2*	*1.0*	*3.1*
	Mixed	*1.7*	*1.1*	*0.3*	*3.1*
	Total	*14.5*	*9.6*	*3.6*	*27.8*
Grand total		*39.3*	*39.2*	*21.5*	*100.0*

Source: elaborations based on the ISTAT Agricultural Census, 2020.

tion is particularly notable for the young farmers, whereas permanents crops are particularly relevant for older farmers (43%).

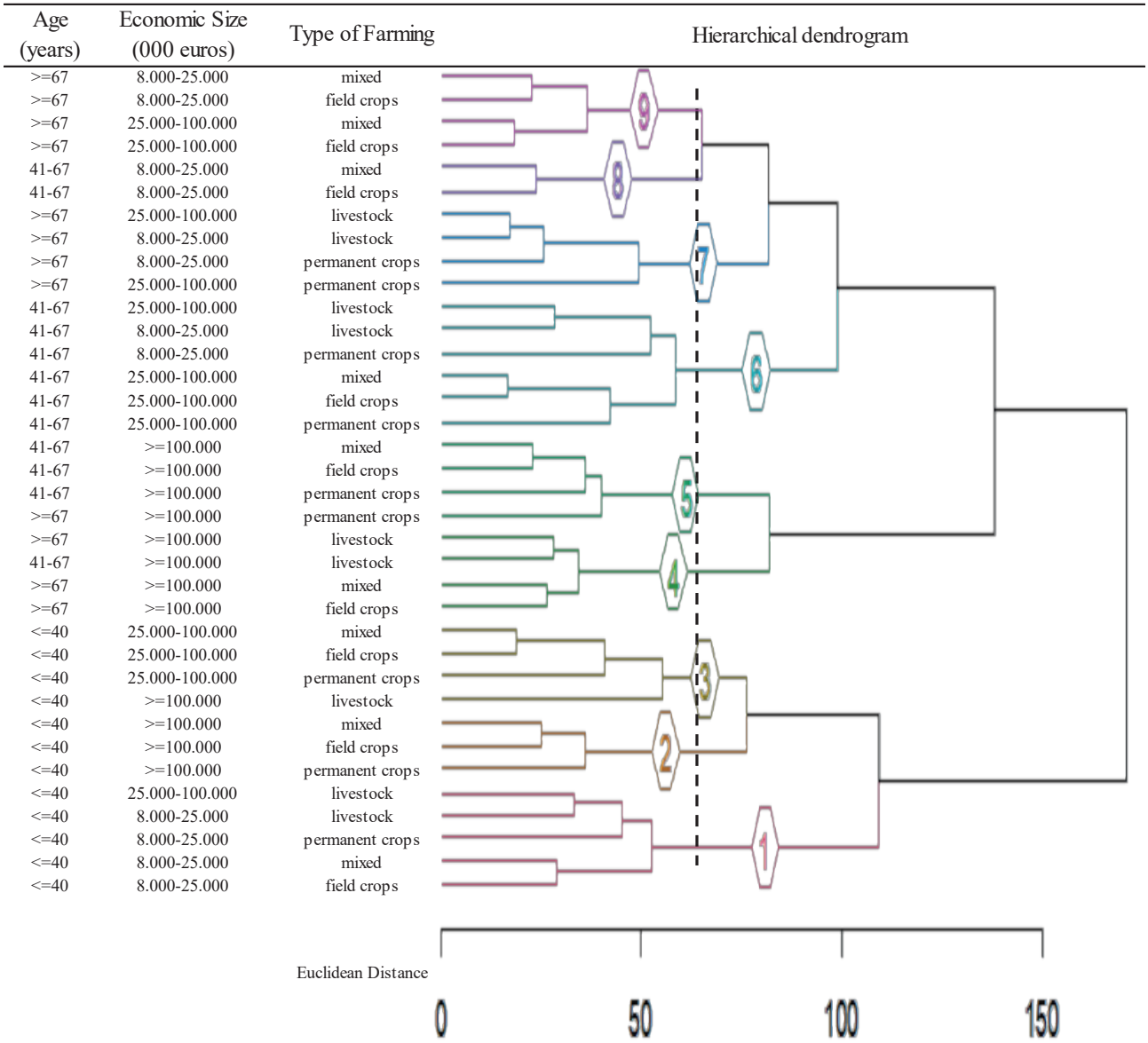
3.2. Presentation and discussion of the entrepreneurial profiles

The dendrogram in Figure 2 graphically represents the aggregation process of the groups from left to right. The black dotted line marks the cut-off position where the nine groups[5] are formed by the clustering process.

We developed specific entrepreneurial profiles based on these clusters by assigning each farm to a specific

[5] We determined the number of clusters by analysing the dendrogram to identify the distance at which observations are most similar to each other but dissimilar from those of the other groups (branch length). A smaller distance would have generated excessive fragmentation of the groups (with one consisting of a single observation), while a greater distance would have aggregated the visibly different groups 8 and 9. This is an empirical method widely used in the literature for hierarchical clustering (Boyko, Tkachyk, 2023; Salvador, Chan, 2004).

Figure 2. The clustering process.



Source: elaborations based on the ISTAT Agricultural Census, 2020.

group. Table A.3 indicates the characteristics which determined the homogeneity and dissimilarity of the clusters. The maximum and minimum values by row (cells with bold and italic text, respectively) indicate the most defining variables for each profile. Table 3 lists the identified profiles, their share on total MOFs and the probability values[6] that estimate the clusters robustness.

Clusters 1-3, which include young farmers, are clearly distinct from clusters 4-9. The first group (5.8% of MOFs) includes young farmers with the highest incidence of the following answers: "no" for outsourcing services, "less than three years" regarding management experience, and "diploma and degree from other

[6] The Approximately Unbiased (AU) p-value is a parameter calculated using multiscale bootstrap resampling (R procedure PVclust) to estimate of a cluster's strength compared to the standard bootstrap probability. For most clusters, the parameter values exceeded 90%, indicating the high reliability of the clustering results. Only the seventh cluster showed lower stability and was more sensitive to variability in the input data.

Table 3. Entrepreneurial profiles of professional active farms (MOFs).

Profile	Characterisation	% share of total	AU p-value (%)
1	Young farmers looking for a stable professional status	*5.8*	*94*
2	Innovative and diversified young entrepreneurs	*2.5*	*91*
3	Young farmers in the entrepreneurial development phase	*6.7*	*93*
4	Experienced entrepreneurs of structured livestock farms	*7.3*	*89*
5	Experienced entrepreneurs of diversified structured farms	*10.3*	*93*
6	Senior farmers of traditional farms	*33.3*	*96*
7	Older entrepreneurs of de-structured small to medium-sized farms	*12.8*	*84*
8	Part-time farmers of less specialised small farms	*10.0*	*98*
9	Older entrepreneurs of declining small to medium-sized farms	*11.4*	*100*

Source: elaborations based on the ISTAT Agricultural Census, 2020.

schools" for the education level. They have the lowest off-farm commitment and participation in associations. These characteristics suggest a profile of young farmers with a fair level of education who mainly work on the farm, but its economic size is insufficient to fully support them. We define them as "young farmers looking for a stable professional status".

The second group (2.5% of MOFs) refers to managers under 40 years of age who have established themselves as agricultural entrepreneurs, manage structured farms (based on the SO), and have specific agricultural education. They are involved in diverse, innovative activities, including organic production and the use of information technology (IT) tools for business management, and participate in producer associations. They do not engage in livestock activities. They are therefore "innovative and diversified young entrepreneurs" who take advantage of the opportunities offered by new technologies and market trends, opting to farm land without the need to purchase it.

The third group of young farmers (6.7% of MOFs) is intermediate between the two previous profiles. They have managed medium-sized businesses for over three years and are predominantly engaged in agricultural activities. They can be labelled "young farmers in the entrepreneurial development phase" and are less professionalised than the second group because they manage farms with a smaller economic size. Nevertheless, this group is larger than the second group and represents a particularly good target of dedicated support policies.

Regarding the other six groups, in the upper part of the dendrogram, the demographic and productive characteristics seem less distinct: in the seventh and ninth groups, older farm managers prevail, while in the fourth and fifth groups the economic size is larger. The details in Table A.3 show that there are significant differences between these groups.

The fourth group includes 7.3% of MOFs and shows the highest level of livestock activities and participation in associations, along with innovative investments. The fifth group (10.3% of MOFs) has similar characteristics as the fourth group but is a little more pronounced, excluding livestock activities. They are two similar entrepreneurial profiles that run structured companies differently in terms of production orientation: the former is more specialised, and the latter is more diversified. Based on these different characteristics, the fourth group is assigned the profile "experienced entrepreneurs of structured livestock farms" and the fifth group is "experienced entrepreneurs of diversified structured farms".

The sixth group is the largest one, with approximately 33% of MOFs; consequently, it is less characterised by class distributions (i.e., it is intermediate). It represents the less-defined profile "senior farmers of traditional farms", due to their low propensity for innovation and their limited diversification.

The seventh group (12.8% of MOFs) includes only older farmers with the lowest level of education but more experience. The profile labelled "older entrepreneurs of de-structured small to medium-sized farms" shows very low levels of diversification, innovation, participation in associations, the use of organic methods, and rented land. These characteristics are indicative of farmers with a weak entrepreneurial profile mainly engaged in the cultivation of permanent crops.

The eighth group (10.0% of MOFs) includes 41–67-year-old farmers who run farms with a smaller economic size with similar characteristics to the seventh group. However, these farmers are younger, have a higher education level, and have more extra-farm commitments compared with the seventh group. This group shows low professionalisation and the highest percentage of off-farm work. The profile is denoted as "part-time farmers of small farms".

The ninth group (11.4% of MOFs) is composed exclusively of older farmers with a low business commitment who predominantly rely on outsourcing services and show little propensity for innovation and quality production. The profile labelled "older entrepreneurs of

declining small to medium-sized farms" includes farmers who appear to have the least professionally active entrepreneurial profile among all those analysed. This group differs from the seventh group based on a greater productive orientation towards short-term agricultural activities (e.g., arable crops).

We next compared our entrepreneurial profiles with typologies that have been reported in the literature for other parts of Europe[7]. Graskemper *et al.* (2021b) identified three farmer typologies in Germany using the PAM cluster method on online survey data. First, "conventional growers" include older farmers primarily involved in arable crops. This aligns with profile 6 ("senior farmers of traditional farms") and, to some extent, profile 5 ("experienced entrepreneurs of diversified structured farms", the most professional segment). Second, "versatile youngsters" include younger farmers, similar to profiles 1-3. However, this group appears to more diverse and less numerous in Italian agriculture. Finally, "family-based farmers" can be associated with profiles 7-9 (older farmers) and partially with profile 5 ("experienced entrepreneurs of diversified structured farms"). Household farms are prevalent in Italy, meaning this characteristic is present across all Italian profiles.

McElwee (2008) identified four farmer types based on interviews in the United Kingdom. First, "farmer as farmer" describes mature farmers with good technical skills but limited innovation or diversification. This profile matches profile 6 ("senior farmers of traditional farms"), which includes farmers who form the core of Italian agriculture. In addition, profiles 7-9 (older farmers of small to medium-sized farms) could also fit here, representing the least dynamic and often declining segment. Second, "farmer as entrepreneur" includes farmer-entrepreneurs who capitalise on market opportunities, even outside agriculture. This aligns with profiles 2 ("innovative and diversified young entrepreneurs") and 3 ("young farmers in the entrepreneurial development phase"). Third, "farmer as contractor" refers to expert entrepreneurs with market knowledge and adequate resources. This typology can be linked to profile 4 ("experienced entrepreneurs of structured livestock farms") and 5 ("experienced entrepreneurs of diversified structured farms"), although the term "contractor" implies a strong supply chain integration that is not always present in Italy. Finally, "rural entrepreneur" represents highly specialised non-agricultural entrepreneurs with strong managerial skills. We did not find an equivalent profile based on our analysis, possibly because in Italy these roles often take legal and organisational forms outside the agricultural sector. Of note, profile 1 ("young farmers looking for a stable professional status") does not fit into the types described by McElwee (2008). This might be because, unlike the United Kingdom, the Italian job market, especially in rural areas, offers limited employment opportunities for young people.

Weltin *et al.* (2017) identified six farm typologies from various European regional case studies using factor and cluster analyses. First, "diversified small farm households" include mainly older, full-time, and quite diversified farmers. As diversification implies other income sources, this group matches profiles 7 ("older entrepreneurs of de-structured small to medium-sized farms") and 9 ("older entrepreneurs of declining small to medium-sized farms"); for these profiles, pensions provide significant supplementary income. Second, "young organic farm households" are similar to profile 2 ("innovative and diversified young entrepreneurs"), due to the use of organic farming methods and extra-family labour. Third, "LFA-adapted mixed farms" considers geographical location[8], which we have not used to identify profiles of Italian farmers. Nevertheless, profile 3 ("young farmers in the entrepreneurial development phase") is similar in terms of economic size and education level. Fourth, "traditional part-time crop farms" shares characteristics with profile 8 ("part-time farmers of less specialised small units") due to low diversification and a lower rate of innovation. Fifth, "small-scale livestock specialists" have similar traits to profile 1 ("young farmers looking for a stable professional status"): they likely continue family livestock activities but with low economic sustainability. Finally, "intensive livestock professionals" is an excellent match to profile 4 ("experienced entrepreneurs of structured livestock farms") due to their large economic size and specialisation. Note that profiles 5 ("experienced entrepreneurs of diversified structured farms") and 6 ("senior farmers of traditional farms") do not align with the types described by Weltin *et al.* (2017). This is likely because they are quite transversal, especially the latter, which represents the largest share of the Italian farms studied.

Despite the limitations due to differing study objectives, this comparison reveals that some farmer profiles are recurrent across European agricultural systems. The main difference in the Italian context is a greater heterogeneity of profiles due to, among other issues, the great variety of farms registered by the 7th ISTAT Agricultural Census and by greater differentiation of age and other

[7] We specifically selected studies that aimed to outline entrepreneurial strategies; however, due to their diverse methodologies and data sources, we could only perform a qualitative, rather than a quantitative, comparison.

[8] Less-favoured area (LFA).

features of farmers. Consequently, border situations coexist with a central core of numerous traditional agricultural farms characterised by low diversification and innovation.

3.3. Comparative analysis of the entrepreneurial profiles

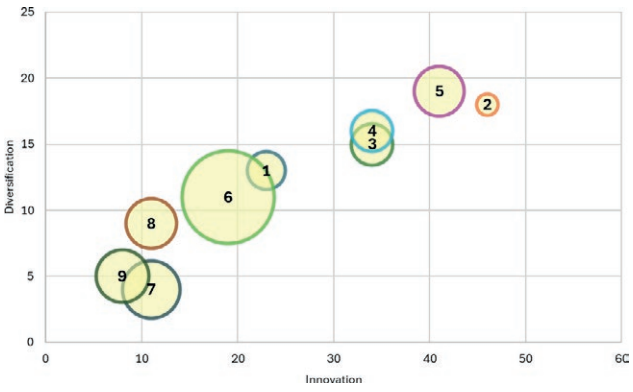
To summarise the differences in the level of entrepreneurship among the nine profiles, we plotted them on graphs according to the economic, social and environmental dimensions of the entrepreneurial attitude. In Figure 3, we measure the economic dimension defined by the propensity to diversify and to innovate in the groups. Figure 4 represents off-farm work and the outsourcing propensity of MOFs. Finally, Figure 5 features technical innovation and organic farming. The size of the bubble in each figure represents the percentage share of the group in the total MOFs

For the economic dimension (Figure 3), the key skills investigated are the ability to broaden the scope and range of business activities (diversification) and the propensity to innovate (Dias *et al.*, 2022). The position of each bubble from the origin to the upper right quadrant indicates an increasing level of entrepreneurial skills, which is lowest in profiles 9 ("older entrepreneurs of declining small to medium-sized farms") and 7 ("older entrepreneurs of de-structured small to medium-sized farms") and highest in profiles 2 ("innovative and diversified young entrepreneurs") and 5 ("experienced entrepreneurs of diversified structured farms"). The entrepreneurial profiles most inclined towards innovation and diversification mainly comprise young and experienced farms who collectively represent approximately a quarter of all professional MOFs. The profiles that are less inclined towards innovation and diversification include both older farms and young entrepreneurs looking for stable employment. Profile 6 ("senior farmers of traditional farms") demonstrates a low to medium level of innovation and diversification.

Figure 4 presents the social implications of farm management choices, based on the off-farm commitment of farmers and the use of outsourcing work (Xu *et al.*, 2022). There is a notable diagonal line that includes seven of the profiles. Specifically, profile 9 ("older entrepreneurs of declining small to medium-sized farms") appears at the far left; these farmers use more outsourcing services despite being mainly employed on the farm. Profile 1 ("young farmers looking for a stable professional status") appears at the far right; these farmers are less committed in the farm but also make minimal use of external services. Profiles 7 ("older entrepreneurs of de-structured small to medium-sized farms") and 8 ("part-time farmers of less specialised small units") fall outside this diagonal line. Profile 7 includes farmers who are more committed to on-farm activities than to adopting external services. Conversely, profile 8 includes farmers who use outsourcing services to compensate for lower on-farm workforce commitment.

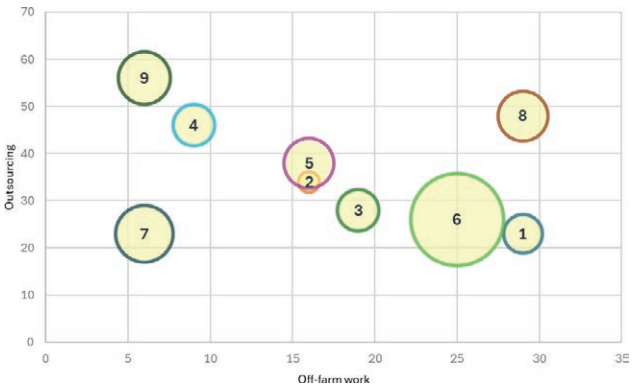
Figure 5 presents an examination of the adoption of technical innovations and organic production methods, building on the assumption that they serve as proxies of environmental sustainability (Kroma, 2008). The connection is clear as the profiles tend to align along the bisector of the Cartesian plane: the incidence of technological investments and the percentage of organic farms increase at the same pace. Organic farming cannot be considered an exhaustive indicator of the environmental sustainability of agricultural activities, but its positive correlation with investments in technical innovations

Figure 3. The innovation and diversification propensity for each entrepreneurial profile.



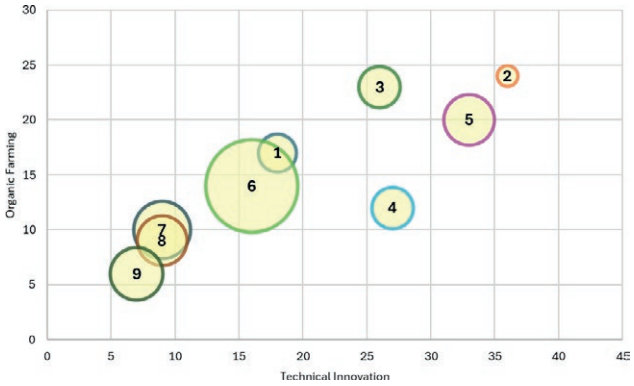
Source: elaborations based on the ISTAT Agricultural Census, 2020.

Figure 4. The off-farm work and outsourcing propensity for each entrepreneurial profile.



Source: elaborations based on the ISTAT Agricultural Census, 2020.

Figure 5. The technical innovation and organic farming propensity for each entrepreneurial profile.



Source: elaborations based on the ISTAT Agricultural Census, 2020.

suggests that the objective of environmental sustainability is well received by the most innovative entrepreneurs, particularly young farmers of profile 2 ("innovative and diversified young entrepreneurs") and older farmers of profile 5 ("experienced entrepreneurs of diversified structured farms").

Our comparative analyses revealed three grouping of the entrepreneurial profiles:

- The *high entrepreneurial group* (profiles 2-5) includes young, innovative, and professionally developing farmers, along with experienced entrepreneurs of structured farms. They show a high propensity for innovation, diversification, and sustainability (Figures 3 and 5). However, their work-related characteristics are less clearly defined (Figure 4). Overall, this group appears to have the highest level of entrepreneurship among professional MOFs.
- The *intermediate entrepreneurial group* (profiles 1 and 6) includes both young farmers looking for a stable professional status and senior farmers of common and not very innovative units, indicating that not all young entrepreneurs are innovators. In fact, young farmers included in profile 1 seem to align with the most widespread agricultural business model among our sample, characterised by moderate innovation and diversification.
- The *low entrepreneurial group* (profiles 7-9) comprises older or part-time farmers who exhibit the fewest entrepreneurial characteristics among the MOFs. They have a low propensity for innovation and diversification.

