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Keynote article

Transdisciplinary perspectives to investigate sustainable food system transitions

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Abstract. The Anthropocene is an unprecedented geological period characterised by large-scale socio-ecological crises, including biodiversity loss, climate change, ocean acidification and irreversible deterioration of soil health, among others. These crises have created concerns among scientists, who are now openly discussing scenarios in which humanity will not be able to inhabit this planet and challenging how they can respond to these mounting challenges. Given this dramatic and contested context, in this essay we pose the following questions: what are the fields of knowledge we need (to collectively create) to solve the crises of a planet in chaos? What (type of) knowledge do we need? From whom and for whom? We tackle these questions by looking at the opportunity to collectively develop transdisciplinary knowledge that would help investigate sustainability transitions as ways in which humanity can respond to the socio-ecological challenges of the Anthropocene and to design systemic change. Among these transitions, we focus on circular and regenerative principles and look at the case of protein transitions as well as agroecology and circular food systems. This informs our discussion on the emergence of transdisciplinary pathways in which agricultural economists can and should have a key role.

Keywords: anthropocene, socio-ecological transitions, transdiciplinarity, sustainability, food futures.
JEL codes: Q56, Q54.

HIGHLIGHTS

- The crises of the Anthropocene require transdisciplinary science
- Agricultural economists can play a significant role in developing transdisciplinary knowledge
- Investigating food system transitions represents an example of transdisciplinary knowledge
- Circular food economies represent ways of food future-making

1. INTRODUCTION

Do agricultural economists have a role in researching sustainable transitions of food systems, or are they losing their relevance and significance? Fresco *et al.* (2021) posed this thought-provoking question by considering the fast-evolving and multidimensional crises our planet is facing, and the rapid realisation that we need to change our approach to problem solving and academic inquiry in the era of the Anthropocene. Food systems are deeply entangled with the causes and effects of the Anthropocene, and as such they deserve to be analysed, investigated and conceptualised through different and multiple lenses (Rockström *et al.*, 2023). Differently from the Holocene, the Anthropocene marks the beginning of an unprecedented geological period for which anthropic actions have irreversible consequences on Earth's systems (Steffen *et al.*, 2018). This era has been characterised by large-scale crises including biodiversity loss, climate change, ocean acidification and irreversible deterioration of soil health, among others (Rockström *et al.*, 2023). It is the multiplicity of these crises that has created serious concerns among scientists, who are now openly discussing scenarios in which humanity will not be able to inhabit this planet, or at large social and economic costs (Whiteman *et al.*, 2013; Whiteman, Williams, 2018; Williams *et al.*, 2025). Those scenarios, such as the Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs) developed by the Intergovernmental Panel on Climate Change (IPCC) research community, investigate how the acceleration of climate change impacts and extreme events, like prolonged droughts, floods or unpredictable weather patterns, define adaptation and vulnerabilities of anthropic communities in different geographical regions (Pedde *et al.*, 2021). They define and discuss alternative *plausible futures*, as pathways of societal development, based on the best current data availability, and related assumptions, and hypotheses about 'which societal elements are the most important determinants of challenges to climate change mitigation and adaptation' (Pedde *et al.*, 2021: 2). Beyond scenario-building, scientists have been exploring more attentively the root causes of the large-scale crises of the Anthropocene and have converged on the idea that waves of colonisation, large-scale industrialisation and urban population growth have accelerated the capacity of '*Homo sapiens*', as a species, to act as a disruptive geological force (Costanza *et al.*, 2007).

What this body of research and knowledge indicates is that the Anthropocene has presented 'timescale' imbalances: in a few generations, humans have been able to use non-renewable fossil-based resources that had accumulated for thousand or millions of years while, in parallel, agriculture, forestry and fibre and food production have altered vast ecosystems now dominate the way we use land on planet Earth (Rockström *et al.*, 2009). The globalisation of industrial production, distribution and consumption, and the dominance of market-based economic relations can be considered as the 'great acceleration' of the Anthropocene (Costanza *et al.*, 2007). This acceleration reflects an exponential increase in the complexity and interconnectedness of social and ecological systems (Gunderson, Holling 2001), which is of great concern for scientists because crises tend to spread from one system to another very quickly, creating (plausible) scenarios of socio-ecological collapse (Costanza *et al.*, 2007).

The broadening of our knowledge on both the complexity and interconnectedness of socio-ecological crises of the Anthropocene, and the emergence of new forms of inter- and transdisciplinary knowledge to investigate the how food systems interrelate with planetary systems (Dentoni *et al.*, 2021), seems to further corroborate the critique proposed by Fresco *et al.* (2021): should agricultural economists depart the comfort of applied economics and start more courageously pioneering the co-creation of more transdisciplinary knowledge co-creation? The stronghold of agricultural economists has been a robust and innovative approach to develop and apply methods to generate impact and to influence policy (Fresco *et al.*, 2021). Our 'sciences' require this rigour and innovativeness, as our dependence on reliable (and plausible) scenario-building and pathways will increase over time. However, can agricultural economists also re-imagine their contribution to the emergence of novel fields of knowledge needed to tackle the multiple crises of the Anthropocene? Other social scientists, for example, have already been stimulated to explore new forms of scholarship devoted to inter-transdisciplinary work through the use of systemic thinking and holistic frameworks (Dentoni *et al.*, 2021), with an aim to understand the intended and unintended consequences of the Anthropocene. In particular, in the social sciences, organisation and management scholars have recently started to debate the (social and political) role of researchers and research institutions in tackling societal issues and grand challenges such as climate change, biodiversity loss, and global externalities such as waste and toxicity (Wright *et al.*, 2013; Biggart, 2016; Williams *et al.*, 2025; Lobbedez *et al.*, 2025). According to this debate, impactful research should produce 'socially valuable knowledge' (Alvesson *et al.*, 2017: 27) and engage multiple actors (Ergene *et al.*, 2021). This scholarship calls for more engaged approaches (Banerjee, 2003; Ergene *et al.*, 2021), which can further and more

forcefully investigate how to enable 'a massive and rapid retooling of our economy and society' (Adler, 2022: 1) and find solutions to the crises of the Anthropocene.

Therefore, engaged and inter- or transdisciplinary scholarship is necessary to reorient how to investigate the socio-ecological foundations of the Anthropocene and to understand how new institutions and governance systems should emerge, morph and be established. This investigation is starting to focus on the wider social and environmental impacts of business economic activities (Wickert, 2021), while developing a holistic approach to design novel forms of socio-ecological governance (Dentoni *et al*., 2021). For these reasons, the Anthropocene and its crises are challenging how scientists respond to it and help society to tackle these mounting challenges. Given this dramatic and contested setting, in this essay we pose the following questions: what are the fields of knowledge that we need (to collectively create) to solve the crises of a planet in chaos? What (type of) knowledge do we need? From whom and for whom?