4. CONCLUSIONS AND FUTURE RESEARCH

The theoretical background and our review of the literature provided a solid framework for us to identify drivers of entrepreneurship in Italian agriculture. Some of these drivers are sector related, others are linked to traditional and innovative activities, and still others are related to territorial disparities stimulated by policies. Our results confirm the coexistence of different well-defined groups of farms in the Italian agricultural sector. They go beyond the classic dichotomies that have dominated traditional analyses because they do not just distinguish between active and inactive; rather, they consider market activities and the prevalent economic objectives. Our analysis confirms that the coexistence of rather overlapping models is a specific feature of Italian agriculture, despite the important changes that have occurred in the last decades, mainly due to the large outflow of farms (Henke, Sardone, 2022).

We focused on MOFs (SO >8,000 euros) assuming they represent the core of Italian farms integrated into the food supply chain. This does not mean that all the other farms are irrelevant to the primary sector and rural areas or to the economy and society as a whole. On the contrary, our findings show that better knowledge of the processes that occur in the primary sector can lead to a more targeted acknowledgement of the actual role these units have on rural territories and in the general process of sustainable development.

Our results help to highlight some relevant policy implications, especially at the time of a rather crucial policy reform and in light of the European Union (EU)'s efforts to tailor public support and the more general goal of a better match between demand and supply of public policies in agriculture and rural areas. Despite the effort of the Common Agricultural Policy (CAP) to improve the targeting and selectivity of public intervention, there is an evident mismatch in the ability of policies to meet the needs of farmers. The effort of the EU to switch from a "one-size-fits-all" model of intervention to a more targeted and tailored approach with selective tools is still underway and has left many actors of the agri-food system unsatisfied with the results (Henke *et al.*, 2018, 2024; Sotte, Brunori, 2025). The recent riots in Italy and other parts of Europe confirm that, beyond the political games and the roles played by the political forces in driving and conditioning the protest, deeper knowledge of the multifaceted activities of farmers, their sources of income, and their innovation capacity are key to design and implement effectives policies able to target beneficiaries (Mazzocchi *et al.*, 2024). For these reasons, the evolution of research and analysis on these matters

and an appropriate and updated set of indicators become particularly relevant.

This issue has also been reignited by the recent document about the vision for the future agriculture and food (European Commission, 2025). First, the European Commission counts on generational renewal for a new season of investment, innovation and diversification in agriculture (Licciardo *et al*., 2024). Given our results, this syllogism should not be taken for granted, at least in Italy, where apparently only some young farmers adopt new business models, while others prefer to continue traditional and low-risk agricultural activities (Carbone *et al*., 2024). Second, the European Commission potentially addresses the CAP financial resources to "farmers that actively engage in food production, towards the economic vitality of farms and the preservation of our environment" (European Commission, 2025, p.8). This is a rather ambiguous definition that opens up a new debate about who are the active farms engaged in agriculture and food production, and the role of those we have identified as MOFs. All this calls for more research and a deeper investigation on farmers and their businesses. Our work is just a preliminary analysis to examine the situation in Italy based on the data collected as part of the 7th ISTAT Agricultural Census.

We tried to provide a definition of active farms and market-oriented farmers, but following this approach the potential beneficiaries of the public support in Italian agriculture and rural areas might be significantly reduced if public policies intend to reach only "real farmers". Consequently, it could also significantly reduce the agricultural area eligible for EU policy support, with dramatic consequences for the proper conditions of land stewardship. Finally, if we add the scarce effectiveness of the support devoted to young farmers, especially in recent years, we must conclude that the way public support is designed and implemented should be reconsidered in an effort to identify new, more coherent, and more effective ways to bring resources into agriculture and rural areas. This endeavour should involve a more in-depth analysis of the entrepreneurial attitude of young people who enter the agricultural sector. Future policies could combine incentive policies with training and education programmes, and redesign accompanying social policies for farmer retirements and planning new forms of access to land (Borda *et al*., 2023; Carbone *et al*., 2024).

Future work requires more in-depth analysis of the data collected from the 7th ISTAT Agricultural Census. The information and data to which we have access – much more robust even compared with the recent past – has allowed us to identify nine entrepreneurial profiles in the Italian agricultural sector. Nevertheless, these results could be further validated and extended by considering emerging key topics such as carbon transition by using other available datasets (e.g., carbon registers, the new FSDN, and updated data about CAP implementation). This approach would improve collaboration among research, academic, and public institutions.

Another relevant issue that we have partially investigated is the wide theme of labour, including the contribution of the farm holders' families. Further investigation about the number of days worked by the holders and their families and the combination of on- and off-farm work is crucial to deeply understand the dynamics in agriculture, as well as the growth of contracted work and services (Hervieu, Purseigle, 2022; Sotte, Brunori; 2025). It would be quite interesting to analyse the links between our entrepreneurial profiles and the trajectories and typologies of labour employed both on- and off-farm.

Another future step from our study is to undertake a comparative analysis on how agricultural entrepreneurial profiles are characterised in the other EU Member States. This could involve a comparison between Northern and Southern EU Member States and more recent EU Member States from Eastern Europe. In any case, the development of studies highlighting the specificities for each Member State, such as the work we have presented here, should also be welcomed considering possible future developments of the CAP under the next Multiannual Financial Framework (2028-2034), where the more limited resources available to support farmers will require Member States to take more targeted and selective national decisions. Once again, we believe that it is crucial to design targeted policies for agricultural start-up activities and young farmers, because generational change in agriculture occurs at a different pace, under different conditions, and with different consequences in each country. We have preliminarily explored this aspect in this paper, and it deserves further specific investigation.

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AUTHOR CONTRIBUTIONS

Conceptualization, A.A., C.C., R.H. and R.S.; Methodology, A.A.; Software, A.A. and C.C.; Data curation, C.C.; Writing, A.A., C.C., R.H. and R.S.; Bibliographic research, A.A., R.H. and R.S.; Supervision, R.H. and R.S.

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APPENDIX

Table A.1. Reclassified variables.

Thematic areas	Variables	Classes	Entrepreneurial Level
Market relations	% Sales revenue % Self-consumption	– Sales >0% and self-consumption <100% (active farms [Afs]) – Sales = 0% and self-consumption = 100% (inactive farms [IFs])	* *
Human capital	Age of the farm manager	– ≤40 years – 41-67 years – >67 years	Medium High Low
	Management experience	– <3 years – 3-10 years – >10 years	Low Medium High
	Education level	– Up to middle school – Diploma and degree from an agricultural school – Diploma and degree from other schools	Low High Medium
Economic size and production orientation	Standard output	– <8,000 euros – 8,000-25,000 euros – 25,000-100,000 euros – >100,000 euros	* Low Medium High
	Type of farming	– Field crops (1-2) – Permanent crops (3) – Livestock (4-5) – Mixed (6-9)	Low High High Medium
	Organic certification	– Yes – No	High Medium
Work organisation	Extra-family work force	– None – Less than family work force (<50%) – Equal or more than family work force (≥50%)	Low Medium High
	Outsourcing services	– Yes – No	Medium High
	Off-farm work commitments of the manager	– ≥ 50% of work amount – < 50% of work amount – None	Low Medium High
Strategic entrepreneurial orientation	Participation in associations	– None – Only producers' organisation – Various associations	Low Medium High
	Related agricultural activities (diversification)	– None – Only broadening activities – Only deepening activities – Multiple activities	Low Medium Medium High
	Innovation investments	– None – Only technical – Only management – Both	Low Medium Medium High
	Information technology tools	– None – Only technical – Only management – Both	Low Medium Medium High
	Leased land	– None – <25% of utilised agricultural area – ≥25% of utilised agricultural area	High Medium Low

Note: * used for preliminary selection.
Source: elaborations based on the ISTAT Agricultural Census, 2020.

Table A.2. Frequency distribution matrix used as input to the cluster analysis (transposed extract of the entire matrix).

Variables and classes	Age	≤40 years								...
	Economic size	25,000-100,000 euros				≥100,000 euros				...
	Type of farming	Field crops	Permanent crops	Livestock	Mixed	Field crops	Permanent crops	Livestock	Mixed	...
Off-farm work commitments of the manager	≥ 50% of work amount	9.6	12.3	8.2	8.2	5.6	4.3	2.7	3.9	...
	< 50% of work amount	10.5	11.6	9.4	12.1	9.5	11.9	6.4	8.1	...
	None	79.9	76.1	82.4	79.7	84.9	83.7	90.9	88	...
Outsourcing services	Yes	35.8	18	16.8	31.2	34.2	31.4	34	39.4	...
	No	64.2	82	83.2	68.8	65.8	68.6	66	60.6	...
Management experience	<3 years	19.1	17.8	17.9	18.9	14.6	13.4	16.3	11.8	...
	3-10 years	54.8	56	49.9	53.6	51.4	52.4	46.8	49.9	...
	≥10 years	26.1	26.3	32.2	27.5	34	34.1	36.9	38.3	...
...	...	...	...	...	...	...	...	...	...	...

Source: elaborations based on the ISTAT Agricultural Census, 2020.

Table A.3. Percentage distribution of farms among classes by variable and entrepreneurial profile.

Variables	Classes	Profiles								
		1	2	3	4	5	6	7	8	9
Off-farm work commitments of the manager	*≥50% of work amount*	19	5	9	*3*	6	17	4	**23**	4
	<50% of work amount	9	**10**	**10**	5	9	7	*2*	6	2
	none	*71*	85	81	92	85	76	**94**	*71*	94
Outsourcing services	*Yes*	*23*	34	28	46	38	26	23	48	**57**
	No	**77**	66	72	54	62	74	77	52	*44*
Management experience	*<3 years*	**19**	14	18	3	3	5	*2*	6	3
	3-10 years	51	52	**53**	12	16	22	*10*	24	11
	>10 years	29	35	*29*	86	80	73	**88**	70	87
Age of the farm manager	*≤40 years*	**100**	**100**	**100**	*0*	*0*	*0*	*0*	*0*	*0*
	41-67 years	*0*	*0*	*0*	67	89	**100**	*0*	**100**	*0*
	>67 years	*0*	*0*	*0*	34	11	*0*	**100**	*0*	**100**
Education level	*Until middle school*	24	*17*	21	65	42	51	**76**	48	75
	Diploma and degree from an agricultural school	21	**33**	27	14	23	13	*5*	11	5
	Diploma and degree from other schools	**55**	50	52	21	35	36	*19*	40	20
Standard output	*8,000-25,000 euros*	74	*0*	*0*	*0*	*0*	32	57	**100**	64
	25,000-100,000 euros	26	*0*	**79**	*0*	*0*	68	43	*0*	36
	>100,000 euros	*0*	**100**	22	**100**	**100**	*0*	*0*	*0*	*0*
Type of farming	*Field crops*	23	42	27	15	38	20	*0*	72	75
	Permanent crops	28	42	37	*0*	49	53	**84**	*0*	*0*
	Livestock	36	*0*	22	**80**	*0*	20	16	*0*	*0*
	Mixed	13	16	15	5	13	8	*0*	**28**	25
Extra-family work force	*None*	84	37	63	57	*35*	76	79	**90**	**90**
	Less than family work force	9	33	23	28	**33**	15	11	5	*5*
	Equal or more than family work force	7	31	14	16	**32**	10	10	*5*	6
Participation in associations	*None*	53	37	47	39	*35*	46	47	**53**	50
	Only producers' organisation	12	**19**	16	14	19	15	17	*9*	10
	Various associations	*35*	44	38	**47**	46	39	36	38	40

Variables	Classes	Profiles								
		1	2	3	4	5	6	7	8	9
Other gainful activities (diversification)	*None*	87	83	86	85	*82*	89	**96**	91	95
	Only broadening activities	5	6	6	7	**8**	5	*2*	5	3
	Only deepening activities	5	**8**	6	6	7	4	*1*	3	2
	Multiple activities	3	**4**	3	3	**4**	2	*1*	2	1
Innovation investments	*None*	77	*54*	66	66	59	81	90	89	**92**
	Only technical	18	**36**	26	27	33	16	9	9	*7*
	Only management	1	**1**	1	1	1	0	*0*	0	*0*
	Both	5	**9**	7	7	7	3	*1*	2	*1*
Information technology tools	*None*	67	*42*	54	48	46	71	**87**	78	86
	Only technical	4	4	5	**10**	4	3	*1*	2	1
	Only management	15	**28**	21	13	27	15	*7*	12	*7*
	Both	14	27	20	**29**	23	11	*4*	8	5
Organic certification	*Yes*	17	**24**	23	12	19	14	10	8	*6*
	No	83	*76*	77	88	81	86	91	92	**94**
Leased land	*none*	40	*22*	27	30	35	54	**79**	56	67
	<25% of utilised agricultural area	*4*	8	6	10	**12**	7	5	6	7
	≥25% of utilised agricultural area	56	**71**	67	60	53	39	*16*	38	26

Note: the sum of the classes per indicator and profile calculated and rounded to one decimal place is always 100%. The values in the table are rounded to the nearest whole number, so the sum of the values can different slightly from 100. *Min* = minimum row share value, **max** = maximum row share value

Source: elaborations based on the ISTAT Agricultural Census, 2020.

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Research article

Assessing costs and benefits of agricultural digitalisation: the case of data collection support tools in agricultural-pastoral farms

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Abstract. The digitalisation of agriculture is transforming production models, offering advanced tools for data management and operational efficiency. This study examines the impact of digital technologies, focusing on agricultural-pastoral farms as a case study, with particular attention to the social, economic, and environmental costs and benefits perceived by stakeholders. A living lab approach was used, involving farmers, technicians, animal science and ICT experts, and supply chain representatives to make a participatory evaluation of a co-designed Farm Management Information System. This study contributes to the literature by offering an insightful analysis of stakeholder-driven digitalisation processes in the agricultural sector. Results indicate no negative social or environmental externalities. Costs are classified as transition for user training, transaction for collaboratively developing the data-sharing and governance infrastructure, and operational for maintenance expenses and return on the public investment that funded its development. Social benefits include improved farmer well-being, reduced administrative burdens, and greater appeal for young farmers. Economic benefits involve increased productivity, enhanced management efficiency, cost reductions, and a higher market value. Environmental benefits arise from optimised resource use, less waste, and reduced antibiotic resistance. These findings highlight the potential of digitalisation to enhance production quality, animal welfare, and farm management, laying the foundation for broader benefits along the supply chain, aligned with the principles of sustainable digitalisation.

Keywords: digital technology, livestock farming, costs and benefits, sustainable digitalisation, living lab.
JEL codes: O13, O33, Q16.

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HIGHLIGHTS

- The living lab facilitated stakeholders' involvement in assessing the costs and benefits of digitalisation.
- Digitalisation is perceived as an opportunity to prevent the decline of some agricultural supply chains and strengthen the competitiveness of farms.

– The transition, transaction, and operational costs for implementing a Farm Management Information System are considered affordable, given the expected benefits.
– Co-designing a technology involves understanding the costs and benefits perceived by users, with implementation depending on demonstrating a favourable ratio between the two.

1. INTRODUCTION

Implementing technologies in livestock farming can help address the issues that threaten the sustainability of agricultural practices. An understanding of their transformative role can emerge by examining their broader impacts, potential for innovation, and relevance to a specific supply chain.

1.1. Digital transformation of agriculture and animal husbandry issues

Digital transformation is significantly impacting the global agricultural system (Trendov *et al.*, 2019) and farm-level production (Wolfert *et al.*, 2017), including livestock agriculture (Klerkx *et al.*, 2019). However, despite its potential, challenges remain in adopting sustainable practices that ensure animal well-being and meet the growing demand for agricultural products. Climate change intensifies these challenges by negatively affecting animal health and productivity (Neethiraja, Kemp, 2021), and emerging ethical issues such as privacy, data ownership, labour, and social justice add complexity to the debate on digital agriculture (Neethirajan, 2023).

Precision livestock farming (PLF) presents a promising solution in addressing sustainability and food security requirements in animal production (Norton *et al.*, 2018). Some solutions allow farmers to remotely monitor animal health and well-being by processing data from sensors, enabling early detection of diseases or pregnancies through wearable biosensors (Neethirajan *et al.*, 2018; Benjamin, Yik, 2019).

In Italy, digitalisation is advancing in livestock farms, with 38.5% of farms using computerised herd management (ISTAT, 2020). However, access to digital tools varies by farm size and region, with northern regions and larger farms showing higher adoption rates. While Italy has improved its overall digital transformation (DESI, 2023)[1], livestock farms show a low propensity to use social platforms and a reduced penetration of cloud computing. Nevertheless, the adoption of PLF tools is significant, including IT systems for herd management (47.8%), production and reproduction monitoring (41%), remote animal identification (29.9%), and milking robots (21.4%) (ISTAT, 2020).

1.2. Presentation of the case study

Cheese production is an important part of the diversified Italian food sector, known nationally and internationally for the typicality of its products (ISMEA, 2023). Pecorino Toscano PDO, a sheep milk cheese with a protected designation of origin status granted by the EU, exemplifies this. Given this status, its production adheres to rigorous standards, overseen by a regulatory body accredited by the Italian Ministry of Agriculture.

Established in 1985, the Consortium for the Protection of Pecorino Toscano PDO (CPT) ensures compliance with the regulations for the cheese produced under this denomination[2], promotes initiatives to safeguard its identity, encourages scientific research, supervises its trade, and counteracts misuse, counterfeiting, and other illegal practices[3].

Although sheep and goat production is marginal in the national agricultural economy (RRN-ISMEA, 2018), their supply chain constitutes one of the main sectors of Italian animal husbandry (Macciotta *et al.*, 2020), with semi-extensive herds primarily relying on natural pastures seasonally: winter-spring in the south and lowlands, and autumn-late spring in the north and high plains. The milking season spans 150 to 250 days (Pulina *et al.*, 2018). As of 2021, Italy produced approximately 4.5 million quintals of sheep's milk annually (ISTAT, 2021), of which (according to CPT data for the same year) more than 195,000 (4.3%) were processed into Pecorino Toscano PDO, yielding more than 3.3 million kg. Currently, 79% of this cheese is sold in Italy (consumer turnover of 39 million euros), while 21% is

[1] From 2014 to 2022, the Digital Economy and Society Index (DESI) summarised indicators on Europe's digital performance and tracked the progress of EU countries. Retrieved at: https://digital-strategy.ec.europa.eu/en/policies/desi

[2] The code of practice for Pecorino Toscano PDO is a document whose fundamentals guarantee the product that follows them all the requirements to obtain the PDO mark. Only cheese produced, matured, packaged, and distributed according to these rules can be defined in this way. Retrieved at: https://www.pecorinotoscanodop.it/wp-content/uploads/2017/08/DisciplinarePecorinoToscano.pdf

[3] The Statute of the Consortium for the Protection of Pecorino Toscano PDO defines the tasks and aims of this body, along with the composition and functions of its corporate bodies, together with the rules that establish how members and producers can access it, and their rights and duties. Retrieved at: https://www.pecorinotoscanodop.it/wp-content/uploads/2017/08/pecorino_toscano_dop_statuto_2017.pdf

exported (12 million euros), primarily to the USA (33%), Germany (14%), and France (13%).

Sheep farming in Tuscany faces ongoing challenges that threaten its stability (Bonari, Mantino, 2015). The Pecorino Toscano PDO supply chain includes 744 certified farms with around 1,200 employees, mostly in family-run businesses. Their number has decreased over time, with fewer animals and an average farmer age of around 60. This has reduced the milk supply for cheese production despite rising demand both domestically and from abroad.

The availability of sheep milk is also at risk due to low innovation levels on farms, which lack modern breeding facilities and technology, leading to low competitiveness and a gradual decline. Consequently, productivity varies widely, with average yields ranging from 75 to 350 litres per animal per year. A lack of structured technical support further impacts productivity, both in terms of quantity and quality, and impedes progress toward reducing environmental impact (Georgofili, 2015).

1.3. Leveraging digitalisation to address critical issues

Smartphones have become a fully embedded element of people's daily lives (Wang *et al*., 2016), and digital technology is increasingly integrated into contexts such as rural life, agriculture, and forestry, which are undergoing significant technological transformation (Trendov *et al*., 2019). This transition involves a multitude of solutions (Bacco *et al*., 2019) that can generate social, economic, and environmental impacts (Rolandi *et al*., 2021) along with open challenges and opportunities (Ferrari *et al*., 2022).

Within this evolving landscape, farming stands out as a sector where advanced decision support systems (DSSs) benefit stakeholders throughout the agri-food supply chain, allowing them to make informed decisions (Fountas *et al*., 2015). The technological solution introduced in this study is a Farm Management Information System (FMIS) app, designed to collect, process, store, and disseminate data as information essential for the operational functions of a farm (Sørensen *et al*., 2010). This tool emerged from an ongoing collaboration between academia and the Pecorino Toscano PDO ecosystem players through various research and innovation projects that explore digitalisation within this supply chain. Among these is the Precision Sheep[4] operational group, which addressed precision agriculture in sheep farming and technical support for milk production (Mantino *et al*., 2019), laying the foundations for the participatory development of this tool.

The FMIS (called Poderi) is available online (in Italian) in a prototypical version[5]. It provides key functionalities, including tracking herd size with animal IDs, managing health records and monitoring pregnancies via ultrasounds, and evaluating animal performance through milk quality metrics with trend visualisation. It also has a digital field notebook, a DSS for optimising fodder production, synchronous communication with agronomists and veterinarians, and a web dashboard. The extensive co-design process made it possible to focus on key user priorities, including data security, interoperability, and usability. The tool employs encrypted storage and access control to protect sensitive information, and it integrates with national databases. In addition, its user-friendly interface is intended to promote its adoption, particularly among users with limited digital skills.

The objective of this digital solution is twofold. On the one hand, it aims to improve the production efficiency of the agricultural-pastoral farms that produce milk for Pecorino Toscano PDO. On the other hand, it seeks to extend this improvement to the entire supply chain of this cheese. This study aligns with key EU initiatives promoting digitalisation and data governance in agriculture, such as the Common European Agricultural Data Space and Data Act (2024) and the CAP Strategic Plans (2023–2027). The discussed technology contributes to these goals by improving agricultural data management and decision-making, thus supporting the transition towards data-driven agricultural systems.

1.4. Aim of the study and research context

As part of the Horizon Europe CODECS project (Maximising the CO-benefits of agricultural Digitalisation through conducive digital ECoSystems), a study is underway focusing on the digitalisation of agriculture. The research presented here specifically aims to identify the perceptions of the costs and benefits of digitalisation, establishing a foundation for evaluating how technology can help resolve challenges within the Pecorino Toscano PDO supply chain, from sheep breeding to cheese marketing.

After an introduction to the context and relevant issues, the paper proceeds with a theoretical framework underlying this research (Section 2); the methodological approach adopted (3); the results as an overview of the

[4] The Precision Sheep strategic plan aims to increase the efficiency of the sheep milk production chain through the introduction of precision farming practices and the use of innovative tools. Retrieved at: https://precisionsheep.it/

[5] https://poderi.app/#start

current state of task management, how digitalisation can support it, and the outputs of the participatory assessment of the costs and benefits (4). A discussion and final remarks conclude the document (5, 6).

2. THEORETICAL FRAMEWORK

2.1. Breeding management based on technology

This research focuses on the digitalisation of agricultural-pastoral farms. Nowadays, technology offers management tools that enhance farm competitiveness while meeting societal, market, and institutional needs (Berckmans, 2016). Precision livestock farming applies engineering principles and technology to manage animal production, viewing animal husbandry as an interconnected network of processes (Wathes *et al*., 2008). At the farm level, it enhances efficiency and promotes animal and human well-being through technological innovation, resource optimisation, and precise process control (Banhazi *et al*., 2012).

While PLF systems are widespread, the field is moving toward digital livestock farming (DLF), representing digital agriculture tailored to livestock (Neethirajan, 2023). Digital farming uses ICT within the cyber-physical cycle of farm management (Wolfert *et al*., 2017), leveraging digital data to inform decision-making across the agricultural value chain and generate exploitable knowledge through big data (Shepherd *et al*., 2020). It connects information from farmers and stakeholders, allowing consumers, for instance, to base purchasing decisions on farm information and enabling farmers to make informed choices based on consumer behaviour (Wolfert *et al*., 2017). Thus, the impact of digital transformation extends beyond the farm or production unit to the entire value chain, highlighting the potential to connect producers and consumers directly (Shepherd *et al*., 2020).

2.2. The basics of sustainable digital transformation of animal husbandry

In discussing digital transformation, a distinction should be drawn between digitisation and digitalisation (Bumann, Peter, 2016). The former refers to technical conversion of analogue information into digital formats (Bockshecker *et al*., 2018) and involves the development of digital infrastructure, including a worldwide network of computers, mobile devices, network connections, and advanced application platforms (Bley *et al*., 2016). This process, described as the third industrial revolution, has driven advancements in digital systems, communication, and computing power, enabling innovations in data processing and sharing (Davis, 2016). Decision support tools and autonomous agronomic systems largely operate at the farm level (Klerkx *et al*., 2019); however, with the Internet, it has been possible to integrate different activities (Porter, Heppelmann, 2014), initiating the fourth industrial revolution, where cyber-physical systems enable enhanced interaction between people and machines, embedding third-revolution technologies into society in a transformative way (Davis, 2016). Increased connectivity and data exchange have allowed these technologies to communicate, moving beyond mere technical conversion (Alm *et al*., 2016).

In contrast, digitalisation addresses both social and technical aspects, reflecting an organisation or society's digital progress and ICT use (Bockshecker *et al*., 2018). This term refers to socio-technical processes of using digital technologies that impact social contexts that rely increasingly on them (Tilson *et al*., 2010). Unlike digitisation, digitalisation transcends individual farms, extending to multiple entities, as in the case of platforms connecting different actors and creating interactive spaces (Wolfert *et al*., 2014; Rose, Chilvers, 2018).

Together, digitisation and digitalisation drive digital transformation (Rijswijk *et al*., 2021), a larger process involving organisational and social changes driven by technological innovation. This process influences business models, processes, products, and structures, while also affecting agriculture, forestry, and rural areas (Bockshecker *et al*., 2018; Poppe *et al*., 2013).

Sustainable development seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). This process emphasizes the interconnectedness and harmony between economic and social progress, including technological advancement, and the environmental dimension, thereby enhancing humanity's potential in both the present and the future (Johnston *et al*., 2007). From the above, sustainable digitalisation can emerge as a goal, where technology development actively contributes to sustainability (Sacco *et al*., 2021). It is important from the perspective of digitalisation as an enabler factor of a transition towards achieving the UN Sustainable Development Goals (SDGs) (Mondejar *et al*., 2021).

2.3. A classification of costs and benefits of digitalisation

Innovation enables farms to gain long-term competitive advantages that can be measured in terms of performance by considering the Input-Process-Output-Outcome framework (Brown, Svenson, 1988). With this

model, digital technology adoption in farming transforms inputs (e.g. land, labour, capital) into outputs (e.g. higher yields), which in turn lead to measurable outcomes, i.e. impact elements that can be viewed as costs or benefits.

To assess digitalisation comprehensively, social costs must be considered. These costs arise because actors do not solely bear all costs or receive all benefits. They combine private costs that fall on individuals directly involved and external costs that fall on other people or companies (De V. Graaff, 2018). The latter is particularly significant, as they include environmental degradation and negative impacts on human beings, their property, and well-being (Dascalu *et al*., 2010), prompting consideration of economic, social, and environmental dimensions of sustainability in public costs and benefits.

Looking at private costs, we can see the following tripartition. First, we have the transition component. From the perspective of measures to contrast the effects of climate change, this refers to "the costs of planning, preparing, facilitating and implementing adaptation measures" or – in terms of benefits – to "the costs of avoided damage or benefits gained as a result of adopting and implementing adaptation measures" (IPCC, 2007). Thus, transition costs and benefits can be considered adaptation costs and benefits. More practically, costs are the total expenditure devoted to adaptation, while benefits are assessed by considering avoided losses, which include direct and indirect damage to property, lives saved, and welfare preserved. In addition, impacts on the local economy and positive side effects, such as reduced future risks, increased productivity of resources and unaffected people, stimulation of innovation, and improved environmental benefits and ecosystem services, can be assessed (EEA, 2023).

Transaction costs are defined as the costs of research, negotiation and validation, and registration and execution of a contract (Williamson, 1975). This grouping looks at the costs of information procurement and purchasing, as well as regulation monitoring and enforcement (Fazeli *et al*., 2020; Dahlman, 1979).

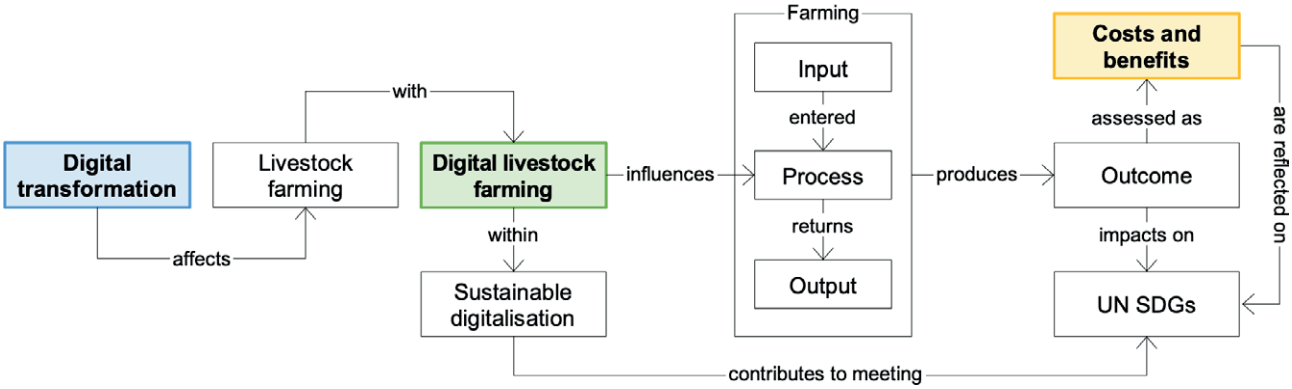
Operating costs occur if an asset is used and are proportional to the degree of its utilisation (Edwards, Duffy, 2013). They are continuous cash outlays required to maintain production, so they are assumed to be incurred during production. Before the startup, they are considered an investment (Collarini *et al*., 2021).

Transition, transaction, and operating costs are evaluated financially and by the human effort required to implement a technological solution. Cost-benefit analysis, as a tool with a long-standing role in the decision-making process of allocating financial resources (Jiang, Marggraf, 2021), systematically categorises impacts as benefits or costs, monetises them, and compares them to a status quo based on net benefits or benefit-cost ratio (Boardman *et al*., 2018). This tool supports social decision-making, helping allocate scarce resources by quantifying policy or investment project impacts on society (Hanley, Barbier, 2009). In this article, the above categories are used to label the perceived costs and benefits associated with farm digitalisation, which have been elicited and described following a qualitative approach.

For sustainable digitalisation, the costs and benefits assessment will include economic, social, and environmental aspects of sustainable development (CODECS, 2022).

Figure 1 illustrates the theoretical framework of this article. *Digital transformation* affects *livestock farming* with *digital livestock farming* (DLF). Adopting the associated technological solutions influences the farming *process* by acting on the *inputs* that are entered and the *outputs* that are returned, producing *outcomes* that are assessed as *costs* and *benefits* of the digitalisation of this process. DLF should be implemented within *sustainable*

Figure 1. General theoretical framework with connections between key concepts



digitalisation, which aims to contribute to meeting the *UN SDGs*, on the achievement of which the outcomes of the digitalised process can have an impact, and which at the same time are a reflection of the costs and benefits assessed on a social, economic, and environmental level.

Building on the above, the methodology presented in the following section aims to address key elements, focusing on the perceived costs and benefits of digitalisation. A participatory approach will explore the stakeholders' perspectives in the process under study.

3. METHODOLOGY

3.1. Description of the living lab, application scenario, and related research question

All research activities were conducted within a living lab, a user-centred open innovation ecosystem based on a systematic user co-creation approach that integrates research and innovation processes in real communities to create a sustainable impact (García Robles *et al*., 2015). The interest in this research approach is growing, and experiences are sufficient to identify its challenges and opportunities (Hossain *et al*., 2019). We define it as a network of farmers, knowledge brokers, stakeholders, and policymakers gathered around an emerging problem in a given application scenario and willing to develop solutions through collaboration (CODECS, 2022).

In the technology domain, an application scenario is defined as the context in which a goal can be achieved using digital tools. It considers the technical requirements that a digital tool must address and defines the intended goal (Rolandi *et al*., 2021). For this study, the application scenario is the farming and livestock management activities carried out on the farm, within the agricultural domain, which is defined as *the practice of cultivating the soil, growing crops, or raising livestock for human use, including producing food, feed, fibre, fuel, or other useful products*[6].

In the first stage of the project, we aim to discuss with stakeholders the potential implementation of a technological solution based on the Farm Management Information System (FMIS) for decision support, designed to simplify the milk collection process from associated farmers. This purpose aligns with Leminen *et al.* (2012), who define living labs as physical regions or virtual realities where stakeholders collaborate to create, prototype, and validate new technologies in real contexts.

Once the application scenario had been defined, the living lab set up its work around the following focal question: *How can digital technology assist farmers in collecting data on business processes, and how can these data be used to improve production quality, farmers' work and life quality, farm visibility, and animal health and well-being?* Within it and more specifically, this study aims to address the following research question: *What are stakeholders' perceptions regarding the social, economic, and environmental costs and benefits resulting from farm digitalisation?*

3.2. Setting up of data collection activity

The overall goal of the CODECS project is to collect information regarding the perceptions of farmers, policymakers, and practitioners about the social, economic, and environmental costs and benefits associated with the digitalisation of farms. Identifying and analysing these aspects is crucial to understanding how costs and benefits are generated and, therefore, to supporting the design and proposal of specific policies (CODECS, 2022).

All research activities have been conducted within the Italian living lab of the CODECS project. The protocol and guidelines for its setting were defined internally and are common to all the living labs of the European consortium. Data collection was carried out in two phases: a preliminary meeting with CPT managers to identify the problem to be addressed, and a focus group attended by 14 participants, where a tailor-made FMIS technology solution was presented and discussed with potential users. The methodological approach involved collecting qualitative data from stakeholders concerning the social, economic, and environmental dimensions of the perceived costs and benefits associated with implementing this solution (Iliopoulos *et al*., 2024).

To this end, participants were asked to answer the following ten questions:

Q1: What comes to your mind when you hear the term "farm digitalisation"?
Q2: Do you think the proposed tool/service might work? Why? Under what conditions?
Q3: How do you think the innovation would change farming activities (operations, organisation, relations in the supply chain, relations with advisers, relations with suppliers)?
Q4: How would the innovation contribute to environmental sustainability? Under what conditions?
Q5: How would it contribute to farmers' incomes and well-being, quality of work, and gender equality? Under what conditions?

[6] Definition provided by the Oxford Reference dictionary. Retrieved at: https://www.oxfordreference.com/display/10.1093/oi/authority.20110803095356555

Q6: What do you think are the economic, social, and environmental costs associated with introducing the proposed digitalisation innovation, and who will incur each type of cost?
Q7: Would you be willing to pay the associated costs? How much would you be willing to pay?
Q8: What kinds of problems do you expect to face as more and more farms become digitalised in the future?
Q9: What kinds of benefits (economic, social, and environmental) do you expect from digitalisation? Please provide some examples.
Q10: Is there anything else you want to share with us regarding farm digitalisation that you have not mentioned so far?

The focus group questions were designed to capture stakeholders' perceptions of the costs and benefits of digitalisation within the Pecorino Toscano PDO supply chain. Q1–Q5 establish the context for understanding their views. Q1 introduces the discussion by inviting participants to share their immediate thoughts on farm digitalisation, helping us to understand pre-existing notions and attitudes. Q2 and Q3 focus on expectations regarding specific digital tools, their feasibility, and their potential impacts on farm operations and supply chain relationships. Q4 and Q5 explore the contributions of digitalisation to environmental sustainability, farm incomes, well-being, and gender equality, capturing perspectives on broader socio-economic and ecological outcomes. Q6 and Q7 focus on cost perceptions, prompting participants to reflect on economic, social, and environmental costs, their distribution across the supply chain, and stakeholders' willingness to pay – all key factors for assessing financial feasibility and adoption. Q8 identifies anticipated challenges in an increasingly digitalised agricultural landscape, helping to uncover potential barriers and unintended consequences. Q9 explores expected economic, social, and environmental benefits, providing insights into stakeholder expectations and contextual factors shaping digitalisation outcomes. Finally, Q10 serves as an open-ended prompt, allowing participants to share additional perspectives not captured by the previous questions. This ensures that the focus group discussions remain flexible and responsive to emerging themes, enriching the dataset with stakeholder-driven insights beyond the structured framework.

The focus group was held in person in November 2023 at the CPT premises (Grosseto, Italy). This exercise followed a double moderator format (Krueger, Casey, 2000). Two researchers supervised the research and data collection activities. The first managed the audio and video support equipment and took notes, while the second moderated the discussion, steering it in accordance with the guidelines (Iliopoulos *et al*., 2024).

The event was recorded and transcribed by hand to elicit its contents through thematic analysis (Vaismoradi *et al*., 2013). Participants' privacy was respected through anonymisation with attribute coding (Saldana, 2013). Specifically, we adopted an alphanumeric coding [XXX#Y], where the first three letters referred to the stakeholders' category, and a number distinguishes attendees within the same category. No preference was given to participants; the numbers were assigned based on the order of their first contribution (they were free to position themselves as they wished). They arranged themselves in a circle around a microphone, while a camera filmed the meeting from outside the group. Two representatives from the University of Pisa were provided with a blackboard and a projector. The meeting began with the CODECS project coordinator outlining the project, followed by a second representative (an expert in animal science) who introduced the digital tool submitted for discussion.

4. FINDINGS

4.1. Data management in the farming process under study

When examining how the task is currently performed and looking at the importance of the technological solution, the role of *data* as a resource and product of the farming process becomes evident. This aligns with the broader research within this living lab. In the context of the production of Pecorino Toscano PDO, the data generated at the farm level are extremely valuable. Preliminary discussions indicate that they are collected across several contexts. Furthermore, the process involves numerous sub-phases and actors, leading to a substantial flow of information that increases as we progress along the supply chain.

At the centre is the *farm*, the physical place of *production*, where farmers and their employees (workers) generate data through various agricultural and animal husbandry practices. From recording the quantities of fodder and milk produced to tracking livestock sales, births, and financial transactions, farmers document essential information daily. In less digitalised farms, these data are often managed manually, using paper records, which serve both for business planning and legal compliance.

Beyond farmers, other key actors contribute as data producers and users, structured around *inputs* with milk as the primary *output*. For instance, animal feeding and health care often involve support from agronomists and veterinarians, who provide *technical assistance*. Information collected from farmers can facilitate these profes-

sionals' work, while additional data generated directly by them are returned to the farmer as verbal or written documentation.

Being part of a protected supply chain also necessitates *collaboration* with specific actors. For instance, dairy companies that receive milk for cheese making conduct a series of incoming checks and share the results with farmers. Further along the supply chain, the level of digitalisation increases, as dairies usually keep telematic systems for data storage and control, allowing them to be stored for a long time. This data exchange – often paper-based, or electronic under specific requests – typically occurs only between farmers and processors for accounting and product valuation purposes. Furthermore, productivity data from the herd may be shared with other entities, such as animal feed suppliers, who often tailor feed formulations to meet a farmer's specific needs. This requires extensive data regarding the quality of the output to manage production at the feed mill and coordinate supplies.

The Consortium plays a relevant role in *supervision*, overseeing both inputs and outputs. Data are also produced, analysed, and stored by academia, which is equally interested in acquiring this information for its *research* activity. Their long-standing partnership has fostered an innovation ecosystem, with the Consortium for the Protection of Pecorino Toscano PDO involved in various Italian and European research projects.

Figure 2 shows how the activity of the actors within the five contexts mentioned above (production, technical assistance, collaboration, supervision, and research) contributes to data generation, often managed in analogue mode. The idea behind the design of this technology is to digitise and systematise these data, making them accessible to all relevant stakeholders. In this specific context, the assumption is that data should not remain the exclusive property of those who generated them, but should be shared across the supply chain, enhancing their usefulness. Implementing this solution may generate *costs* and *benefits* for those interacting with it, even in different roles.