We believe agricultural economists play a crucial role in understanding sustainability and how social and natural systems work and change over time, particularly through their focus on investigating the governance of food systems, from production to consumption, from regulatory processes to welfare implications. We therefore tackle these questions by looking at sustainability transitions in food systems, a field of inquiry well explored and investigated by agricultural economists, and as examples of ways in which humanity can respond to the socio-ecological challenges of the Anthropocene to design systemic change (Ambikapathi *et al*., 2022; Barrett, 2021). We particularly focus on the protein transitions since they represent compelling examples of socio-ecological transitions in which significant changes in the food systems are aiming at creating sustainable and desirable futures in a general sense (Haas *et al*., 2020; Borrello *et al*., 2020; Pascucci, 2020; Webster, Pascucci 2024). Among these transitions, we focus on the case of protein transitions because they represent compelling examples of socio-ecological transitions aiming at creating sustainable and desirable futures (Haas *et al*., 2020; Peeters *et al*., 2024). Drawing inspiration from the narratives and examples of circular and regenerative food economies, in this paper we discuss the potentials of designing diverse sustainability transitions to achieve desirable and actionable (food) futures (Wright *et al*., 2013; De Cock *et al*., 2021; Gümüsay and Reinecke, 2022). Focusing on desirable and actionable futures is different from the current focus on plausible futures, as in the case of scenario-building strategies and related transition pathways. Scenarios are '*plausible and often simplified descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and relationships*' (Pedde *et al*., 2022: 2). Instead, desirable futures refer to 'how things should be' and '*by imagining or helping others imagine them in the first place*' (Gümüsay and Reinecke, 2024: 3), '*which involves bringing about a desired future reality through practising it in the present*' (Gümüsay and Reinecke, 2024: 5). This means a different positionality for researchers in the process of co-creation of knowledge with other actors in society and eventually the consideration of non-humans in their work as well. This approach departs substantially from the idea of future-making through forecasting and projecting the past and the present in a plausible future. It is about understanding and investigating how the future can be different and more desirable. Moreover, it calls for pragmatic actions and to bridge the imaginative capacity of human beings with concrete actions, where change is enacted, not only imagined. We claim that this type of future-orientation and values-based exploration (Gümüsay and Reinecke, 2024) challenges the nature and aims of the more traditional and predominantly positivist-empiricist tradition of scenario-building and forecasting of agricultural economists. Instead, a transdisciplinary field of knowledge can emerge and be co-created to define desired and actionable futures by adopting a *pragmatist, preparatory and prefigurative* orientation (Gümüsay and Reinecke, 2024). It is pragmatic because it helps sciences to be repositioned as 'a technique for coping with a complex and uncertain world', and 'help humans find their place in a hectic, complex, and often dangerous world' (Gümüsay and Reinecke, 2024: 4). It is preparatory because instead of 'simply' predicting, it helps actors involved and concerned about the future to prepare for it, to contemplate alternatives, to challenge the given-for-granted, to explore different possibilities. Finally it is prefigurative because aims at changing the future through actions, and to mobilize the potential of science to shape the meaning systems of the society and thus [its] common activities' (Gümüsay and Reinecke, 2024: 4).

In this essay we use this approach and focus on how to re-design food systems considering the crises of the Anthropocene and using collective imagination for future-making strategies related to new sources of proteins and nutrient-rich and affordable diets. This eventually informs how to co-create forms of knowledge that go beyond current disciplinary boundaries and forge novel fields of inquiry, in which agricultural economists would be actively engaged in re-thinking (desirable) (food) futures (Pascucci, 2020).

We start by asking two questions: (i) what is future and how do we create it collectively? Subsequently, (ii) what are the methodologies, ontologies and epistemologies we need as scholars (social and natural scientists – agricultural economists) to investigate sustainable and desirable (food) futures?

We will use protein transitions in food systems as an opportunity to address these questions and to illustrate processes of transdiciplinarity related to future-making, particularly regarding how our collective imagination can be engaged by the principles of regenerative agriculture[1] and circularity to redesign food systems (Truffer *et al*., 2022). Looking at these 'imaginaries' as 'ontologies' – and thus future realities that we can investigate – we have developed reflections on how these imaginaries can contribute to the development of a transdisciplinary research agenda for social and natural scientists, where agricultural economists can thrive and find new academic identities and practices, inspired by a regenerative and circular economy to redesign food systems. Indeed, this will inform our discussion on the emergence of transdisciplinary pathways in which agricultural economists can have a key role.

2. SUSTAINABILITY TRANSITIONS AND FOOD FUTURES

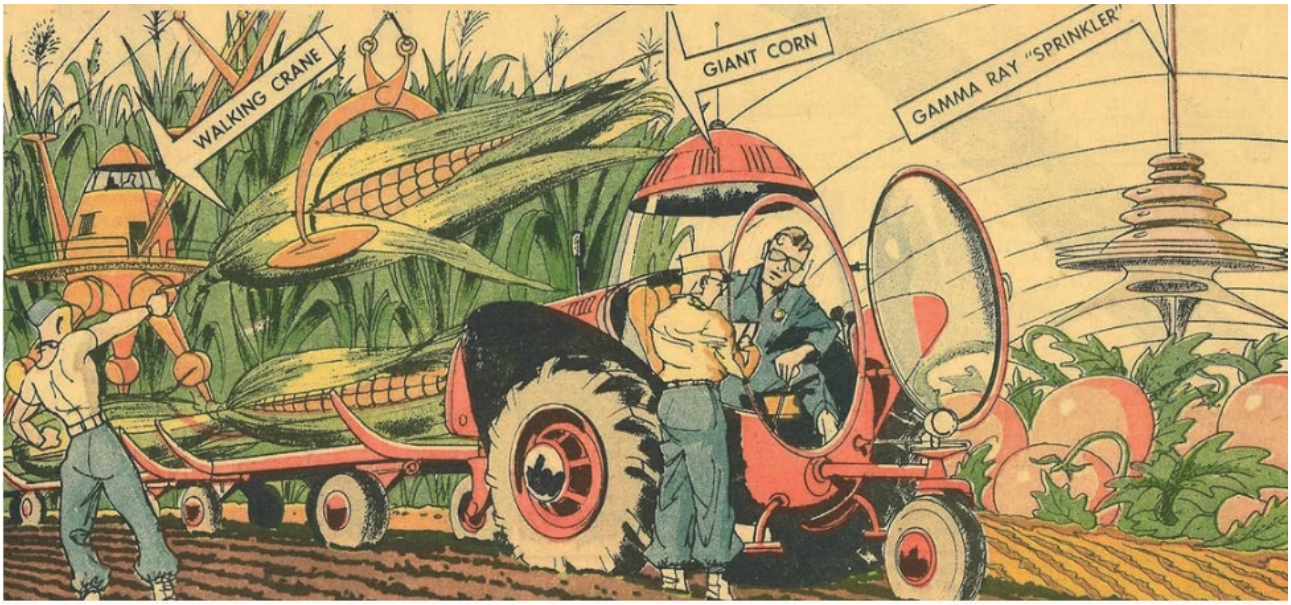
Futures and future-making are currently at the core of the debate around and about sustainability transitions (Truffer *et al*., 2022). This scholarship is widely engaged in finding (feasible) solutions to tackle the mounting crises of the Anthropocene by investigating pathways leading to alternative socio-ecological configurations (e.g. sustainable futures created by rethinking and redesigning systems of extraction, production, distribution and consumption). This includes investigating transitions in energy, food, water, mobility, building, infrastructure, health services and provisioning systems (Markard *et al*., 2012; Köhler *et al*., 2019). In sustainability transitions, scholarship addressing the governance of socio-ecological challenges of the Anthropocene is also becoming more and more prominent (Geels, 2018; Köhler *et al*., 2019). These transitions tend to be challenging for the social sciences because they involve multiple stakeholders and are long-term, disruptive, contested and non-linear processes (Geels, 2018; Weituschat *et al*., 2022). Food system transitions are largely debated – and key – because agriculture and food production, distribution and consumption are central in defining the root causes, impacts and interrelatedness of the crises of the Anthropocene (Willett *et al*., 2019). Hence, given the prominent role of food systems in defining the crises of the Anthropocene, it is not surprising that redesigning food systems is becoming an urgent discussion and equally a contested arena for scholars, social activists and policymakers (Reisman, Fairbairn, 2020). Moreover, food system transitions and the future of food in more general terms have always stimulated imaginaries, particularly in the techno-ecological sphere (Figure 1). A more recent example is provided by the fierce discussion around resilience and sustainable food systems (Fresco *et al*., 2021), and particularly regenerative agriculture and food system transitions.