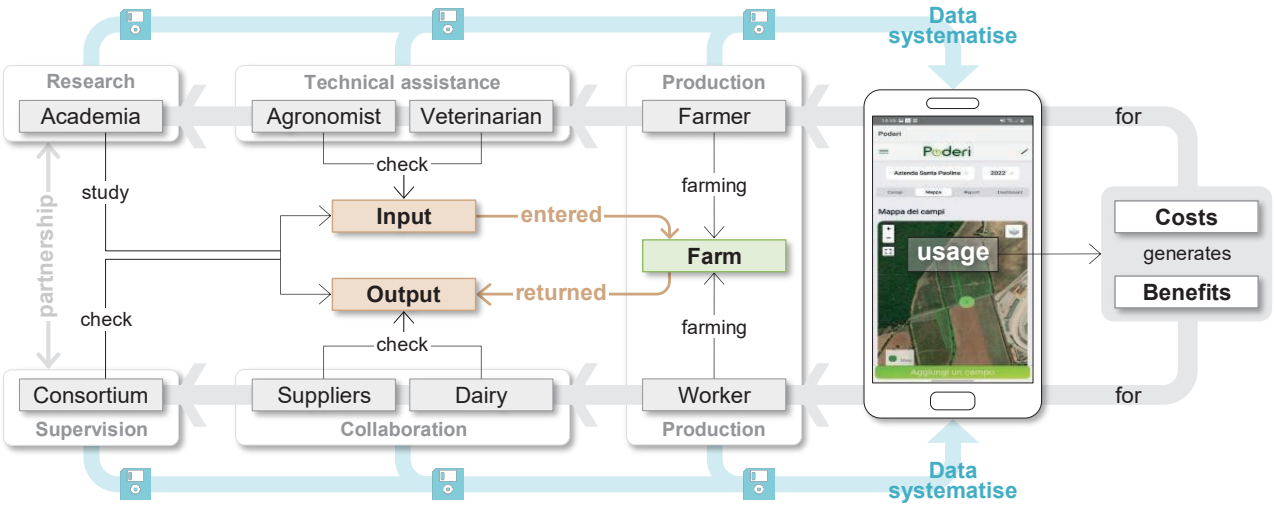
The above highlights the potential of digitalisation in managing data within the process under study. This context provides a foundation for understanding how stakeholders evaluate its social, economic, and environmental implications in terms of perceived costs and benefits.

4.2. Stakeholders' perceptions of costs and benefits

The focus group participants were selected to ensure representation across five key areas of data generation and use within the agricultural phase. The groups comprised farmers [FRM] for production, professionals [PRO] for technical assistance, academia [ACD] for research, collaborators [CLB] for collaboration, and the Consortium for the Protection of Pecorino Toscano PDO [CPT] for supervision. Technology providers [ITC] also joined the discussion, bringing their expertise as experts in the subject and developers of the app.

The participants shared a variety of perspectives on what the digitalisation of farms means for them (Q1). According to one professional, it implies "novelty and facilitation" because it is something innovative that makes life easier. ITC#3 emphasised "cost reduction", explaining that technology should ideally reduce

Figure 2. Definition of the actors involved and the data flow to be systemised in the FMIS application



both financial expenditures and time losses on the farm, which would enhance productivity, provide farmers with more free time, and potentially attract younger generations to this work. For FRM#2, digitalisation means "future" as technology increasingly shapes the future of agriculture, and without it, farming might face decline, as noted by FRM#3. A feed company representative highlighted its utility when integrated into farm growth, suggesting that it can streamline farm operations. FRM#1 further noted that digitalisation offers income growth and attractiveness, two crucial factors as the sector lacks a generational transition. ITC#1 echoed this feeling, linking digitalisation to modernisation, which could make farming more attractive to young people. Finally, another professional remarked that with digitalisation comes "improvement and growth", underscoring the danger that without technological tools for collecting, processing, and using data, livestock farming as a job will disappear.

With regard to the possible effectiveness of the proposed technological solution and the necessary conditions for it (Q2), FRM#1 expressed confidence that the app, whose design takes into consideration the main functions of the farm, would be effective, adding that "... it must work!" This idea aligns with the belief, shared by CLB#1, that digital solutions can revitalise this sector and prevent further decline. FRM#2 proposed additional features to enhance herd management and support work with groups of animals. Other participants emphasised data sharing, underlining its potential value for the entire supply chain, particularly in facilitating product traceability. In this regard, ITC#2 mentioned blockchain as a potential technology for these functionalities, highlighting its relevance in securing shared data.

In regard to the change that this innovation would bring (Q3), participants discussed how the proposed app, which collects farm-level data, could foster greater involvement among supply chain actors when integrated with other processing-level technologies. CPT#1, representing the Consortium, noted their commitment to innovation, supported by a long-standing collaboration with ACD#2's research group. This collaboration includes a project to establish a "digital footprint" for each farm in the Pecorino Toscano PDO supply chain, implementing technologies such as blockchain. The goal is to enable traceability from field to consumer, collecting data at all levels and sharing them with authorised monitoring bodies, thereby adding value to the raw material, as well as the semi-finished and finished product, including in the eyes of the end consumer.

With respect to environmental sustainability (Q4), PRO#2 observed that the app could optimise the use of resources on farms, particularly in feed management, reducing waste and directing it to animals that need them most. More efficient agronomic practices could further benefit the environment. The app could allow better health monitoring and careful use of drugs, as well as mitigating the risks of antibiotic resistance, which is particularly challenging on larger farms but could be effectively managed with technological support.

The discussion on how this tool could contribute to farmers' income and well-being, quality of work, and gender equality was very insightful (Q5). In terms of economic impacts, participants agreed that technology could improve income through increased productivity, better farm management, and cost reduction. One farmer stated that many notes need to be made and that this is often done in the evening and sometimes postponed due to tiredness, so a tool that facilitates quick data entry could be handy. CLB#1 mentioned time constraints in customised feed production, explaining that a whole day can be spent setting up data, which could be streamlined through this app. The farmer also complained that pastoral life has changed little over the past 50 years, or may even have worsened due to the number of bureaucratic tasks required, and expressed optimism that digital tools could improve quality of life by saving time. As regards gender equality, he pointed out that his wife works with him on the farm, commenting that automating manual tasks, such as making annotations and keeping stock accounts, could ease workload pressures and encourage more family and female involvement in farm management.

While no significant concerns were raised regarding potential social or environmental costs of this innovation, the discussion on economic costs was more extensive (Q6). A representative from academia noted that these costs could be measured in hours worked by technicians or farmers. Development costs include design, creation, updates, and improvements, which, supported by public funding, represent an investment that must be remunerated so that it does not remain at the expense of the community. Therefore, the app might be offered as a subscription-based service. Initial estimates suggest a subscription fee of 100–250 euros/year per farmer within the Consortium. Participants also discussed the European Rural Development Policy, which could subsidise precision farming costs, including digital applications. RES#2 added that training costs for end-users, which are crucial for including less digitally advanced stakeholders, would also need to be considered.

When discussing the willingness to pay for these costs (Q7), RES#2 noted that training costs would likely be acceptable, especially as co-design is integral to the

living lab process of CODECS, bearing in mind that some farmers were already involved in similar projects. There was consensus that if the Consortium covered the subscription, more farmers would likely use the app. Its manager confirmed that it is prepared to fund this cost to support the primary sector, which is crucial for the future of the Pecorino Toscano PDO supply chain. FRM#1 added that the subscription cost seemed reasonable, given the returns in milk pricing, but underscored the importance of a clear cost-benefit demonstration for farmers.

Looking toward a future with increasingly digitalised farms (Q8), participants raised no objections. FRM#1 expressed a willingness to share data as long as they remain anonymous, referring to the importance of collective, rather than individual, health alerts. The technology expert intervened on this point, reassuring everyone that data can be anonymised and selectively shared as needed. ACD#2 explained that while farm data sharing is limited to dairy entities and does not occur among farmers, data generally appear in aggregate form, and access can be provided to authorised parties.

Finally, the expected benefits from digitalisation were examined across economic, social, and environmental dimensions (Q9). Economically, digital tools could significantly enhance time management, thereby improving operational efficiency. In a hypothetical scenario, participants compared digitalised and manual inventory operations and controlling the number of animals in the herd, noting how digital solutions could save time. On the social side, the well-being of farmers could be improved by reducing paperwork, which often takes until the evening. Additionally, technology could facilitate generational change, which is currently too closely linked to father-son succession but could be extended to new young workers who are attracted by a working environment where digital can offer new stimuli. Participants also considered consumer confidence, as the Consortium's traceability efforts could strengthen the identity of each supply chain actor, fostering a sense of shared value. Finally, environmental impacts are linked to a more efficient management of inputs, both in the part of the farm dedicated to fodder production and in the drugs used in herd management.

Table 1 summarises the results of the discussion within the focus group. The contents are presented as keywords related to the answers to each question concerning the proposed digital solution (PDS).

5. DISCUSSION

Despite being renowned within Italian agri-food traditions and appreciated both domestically and internationally, Pecorino Toscano PDO cheese faces production risks due to long-standing issues. These challenges, notwithstanding advances in knowledge and the opportunities offered by digital transformation, are not being solved. Through a living lab, the Horizon Europe CODECS project has begun exploring these issues, ini-

Table 1. Keyword summary of the findings elicited from stakeholders

Investigated issues	Emerged themes and insights
Stakeholders' perspectives on digitalisation.	*Novelty, facilitation, cost reduction, future, business growth, farm control, income growth, attractiveness, keeping up with the times, improvement.*
What the PDS looks at.	*Effectiveness, being promising, farm operations, confidence, revamping, improvement, additional features, data sharing, traceability.*
Transformative changes introduced by the PDS.	*Integration, involvement, innovation, food digital footprint, traceability, added value.*
PDS influence on environmental sustainability.	*Impacts, input optimisation, waste reduction, better agronomic management, reduced antibiotic resistance, caution in using drugs.*
Potential contributions of the PDS.	*Increased productivity, farm management efficiency, cost reduction (to farmers' income), convenience, usefulness, speed, quality of work, simplification (to farmers' welfare), work relief (to gender equality).*
Economic cost components associated with the PDS.	*Development costs, improvement costs, public funding, investments, subscription charges, training costs.*
Additional cost-related issues of the PDS.	*Subscription, willingness to pay, bearing the costs, awareness of benefits, cost-benefit evaluation.*
Processes and implications of farm digitalisation.	*Taking advantage, data anonymisation, data sharing, data flow, trust issues.*
Expected benefits of agricultural digitalisation.	*Time management, business efficiency, control, final product value (economic), farmer's well-being, generational change, consumer confidence, sense of belonging (social), management of agronomic and livestock inputs (environmental).*

tially engaging stakeholders in discussions on implementing an FMIS solution. It aims to foster sustainable innovation at the farm level (SDG 9 – Target 9.c) and address the barriers that threaten its survival. To this end, key data generation and data use actors from the farming phase were questioned, as these contexts represent viable areas for technological intervention. Although digital tools are effective for dairy farm management (Kassahun *et al*., 2021), obstacles to adoption can limit their implementation (Giua *et al*., 2021).

Participants largely showed a positive approach to innovation, expressing openness to digitalisation without technological resistance. According to potential users, the proposed app meets the essential functions for on-farm use, and farmers place significant trust in its potential to address the ongoing crisis in sheep farming, which they see as backward and without a future. Despite the optimism, we know that the decision to adopt technological support in animal husbandry can vary due to factors such as farm size, specialisation, and tool usability (Groher *et al*., 2019) – aspects that require further exploration within this study.

The innovation proposed here involves integrating stakeholders, with a focus on producers and technicians, to enhance the farming experience through improved technical assistance (SDG 2 – Targets 2.3, 2.4, 2.5, 2.a), identified as a critical area in sheep farming (Bonari, Mantino, 2015). Digital technology can impact the value chain (Rolandi *et al*., 2021), and in this case, its positive effects would involve all actors. In particular, integration between farming and processing stages is expected to boost the perceived value of raw, semi-finished, and finished products for end consumers (Islam, Cullen, 2021).

Participants expressed no concerns about increased digitalisation in sheep farming. The importance of data as a factor in production was widely acknowledged, and farmers exhibited a willingness to share their own, recognising their value across the supply chain. This reflects the broader trend in agriculture toward enhanced data collection and utilisation to support smart farming (Pham, Stack, 2017), though the large data volumes needed lead to considerations around governance (Wolfert *et al*., 2017). While information sharing is already common in this context, trust between actors along the agri-food value chain is crucial, particularly in selecting reliable partners with whom to share information (Van der Burg *et al*., 2019). Technologies like blockchain, which is planned to be implemented by the CPT, aim to address this need for trust (Zhao *et al*., 2019). Anonymisation could also alleviate ethical concerns linked to digitalisation, a topic broadly discussed in the literature (Royakkers *et al*., 2018). However, its adoption in agriculture presents key technical and social challenges (Torky, Hassanein, 2020), which match the concerns raised within stakeholder discussions. In particular, issues related to privacy and unclear governance frameworks on data ownership contextualise these aspects among sociocultural barriers to digitalisation (Ferrari *et al*., 2022; Neethirajan, 2023).

For environmental sustainability, optimising input use is key. Technology can support wiser decision-making (Fountas *et al*., 2015) in areas like feed and drug use, reducing waste, and resistance to antibiotics. In particular, the effects would be proportional to the size of the farms, and this is very important because it emerged that extension in this sector brings with it management complexity. In 2019, the EU approved the European Green Deal, aiming for climate neutrality by 2050 through substantial commitments and funding. This is especially important for this animal husbandry sector, where there is a risk of not finding private investors willing to finance the design and development of these tools. Development partner institutions are important, especially in some low-income countries (Causevic *et al*., 2022), but they require a commitment to environmental sustainability. This aligns with the Tuscany region's conditionalities, which the functionalities of this app aim to meet.

Participants believe technology can improve farmers' economic conditions through increased productivity, management efficiency, and cost reduction, as confirmed in Rolandi *et al.* (2021). As regards farmer well-being, it is pointed out that there is a lot of work to be done on the farm and that technology may reduce the amount of work brought home, which currently encroaches on free time, a key factor deterring new generations of potential workers from entering this sector. Additionally, digital tools could alleviate the administrative burden on farmers by enabling institutions to take over some responsibilities for data by integrating this app into institutional channels.

With respect to gender equality, participants indicated that women already participate in this work without discrimination. However, from our perspective – and bearing in mind that the app is still an unimplemented prototype – the stakeholders' perceptions are not sufficient to conclude that this tool will actually increase female involvement in this specific context. Although there is no quantification of women's employment in this supply chain, this aspect cannot be overlooked, given their significant presence within agri-food systems (FAO, 2023). Our findings suggest that reducing workload is a leverage point for enhancing female participation. It aligns with existing literature – primarily focused on emerging contexts – which underscores the potential of technology to improve women's involvement in agri-

culture (Ball, 2020; Vemireddy, Choudhary, 2021) and their overall employment conditions (Nguyen-Phung *et al*., 2024). Furthermore, our data reveal that they tend to perform tasks more akin to administrative roles rather than manual labour. In this regard, the FMIS could promote their engagement by enhancing their autonomy in farm management; however, the absence of female farm leaders and the predominance of family-run businesses in our sample prevent us from comprehensively assessing female empowerment in this direction – a debate that remains active, with some suggesting that ICT holds significant potential to foster it (Mackey, Petrucka, 2021). While technology can narrow the gender gap, many women currently lack access to it (OECD, 2018), and although our study only marginally addresses this matter, we do not expect our app to affect this issue negatively (SDG 5 – Target 5.b).

In terms of costs, no adverse social or environmental externalities were mentioned. For private costs, development and prototyping expenses are considered investments, currently borne by the community. The beneficiary users should bear this monetary outlay in the form of operating costs that remunerate the public investment and support the improvement it will require. These costs would fall mainly on farmers, who appear willing to bear them, while professionals and collaborators could recover them by offering services. It is worth mentioning that it is possible to offer this service to farmers by charging the Consortium entirely for this cost. It views the integration of the supply chain as a strength, demonstrating the perception of a higher benefit than the cost of implementing the technology. Transition costs include training expenses for end-users to understand the working of the app, while transaction costs involve time and financial resources invested by academia, researchers, and the CPT in developing and improving this solution. They also include the opportunity costs for farmers, professionals, and collaborators who dedicated time to this research, especially given the digitalisation gap among Pecorino Toscano PDO supply chain actors.

In terms of benefits, participants stressed the need to communicate the potential of technology and analyse the costs and benefits of innovation, which is a challenging task when introducing new tools to farmers. However, digitalisation offers economic opportunities beyond private gains, such as improved productivity and resource efficiency, supporting economic growth decoupled from environmental degradation (SDG 8 – Targets 8.1, 8.2, 8.4) and sustainable production and consumption (SDG 12 – Target 12.2). Externally, benefits include enhanced consumer confidence through traceability, with blockchain (which this app aims to integrate) recognised as a game-changer that promotes greater trust and transparency in the food sector (Yiannas, 2018). Participants also acknowledged social benefits, such as improved farmer well-being and generational turnover, and environmental benefits in reducing the impact of livestock farming on water (SDG 6 – Targets 6.3, 6.6), water ecosystems (SDG 14 – Target 14.1), and land (SDG 15 – Target 15.1), to contrast climate change and its impacts by controlling emissions (SDG 13 – Target 13.3).

Limitations of this research include emphasising a specific supply chain, which may constrain the generalisability of the findings. Also, although the focus group approach captured stakeholder perceptions effectively, the sample, while representative of key stakeholders, may not fully reflect the complexity of the ecosystem. Additionally, group discussions may have biased the viewpoints expressed.

Future research may advance these findings by extending the analysis to different supply chains, providing a comparative perspective on the digitalisation of this sector, and incorporating further gender analyses to assess their impact on equality outcomes. In addition, quantitative analyses could further clarify the cost-benefit dynamics of adopting technology, offering more robust evidence to support stakeholders' and policymakers' decisions.

6. CONCLUSIONS

In conclusion, within the context of digital transformation in livestock farming, the discussed technological solution is part of a significant innovation process aimed at strengthening, through technology, the weakest link in the Pecorino Toscano PDO supply chain: the farming level. Here, the FMIS app can influence the production process by optimising inputs and aiming to maximise outputs. Beyond what is already known in the literature, looking at the current process allowed us to contextualise the needs and propose a valid solution, starting with identifying weak points. The outcomes resulting from the improved process were evaluated positively, and while the perceived benefits appear to outweigh the costs, expectations regarding the contribution to the SDGs touch on all three dimensions of sustainability. This leads us to affirm that implementing this tool can act as an enabling factor for improving the agricultural phase of milk production and aligns with the principles of sustainable digitalisation.

In providing an initial answer to the living lab's general research question, we can state that various contexts for data generation and use exist within farming

activities and that digital technology can assist farmers (or close stakeholders) in collecting and managing them more efficiently. These data can be leveraged to enhance production quality, as the primary goal is to improve the technical assistance available to farmers and act on animal health and welfare. The benefit for the quality of work on the farm and farmers' well-being is also considerable. However, in the subsequent stages of the research within this living lab, the value of these benefits will be demonstrated for the rest of the supply chain as well, intervening on objective quality through process control and the relative quality perceived by consumers, who are increasingly concerned with food traceability, thus also enhancing the farm's visibility.

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AUTHOR CONTRIBUTIONS

F.L.: Conceptualisation, Investigation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. L.O.: Investigation, Writing – review & editing. C.I.: Methodology, Writing – review & editing. D.V.: Writing – review & editing. G.B.: Conceptualisation, Writing – review & editing, Supervision, Funding acquisition.

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Short communication

Custodian farmers' perspectives on improving Common Agricultural Policy payments for local-breed conservation in northern Italy

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Abstract. The purpose of this short communication is to draw attention to the issue of farmers' perception of Common Agricultural Policy (CAP) payments for the conservation of livestock biodiversity. We gathered data through semi-structured interviews with a sample of nine farmers located in north-western Italy (Lombardy and Piedmont). Based on these interviews, we identified the main challenges of the current subsidy mechanisms, including bureaucratic complexity, insufficient financial support, and concerns about long-term dependency. The farmers emphasised the need for policy refinements, such as the improved allocation of funds, active conservation strategies (e.g. genetic improvement programmes) and market-oriented solutions (e.g. niche product development). This study highlights a discernible gap between short-term subsidies and sustainable breed conservation, underscoring the significance of community-based approaches and consumer awareness in enhancing economic viability. The necessity for participatory policy and customised support to align conservation objectives with farmers' socioeconomic realities is emphasised, offering insights into more effective agrobiodiversity conservation within the CAP.

Keywords: livestock biodiversity conservation, CAP subsidies, farmer perceptions, direct subsidies, genetic resources, policy effectiveness.
JEL codes: Q18, Q57, Q12.