In his bestselling book *Regenesis*, George Monbiot (2022) calls for redesigning food systems at a large scale. This approach could mobilise ideas and actions to define a sustainable food future characterised by highly productive food systems that can minimise land, energy and water use, to support re-wilding and 'giving back to nature'. It would help make the best of the potentials of soil regeneration biodiversity in a climate-sensitive way based on advancements in food technologies and supporting exclusively plant-based diets. At the same time, it would ensure affordable food for everyone. In his vision of the future of food systems, farmers are not squeezed by rapacious big-food retailers. Feedstock to produce meat or dairy is relegated to the history books. In presenting this food future, Monbiot is also future-making, specifically a communicative and political agenda. In fact, Monbiot has no problem in defining his investigative journalism as a sign of political activism. However, what if we want to investigate this process through (social) scientific lenses? In other words, what if we take future-making seriously, as Monbiot does, while we debate the (social) science(s), and its methods, for future-making?

Food system transitions give us a very stimulating playground from which we can begin. Let's start from what we define as the 'Monbiot paradox': as he describes it, a good place to start to redesign food systems to enhance their sustainability would be to investigate how we, as humans, get proteins in our diets. Proteins are the gold nugget of anthropic diets, because they are a core

[1] The term regenerative agriculture (RA) in this paper largely builds on recent literature and particularly on Tittonell *et al.* (2022: 4) in which RA is presented as a system of farming principles and practices that increases biodiversity, enriches soils, improves watersheds, and enhances ecosystem services, aiming to capture carbon in soil and aboveground biomass, reversing current global trends of atmospheric accumulation, and offers, at the same time increased yields, resilience to climate instability, and higher health and vitality for farming and ranching communities. RA draws from decades of scientific and applied research by the global communities of organic farming, agroecology, holistic management, and agroforestry.

Figure 1. An example of imaginaries of food futures.



Arthur Radebaugh imagined gigantic crops in his syndicated Sunday comic strip *Closer Than We Think*, which ran from 1958 until 1963.

Arthur Radebaugh

Source: Radebaugh, (1953).

building block of human metabolism (Aiking, de Boer, 2020). Monbiot poses a paradox by looking at the evolutionary and historical patterns of how humanity has collectively 'designed' a food system in which proteins have been progressively sourced from mammals, in the form of livestock and animal husbandry. He is particularly pungent when highlighting the contradiction of 'spending thousands of years' to domesticate and manipulate the ecology and physiology of just a few species to dedicate a large amount of labour, capital, energy, water and land to mammal-based protein sources, and to select animals whose protein conversion rate is very low, and largely inefficient. We have designed this system of protein sourcing by inflicting immense pain on these animals and driving to extinction, or close to it, other species whose habitats and food we have altered and used just to get our protein demand sorted. His point is that from a system design thinking perspective, our protein sourcing strategies are questionable. There are also ethical implications, but if we stick to the system design perspective, the Monbiot paradox offers a very powerful space for collective and scholarly reflections. The protein transition, in fact, is a hot topic in policy and science (Aiking, de Boer, 2020; Tziva *et al.*, 2020). Humanity needs better and planet-friendly proteins, which can be accessed at an affordable cost and without disrupting food economies and cultures (Tziva *et al.*, 2020). Proteins from fungi, insects, algae, microbes, legumes and various related food technologies are just a few examples of food futures in which proteins are no longer sourced from mammals, but rather from other types of living organisms (Aiking, de Boer, 2020). So, the Monbiot paradox is not just metaphorical, philosophical or thought provoking. It is part of a context where concrete, tangible and actionable food futures are discussed and enacted. This paradox brings us to ask the following questions: if producing, distributing and consuming proteins from mammals is so detrimental for the planet, and highly inefficient in terms of resource use, why is it so challenging to remove cows, pigs, sheep and goats from our food systems? Moreover, why is it so challenging to introduce 'alternative' sources of proteins? Why is future-making so hard?

To answer these questions, we suggest moving beyond a mechanistic view of sustainability and socio-ecological transitions. Instead, we should investigate 'future-making' as a more contested domain, as a place where we can build inter- and transdisciplinary knowledge. Futures become the unit of inquiry and future-making the set of socio-ecological processes that lead to alternative futures. In our view, this shift implies the

need to tackle the issue of how to move from desirable to actionable futures, and the wickedness and complexity that these dimensions of future-making bring with them. In the next section, we focus on future-making and food futures, in particular.

3. FUTURE-MAKING FROM DESIRABLE TO ACTIONABLE FOOD FUTURES

Understanding and investigating future-making strategies, such as protein transitions, is a counterintuitive process. In fact, 'future poses a peculiar problem – by definition, it is not present yet [...] empirical social science deals primarily with the social world as it exists and came to be. Its methodological tools are centred around data sourced from observable events that have already occurred' (Gümüsay, Reinecke, 2024: 2). As such, (social) sciences aiming at investigating future(s) will need to engage with collective imagination to rethink (desirable) futures, as contested and situated fields of inquiry that have not yet materialised in a given reality. These sciences will then have to deal with how collectives move from desirable to actionable futures. This poses a dilemma. Future activities are already a concern for several scientists – for example, in terms of predictions and forecasting. Think about the '60-harvest left' theory (Ritchie, Roser, 2024): according to this framework, soil degradation is so extreme that we, as humanity, are left with no more than 60-100 cycles of agricultural production. Scientific evidence cannot support this claim, and in fact it does not. Instead, it indicates that the lifespans of soil degradation (as well as regeneration) vary in terms of timescales and landscapes (Figure 2). However, this type of scientific approach can underestimate the non-linearity and systemic nature of these phenomena. Forecasting soil degradation in isolation – similarly to climate change or biodiversity loss, core manifestations of the Anthropocene – can be an unforgivable mistake, because it misses the point to realise in which 'future' this degradation (or regeneration) is taking place. Moreover, utilising data from the past or present to predict the future is also not the point. Rather, 'the goal is not to enable better predictions or forecasting of a likely future but [...] to cultivate the creation of desirable futures by imagining, or helping others imagine them in the first place' (Gümüsay, Reinecke, 2024: 2).