HIGHLIGHTS

- Farmers have expressed concerns regarding Common Agricultural Policy payments for the preservation of livestock biodiversity.
- The main challenges identified by farmers include bureaucratic complexity, insufficient funding, and risks associated with long-term dependency.
- Farmers have called for better allocation of funds and market-oriented solutions.
- The possibility of stimulating and involving farmers in a participatory policy process has emerged, offering them tailored support that addresses their specific needs.

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1. INTRODUCTION

Agrobiodiversity – defined as 'the variety of animals, plants and micro-organisms used in food and agriculture, from genetic resources (varieties, breeds) to supporting species (soil microbes, pollinators) and ecosystems' (FAO, 1999a) – is necessary to support the cultural (Hall, 2019) and ecological (Marsoner *et al*., 2018; Velado-Alonso *et al*., 2021) benefits linked to local livestock breeds. In the past 20 years, numerous scholars have emphasised that, to address the complex issue of preserving these livestock breeds, we need to combine economic, cultural, and ecological aspects (e.g., Boggia *et al*., 2010; Hoffmann, 2011; Martin *et al*., 2020). For example, Pirani *et al*. (2010) emphasised that at-risk breeds require a strategic combination of policy support and market-oriented interventions, underscoring the necessity of integrating conservation goals with the economic sustainability of custodial farming systems. The European Green Deal plays a central role in promoting the preservation of these breeds, supporting sustainability, and preserving agricultural diversity through a variety of initiatives. Among these initiatives is financial support for custodian farmers, who are individuals committed to conserving genetic diversity by protecting endangered local breeds.

The Common Agricultural Policy (CAP) specifically supports farmers in conserving local livestock breeds at risk of extinction through targeted payments. These payments have evolved over time, starting with Council Regulation (EC) No 1698/2005, which outlined support for rural development, including 'local breeds in danger of being lost to farming'. This was further formalised with the introduction of Regulation (EU) No 1305/2013 and the CAP for the 2014-2020 period. Under the current CAP 2023-2027 framework, payments for the *in situ* conservation of local breeds are categorised as agro-climatic environmental payments, referred to as ACA14 ('Farmers as custodians of agrobiodiversity'- Ministero dell'Agricoltura, Sovranità Alimentare e Foreste, 2023) in the Italian National Strategic Plan. Farmers who voluntarily commit to conserving local genetic resources at risk of extinction are eligible for financial support, which is calculated per livestock unit (LSU) based on the additional costs and lower revenues associated with their maintenance compared with conventional breeds. These payments consider productivity differences between industrial and endangered breeds, and they are intended to support the broader goals of preserving agrobiodiversity. They are compatible with other agri-environmental measures and linked to investments, advisory services, training and collective approaches aimed at strengthening sustainability across farming systems. Although these payments have potential advantages, questions have been raised about their sufficiency and effectiveness, leading to calls for a more focused approach to agro-biodiversity conservation (Hermoso *et al*., 2022).

As highlighted by Ahtiainen and Pouta (2011), there has been limited evaluation of CAP support for the conservation of animal genetic resources, with only a few pioneering empirical studies (e.g., Cicia *et al*., 2003; Birol *et al*., 2006) and a lack of in-depth analysis of factors that shape farmers' participation. There are several obstacles, including excessive bureaucracy and the perceived inadequacy of payments. In Slovenia, Juvančič *et al*. (2021) found that CAP procedures are considered overly burdensome – particularly for small farms – while uniform per-unit payments often fail to reflect real opportunity costs. A stated-preference survey of 301 livestock farmers revealed that willingness to accept compensation was 27% lower than current rates for sheep and goats but 5% higher for pigs, indicating that differentiated payments could be more cost-effective and should be paired with reduced administrative requirements and market support. A discrete choice experiment with 159 German cattle breeders confirmed that farmers prefer short, flexible contracts and collective bonuses linked to breed population increases, while rigid technical conditions act as deterrents (Schreiner, Latacz-Lohmann, 2024). Notably, many breeders would participate even without monetary compensation, highlighting strong intrinsic motivations.

Given these concerns, we explored how CAP payments can be tailored more effectively to support the conservation of biodiversity while simultaneously addressing the needs of custodian farmers. Specifically, the objective was to explore how Italian farmers experience the tools and measures designed for the conservation of local cattle breeds within the framework of CAP policies. To this end, we conducted an exploratory study to examine the perspectives of farmers – the direct beneficiaries of these policies – focusing on the practical barriers and opportunities they encounter when participating in CAP programmes.

2. METHOD

2.1. Study area

We focused on farmers in the north-western Italian regions of Lombardy and Piedmont, areas distinguished by both highly intensive livestock systems and long-standing traditions of breeding local cattle breeds. We selected these regions because they are important in

Table 1. Farmers/farm characteristics

Pseudonym	Gender	Age (years)	Education level	Organic certification	Breed specialisation	Herd
Eleonora	F	38	Bachelor's degree	Yes	Dual-purpose: meat and milk (cheese)	7
Carlo	M	54	High school diploma	No	Meat production	23
Roberto	M	36	High school diploma	No	Meat production	23
Paola	F	63	High school diploma	Yes	Meat production	26
Samuele	M	56	High school diploma	No	Meat production	75
Giovanni	M	52	Middle school	No	Meat production	5
Lucia	F	62	Middle school	Yes	Meat production	20
Giuseppe	M	53	Master's degree	Yes	Meat production	105
Dino	M	67	High school diploma	Yes	Dual-purpose: meat and milk (cheese)	57

Italy's livestock sector and because modern, large-scale operations coexist with small-scale farms dedicated to conserving endangered local breeds. By examining these contrasting agricultural contexts, we aimed to understand how local conservation measures under the CAP framework interact with everyday farming practices.

2.2. Sampling strategy

The sampling strategy, based on the concepts proposed by Patton (2002) and expanded upon by Staller (2021), can be classified as purposive, incorporating elements of criterion sampling. We devised this approach to identify cases that might either enrich patterns discerned through data analysis or serve as counterexamples for exploring divergent explanations. The selection criteria were grounded in principles that recognise how economic activities in rural settings are shaped by local traditions, institutional constraints, and collective relationships[1]. We used this perspective to understand how farmers balance economic imperatives with cultural values in the context of breed conservation. In Lombardy and Piedmont, small-scale farms maintaining local breeds exemplify this balance: they have adapted to external economic forces while anchoring their practices in local traditions and communal ties. As described by Tregear and Cooper (2016), this balance highlights the interdependencies that sustain traditional farming systems in such industrialised regions. To identify eligible participants, we collaborated with a breeder association to select farms that met specific requirements such as geographic proximity, the conservation of endangered breeds and sustainability-oriented practices. Access to the farming community was facilitated through collaboration with the president of this association, who acted as a gatekeeper. This intermediary enabled us to establish a rapport and trust with the participants and provided deeper insights into the context. The final sample comprised nine farms, all situated within a 150-km radius, ensuring uniformity in contextual conditions. Initially, we selected 12 farmers from the breeders association, and 11 agreed to participate in the study. We later excluded two of these farmers: one due to farm closure and one who declined further involvement, expressing distrust in research methods and satisfaction with existing practices. The final sample comprised nine farms (see Table 1 for the farm characteristics).

2.3. Data collection

For our fieldwork (January-May 2023), two researchers conducted semi-structured interviews with farm owners or managers, alternating the interviewer and observer roles. The 60-90-minute sessions, recorded and supplemented with field notes, explored breeding strategies, economic challenges, and CAP subsidy experiences within the farmers' working environments. This setting fostered spontaneous dialogue while enabling direct observation of livestock management practices. The research design evolved iteratively: initial interviews under an established project revealed unexpected concerns about subsidy mismanagement, prompting a dedicated second phase to examine financial mechanisms' impact on conservation.

Our longitudinal engagement – built through repeated farm visits for data collection and technical activities – created a rare observational opportunity. By participating

[1] As Granovetter (1985) points out, economic actions are *embedded* in social structures whereby there is no actor as an 'atom' within the market, but farmers' decisions as entrepreneurs are immersed in and shaped by local traditions, institutional constraints, and collective relations. In this study, we applied this perspective to understand how farmers manage the tension between economic imperatives and cultural values in the context of breed conservation.

in routine operations such as farm visits and breeding selections, we gained privileged insights into work practices while strengthening farmer-researcher trust. This sustained presence allowed us to contextualise the interview findings through informal conversations and first-hand observations of breed management challenges. The dual-phase approach combined systematic data collection (structured around farm histories, business models, and conservation strategies) with the flexibility to pursue emergent themes, particularly regarding subsidy effectiveness and alternative sustainability models.

2.4. Data analysis

We adopted a hybrid thematic analysis approach (Braun, Clarke, 2006; Fereday, Muir-Cochrane, 2006) combining inductive and deductive methods. After transcribing the interviews, they were read repeatedly for data familiarisation while preserving the original meanings and contextual nuances. The coding phase integrated inductive identification of emergent themes from raw data with deductive application of embeddedness theory (Hess, 2004) and agricultural policy frameworks. Through constant comparative analysis (Miles, 1994), codes were systematically clustered into coherent thematic patterns, focusing particularly on farmers' conservation narratives (Buetow, 2010). Cross-farm comparison revealed both commonalities and significant differences in the participants' experiences with breed conservation policies and subsidy systems. Two primary thematic areas emerged: tensions between CAP subsidy dependency and long-term sustainability, and farmers' proposals for cooperative models and market differentiation strategies. Methodological rigor was ensured through multiple validation strategies including triangulation with observational data and documentation, peer debriefing sessions (Nowell *et al*., 2017), and systematic reflexivity to monitor the positioning of the researcher and potential bias influences (Galdas, 2017). The final interpretation balanced theoretical contextualisation with authentic perspectives from the participants, maintaining solid grounding in the farmers' concrete experiences while connecting the findings to the broader agricultural policy literature and ensuring analytical transparency throughout the interpretive process.

3. RESULTS

As shown in Table 1, the participants included both male and female farmers aged 36-67 years. The educational level varied, ranging from middle school to a master's degree. While some farmers were certified organic producers, others were not, reflecting diverse farming practices. The focus of the farms varied from single-use meat production and dual-purpose systems involving both meat and milk (cheese) production. The number of animals on each farm ranged from 5 to 105, representing both small and big-scale operations within the sample. Below, we present the two key thematic areas that emerged during the interviews.

3.1. Perceived shortcomings in the implementation of CAP financial support for livestock conservation: the balance of economic dependency versus long-term viability

This theme relates to the concerns raised by farmers regarding the shortcomings of CAP financial support for livestock conservation, with a particular focus on issues related to the distribution and effectiveness of aid. It also includes the possible improvements to the system to better support livestock breed conservation initiatives suggested by farmers during the interviews.

Farmers' concerns about financial support for local breed conservation

For the 2023-2027 period, measure ACA14 ('Farmers as custodians of agrobiodiversity') provides annual financial support calculated per LSU: from €98.48 to €358.61 per LSU per year in Lombardy, and €400 per LSU per year in Piedmont. Payments, disbursed in a single tranche by the end of the year, are fully compatible with other agri-climate-environmental commitments (AECM) and with regional animal welfare schemes. In addition, beneficiaries have free access to advisory services (SRH01) and technical training (SRH03) provided by regional rural development agencies, including annual on-farm visits, genetic management workshops, and administrative support. All interviewed farmers acknowledge the value of this package, considering the higher costs of raising these 'less productive animals' (Samuele, 56). As Eleonora (38) pointed out, 'the subsidies are essential for us, but we can't rely on them forever'. Carlo (54) added, 'if they cut these subsidies in the next CAP plan, it will no longer be worth keeping these animals'. While many farmers appreciated the immediate financial relief, concerns about the long-term implications of this dependence were widespread. There seems to be a general feeling that relying on long-term subsidies might limit innovation and self-sufficiency. As Roberto (36) emphasised, 'we need to find a way to make these breeds economically viable on their own [...], otherwise I'm sure

many of us (probably most) will stop raising them soon'.

Another issue that came up was criticism of how funds are distributed. Some farmers believe that the subsidies are often inefficient or poorly allocated. 'Some of us... [I won't name names...] yes, they get the subsidies, but they don't actually invest in improving the breed [...] it seems like they just keep these animals for other reasons, mainly to display them to the public in a farm as part of a tourist attraction, among other animals' (Giovanni, 52).

Balancing short-term support with long-term sustainability

A recurring issue in the discussions is the tension between the short-term support provided by CAP aids and the long-term sustainability of breed conservation. While many farmers appreciated the immediate financial assistance, they expressed concern that long-term reliance on these subsidies could undermine the development of more *sustainable* models. In particular, some farmers suggested that increasing the market value of products derived from local breeds – such as premium meats and cheeses – could reduce their dependence on subsidies. The farmers expressed concerns about their dependency on CAP subsidies while also acknowledging that alternative economic models would be difficult to sustain within current policy frameworks. One farmer explained, 'If we can create a market for our products, like cheese from these local breeds, then we don't need to rely so much on the aids' (Paola, 63). However, others, particularly older farmers, expressed doubt that niche markets alone would be enough to generate sufficient income. They argued that CAP aid should continue to play a role, though not be the sole source of support. In contrast, younger farmers were more optimistic about the potential for creating sustainable niche markets. Moreover, the farmers highlighted concerns about the misuse and misallocation of CAP funds. Several of the interviewees mentioned that some farmers only maintain the minimum number of autochthonous animals required to qualify for aid, without making substantial investments in conservation. This has led to calls for improved transparency and accountability in how funds are distributed. As one farmer pointed out, 'we need more controls in place to make sure the aids are going to those who are serious about conservation. Otherwise, it's just money wasted' (Lucia, 62).

Shifting towards active conservation strategies

The interviews highlighted the need to move from mere passive protection of local breeds to active conservation strategies. CAP subsidies have been essential so far in keeping these breeds alive, but many farmers are calling for more proactive measures. As Giuseppe (53) observed, 'if we can improve the breeds themselves, then they can become more economically viable [...] The aids should be helping us do that, not just paying us to keep things as they are'.

The farmers advocated for dedicated support to selection programmes that increase genetic variability, strengthening resistance to diseases and climate stress, while being aware of possible trade-offs on growth or yield. An exclusive focus on productivity risks undermining the rusticity of the animals. Therefore, they see CAP funds as a key tool to balance these trade-offs, while safeguarding both farm profitability and the ecological robustness of native breeds. This call for active conservation aligns with the most recent agricultural policies, which are increasingly oriented towards sustainability and innovation. Research has confirmed that targeted selection of traits such as disease resistance, heat tolerance, and feed efficiency –already documented in Mediterranean sheep and cattle – can enhance resilience without reducing agro-biodiversity (Biscarini *et al*., 2015).

3.2. Proposed solutions for sustainable breed conservation

This thematic area includes the solutions proposed by the farmers to improve breed conservation practices, focusing on approaches that promote sustainability and long-term viability from farmer perspective.

Many of the farmers emphasised the potential of community-driven approaches, highlighting the importance of local networks and consortia in improving breed production and marketing. These networks can facilitate knowledge exchange and resource sharing, enabling farmers to overcome challenges related to breed conservation. For example, breed-specific consortia allow farmers to work together on marketing strategies, share breeding techniques, and advocate for more tailored policy support. As one farmer put it, 'working together, we can do more [...] If we want to keep these breeds alive, we need to build strong local networks that can support each other' (Roberto, 36). This perspective reflects a growing recognition that successful breed conservation often requires collective action and the pooling of local resources.

In addition to community-based models, several farmers pointed to the importance of increasing consumer awareness to support breed conservation. Raising awareness about the cultural and environmental significance of local breeds could lead to greater demand for niche products, such as locally produced meats and

cheeses, thus creating new markets that would contribute to the economic viability of these breeds. Some farmers proposed initiatives aimed at educating consumers, particularly through outreach programmes in schools. This would help foster a deeper understanding of the role these breeds play in both local heritage and sustainable agriculture, ultimately encouraging consumers to make more informed purchasing decisions. As one farmer suggested, 'we need to teach people – especially young people – about the importance of these breeds, so they grow up understanding their value and choose to support them' (Samuele, 56).

The farmers also pointed to the potential of these community-based models to address the unique challenges faced by those working with autochthonous breeds. By collaborating, farmers can overcome financial and technical barriers that might be difficult to handle individually. These cooperative models help in creating a sense of shared responsibility and a unified voice in advocating for breed-specific policies.

4. DISCUSSION

Efforts to preserve local breeds can be justified not only to preserve livestock genetic heritage, but also to balance cultural values, economic viability and environmental sustainability. Yet, the practical challenges farmers face often come down to economic concerns.

Embeddedness theory, as outlined by Granovetter (1985) and elaborated by Hess (2004), reveals that farmers' economic decisions emerge from a single socio-institutional context and depend on a coherent interplay between horizontal relationships and vertical constraints. Based on the interviews, farmers rely on peer networks and the regional livestock association to share knowledge, to build trust, and to maintain the flexibility needed for collective innovation. At the same time, they must align their investment and management choices with the timing, amounts, and conditions of payments. When the policy incentives and community support are not properly synchronised, social capital remains underutilised and farmers struggle to translate innovation into practice, underscoring the need for policies that harmonise institutional 'push' with community 'pull'. We examined farms located in areas characterised by highly intensive agriculture, where the protection of local breeds is an exception. These farms are significantly dependent on CAP subsidies, which points to a strong integration in the institutional system (Tregear, Cooper, 2016). While public support sustains them, it may also limit their independence and innovation. Moreover, while farmers recognise the cultural and ecological value of these breeds, many view conservation efforts as secondary to their immediate financial needs. This creates a tension, where the cultural importance of these breeds may not be enough to drive long-term, sustainable farming practices without clear economic incentives.

The gap between the theoretical value of conservation and the practical reality of agriculture is evident in all agricultural practices, not only in the case of local breeds. For example, research on agricultural cooperatives has highlighted that, although the theory behind cooperatives suggests benefits such as market power and resource sharing, in practice, these cooperatives often face significant inefficiencies (Candemir *et al*., 2021). This example illustrates how, in many cases, there is a discrepancy between theoretical goals and practical challenges. Regarding the conservation of local breeds, success depends not only on economic incentives, but also on the strength of local networks and the ability of farmers to collaborate in accessing specialised markets and gaining greater visibility for their products. Many farmers are primarily focused on economic survival, and unless they see a direct and tangible benefit from their conservation efforts – such as better market access, higher prices, or government support – they are unlikely to prioritise these initiatives. An effective approach might involve formulating breeding programmes that prioritise productive traits conducive to the development of distinctive products, supported by targeted marketing strategies. However, these initiatives must also preserve the historical and cultural value of local breeds. The improvement of genetic performance through structured breeding plans could be facilitated by financial support from European Union (EU) funds, thus ensuring systematic genetic improvement. Although EU funds and advisory services support supply chain and marketing projects, real success depends on the active engagement of farmers (Marescotti *et al*., 2024). Specialised agencies can facilitate funding and strategies, but a bottom-up approach, where farmers co-design and lead initiatives, seems crucial for a dynamic and sustainable conservation of local breeds (Haile *et al*., 2023).

A key consideration is that many farmers who raise local breeds do not have a flagship product, such as the premium products found in other sectors, which makes it even more difficult for them to justify the extra effort involved in breed conservation. Without a high-value product on which to rely, the challenge of balancing conservation efforts with financial sustainability becomes even more pronounced. The comparison between beef cattle farming in Galicia and Parmigiano-Reggiano cheese production in Emilia Romagna made by Swage-

makers (2021) helps illustrate this point. Both regions highlight the importance of local breeds and sustainable farming practices. However, their strategies differ significantly. In Emilia Romagna, Parmigiano-Reggiano has strong brand recognition, with cooperative structures that allow farmers to negotiate better deals and promote a product that consumers are eager to pay a premium for. On the other hand, Galicia's beef sector still relies heavily on public subsidies and agri-environmental schemes, which can sometimes feel like a band-aid solution rather than a pathway to long-term sustainability. This discrepancy shows that while market incentives are crucial, government support plays a key role in making sure these breeds – and the farmers who care for them – remain viable (Swagemakers, 2021).

Another important aspect is the ecosystem services that local breeds provide. These animals help maintain agro-biodiversity, but their impact on soil health and carbon sequestration is not as clear. The available evidence is not definitive, and the outcomes depend heavily on factors such as farming practices, grazing systems, land use, and overall management. It is essential to recognise that breed alone does not determine environmental impact: its contribution to emission reductions depends on improving production efficiency (Cusack *et al*., 2021) rather than merely selecting a specific breed. The value of these services often goes unrecognised in market systems, and their full potential can only be realised by considering these additional variables.