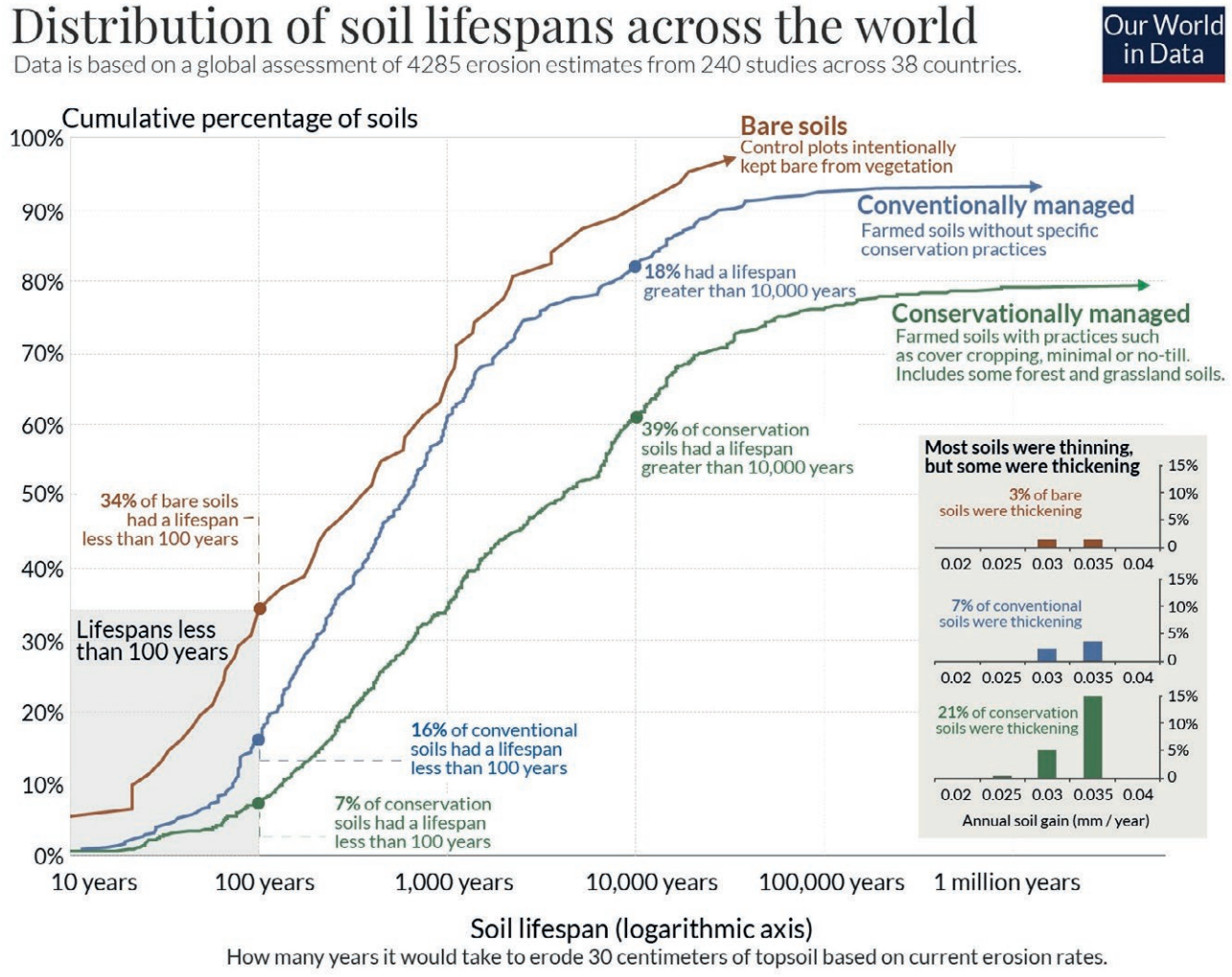
What is a future where soil is healthy? How do we make it? Is it sustainable and desirable for everyone? In a scientific future-oriented approach, sustainability transitions help to achieve socio-ecological orders that need to be imagined in the first place. The goal for social scientists is to conceptualise the (un)likelihood of the emergence of these futures, assuming a prospective and not just prescriptive way of theorising (Gümüsay, Reinecke, 2024), by using novel methodologies – for example, by combining the logics of collective sensemaking (Mills *et al*., 2010; Whiteman, Cooper, 2011) with the collective identity work process methods (Langley, 1999).

Inquiring with sensemaking and process data, in fact, implies the need to investigate a phenomenon through the relationship between events, from a temporal, multilevel and multiagency perspective (Figure 3). In most cases, transitions relate to 'events' that have not yet happened, so they cannot be fully sensed, assessed or measured, and are future-facing and still imaginary in many aspects. Thus, an idea is to extend sensemaking and process methodological approaches to imaginaries, for example, utopian considerations, in which process data are 'sensed' not in relation to the past or the 'existing', but to 'imaginary' events. To illustrate the shift to 'future' as a 'strategic resource', and 'future-making' as a 'strategic sensemaking process', we suggest looking at food futures as an example of 'making' desirable futures through socio-ecological transitions utopias (Stock *et al*., 2015). In particular, we present the case of food futures as originated through the narratives of a circular economy, and specifically food systems that are configured as industrial symbioses, or food systems configured as multiple agroecological systems (Pascucci, 2020).

4. INVESTIGATING CIRCULAR AND REGENERATIVE FOOD SYSTEMS AS SUSTAINABLE FUTURES

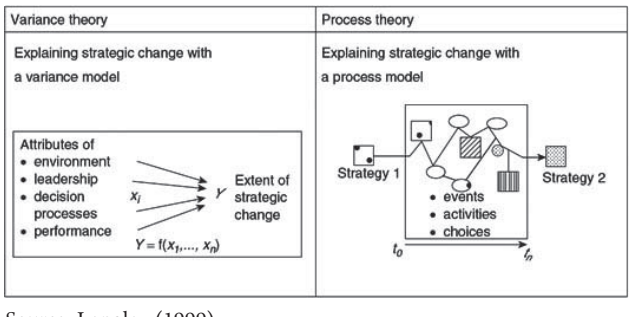
A circular economy can be seen as a framework for collective actions and sensemaking, and from that perspective as a rather powerful and evocative 'future-making' heuristic (Borrello *et al*., 2020). An example is the so-called 'butterfly' diagram, which depicts, graphically, the transition from a linear (the central part of Figure 4) to a circular economy, through restorative cycles of legacy and technical materials and regenerative cycles of biological/bio-based materials (the green wing in Figure 4). The metabolic symbolism of this narrative is coupled with the opportunity that the butterfly diagram, the underpinning framework, provides for the cyclical flows of materials. These carefully assessed, selected, designed and managed materials can be applied to a single product, thus following the logic approach of cradle-to-cradle design thinking, as well as to an industrial sector, thus following the logic of industrial ecology (i.e. an event to a global complex economy) (Webster,

Figure 2. Distribution of soil lifespans.



Source: Ritchie, 2024.

Figure 3. From variance to process theory to investigate future-making strategies.



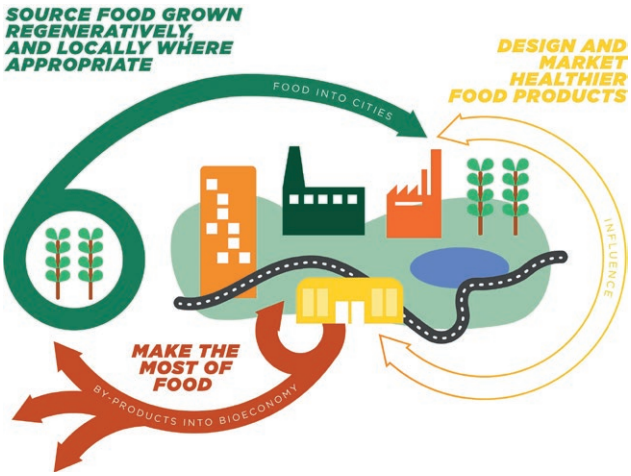
Source: Langley (1999).

Pascucci, 2024). This ductility makes this heuristic so powerful: it makes sense, it has a low cognitive load, it is challenging but not contentious, inclusive and evocative, business and policy friendly, incremental with a flavour of radicalism, and scientifically sound (Alexander *et al.*, 2023). Hence, it is not surprising that it has worked as a powerful and generative tool for future-making, with the explicit agenda of reforming and retooling capitalistic economies from within, without challenging its foundations (e.g. growth), and to bring these economies back 'within the planetary boundaries' and a 'safe space for humanity' (Webster, Pascucci, 2024). While the emphasis on legacy and technical materials has prevailed in these future-making processes, food futures and transitions

into bio-based economies have lately become especially important and prominent.

We consider two main future-making pathways, following the analytical and conceptual approach developed by Pascucci (2020) in a previous inquiry. We focus on two food futures stemming from circular imaginaries: a circular food economy that resembles the features of industrial ecology, and a circular food economy that resembles the features of agroecology. In particular, we focus on the implications of these pathways for food future-making and then use them to reflect on a wider process of future-making, namely how it can be linked to the emergence of a transdisciplinary field of knowledge co-creation to study and tackle the socio-ecological crises of the Anthropocene.

Figure 4. Imaginary of a food industrial ecology.



Source: EMF (2023).

4.1. Imagining a circular food economy based on industrial ecology

The first food future is based on a circular food economy designed based on industrial ecology, emerging from the principles and practices to rethink industrial food systems, also defined as 'linear' or 'extractive' (Pascucci, 2020). The starting point of this imaginary is the identification of regenerative agriculture and a circular economy as an opportunity to identify 'socio-technological fixes at system level' (Webster, 2013). In this imaginary (Figure 4), food producers, distributors and consumers develop relations which ensure that key natural resources are used safely and returned into the biosphere. This approach generates (new or improved) ecosystem services and protects (and possibly enhances) biodiversity, guided by the principles of sustainable intensification (Tittonell *et al*., 2022; Cassman, Grassini, 2020).

In this imaginary, nutrients are recovered after feed or food consumption – for example, by extracting phosphorus, nitrogen and water from food waste, urine and manure through bio-based technology, bio-composting or anaerobic digestion (Figure 5) (Pascucci, 2020). Material reutilisation supports the development of a bio-based economy in which bio-based products can substitute for technical nutrients, such as plastics. Moreover, this economy is designed to use renewable energy along the food supply chains – from farming to food consumption (Figure 5). This circular food economy further upscales the 'green revolution' in which a set of bio-based technological practices and related social and institutional infrastructures are designed to increase the 'productivity and resource use efficiency' of food provisioning systems.

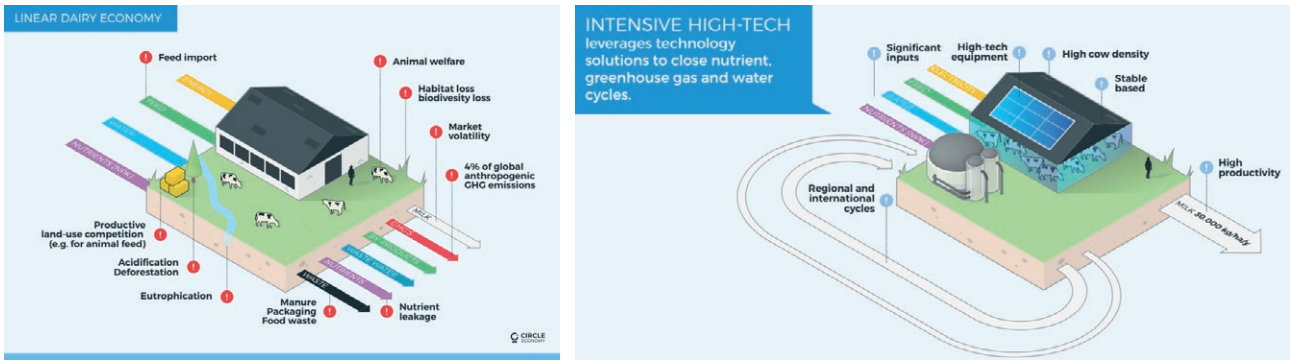
In this imaginary, large agribusiness conglomerates and multinational corporations are dominant in regulating the relations between food production, distribution and consumption. Moreover, while food provisioning is coupled with a renewed capacity of the food economy to (re-)generate (rather than exploit) ecosystem services, thus designing an economy aligned with ecological values, food products remain commodities whose values are prevailingly defined by markets and trading relations.

4.2. Imagining a circular food economy based on agroecology

This food future is based on the perspective of considering soil fertility, biodiversity and ecosystem services as the key pillars to design any food economy. In this imaginary, circularity is linked to designing food systems as living systems, keeping the use of natural resources in food-provisioning systems within planetary boundaries. It also identifies agricultural and food-related practices as inherently embedded in connected with social practices (Pascucci, Duncan, 2017). They are in fact part of agrarian food cultures, embedded in specific socio-ecological contexts. They are 'place based' and 'community oriented' (Figure 6).

In this imaginary, the regenerative capacity of an ecosystem is a key aspect to design food systems coupled with agricultural practices that consider the need to maintain restoration cycles of key nutrients, using the minimum amount of external inputs. The aim is to maximise diversity within the systems by adopting synergic mutualistic relations rather than forcing the system to be maintained at an 'imposed simplified order' against the natural tendency toward entropy, diversity, stability (Tittonell, 2014; Pascucci, 2020). There is a dominant

Figure 5. From linear to circular economy through socio-technological transitions.



Source: Circle Economy (2016).

Figure 6. The Big Food Redesign Manifesto – EMF.

Source: EMF (2023).

biomimetic and ecological worldview in this vision, complemented by a social justice perspective (Rhodes, 2012). Increasing productivity is not subordinate to achieve just, fair and safe access to food for everyone. These practises often imply that farming and food provisioning are part of a wider network of social and political relations between food producers and consumers, and between human and non-human beings (Pascucci *et al.*, 2021). A circular food economy in this imaginary is based on agroecology. As such, balance between the biophysical, technological and socio-economic components of the economy is maintained. For example, productivity is seen as the capacity of an agricultural system to sustain yields and to optimise the use of local resources while minimising any negative environmental and socio-economic impacts of agricultural practices (Tittonell, 2014). In fact, this imaginary is centred on the concept of regenerative agriculture as an approach to food and farming systems that regenerates topsoil and increases biodiversity now and long into the future (Pascucci, 2020). Regenerative practices carefully manage cycles of nutrients and enhance their availability and quality, enhance ecosystem services, increase resilience to climate fluctuation, and strengthen the health and vitality of farming communities (Rhodes, 2012). This type of circular food economy is based on communities rather than corporations and market-based relations. It relies on small-scale processes and adaptation to local conditions instead of designing large-scale and 'easy-to-standardise' processes. In fact, a key design principle is the restoration and regeneration of the 'ecological health' of food systems to realise a safe, just, resilient and sustainable food economy (Rhodes, 2012).

5. A TRANSDISCIPLINARY FIELD TO INVESTIGATE FOOD FUTURES IN THE ANTHROPOCENE

What can we learn from the investigation of food future-making through a regenerative and circular economy? Moreover, how can this exercise be used to co-create an interdisciplinary field to investigate future-making processes in the Anthropocene? Food system redesign pathways seem to indicate that how we define food futures and exercise for both desirable and actionable futures is becoming more relevant among scholars

and practitioners. What seems to be undisputed is that the multiple crises of the Anthropocene demand unusual and radical responses, and urgent actions. As Gümüsay and Reinecke (2024: 2) highlight, reflecting on what is happening in management organisation scholarship, '[...] there is a growing demand for impact-driven management organization theory (Wickert *et al*., 2021) engaged scholarship (Sharma, Bansal, 2020; Ergene *et al*., 2021) to address societal grand challenges (George *et al*., 2016; Gümüsay *et al*., 2022)'. Put more provocatively, social scientists are not entitled to get a free pass in this process. Rather, they are asked to explore new forms of inquiry and contribute to, and thus help to co-create, desirable and sustainable food futures. As we have seen, food systems are at the core of the necessary socio-ecological transitions to tackle the crises of the Anthropocene. However, tackling these transitions with old, past-facing approaches may not be a 'good enough' strategy, given the urgency of these crises. What if we really had only 60 harvests left? To answer this question, we would need a future-oriented scientific line of inquiry, which we claim we still have not fully developed. There are three core aspects that an interdisciplinary field of inquiry focused on future-making should consider and debate: (i) moving from prescriptive to prospective conceptualisation/theory building, particularly to resolve the tensions and ambiguities between desirable and actionable futures; (ii) embracing temporal processes and temporality as a key ontology for investigating alternative and desirable and actionable futures; and (iii) the (risk of) commodification of futures. We will briefly present these aspects and use them to define a collective research agenda on this topic.

(i) Prospective theory-building involves the move from perspective to prospective ways of conceptualising and theorising. Prospective theorising regards the co-creation of futures 'by fostering imaginative capacity about what the future could be' and not by developing prescriptive interventions based on a positivist worldview (Gümüsay, Reinecke, 2024: 4). More specifically, prospective theorising embraces a pragmatist philosophy, meaning that it does not seek truth as a fixed and objective property of beliefs or propositions, but rather is concerned with the practical consequences of theorising and its usefulness in solving problems and achieving desired outcomes. Prospective theorising is about preparing for diverse futures, not predicting them. It deals with changing the future through prefiguring desirable and actionable futures. Similarly to prefigurative organising, which involves bringing about a desired future reality through practising it in the present (Reinecke, 2018), theorising can be prefigurative by bringing about a desired future reality through theorising into the present.