Looking at consumer awareness, there is clearly an opportunity to do more. While there is a growing market for sustainable, locally produced goods, many consumers do not fully understand the value of local breeds or the role they play in maintaining agro-biodiversity and cultural heritage (Boaitey *et al*., 2018). If more consumers understood the unique qualities of products made from these breeds – whether it's meat from Galician cattle or cheese from Emilia Romagna – they might be willing to pay a premium price, a finding in line with research by Demartini *et al*. (2021). This would, in turn, make conservation more economically viable for farmers.

5. CONCLUSION

Our findings suggest that conserving local livestock breeds in intensive agricultural contexts requires more than financial subsidies: it demands an integrated policy framework that empowers custodial farmers, aligns institutional incentives with community dynamics, and fosters market viability, moving beyond financial subsidies alone. The farmers emphasise the need for public policy to go beyond simple payment schemes by streamlining administrative procedures, enhancing market access, and investing in skills development. Cooperatives and producer associations are essential partners in this effort to pool resources, to disseminate technical expertise, and to secure better market terms. However, without mechanisms for genuine farmer participation in policy design, top-down interventions risk remaining detached from on-farm realities and failing to address the practical challenges that producers face daily. A complementary bottom-up governance model – operationalised through regional participatory forums of farmers, researchers, extension agents, and policymakers – seems to offer a pathway forward. These platforms can co-construct genetic improvement programmes, supply-chain financing schemes, and consumer-outreach campaigns that integrate farmers' experiential knowledge with scientific innovation. As the farmers pointedly remind us, 'these animals aren't pandas'. This provocative assertion challenges us to recognise a fundamental distinction. Unlike iconic wildlife that primarily serves symbolic conservation purposes, local livestock breeds are living agricultural systems that simultaneously deliver cultural heritage, economic value, and ecosystem services. Future research should rigorously evaluate farmer-led, marker-assisted breeding trials embedded within bottom-up governance structures, assessing their effects on breed resilience, farm profitability, and community well-being. By outlining potential alignments between institutional 'push' and community 'pull', this case study provides practical guidance for the sustainable management of local breeds in rural areas.

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AUTHOR CONTRIBUTIONS

AFC: Conceptualization, Methodology, Software, Data Curation, Writing - Original Draft Preparation, Visualization, Investigation, Writing - Reviewing and Editing; MEM: Conceptualization, Investigation, Writing - Original Draft, Writing - Reviewing and Editing; EG: Writing - Original Draft Preparation, Conceptual-

ization, Validation, Supervision; AG: Writing - Reviewing and Editing, Funding Acquisition, Supervision

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Keynote article

L'abbandono dell'agricoltura ci riguarda?

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Abstract. L'abbandono dei terreni agricoli in Italia è strettamente legato allo spopolamento rurale; tuttavia, le politiche agricole attuali si sono rivelate insufficienti per contrastare il fenomeno. La ricerca ha identificato i suoi fattori determinanti e i relativi effetti, ma le loro interconnessioni e le implicazioni sociali restano ancora poco esplorate. È fondamentale valutare i servizi ecosistemici e le esternalità agricole per supportare decisioni informate, anche se l'applicazione pratica di tali valutazioni risulta ancora complessa. La principale causa dell'abbandono è la bassa redditività; garantire redditi equi è necessario, ma non sufficiente se non si considerano le condizioni di vita locali e i fattori legati alla qualità della vita. Approcci integrati, sostenuti da quadri teorici come quello delle capabilities di Sen, possono orientare strategie specifiche per i diversi contesti al fine di sostenere i mezzi di sussistenza rurali. Risposte efficaci richiedono una governance multilivello coordinata, una pianificazione territoriale mirata e strategie che combinino competitività, benessere sociale e sostenibilità economica. Le tendenze demografiche, il ricambio generazionale e il calo di attrattività del settore accrescono l'urgenza di un intervento. Le politiche europee e nazionali riconoscono sempre più il legame tra spopolamento e declino agricolo, rendendo questo un momento cruciale per agire. Gli economisti agrari e applicati possono svolgere un ruolo centrale, se disposti ad accettare la sfida.

Keywords: land abandonment, depopulation, well-being, profitability, agricultural policy.
JEL codes: R11, R14, R23.

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HIGHLIGHTS

- L'abbandono dei terreni agricoli in Italia è strettamente legato allo spopolamento rurale; le politiche attuali non sono riuscite a fermarlo.
- La bassa redditività rappresenta un problema cruciale; garantirne livelli adeguati è necessario ma non sufficiente.
- Analizzare i determinanti della qualità della vita nelle aree marginali è essenziale per promuovere autentici percorsi di sviluppo.
- Una governance coordinata e l'economia applicata sono fondamentali per trasformare la consapevolezza in soluzioni rurali concrete e sostenibili.

1. INTRODUZIONE

«L'Europa offre una qualità della vita unica: dalla sicurezza sociale ai prodotti alimentari regionali di alta qualità. Campi di colza, vigneti e frutteti non rappresentano solo il nostro cibo e le nostre bevande, ma fanno parte della nostra identità. Per questo, il futuro dell'agricoltura è una questione tanto importante quanto delicata per noi europei». Con queste parole, la Presidente della Commissione Europea Ursula von der Leyen ha aperto il suo intervento al Parlamento Europeo il 18 luglio 2024, sottolineando il ruolo centrale che l'agricoltura riveste per il modello europeo di sviluppo.

Eppure, il futuro dell'agricoltura in Europa appare sempre più incerto, soprattutto in alcune aree rurali e marginali. Negli ultimi decenni, l'abbandono delle terre agricole è diventato un fenomeno sempre più diffuso, ponendo importanti interrogativi di natura economica, ambientale e sociale (Terres *et al*., 2015; Fayet *et al*., 2022; Dax *et al*., 2021; Lasanta *et al*., 2017). Intere porzioni di territorio coltivato sono state progressivamente dismesse, in particolare laddove i sistemi agricoli tradizionali a basso input non risultano più sostenibili (Cusens *et al*., 2024; Quintas-Soriano *et al*., 2022; Ustaoglu *et al*., 2018; Plieninger *et al*., 2006). In questi territori si assiste inoltre, molto spesso, anche al fenomeno più ampio dello spopolamento. L'agricoltura non è sostituita da altre attività economiche e il territorio "muore". I due fenomeni sono intimamente collegati anche se non sempre è chiaro chi sia la causa e chi l'effetto. Nel corso del lavoro chercherò di trattare.

Secondo un rapporto della Commissione Europea – Joint Research Centre (JRC), l'abbandono dei terreni agricoli può essere definito come «la cessazione della gestione delle terre agricole, che comporta effetti indesiderati sulla biodiversità e sui servizi ecosistemici» (Terres *et al*., 2013: 22), altri Autori evidenziano però anche la presenza di potenziali impatti positivi dal punto di vista ambientale (Van der Zanden *et al*., 2017). Si tratta in realtà di fenomeno molto complesso sia come effetti sia come cause essendo il frutto di una complessa interazione di fattori economici, ambientali e demografici. Pur essendo un fenomeno pan-europeo, infatti, le cause e le implicazioni dell'abbandono agricolo variano sensibilmente tra le diverse regioni, riflettendo le specificità locali e i contesti politici in cui esse sono inserite (Pawlewicz *et al*., 2023; Renwick *et al*., 2013).

La crescente rilevanza del fenomeno ha stimolato una ricca produzione scientifica che spazia dall'analisi dei trend futuri (Vacquie *et al*., 2015; Mouchet *et al*., 2017), agli effetti sui servizi ecosistemici (Plieninger *et al*., 2014; Gabarrón-Galeote *et al*., 2015), fino alla valutazione qualitativa e quantitativa delle conseguenze e delle implicazioni politiche dell'abbandono (Lasanta *et al*., 2015; Keesstra *et al*., 2018). Tuttavia, gli studi empirici mettono in luce la necessità di definire un quadro di riferimento comune per la valutazione degli impatti e per guidare le politiche e la pianificazione territoriale, pur nella necessità di adeguare gli interventi in base alle specifiche realtà locali (Ustaoglu, 2018).

La rilevanza strategica del tema è confermata anche dal recente documento di visione della Commissione Europea, che anticipa i contenuti della futura riforma della Politica Agricola Comune (PAC). In tale documento si legge: «L'agricoltura e il cibo sono il cuore dello stile di vita europeo. Radicate in tradizioni ricche, le modalità con cui produciamo e consumiamo alimenti hanno plasmato le comunità, le culture e i paesaggi che definiscono l'identità europea. (…) Le aree rurali ospitano il 25% della popolazione dell'UE e coprono il 75% del territorio, costituendo una parte integrante dell'identità europea. Comunità rurali e costiere vitali sono essenziali per contrastare lo spopolamento e garantire il diritto a restare» (Commissione Europea, 2024).

Il documento identifica quattro priorità fondamentali per il futuro del sistema agroalimentare europeo:

- Un settore attrattivo e prevedibile, in grado di garantire redditi adeguati agli agricoltori e attrarre le nuove generazioni.
- Un sistema competitivo e resiliente, capace di rispondere alla concorrenza globale e agli shock economici.
- Un'agricoltura sostenibile, in equilibrio con i limiti planetari.
- Un settore che valorizzi il cibo, promuova condizioni di vita e lavoro dignitose, e sostenga territori rurali connessi e vitali.

In almeno due di queste quattro priorità è evidente la preoccupazione per un settore agricolo che presenta forti segnali di crisi in vaste aree europee. L'obiettivo dei territori rurali connessi e vitali viene infatti integrato proponendo una politica agricola e non solo che ponga al centro l'attrattività per le nuove generazioni, ottenibile solo garantendo una redditività adeguata insieme condizioni di vita e lavoro dignitose.

In questo contesto, emergono con forza alcune domande centrali: qual è oggi la condizione delle aree rurali in Italia? Quali strumenti teorici ed empirici offre il mondo della ricerca per analizzare e affrontare l'abbandono delle terre agricole? Quali leve economiche, istituzionali e politiche possono essere attivate per contrastare questo fenomeno?

L'obiettivo di questo lavoro è offrire alcune risposte a tali interrogativi, attraverso un'analisi delle dinamiche

attuali che interessano l'agricoltura e le aree rurali italiane. Nei prossimi paragrafi, dopo una descrizione dell'attuale situazione, verrà presentato un quadro sintetico dei contributi scientifici più significativi sul fenomeno dell'abbandono rurale, con un focus su cause, effetti e strumenti di intervento. Saranno approfonditi in particolare due temi centrali per la tenuta dei sistemi agricoli e territoriali: la redditività dell'attività agricola e la misurazione del benessere nelle aree rurali. In definitiva, si cercherà di comprendere quali siano i percorsi di ricerca più promettenti e le politiche più efficaci per contrastare l'abbandono agricolo e favorire lo sviluppo sostenibile del mondo rurale.

2. LE DINAMICHE IN ATTO

L'abbandono delle terre agricole rappresenta una delle principali sfide territoriali ed economiche per l'Italia e per molti altri paesi europei, in particolare nell'area mediterranea. A livello europeo, il fenomeno dell'abbandono agricolo è stato oggetto di crescente attenzione negli ultimi decenni, con numerosi studi che ne analizzano le cause, le dinamiche territoriali e gli impatti. A partire dagli anni '90, l'uso del suolo in Europa ha seguito traiettorie diversificate: se nel Nord e nell'Ovest si è assistito a una intensificazione dell'agricoltura e a una crescente urbanizzazione (Plieninger *et al*., 2016; Levers *et al*., 2018), nei paesi dell'Est Europa si è verificata una notevole espansione delle aree forestali, mentre nell'Europa meridionale – in particolare in Italia, Spagna, Grecia e Portogallo – l'abbandono dei terreni agricoli è diventato il cambiamento prevalente (Kuemmerle *et al*., 2016).

Le dimensioni quantitative del fenomeno sono considerevoli: secondo Hatna e Bakker (2011), oltre 118.000 ettari sono stati abbandonati nell'Europa meridionale tra il 1990 e il 2006; Feranec *et al.* (2010) stimano 88.000 km² tra il 1990 e il 2000; Kuemmerle *et al.* (2016) identificano circa 20.500 km² tra il 2000 e il 2012. Questo processo è spesso accompagnato da fenomeni di riforestazione spontanea (Burrascano *et al*., 2016), che se da un lato comportano benefici ecologici, dall'altro possono portare alla perdita di paesaggi agricoli tradizionali e di biodiversità coltivata.

Tra gli Stati europei, l'Italia si distingue per la gravità del fenomeno, che colpisce soprattutto le aree montuose e collinari caratterizzate da agricoltura estensiva e a bassa redditività (Zavalloni *et al*., 2021; Malavasi *et al*., 2018; Cocca *et al*., 2012).

A livello nazionale, i dati dei censimenti più recenti evidenziano una situazione altamente preoccupante: su 7.896 comuni, oltre 2.000 mostrano una riduzione della SAU superiore al 50% tra il 1990 e il 2020, e altri 1.550 hanno registrato riduzioni comprese tra il 30% e il 50%. Questi comuni si trovano principalmente nelle aree interne (Figura 1). Tali aree sono caratterizzate da una complessa morfologia collinare e montana, scarsa connettività nei trasporti e accesso limitato ai servizi pubblici (Cardillo *et al*., 2022; Salvia *et al*., 2019). Alcuni casi di espansione delle superfici agricole, riscontrati principalmente in Sardegna, sono legati all'aumento delle colture estensive come i prati-pascolo, ma non invertono la tendenza allo spopolamento, come mostrato nella Figura 2. Le uniche eccezioni significative si ritrovano nel Nord-Est, dove specifiche condizioni socio-economiche favoriscono lo sviluppo e la permanenza delle giovani generazioni anche nelle aree montane. Questi casi meritano studi specifici finalizzati a esaminare tutte le condizioni presenti e a valutarne la trasferibilità in altri contesti.

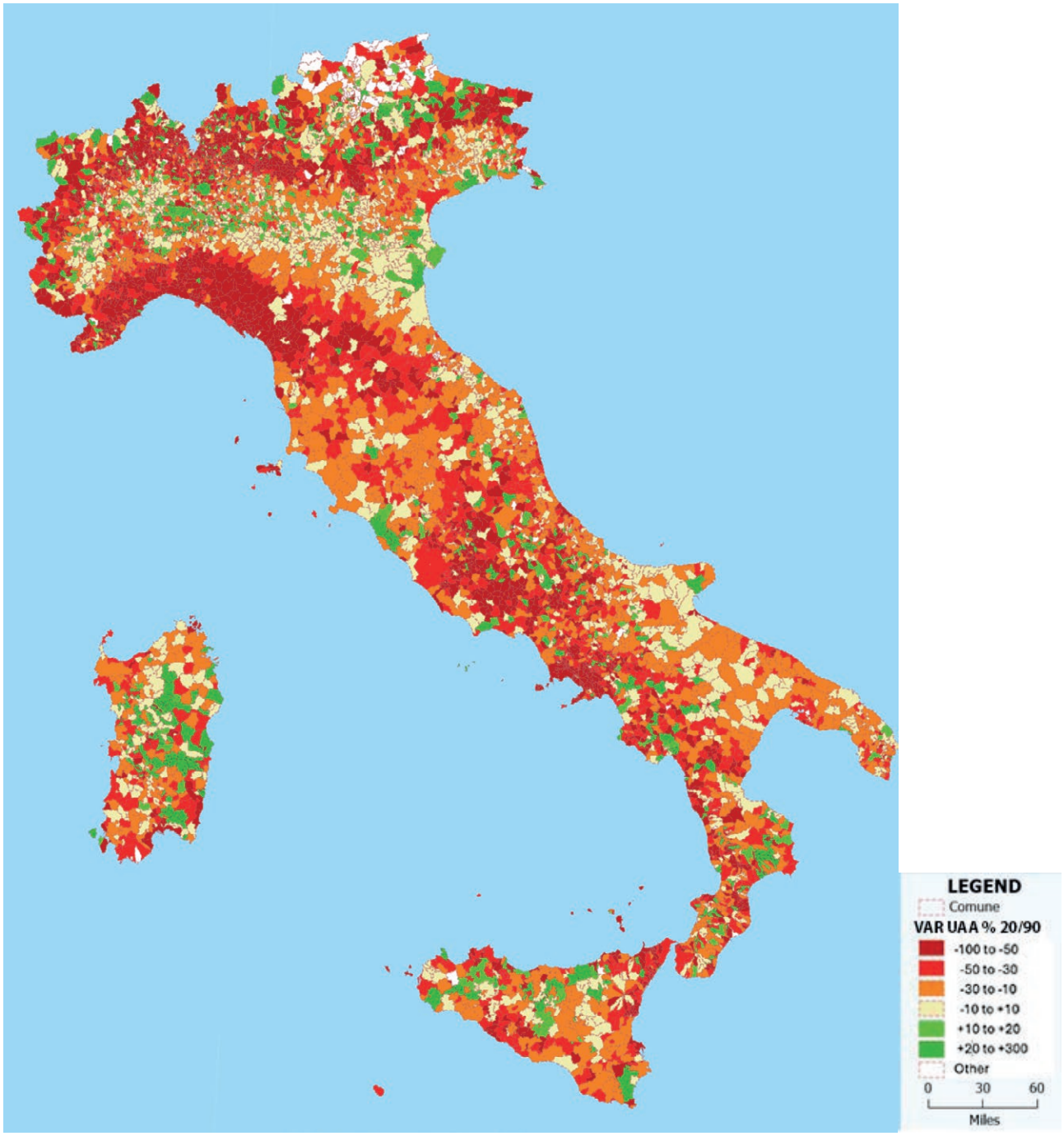
La Figura 2 mostra chiaramente la forte interrelazione tra l'abbandono dei terreni agricoli e l'emigrazione della popolazione. Circa 2.000 comuni hanno registrato sia una riduzione della Superficie Agricola Utilizzata (SAU) superiore al 30% sia un calo demografico, e circa 1.600 di questi si trovano in aree rurali. In molte zone interne collinari e montane si sono rilevati decrementi di popolazione superiori al 10% tra il 1991 e il 2024. Questi fenomeni risultano particolarmente evidenti nell'Italia meridionale, nelle isole e in Liguria, a conferma del fatto che spopolamento e abbandono dei terreni sono due facce della stessa realtà. In molti di questi territori, marginalità agricola e marginalità sociale coesistono, dando origine a una crisi difficile da invertire, proprio a causa della complessità delle sue cause e delle loro reciproche interazioni. Come osservato da Terres *et al.* (2015) "The reasons for farmland abandonment are multidimensional, and there is no clear-cut division among drivers as it rather depends on the result of their co-occurrence and interactions".

3. LE CAUSE

Numerosi studi internazionali hanno analizzato le cause dell'abbandono delle terre agricole e del progressivo spopolamento delle aree interne, con particolare attenzione al contesto europeo. Tuttavia, il contributo specifico degli economisti italiani su questi temi risulta, ad oggi, ancora limitato.