(ii) Future-making and its relation to the definition and investigation of desirable and actionable futures bring time and temporality to the fore (Gümüsay, Reinecke, 2022). While there is growing interest in understanding the role of time and temporality in strategic actions and transition pathways, this line of inquiry remains an overlooked topic. Assuming temporal lenses is crucial for the emergence of an interdisciplinary field of inquiry devoted to the socio-ecological crises of the Anthropocene and, in particular, to define alternative approaches and worldviews to better understand the socio-ecological relations and to provide new ways for organisations to innovate for desirable and actionable futures (Gümüsay, Reinecke, 2022). There is a better understanding of the presence of multiple temporal issues that generate challenges for navigating transitions to sustainable futures. For example, when looking at materials and technologies needed in the future-making processes, there are relevant differences in terms of temporal rhythms or structures, which leads to asynchrony and diachrony (Garud, Gehman, 2012). Moreover, moving from desirable to actionable futures may require solutions such as technologies and production methods that are unknown or have yet to be developed. Desirable futures may require connecting processes with different temporal perspectives, such as the short and long term (Slawinski, Bansal, 2015) or the past, present and future (Kim *et al*., 2019). For example, organisations may use the past as a generative resource to co-create forward, thereby making imagined futures actionable in the present (Garud *et al*., 2010). Finally, moving from desirable to actionable futures may require organisations to engage in new forms of collaboration between entities with different temporal frames (George *et al*., 2016), including across companies, universities, startups and even competitors (Bowen *et al*., 2018).

(iii) Regarding commodification of the future, the way we facilitate, control and manipulate future-making has implications for exploiting futures as assets and commodities. Alterative futures create different sets of 'losers and winners' and actively engage and morph future-making, so it becomes more and more relevant to define these sets. Futures can be commodified and exploited as any other resource, and how actors engage with future-making should be understood as not being value neutral or unrelated to political and economic agendas. For example, defining futures through food policies (e.g. the European Union Green Deal) is a form of altering future-making so that it is suitable for some and less for others. Understanding this process will help to design business and policy strategies that are more attentive to inclusion and exclusion criteria and eventu-

ally help scholars to interrogate policy and strategy-making through more critical lenses.

Our final point refers to future research agendas. The debate on sustainability transitions, a circular bio-based economy and regenerative agriculture have brought to light the relevance of food systems and economies and the sciences that are engaged to understand them. In this short essay, we have offered a perspective that embraces future-making as a possibility to expand existing scientific fields, and particularly applied social sciences such as agricultural and food economics. We believe that a conversation about the future of food is needed in this space, and we hope that our essay provides a catalyst for it.

6. CONCLUDING REMARKS

Given the dramatic and contested reality of the Anthropocene, and the urgency to investigate and mobilise scientists for sustainable and desirable food system transitions, in this essay we have asked the following questions: what are the sciences, and fields of knowledge, that we need (to collectively create) to solve the crises of a planet in chaos? What (type of) knowledge do we need? From whom and for whom? Our response to these questions has emphasised the opportunity of investigating sustainability transitions in food systems as a example of how humanity can respond to the socio-ecological challenges of the Anthropocene and design systemic change (Alexander *et al*., 2023). We have focused on circular and regenerative principles and looked at the case of protein transitions. These principles have already inspired several food transitions, framed as desirable and actionable futures (Webster, Pascucci, 2024). A few concluding remarks can be drawn from our approach.

First, the role of scientists traditionally engaged in investigating the relationships between nature, society and economy will become more relevant in the future, where we argue a transdisciplinary science will become necessary to tackle the challenges of the Anthropocene. By rethinking and redesigning food systems using transdisciplinary knowledge, these scientists will co-create and increase our capacity to investigate and assess future-making strategies, and explore the tensions between desirable and actionable (food) futures (Pascucci, 2020).

Second, transdisciplinary knowledge will emerge, in our view, through collective co-creation. Subsequently, new methodologies, ontologies and epistemologies will emerge to help scientists to investigate desirable and sustainable futures. The core of this new form of knowledge co-creation will be research on and analysis of sustainability transitions. This endeavour will provide an opportunity to illustrate future-making processes, and how collective action in science can produce projects that attempt to redesign socio-ecological systems such as food systems. A transdisciplinary science of future-making will look at food futures and imaginaries of desirable food systems as 'ontologies', something that can and should be investigated through the lenses, principles and rules of scientific practice. We have briefly discussed some of these imaginaries and how they can contribute to the development of regenerative and circular food futures. We believe that agricultural economists are particularly well suited in this space, and their role and contribution to co-create such a transdisciplinary knowledge is essential.

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Research article

Should I stay or should I go? Tie stalls or loose housing to improve dairy cow welfare

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Abstract. Consumers consider the housing system to be a key factor that influences farm animal welfare (FAW). The European Food Safety Authority's unfavourable assessment of tie-stall systems may encourage a shift towards adopting loose-housing practices. Several factors impact the likelihood of implementing practices aimed at improving FAW. This study evaluates some variables that affect the adoption of loose housing in Italian dairy farming, where the tie-stall system remains diffuse. We assessed socio-demographic, farm-related, and opinion variables that influence the intention to move from tie-stall to loose-housing system by means of a direct survey of 98 farmers who currently use the tie-stall system. The results indicate that gender, age, and financial considerations significantly influence the intention to adopt a loose-housing system. Additionally, the findings underscore the importance of farmers' perceptions of improvements in animal welfare. The conclusions highlight the importance of the farmers' sensitivity to FAW and their demand for subsidies to support structural changes.

Keywords: sustainable livestock practices, farmers' perception, animal husbandry, tie-stall housing, loose housing
JEL codes: Q18, Q16, D60.

HIGHLIGHTS

- This study assesses the environmental, social, and economic viability of the transitioning from tie-stalls to a loose-housing system in dairy farming.
- The data were collected from interviews with 98 farms in Northern Italy.
- The main findings suggest the importance of the economic aspect in the decision to change the livestock system.
- Young and female farmers seem to be more inclined towards the adoption of a loose-housing system.

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1. INTRODUCTION

Farm animal welfare (FAW) is a significant concern when evaluating agricultural systems. As the concept of sustainability continues to evolve, agricultural systems are now expected to balance increased productivity with the stewardship of natural resources, in order to meet new consumer expectations at both environmental and ethical levels (Balzani, Hanlon, 2020; Irico *et al*., 2018). FAW is a multidimensional concept that is intrinsically tied to the changing sensitivities and daily choices of both consumers and producers (Buddle *et al*., 2021; Gaworski, Bockowski, 2018).

Within the broader debate, stakeholders recognise that housing systems are a key factor that affects FAW (Ochs, 2019; Perttu *et al*., 2020; von Keyserlingk, Hotzel, 2014; Zuliani *et al*., 2017). Several studies have investigated how consumer's preferences and willingness to pay are influenced by their sensitivity to FAW, often leading them to favour welfare-friendly products (Alonso *et al*., 2020; Cornish *et al*., 2020; Gorton *et al*., 2023; Kühl *et al*., 2019; Mazzocchi, Sali, 2022; Mazzocchi *et al*., 2022; Ortega, Wolf, 2018). According to Zuliani *et al*. (2017), people have identified adequate housing space for cattle as one of the most important factors for animal welfare. Specifically, Mazzocchi, Sali (2022) confirmed that consumers prefer dairy products with a label that indicates the cattle have access to grazing areas, meadows, or external paddocks. In fact, consumers tend to prefer systems that allow animals to roam freely and to exhibit natural social behaviours (Beaver *et al*., 2021; Biasato *et al*., 2019; Cardoso *et al*., 2016; Robbins *et al*., 2019; You *et al*., 2014; Yunes *et al*., 2017). Farmers, on the other hand, are aware that implementing the correct housing system can improve farm profitability by enhancing animal productivity, efficiency, and product quality (Ahmed *et al*., 2021; Biasato *et al*., 2019; Buddle *et al*., 2021; Tarantola *et al*., 2016).