Un contributo rilevante in ambito europeo è fornito da Terres *et al.* (2015), che sottolineano come le cause dell'abbandono siano multidimensionali e derivino dall'interazione di diversi fattori, piuttosto che da singole variabili isolabili. Gli Autori evidenziano inoltre come

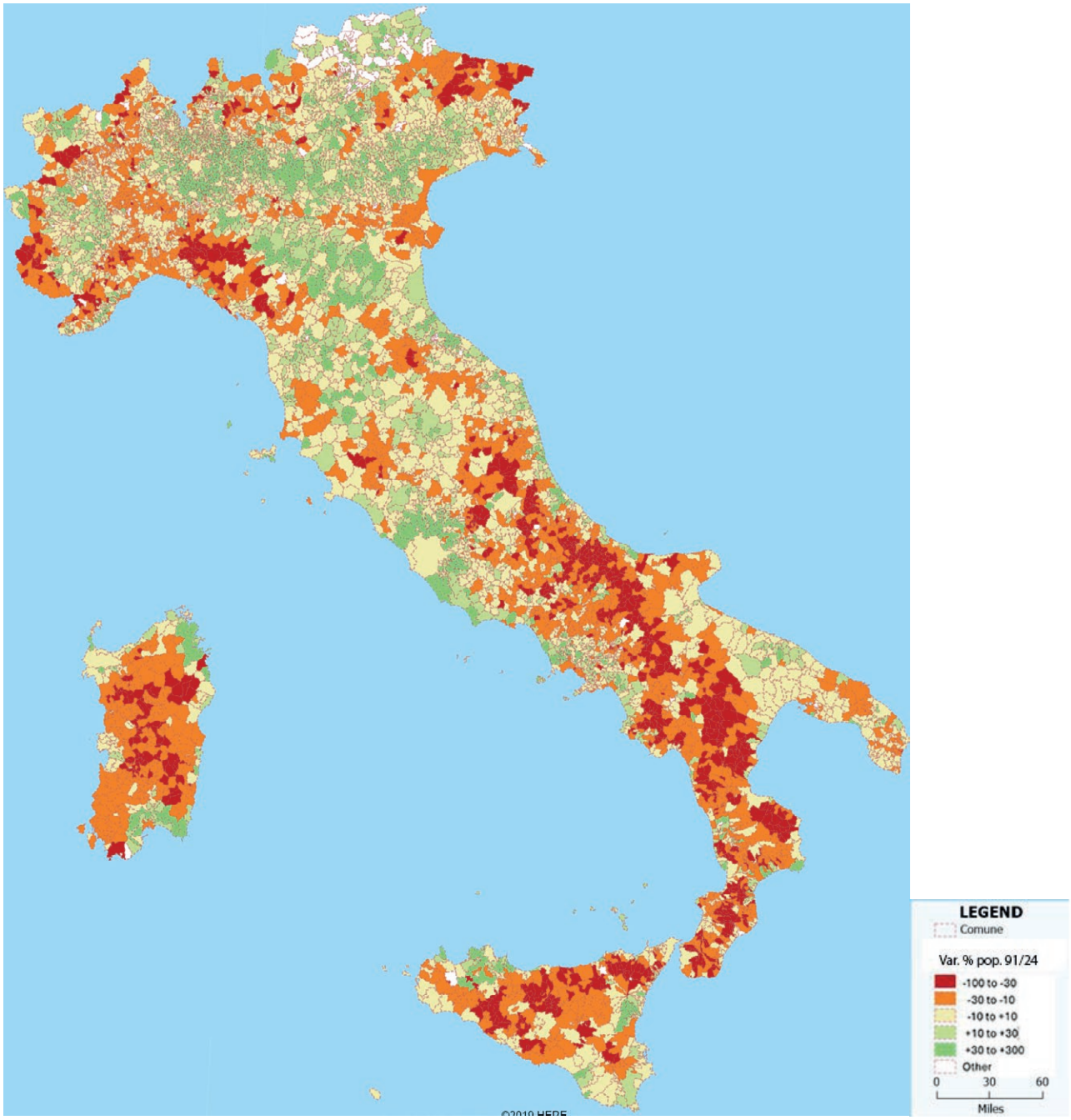
Figura 1. Variazione percentuale della SAU a livello comunale, Censimenti 1990-2020 (ISTAT).



questo fenomeno abbia specifiche caratteristiche territoriali e temporali: "The causes of farmland abandonment in Europe are manifold, depending on the area and the period under consideration. It is a complex process which can have a wide range of drivers, varying between Member States and sometimes within a single country".

Le potenziali cause dell'abbandono citate in letteratura sono molteplici: tra le più rilevanti ci sono i vincoli naturali, il degrado ambientale, le condizioni socioeconomiche, i cambiamenti demografici e i contesti istituzionali (Lasanta *et al.*, 2017; FAO, 2006). Inoltre, nelle aree caratterizzate da suoli di scarsa qualità o

Figura 2. Variazione percentuale della popolazione a livello comunale – anni 1991-2024 (ISTAT).



da condizioni climatiche difficili, l'agricoltura diventa sempre meno sostenibile a livello economico, portando a tassi di abbandono più elevati (Varela Pérez *et al.*, 2022). Il degrado del suolo, aggravato dalle pratiche agricole intensive e dai cambiamenti climatici, allo stesso tempo riduce ulteriormente la sostenibilità agricola in alcune regioni (Nunes *et al.*, 2023; Lucas-Borja *et al.*, 2019; Zambon *et al.*, 2018). I fattori socioeconomici sono altrettanto rilevanti: l'aumento dei costi di produzione, il calo dei prezzi agricoli e la pressione della concorrenza globale hanno ridotto la redditività dell'attività agricola (Osawa, T.,2016, Kumm *et al.*, 2020; Zgłobicki *et al.*, 2020; Ustaoglu *et al.*, 2018; Coppola, 2004), spingendo molti agricoltori a cercare mezzi di sussistenza

alternativi o a migrare verso le aree urbane (Chen *et al*., 2024; Qianru *et al*., 2021; Munroe *et al*., 2013). Questa tendenza è particolarmente accentuata nelle regioni con popolazioni in invecchiamento e dove le opportunità di subentrare nelle attività agricole sono limitate per le nuove generazioni (Robinson, 2024; Zhang *et al*., 2022; Sroka *et al*., 2019).

L'Italia affronta sfide particolarmente complesse, in linea con le tendenze osservate nell'area mediterranea. L'abbandono delle terre agricole riguarda soprattutto le zone montane e collinari (Zavalloni *et al*., 2021; Malavasi *et al*., 2018; Cocca *et al*., 2012), storicamente caratterizzate da un'agricoltura di sussistenza su piccola scala. In questi territori, la concorrenza con le aziende operanti in aree più produttive risulta sfavorevole, e la qualità della vita è spesso percepita come inadeguata, soprattutto dai più giovani (Riccioli *et al*., 2016). Le specificità italiane comprendono anche la frammentazione fondiaria, che ostacola i processi di ammodernamento aziendale e di incremento della produttività (Praticò *et al*., 2022; Smiraglia *et al*., 2019; Romano *et al*., 2012), nonché la carenza infrastrutturale e la difficile accessibilità di molte aree (Remondino *et al*., 2022; Coppola *et al*., 2018). Su tutto questo si inserisce anche la riduzione del tasso di natalità, che aggrava le criticità ora descritte, e che richiederebbe uno studio specifico per analizzarne cause e soluzioni.

Rizzo (2024) richiama l'attenzione sullo studio di Drudy (1978) relativo al contesto inglese, il quale evidenzia l'interazione tra fattori di "spinta" (disoccupazione agricola, mancanza di alternative) e fattori di "attrazione" (offerta occupazionale e migliori condizioni di vita nelle città industriali). Drudy utilizza la teoria della "causazione cumulativa" (Myrdal, 1957), secondo cui la contrazione dell'agricoltura avvia un circolo vizioso di migrazione, riduzione dei servizi pubblici e invecchiamento della popolazione rurale, che rende ancor meno attrattivi i territori interni.

Nel suo lavoro sulla Sicilia, Rizzo propone una classificazione delle aree rurali in tre gruppi: "Territori Lenti", "Territori in Transizione" e "Territori in Declino". I primi si distinguono per una crescita lenta ma resiliente, grazie a strategie di sviluppo legate ai mercati del cibo di qualità e all'agriturismo (Marsden, 1998). I "Territori in Declino", al contrario, non sono riusciti a integrare l'economia agricola con attività complementari e soffrono un forte spopolamento. I "Territori in Transizione" mostrano caratteristiche miste, con economie rurali avanzate ostacolate però dalla perdita demografica. Fattori chiave di differenziazione sono l'accessibilità e la vicinanza a poli urbani, aree industriali o destinazioni turistiche. Le implicazioni del modello suggeriscono l'importanza della diversificazione, della multifunzionalità e di un'adeguata connettività per trattenere la popolazione.

Anche l'OCSE (2006) sottolinea l'attualità della teoria di Drudy per spiegare i processi contemporanei di spopolamento. Secondo l'organizzazione, la perdita di capitale umano (giovani istruiti) e il disinvestimento pubblico e privato nelle aree rurali producono una spirale regressiva che compromette le prospettive di sviluppo agricolo. Dal punto di vista ambientale, Antrop (2000; 2004) critica la Politica Agricola Comune (PAC) per non aver tenuto conto delle specificità locali delle regioni rurali europee. Proposte più recenti evidenziano la necessità di una tassonomia dei paesaggi e di scale analitiche adeguate per indirizzare in modo mirato le politiche europee (Van Eetvelde e Antrop, 2004).

Infine, diversi studi hanno evidenziato il ruolo delle politiche agricole nella generazione di abbandono "indotto". Il regime della PAC ha incentivato tra il 1988 e il 2008 il ritiro temporaneo (set-aside) o permanente (land retirement) di terreni agricoli per contenere le eccedenze produttive (Lasanta *et al*., 2015; García-Ruiz e Lana-Renault, 2011). Questi programmi hanno escluso fino al 15% dei terreni dalla produzione (Tscharntke *et al*., 2011). Altri fattori politici includono la difficoltà di rinnovo dei contratti agroambientali, l'introduzione di nuovi standard sanitari e il disaccoppiamento dei pagamenti diretti dai prodotti agricoli, con effetti rilevanti nei Paesi dell'Est Europa (Pointereau *et al*., 2008). Keenleyside e Tucker (2010) osservano che, nonostante l'incertezza sull'evoluzione di alcuni fattori, molti di essi sono destinati a intensificarsi con l'integrazione nei mercati agricoli globali (Ustaoglu, 2015).

3.1. La redditività

Per analizzare il rischio di abbandono delle aziende agricole, in un recente studio (Fantechi *et al*., 2026) ci siamo concentrati su una delle principali determinanti del fenomeno: la produttività/redditività del lavoro, ovverosia il Valore Aggiunto per addetto full time. L'analisi ha riguardato i dati RICA-REA di tre dei principali tipi di orientamento tecnico-economico (OTE) dell'agricoltura italiana (Seminativo, Viticolo, Olivicolo), prendendo in considerazione dati sia al lordo che al netto degli aiuti, in termini nominali e reali.

L'analisi si è focalizzata sulle aziende con una dimensione economica superiore ai 25.000 euro (ESU), al fine di escludere quelle con finalità prevalentemente hobbistiche o part-time, per le quali la redditività non costituisce necessariamente un vincolo strutturale.

I risultati emersi delineano un quadro preoccupante. Un numero significativo di aziende – distribuite in

tutte le macroaree e in tutti e tre gli orientamenti analizzati – presenta livelli di Valore Aggiunto per addetto inferiori alla soglia di rischio abbandono, inferiori cioè al 60% del valore del GDP pro capite (in Italia al 2022 33.000 euro), analogamente a quanto proposto da Terres *et al.* (2015). Per i tre OTE considerati la percentuale di aziende a rischio abbandono risulta di oltre un terzo con una punta di quasi il 60% per le aziende olivicole. Per questo OTE anche le grandi aziende non sono del tutto immuni, sebbene le piccole e medie risultino maggiormente vulnerabili. Le criticità aumentano procedendo da nord a sud, con picchi superiori al 50% nel Sud Italia, in linea con quanto già segnalato dalla letteratura (Salis *et al*., 2022; Andreoli *et al*., 2018; Streifeneder, 2016; Bonelli *et al*., 2018).

Considerando l'ampiezza della superficie agricola utilizzata (SAU), sebbene le percentuali siano inferiori a quelle riferite al numero di aziende, emergono comunque dati allarmanti: in alcune macroaree, soprattutto nel Centro e Sud Italia per l'OTE 37, il rischio coinvolge quasi la metà della superficie agricola.

Dal punto di vista dimensionale, l'analisi conferma una netta differenza tra grandi e medie aziende. In molti casi, le aziende medie presentano valori di produttività vicini o inferiori alla soglia di rischio abbandono, mentre le grandi aziende – specialmente nel Nord Italia – mostrano una maggiore capacità di adattamento e resilienza.

Particolarmente critiche sono le tendenze di lungo periodo: tra il 2010 e il 2022, la produttività del lavoro, in termini reali, è risultata in calo pressoché generalizzato, tanto al lordo quanto al netto degli aiuti. I dati in termini reali evidenziano una situazione ancora più grave rispetto a quella che appare dai valori nominali, con segnali negativi anche per le aziende di maggiori dimensioni.

Questi risultati confermano e dettagliano, a livello subnazionale e per specifici orientamenti produttivi, quanto emerso in altri studi europei (Ferreira *et al*., 2023; Wang *et al*., 2023; Lasanta *et al*., 2017), evidenziando la necessità di porre la redditività agricola al centro delle politiche per lo sviluppo rurale, in particolare nelle aree marginali ed evidenziano la necessità di interventi pubblici mirati per riequilibrare le condizioni di sviluppo e promuovere una convergenza verso livelli di produttività sostenibili, ponendo particolare attenzione alla redditività delle aziende agricole professionali.

"Balanced demographic, social, and economic structures are part of the attractiveness of rural areas' appeal. The lack of opportunities in rural areas leads to ageing and rural exodus, which jeopardizes the generational renewal of agriculture. These must be countered with rural proofing policy, understood as a coherent set of political measures to preserve and empower rural communities in their diversity and avoid territorial desertification" (European Commission, 2024). Questo passo tratto dallo Strategic Dialogue on the Future of EU Agriculture ci illustra un quadro in cui la redditività delle aziende professionali è un elemento centrale proprio per evitare il circolo vizioso generato da bassi redditi, esodo delle nuove generazioni, riduzione delle capacità imprenditoriali, e così via.

3.2. La qualità della vita

Accanto alle ben note cause economico-produttive, come la ridotta redditività dell'agricoltura, la scarsa competitività, o l'assenza di infrastrutture, emerge con forza una causa più sottile ma decisiva: l'insufficiente qualità della vita percepita da chi abita in questi territori.

Diversi studi (Peel *et al*., 2016; Casini *et al*., 2019) hanno evidenziato che i livelli di benessere e i fenomeni di spopolamento sono fortemente correlati. Una "buona" qualità della vita, infatti, rappresenta una precondizione per la vitalità economica e sociale di un territorio. Dove le condizioni di vita non sono percepite come dignitose o soddisfacenti, le persone tendono ad abbandonare il territorio, in cerca di migliori opportunità altrove.

Tuttavia, nonostante la centralità del tema, gli interventi di policy volti a migliorare la qualità della vita nei contesti rurali sono stati finora limitati e con risultati poco significativi in molte realtà. Una delle ragioni principali risiede nella difficoltà, da parte dei decisori politici, di individuare con precisione quali siano le dimensioni del benessere realmente determinanti per i diversi territori. Il concetto di "well-being" è infatti ampio, multidimensionale e relativo, nel senso che è fortemente dipendente dalle condizioni socio-culturali, ambientali ed economiche specifiche di ciascun territorio.

Il recente Piano strategico nazionale delle aree interne (PSNAI 2025) offre alcune indicazioni su quali siano i principali costituenti del well-being. Il Piano ha come scopo "... quello di offrire una cornice strategica per il sostegno e lo sviluppo di aree periferiche e ultraperiferiche in declino o a rischio demografico il cui presidio attivo di Comunità risulta essere cruciale per la tenuta complessiva del territorio sotto il profilo idrogeologico, paesaggistico e dell'identità". La determinazione delle così dette Aree Interne si fonda principalmente sulla classificazione dei comuni italiani in base alla fruibilità di tre categorie di servizi pubblici. Più in dettaglio si individua come criterio principale di definizione delle aree interne la distanza oraria per il raggiungimento dei "Centri di offerta di servizi", ovverosia da Comuni che siano in grado di offrire simultaneamente: a. un'articola-

ta offerta scolastica secondaria superiore; b. un ospedale sede di Dipartimento di Emergenza Urgenza e Accettazione (DEA) almeno di I livello; c. una stazione ferroviaria di livello Platinum, Gold o Silver. L'importanza della disponibilità di servizi pubblici per la qualità della vita nei territori è stata ampiamente dimostrata (Casini *et al*., 2021), in questo caso però l'analisi è molto ristretta e probabilmente, anche se considera tre categorie di servizi molto importanti, non riesce a valutare correttamente tutti le componenti che costituiscono la qualità del vivere quotidiano e quindi le determinanti dell'abbandono o meno del territorio. Il rischio che appare è proprio quello di una errata valutazione dei problemi dei territori esaminati, con una conseguente allocazione delle risorse non efficiente. Questa classificazione è solo la base di partenza per la selezione delle aree di intervento, per cui è prevista una procedura complessa con Regioni e comuni che interagiscono, ma può già rappresentare un limite per l'indicazione che offre di eccessiva semplificazione delle componenti del benessere.

Per affrontare la complessità di un concetto come quello della qualità della vita, il contributo teorico più promettente e ancora oggi di grande attualità, è quello proposto da Amartya Sen attraverso la sua teoria delle "capabilities" (Sen, 1983; 1992; 1993). A differenza degli approcci economici tradizionali, come quello utilitarista o basato sull'opulenza, in cui il benessere è misurato in termini di utilità individuale o quantità di beni posseduti, Sen propone una lettura radicalmente diversa: il benessere è definito dalle libertà reali che gli individui hanno di fare e di essere ciò che hanno motivo di valorizzare.

Secondo questa impostazione, la qualità della vita non è determinata dal solo possesso di risorse materiali, ma dalla capacità delle persone di accedere effettivamente a una serie di opportunità essenziali, le cosiddette *capabilities*, che consentano loro di vivere una vita che ritengono significativa. Desai (1995) ha proposto un approccio applicativo della teoria di Sen i definendo una lista di capabilities che consentisse una loro valutazione pratica. Le principali sono: Salute, servizi sanitari; Accesso all' istruzione; Libertà di lavorare, autonomia economica; Libertà di muoversi; libertà di esprimersi; Accesso a risorse casa, terra, credito, tecnologie; Assenza di discriminazioni, riconoscimento sociale; Equo rapporto fra lavoro e tempo libero. Chiaramente il grado di rilevanza e la valutazione di ciascuna di esse dipenderà dagli specifici contesti in cui l'approccio di Desai verrà applicato, ma secondo l'autore esse manterranno sempre una loro importanza nella determinazione del wellbeing. Proprio per la specificità e relatività del concetto di benessere approcci partecipativi con il coinvolgimento degli abitanti appaiono la strada corretta per affrontare il tema dell'abbandono, in modo da comprendere realmente quali capabilities risultano oggi insoddisfacenti per quel dato territorio.

Applicata al contesto delle aree rurali, la teoria delle capabilities permette di leggere l'abbandono non solo come esito di dinamiche economiche sfavorevoli, ma come conseguenza di una privazione sistematica di opportunità e libertà. In molte zone rurali, infatti, si assiste a un impoverimento delle condizioni di accesso a servizi fondamentali (sanità, istruzione, mobilità), a un'erosione del tessuto sociale e culturale, e a una crescente percezione di isolamento e marginalizzazione. Questa condizione di "deprivazione di capabilities" può generare un senso diffuso di esclusione sociale, che alimenta ulteriormente i processi di abbandono.

Per analizzare in modo empirico questi processi, uno studio recente condotto in Toscana (Casini *et al*., 2021) ha adottato proprio la cornice teorica di Sen per costruire un modello di valutazione del "community well-being", basato su misurazioni soggettive riferite non all'individuo, ma alla collettività. Il benessere, in questo approccio, è stato scomposto in diverse dimensioni, come la salute, l'accesso a beni e servizi, le opportunità culturali e ricreative, e la qualità delle relazioni sociali. Un questionario somministrato a 228 residenti delle aree rurali ha permesso di raccogliere valutazioni su ciascuna di queste dimensioni, successivamente analizzate mediante un modello a equazioni strutturali.

I risultati confermano che molte dimensioni del benessere collettivo risultano insoddisfacenti, in particolare quelle legate alla partecipazione civica, all'accesso ai servizi e alla percezione di opportunità per le nuove generazioni. Questi elementi, se non affrontati, rischiano di rendere permanente lo stato di marginalità delle aree rurali, alimentando un circolo vizioso di spopolamento e declino. La forza dell'approccio basato sulle capabilities è duplice. Da un lato, consente una lettura integrata e contestuale del benessere, superando la dicotomia tra indicatori soggettivi e oggettivi. Dall'altro, fornisce una base teorica solida per costruire strumenti di valutazione partecipata, in cui le comunità non sono semplici destinatarie di politiche, ma diventano protagoniste nella definizione degli obiettivi di sviluppo.

In conclusione, affrontare l'abbandono delle aree rurali richiede un cambio di paradigma: occorre passare da politiche focalizzate esclusivamente sulla produttività o sugli incentivi economici a strategie orientate al benessere, inteso come capacità delle persone di vivere in un contesto che offra opportunità significative. Essere agricoltore oggi è qualcosa di molto diverso dal passato, ma qual è la percezione che hanno oggi le giovani generazioni di questa professione? La redditività è fon-

damentale, ma quali sono le altre componenti del well being che vengono considerate positive e negative dell'essere agricoltore? Sono queste le domande a cui dovremmo rispondere per creare le condizioni per uno sviluppo futuro delle nostre aree rurali. La teoria delle capabilities offre una cornice preziosa per progettare interventi che mirino a creare un "agri-food sector that values food, fosters fair working and living conditions and vibrant and well-connected rural and coastal areas" (European Commission, 2025).

4. GLI EFFETTI

L'abbandono delle terre agricole rappresenta un fenomeno strutturale che interessa numerose aree rurali europee, con particolare intensità nei contesti mediterranei e montani, con effetti in larga parte molto negativi. In molte regioni, infatti, le pratiche agricole tradizionali hanno contribuito nel tempo a costruire paesaggi di alto valore ecologico e culturale, mantenendo habitat seminaturali e sostenendo una biodiversità legata ad ambienti aperti, come prati-pascoli e colture estensive. L'abbandono di queste pratiche, accompagnato dalla dismissione delle terre e dalla mancata manutenzione del territorio, comporta non solo una perdita di biodiversità e servizi ecosistemici, ma anche il rischio concreto di erosione del suolo, aumento della suscettibilità agli incendi boschivi e squilibri idrogeologici, con conseguenze rilevanti sulla sicurezza dei territori e sulla qualità della vita delle popolazioni (Agnoletti *et al*., 2019; Salis *et al*., 2022).

Dal punto di vista socioeconomico, l'abbandono agricolo si intreccia strettamente con i processi di spopolamento rurale. La crisi della redditività agricola, l'isolamento infrastrutturale e la riduzione progressiva dei servizi pubblici hanno favorito l'esodo delle giovani generazioni verso i centri urbani, innescando un circolo vizioso che accentua la marginalità di intere aree. La perdita di popolazione, a sua volta, indebolisce le reti sociali, compromette la trasmissione intergenerazionale delle conoscenze agricole e determina un impoverimento culturale e relazionale, che incide sul senso di appartenenza e sulla coesione comunitaria (Benassi *et al*., 2023; Reynaud *et al*., 2018). In questo scenario, l'abbandono non rappresenta solo una trasformazione d'uso del suolo, ma anche una perdita di capitale umano, culturale e sociale. Inoltre, la riduzione della superficie coltivata limita la capacità del sistema agricolo nazionale di produrre beni primari, con effetti sulla sicurezza e sulla sovranità alimentare, resi particolarmente evidenti dalle recenti crisi internazionali che hanno colpito le catene globali di approvvigionamento (FAO, 2017).

Nonostante questi effetti, l'abbandono non è un fenomeno univocamente negativo. In alcuni casi, la ricolonizzazione vegetale delle aree agricole dismesse può generare benefici ambientali, come il sequestro del carbonio, l'aumento della copertura forestale e il rafforzamento di processi ecologici naturali. Tuttavia, tali benefici non sono automatici né garantiti, e dipendono fortemente dal contesto territoriale, dalla gestione successiva delle aree abbandonate e dalla capacità delle politiche pubbliche di orientare tali trasformazioni. Senza un presidio attivo, infatti, le aree incolte rischiano di evolvere verso stati ecologici instabili, caratterizzati da una vegetazione degradata, un'elevata infiammabilità e una scarsa resilienza (Chauchard *et al*., 2007; Marquez Torres *et al*., 2023). Inoltre, in molti casi, la rinaturalizzazione comporta la perdita irreversibile di paesaggi culturali complessi, modellati da secoli di interazione tra uomo e natura, e percepiti dalle comunità come parte integrante della propria identità.

Alla luce di questa complessità, risulta evidente come l'abbandono agricolo non possa essere affrontato con strumenti settoriali o approcci monodisciplinari. Occorre piuttosto adottare un approccio integrato e sistemico, in grado di valutare i trade-off tra agricoltura, forestazione e abbandono, considerando i molteplici servizi ecosistemici coinvolti e il loro impatto sul benessere umano (Van der Zanden *et al*., 2017). A questo proposito, lo studio di Zavalloni *et al*. (2021) rappresenta un tentativo interessante di modellizzazione complessiva, confrontando scenari di uso del suolo alternativi in funzione sia della redditività agricola privata che del benessere collettivo.

Un contributo significativo per comprendere a fondo le implicazioni dell'abbandono è fornito dal quadro teorico "Nature's Contributions to People" (NCP), sviluppato dall'IPBES. Questo approccio amplia la visione dei servizi ecosistemici, includendo dimensioni immateriali come il senso di identità, l'estetica del paesaggio, la memoria collettiva e il benessere percepito dalle comunità. Applicare questo paradigma alle aree agricole marginali significa riconoscere che l'interruzione delle attività agricole non è solo una questione di perdita di produzione o biodiversità, ma anche di trasformazione dei legami tra le persone e i territori. Studi recenti mostrano infatti che in molte comunità rurali l'abbandono è associato a emozioni negative, senso di abbandono istituzionale e deterioramento della qualità della vita, elementi spesso trascurati nelle valutazioni convenzionali (Quintas-Soriano *et al*., 2016; Van der Zanden *et al*., 2018).

In sintesi, il fenomeno dell'abbandono delle terre agricole pone sfide complesse ma anche opportunità strategiche. Affrontarlo significa ripensare radicalmente il rapporto tra agricoltura, ambiente e società, adottan-

do un approccio territoriale che valorizzi la multifunzionalità del paesaggio rurale, promuova il benessere delle comunità e integri strumenti economici, ambientali e culturali in un quadro di sostenibilità a lungo termine. Solo così sarà possibile trasformare l'abbandono da sintomo di declino a occasione per una nuova progettualità rurale, capace di coniugare resilienza ecologica, giustizia sociale e rigenerazione dei territori.

In conclusione, affrontare l'abbandono agricolo non significa solo recuperare ettari coltivati, ma ripensare le politiche territoriali alla luce di un concetto più ampio di benessere rurale, valorizzando il ruolo delle comunità, delle culture locali e dei servizi ecosistemici immateriali come elementi centrali per una rigenerazione sostenibile.

5. GLI STRUMENTI

Gli strumenti di intervento pubblico per contrastare l'abbandono delle terre agricole ricadono nel più ampio campo degli interventi per evitare lo spopolamento dei territori, proprio in considerazione delle fortissime interrelazioni esistenti fra i due fenomeni come visto nei paragrafi precedenti.

Un recente articolo di Karcagi-Kovats, Katona-Kovacs (2012) riassume come le strategie nazionali di sviluppo sostenibile (NSDS) e i programmi nazionali di sviluppo rurale (NRDP) degli Stati membri dell'Unione Europea (UE) affrontano i processi di spopolamento delle aree rurali. Il lavoro fornisce, infatti, una panoramica sistematica dei principali fattori di declino demografico individuati nelle strategie e nei programmi, elencando gli obiettivi fissati e le misure proposte da tali documenti. La sintesi che ne traggono gli Autori è che "sebbene la maggior parte dei documenti riconosca il processo di spopolamento e tutti lo considerino un fenomeno negativo, non esistono obiettivi o principi comunemente accettati riguardo all'entità desiderata dei cambiamenti demografici nelle aree rurali: le finalità variano tra il 'ridurre', 'fermare', 'stabilizzare' e 'invertire' lo spopolamento delle aree rurali." Gli autori suggeriscono che le politiche rurali necessitano di una base teorica più solida per rispondere agli effetti complessivi – non solo economici, ma anche ambientali e sociali – dello spopolamento, e che le future strategie nazionali di sviluppo sostenibile dovrebbero prestare maggiore attenzione a questo problema.

A livello nazionale la Strategia per le Aree Interne è il documento più completo che affronta i problemi dello spopolamento e del basso accesso ai servizi in Europa. Tutti e quattro i Fondi Strutturali e di Investimento Europei sono combinati con finanziamenti nazionali per sostenere strategie sia di sviluppo locale sia di innovazione dei servizi in 72 aree pilota. È previsto un investimento mirato di circa 1 miliardo di euro, utilizzando un "approccio place-based" che unisce diversi settori e livelli di governo. Le associazioni di sindaci sono generalmente alla guida del processo, mentre i Gruppi di Azione Locale LEADER possono svolgere una varietà di ruoli, che vanno dal supporto alla progettazione degli interventi fino all'attuazione diretta delle misure del FEASR nell'area.

Il recente Piano strategico nazionale delle aree interne (PSNAI) (Presidenza del Consiglio dei Ministri 2025) per il periodo 2021-2027 individua 4 strategie principali con i seguenti obiettivi: Inversione di tendenza relativamente alla popolazione; Inversione di tendenza relativamente alle nascite; Contenimento della riduzione delle nascite (da diminuzione accentuata a moderata); Accompagnamento in un percorso di spopolamento irreversibile.

Su queste basi "ogni Comune deve poter valutare in quale di queste quattro tipologie si colloca, in base ai dati disponibili sulla situazione demografica e sulle condizioni sociali ed economiche, e potersi dotare di competenze e di strumenti più adatti al proprio caso per ottenere gli obiettivi specifici. Le specificità locali sono fattori chiave su cui puntare per favorire uno sviluppo endogeno con effetti duraturi nel tempo in grado di limitare lo spopolamento e rendere questi territori attraenti per i giovani". Si tratta di una impostazione che individua nel Comune l'unità minima di riferimento per la programmazione e che per la situazione italiana è probabilmente l'unica possibile anche se presenta varie limitazioni. Le diversità strutturali dei nostri comuni sono tali da poter creare inefficienze sia per l'eccesso della superficie interessata sia per l'esiguità della stessa e l'insufficienza delle competenze presenti. L'auspicata "…capacità dei Comuni di costruire una efficace strategia partecipativa dell'insieme dei soggetti che vivono la realtà del territorio e della comunità in prima persona" (PSNAI 2025) non sembra sempre facile da realizzare. La definizione di adeguate forme di governance multi-livello appare quindi fondamentale.

Un altro punto su cui porre l'attenzione è la difficoltà di definire un quadro teorico chiaro di riferimento su cui fondare le scelte operative. La scelta dell'allocazione delle risorse, le decisioni sulle priorità possono esprimere la loro piena efficacia solo se ispirate a linee guida chiare e fondate su una visione complessiva del fenomeno abbandono. Ripartizioni delle risorse basate su criteri puramente aritmetici, come purtroppo sembrano emergere anche in questo Piano, oppure su definizioni semplicistiche delle componenti del benessere di un territorio, non potranno produrre gli effetti auspicati. Anche gli indicatori di risultato, se non ben inseriti in un quadro complessivo della qualità della vita nei territori con-

siderati, possono non essere da soli in grado di dimostrare la validità delle azioni intraprese e degli interventi attuati, lasciando spazio a soluzioni non efficaci.

Relativamente agli strumenti specifici per il contrasto all'abbandono delle terre coltivate, lo studio di Alan Renwick et alii (2013) analizza gli effetti delle riforme agricole e commerciali sul rischio di abbandono, utilizzando una versione modificata del modello CAPRI (Common Agricultural Policy Regionalised Impact) integrato con il framework spaziale "Dyna-CLUE ", capace di stimare le implicazioni geografiche delle riforme con maggiore dettaglio. Un risultato chiave dello studio riguarda la eterogeneità spaziale degli effetti delle riforme, evidenziando l'incapacità della Politica Agricola Comune (PAC), nella sua impostazione generalista (Pillar I), di rispondere a una molteplicità di obiettivi ambientali in contesti agricoli e naturali fortemente diversificati. La soluzione proposta consiste nello sviluppo di politiche più mirate e territorialmente differenziate, in grado di contrastare selettivamente l'abbandono indesiderato, senza ostacolare gli effetti positivi legati alla rinaturalizzazione in altre aree.

Coerentemente con le raccomandazioni della FAO (2006), gli autori concludono che il semplice obiettivo di mantenere la terra in produzione non rappresenta una strategia efficace o efficiente per gestire l'abbandono. Serve invece un "approccio territoriale ", basato su un'analisi dettagliata delle dinamiche locali e sulle preferenze espresse dalla società in termini di beni pubblici. Solo così sarà possibile affrontare le molteplici sfide che l'abbandono dei suoli pone alla sostenibilità dell'agricoltura europea.

Oggi gli strumenti della PAC per intervenire sui processi di sviluppo delle aree rurali sono attivati principalmente tramite i programmi di sviluppo regionali e hanno come obiettivo il contrasto dell'abbandono agricolo da realizzarsi prevalentemente tramite forme di sostegno al reddito o agli investimenti. L'allocazione delle risorse sul territorio e la scelta dei relativi strumenti applicativi avvengono prevalentemente con forme di zonazione su base amministrativa che normalmente non vanno oltre l'individuazione delle classiche 4, 5 zone a livello regionale: Aree rurali ad agricoltura intensiva; Aree rurali intermedie in transizione; Aree rurali intermedie in declino; Aree rurali con problemi di sviluppo. Storicamente le principali risorse del secondo pilastro sono state, infatti, indirizzate al sostegno alle aziende nelle forme degli aiuti agli investimenti o come sostegno al reddito legato all'adozione di tecniche a basso impatto, senza alcuna visione territoriale specifica. Questa visione è presente principalmente solo nei provvedimenti riconducibili all'asse Leader, che costituisce quindi la componente più rilevante dal punto di vista dello sviluppo territoriale, dove in varie realtà la programmazione dal basso ha permesso di innescare significativi percorsi di sviluppo. Da evidenziare, comunque, come anche le aree Leader siano molto ampie, comprendendo più comuni e con evidenti disomogeneità interne. Difficilmente si giunge a proporre strumenti e strategie per aree più specifiche. Questo approccio sembra quindi in contrasto con le indicazioni offerte dagli studi precedentemente riportati e anche dal PSNAI, che sottolinea l'importanza di interventi molto mirati a livello territoriale.

Gli ultimi documenti della Commissione sembrano aver acquisito consapevolezza del tema dell'abbandono e dell'attrattività delle aree interne soprattutto per i giovani. Si tratta quindi di vedere se anche gli strumenti operativi saranno coerentemente sviluppati. Non dimentichiamo infatti che vari studi hanno identificato fra i motivi dell'abbandono anche proprio alcuni strumenti della PAC.

In ogni caso, per affrontare efficacemente questi effetti multidimensionali è necessario attivare forme di governance multilivello, che coinvolgano in modo coordinato istituzioni europee, nazionali, regionali e locali, oltre ai soggetti della società civile. Le politiche territoriali – come la Strategia Nazionale per le Aree Interne (SNAI), i Programmi LEADER o i meccanismi di pagamento per i servizi ecosistemici – rappresentano esempi di approcci integrati che, se adeguatamente implementati, possono contrastare l'abbandono agricolo valorizzando le risorse locali, incentivando il ritorno all'agricoltura sostenibile e rafforzando il tessuto sociale delle aree rurali. Tuttavia, perché tali strategie siano efficaci, è necessario che siano costruite in modo partecipato, a partire dalle esigenze delle comunità, riconoscendo le specificità territoriali e superando la frammentazione tra settori e livelli decisionali, e, non ultimo, abbiano solidi riferimenti teorici di riferimento.

6. CONCLUSIONI

L'abbandono delle terre agricole è un fenomeno molto rilevante in Italia e fortemente correlato allo spopolamento delle aree interne. Gli attuali strumenti di politica agraria fino ad oggi impiegati non sono stati in grado di contenere questo fenomeno in vaste aree del Paese. Gli studi condotti hanno permesso di fornire un quadro esauriente delle cause che possono determinare l'abbandono e hanno delineato in modo chiaro i suoi possibili effetti anche se non sempre in modo complessivo, delineando le interrelazioni fra di essi e quindi l'impatto complessivo sulla società. In questo contesto la valutazione

dei servizi ecosistemici e più in generale delle esternalità prodotte dalle attività agricole è un elemento centrale. Sia che tale valutazione avvenga direttamente o indirettamente, attraverso approcci negoziali fra le parti, essa è necessaria per un corretto processo decisionale volto al benessere sociale. Vari sono stati contributi anche di economisti agrari italiani, molto difficile è ad oggi però una applicazione delle metodologie proposte a casi concreti. Questo appare un punto centrale su cui lavorare per permettere la definizione di obiettivi corretti di intervento.

La nuova visione della commissione europea per la riforma della PAC sottolinea la necessità di investire sull'attrattività delle aree rurali e sulle condizioni di lavoro in agricoltura. Forse in alcune aree è tardi, ma è importante provarci. Le molteplici cause dell'abbandono sono chiare, ma vanno calate nelle specifiche realtà locali considerando anche l'"altro", ovverosia quelle condizioni di vita che ad oggi sono offerte solo dalle aree urbane evitando che si creino condizioni di esclusività: o il mondo agricolo o il mondo urbano. Non trascurando in ogni caso la causa principale di abbandono: la "insufficiente" redditività. Come evidenziato in precedenza, molte attività agricole non presentano redditività adeguate alla permanenza, sia in termini relativi, sia assoluti. L'attuale distribuzione degli aiuti non appare adeguata a rispondere all'esigenza di garantire redditi adeguati in molte situazioni.

Le soluzioni socialmente corrette non possono non passare da una valutazione complessiva del ruolo che l'agricoltura svolge nei diversi territori e da forme di intervento che non pregiudichino la competitività, garantendo però allo stesso tempo la soddisfazione del lavoro agricolo in termini sia economici che sociali. Alcuni esempi virtuosi esistono soprattutto nelle regioni del Nord Italia, si tratta di verificarne l'applicabilità in altri contesti, ma la strada deve essere necessariamente quella di garantire redditi soddisfacenti dove si ritiene che l'agricoltura debba permanere.

Come evidenziato in vari contributi la redditività è una condizione necessaria, ma non sufficiente, per affrontare efficacemente il tema dell'abbandono agricolo e a maggior ragione quello dello spopolamento, è essenziale l'adozione di strumenti operativi fondati su approcci teorici in grado di spiegare gli elementi che in quel lugo e in quel tempo contribuiscono a definire la qualità della vita. Solo avendo una lettura integrata e comprensiva di tutti gli elementi che influiscono sulla valutazione della qualità della propria vita è possibile intervenire per limitare se non eliminare i fenomeni di abbandono. L'approccio delle capabilities di Sen può costituire un riferimento utile, anche se non necessariamente il solo. Le capabilities fondamentali proposte da Desai - fra cui il lavoro/reddito è una componente fondamentale - possono costituire il paradigma applicativo di riferimento per indirizzare le politiche di sviluppo delle aree critiche. Esse dovranno essere adattate ai singoli contesti e potranno variare nelle componenti elementari in funzione del tempo e del luogo, ma nel complesso dovranno conseguire livelli soddisfacenti di benessere nella "percezione" degli abitanti per poter permettere un futuro per i territori considerati. La proposta di strumenti operativi per la rilevazione corretta di tali percezioni per le diverse capabilities ed anche i trade-off fra di esse, sono temi ancora non molto studiati e che invece meriterebbero maggiore attenzione.

Il PSNAI rappresenta uno strumento importante come linee guida per affrontare le crisi delle aree interne, ma manifesta ancora vari limiti, come il riferimento ai confini amministrativi, oppure quelli legati ai criteri di allocazione delle risorse, come dimostra il riparto per le nuove aree interne, ed infine proprio quelli sulle modalità di rilevazione dei fattori critici. Anche in questo caso la realizzazione di strumenti teorico-metodologici per guidare il percorso di miglioramento delle condizioni di vita in queste aree risulta fondamentale, ma ben pochi sono i contributi ad oggi disponibili da parte del mondo scientifico.

Dai lavori precedentemente citati emergono anche altri temi su cui, come economisti applicati ai temi agrari, alimentari e territoriali, possiamo e forse dobbiamo intervenire. La zonizzazione del territorio che nel passato ha visto numerosi contributi, oggi appare essenziale per rispondere alle necessità di comprensione dei fenomeni di abbandono e spopolamento come evidenziato da vari contributi.

Per le aree agricole dei territori marginali del Paese siamo ad un passaggio fondamentale: la maggioranza dell'attuale generazione degli agricoltori sta per lasciare l'attività; l'attrattività del settore è bassa per le nuove generazioni; l'andamento demografico aggrava entrambi i fenomeni. Il rischio dello spopolamento e dell'abbandono di larga parte del territorio è concreto. A livello sia europeo che nazionale, vi è una crescente consapevolezza della critica interrelazione tra spopolamento e declino agricolo, e viceversa. Se vogliamo garantire un futuro al mondo rurale in molte delle nostre regioni, il momento di agire è adesso. Per farlo in modo efficace, è necessario assicurare che le risorse che verosimilmente diventeranno disponibili siano utilizzate nel modo più efficace possibile, attraverso una governance multilivello, una visione di sviluppo condivisa e teoricamente solida, e un'analisi approfondita di ciascun contesto territoriale.

In tutto questo, vi è un lavoro considerevole da svolgere per gli economisti applicati, e in particolare per

gli economisti agrari. La domanda è se vi sia sufficiente interesse e volontà di raccogliere questa sfida.

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