In the dairy sector, the tie-stall system has been debated for years, yet it remains used in traditional Italian production contexts, particularly in mountainous areas (Irico *et al*., 2018; Tarantola *et al*., 2016; Zuliani *et al*., 2017). In tie-stall barns, cows are tethered at the neck in individual stalls for at least 180 days a year, where they are fed and milked. Although tie-stalls can help farmers monitor injuries and individual feed consumption (Zuliani *et al*., 2017), research indicates that the incidence of diseases such as mastitis, ketosis, hock injuries, and ocular discharge is higher in tie-stall systems than in loose-housing systems (Hultgren, 2002; Popescu *et al*., 2014; Regula *et al*., 2004; Tarantola *et al*., 2016). Additionally, cattle reared in loose-housing systems generally exhibit lower cortisol levels, suggesting that this approach to housing is less stressful for animals compared to tie-stalls (Irico *et al*., 2018; Starvaggi Cucuzza *et al*., 2014; Tarantola *et al*., 2016).

Although the perception of FAW among farmers has traditionally received less attention than that of other stakeholders (Buddle *et al*., 2021; Neave *et al*., 2022; Ortega, Wolf, 2018), research shows that farmers typically feel an ethical obligation towards FAW (Croyle *et al*., 2019; Schuppli *et al*., 2023). However, the implementation of new technologies intended to improve animal welfare is influenced by various technical, financial, cultural, and individual factors, which can affect farmers' willingness to adopt best management practices (Araujo *et al*., 2022; Bechini *et al*., 2020; Groher *et al*., 2020; Hyland *et al*., 2018; Nguyen, Drakou, 2021). In relation to FAW, studies suggest that the financial viability of implementing animal-friendly facilities and husbandry systems (Ahmed *et al*., 2021), individual vocation and education (Nadlucnik *et al*., 2022). Moreover, the manner in which FAW advice is given to farmers (Croyle *et al*., 2019) can influence the adoption of new technologies and, consequently, the welfare of livestock. Improving the well-being of farm workers could be an important prerequisite for enhancing FAW on farms (Anneberg, Sandøe, 2019; Kauppinen *et al*., 2010; Neave *et al*., 2022; Ortega, Wolf, 2018; Spigarelli *et al*., 2021). Understanding farmers' perceptions of animal welfare and the factors that influence technology adoption is thus crucial for designing effective and enforceable FAW policies that can also be applied to housing systems (Balzani, Hanlon, 2020; Kauppinen *et al*., 2010).

The existing legislation on the protection of animals in farming (Directive 98/58/EC) is currently being reassessed within the context of the European 'Farm to Fork' strategy, part of the 'European Green Deal'. While some European countries, such as Denmark and Norway, have already implemented stringent policies setting deadlines for the transition to loose-housing systems (Hansen *et al*., 2022; Retsinformation, 2017), there is still no specific regulation at the European Union level governing the welfare of dairy cattle. However, the negative opinion of the Panel on Animal Health and Welfare of the European Food Safety Authority (EFSA) on tie stalls could influence the development of new directives. According to the EFSA (2023), 'dairy cows should not be permanently housed in tie-stalls because of the continuous and severe restriction of movement and social behaviour, and the risk of thwarting of lying down and rising up movements as well as prevention of comfortable resting postures. While from a welfare perspective, housing in tie-stalls should in general not be practiced, in a transi-

tion period, housing in tie-stalls with regular access to a loafing area, or access to summer pasture, could be used to reduce the impact on restriction of movement, resting, and social behaviour'.

Given these considerations, we might witness a growing transformation of tie-stall housing barns into free housing for livestock in the coming years. However, this transition requires significant adaptation by the animals to the new social context as well as the adaptation to the new milking system. This could result in a temporary decline in milk yield and negative effects on udder health (Brouček *et al*., 2013; Hovinen *et al*., 2009). A significant effort is also required by farmers, who must be supported through a satisfactory transition in terms of both welfare and productivity over the long term. To date, few studies have explored the environmental and economic sustainability of shifting from tie-stall to loose housing and its effects on productive, behavioural and health parameters in cattle (Broucek *et al*., 2017; Brouček *et al*., 2013; Hovinen *et al*., 2009; Tarantola *et al*., 2016).

The goal of this study is to assess the ethical and socio-economic factors that may impact the maintenance of tie-stall systems in Italian dairy farming. This research uses a direct survey conducted among dairy farmers who currently employ the tie-stall system. This paper is organised as follows: Section 2 introduces relevant literature related to studies on FAW and farmers' perception of it. Section 3 describes the methodology and data collection. Section 4 presents the results and discussion, while Section 5 offers the conclusions and addresses limitations.

2. REVIEW OF THE LITERATURE ON FARMERS' PERCEPTION OF ANIMAL WELFARE

As farmers' and consumers' interests may differ, research on FAW has increasingly focused on understanding farmers' perspectives, a viewpoint that has historically received less attention compared to that of other stakeholders (Buddle *et al*., 2021; Neave *et al*., 2022; Ortega, Wolf, 2018). In a semi-systematic review of the existing studies on FAW perception among farmers, Balzani, Hanlon (2020) highlighted the research that has been dedicated to identifying the factors that shape farmers' attitudes towards FAW. Studies indicate that farmers view knowledge, education, attitude, experience, and the ethics of care as key factors that shape their understanding of FAW, with these variables often influencing one another (Adler *et al*., 2018; Anneberg, Sandøe, 2019; Balzani, Hanlon, 2020; Beaver *et al*., 2020; Bock, von Huik, 2007; Schuppli *et al*., 2023; Spooner *et al*., 2014).

Another important factor is farmers' perception of the economic advantages and disadvantages associated with implementing FAW practices, such as the impact of space rearrangement on farm profit margins (Ahmed *et al*., 2021). In their study involving Slovenian cattle farmers, Benedicic *et al*. (2022) demonstrated that many participants adopt environmentally friendly housing systems primarily to qualify for full direct payments, suggesting that their actions are often driven by economic considerations or, similarly, by social expectations. The influence of social norms on farmers' perceptions of FAW has also been noted by other authors (Balzani, Hanlon, 2020; Bock, Huik, 2007; Buddle *et al*., 2021). Moreover, Buddle *et al*. (2021) highlighted producers' concerns about negative public perception of their behaviour regarding FAW.

The relationship between farmers and other stakeholders, such as advisors, veterinarians, and researchers, is another crucial factor (Balzani, Hanlon, 2020; Croyle *et al*., 2019). Discussions within focus groups of dairy farmers in Ontario, Canada, revealed that producers consider communication with experts to be vital to their receptiveness to FAW advice (Croyle *et al*., 2019).

The conceptualisation of FAW itself has been explored in several studies. There is broad agreement among producers in defining FAW primarily in terms of biological functioning and health (Balzani, Hanlon, 2020; Beaver *et al*., 2020; Bock, Huik, 2007; Buddle *et al*., 2021; Cardoso *et al*., 2016; Kauppinen *et al*., 2010; Schuppli *et al*., 2023; Spooner *et al*., 2014; Te Velde *et al*., 2002; Vanhonacker *et al*., 2008). While the physical dimension of FAW has been most studied, the affective state of animals also plays a critical role in determining overall welfare (Balzani, Hanlon, 2020; Beaver *et al*., 2020; Schuppli *et al*., 2023). The bond between farmers and their animals is essential for allowing livestock to engage in natural behaviour. FAW is closely linked to affective states and highly valued by consumers concerned with the sustainability of food production (Buddle *et al*., 2021; Neave *et al*., 2022; Ortega, Wolf, 2018). However, studies by Kauppinen *et al*. (2010) in Finland and Schuppli *et al*. (2023) in Canada have demonstrated that naturalness is an important characteristic of the FAW concept. In contrast, based on interviews conducted by Anneberg, Sandøe (2019) in Denmark, this aspect is sometimes viewed as 'negotiable' when compared with physical health and production. This perception is also evident based on interviews with producers in Ontario: the participants appeared hesitant to implement practices such as access to pasture or outdoor grazing, which would allow animals to engage in natural behaviours but might also reduce productivity (Schuppli *et al*., 2023).

3. MATERIALS AND METHODS

3.1 Conceptual framework

In line with the literature discussed in Section 2, this study examines the relationship between explanatory factors and farmers' intentions to adopt a loose-housing system. The dependent variable is a categorical variable derived from a request for the respondents to define how much they agree with the statement: 'I will not implement a loose-housing system until it is mandatory', on a scale from 1 to 10 (Table 1). As shown in Table 1, the potential explanatory variables are categorised into three groups: 1) socio-demographic variables, 2) farm-related variables, and 3) opinion variables.

The variables are grouped considering that the behavioural aspect of humans plays a crucial role in the adoption of new technologies (Venkatesh, Davis, 2000). Behavioural intentions are the most effective predictors of an individual's actions; thus, the stronger a person's intention to engage in a particular behaviour, the more likely they are to adopt it (Li *et al*., 2023). The three groups of variables are consistent with authors who have affirmed that the adoption of new technologies designed to enhance animal welfare is influenced by a range of technical, financial, cultural, and individual factors (Araujo *et al*., 2022; Bechini *et al*., 2020; Groher *et al*., 2020; Hyland *et al*., 2018; Nguyen, Drakou, 2021).

The socio-demographic variables include factors such as gender, age, and education. In addition, variables related to the farmer's experience in livestock breeding are included to assess how experience influences the decision to implement a loose-housing system.

The farm-related variables consist of factors that describe farm characteristics, such as farm size. This choice follows previous studies that have explored how herd size affects farmers' perceptions of FAW (Balzani, Hanlon, 2020; Schuppli *et al*., 2023). Within this group, the average daily milk yield is considered to be an indicator of livestock system intensification, while the utilised agricultural area serves as a proxy for the farm's business dimension. Access to pasture is also included; it is considered to be important for farmers' perceptions of animal welfare (Zuliani *et al*., 2017). In addition, the farm's altimetric area (FARM_ALT) is included to assess the influence of farm location, given that tie-stall systems are still prevalent in mountainous regions (Irico *et al*., 2018; Zuliani *et al*., 2017).

The opinion variables capture the respondents' views on FAW, particularly in terms of animal health, labour, economic viability, and the potential abandonment of tie-stall systems (Table 1). These variables gather farmers' opinions on FAW issues, focusing specifically on the logistical aspects of the husbandry system (tie-stall versus loose-housing systems). These factors are presented as statements, with the respondents indicating their level of agreement on a Likert scale from 1 (total disagreement) to 10 (total agreement).

3.2 Data description

Because approximately 60% of Italian milk production from dairy cattle is concentrated in Northern Italy, the respondents for this study were selected from dairy farmers in the Lombardy, Emilia-Romagna, Piedmont, and Veneto regions. However, the majority of the farms are located in Lombardy and Emilia-Romagna. According to Unioncamere Lombardia (2023), 46% of the milk produced in Italy in the second half of 2022 came from farms in Lombardy, and 16% came from farms in Emilia-Romagna.

In Italy, tie-stall systems are more common in mountainous areas, where available space is limited, but they are also present to some extent in the Po Valley. Up to 10 years ago, approximately 20% of dairy farms in Lombardy used tie-stall housing (Tangorra, Zanini, 2014). Additionally, according to the Quality Control Body of Regulated Productions, in 2018, 58% of farms in the Parmigiano Reggiano Consortium area utilised tie stalls.

With the valuable support of several cooperatives and milk producer associations (Cooperativa Santangiolina, Consorzio Parmigiano Reggiano, Confcooperative Lombardia, ASL Biella, and ANABoRaRe), dairy cattle breeders using tie-stall barns were contacted by phone, following prearranged agreements with producer associations and with the farmers' prior consent. Experienced interviewers conducted face-to-face interviews to facilitate the inquiry, to clarify its purpose, and to ensure confidentiality. Data collection was carried out using surveys created with the Qualtrics Software between April and July 2023. This process resulted in 87 completed questionnaires out of 98 recruited farmers, yielding an 89% response rate. On average, the respondents took about 17 minutes to complete the survey.

3.3 Econometric approach

To investigate the factors that influence Italian dairy farmers' intentions to transition from tie-stalls to a loose-housing system, we employed a comprehensive econometric approach. This section details the rationale behind the model selection, specification of the variables, and the robustness checks we performed to ensure the validity of our findings.

Table 1. Description of the variables included in the survey.

Variables	Group description	Description	Measurement
DEP	Dependent	'I will not implement a loose-housing system until it is mandatory'	Likert scale (from 1 = totally disagree to 10 = totally agree)
DEM_SEX	Socio-demographic	Sex	Dummy (0 = male; 1 = female)
DEM_AGE	Socio-demographic	Age	Number of years
DEM_EDU	Socio-demographic	Education (STEM)	Dummy (0 = no STEM studies; 1 = STEM studies)
DEM_EXP	Socio-demographic	Farmer's experience in breeding (class)	Class (1 = less than 10 years; 2 = between 10 and 30 years; 3 = more than 30 years)
DEM_FAM	Socio-demographic	Farmer belongs to a family of farmers	Dummy (0 = no; 1 = yes)
FARM_COW	Farm-related	Number of lactating cows per farm	Number
FARM_MILK	Farm-related	Average daily milk yield per cow	Litres
FARM_UAA	Farm-related	Utilised agricultural area (class)	Class (0 = no utilised agricultural area or less than 2 ha; 1 = from 2 to 9.9 ha; 2 = from 10 to 29.99 ha; 3 = from 30 to 49.99 ha; 4 = from 50 to 99.99 ha; 5 = more than 100 ha)
FARM_RENT	Farm-related	(Surface on lease / total surface) × 100	Percentage
FARM_ORG	Farm-related	Certified organic farming	Dummy (0 = no; 1 = yes)
FARM_OWNER	Farm-related	Full-time owner	Dummy (0 = part-time employee; 1 = full-time)
FARM_EMPL	Farm-related	Number of employees	Number
FARM_PASTURE	Farm-related	Summer pasture practices	Dummy (0 = no; 1 = yes)
FARM_ALT	Farm-related	Altimetric area	Class (1 = plain; 2 = hill; 3 = mountain)
OPIN_AN_WEL	Opinion	Compared to tie-stall, loose-housing allows greater welfare for cattle	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_QUA	Opinion	The quality of milk produced in loose-housing farms is better than that produced in tie-stall farms	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_CAL	Opinion	The identification of oestrus is easier in a loose-housing system than in tie-stalls	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_DIS	Opinion	Loose housing stimulates the immune system and reduces the incidence of diseases	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_WORK	Opinion	Compared with tie-stalls, loose housing requires less labour in herd management	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_MAN	Opinion	Compared with tie-stalls, loose housing requires a greater management effort	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_TIME	Opinion	Compared with tie-stalls, loose-housing management takes less time	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_KNOW	Opinion	It is easy to gain the skills required to implement a loose-housing system	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_SOC	Opinion	It is worth listening to other farmers' opinions on technical issues and business choices	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_SUBS	Opinion	Starting a loose-housing system requires subsidies	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_COST	Opinion	The upfront costs needed to implement a loose-housing system are too high	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_DIFF	Opinion	Compared with tie-stalls, loose housing is more difficult to manage	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_SMALL	Opinion	An undersized herd prevents me from implementing loose housing	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_ECON	Opinion	Implementing a loose-housing system is not economically viable	Likert scale (from 1 = totally disagree to 10 = totally agree)
OPIN_SPACE	Opinion	Implementing a loose-housing system requires too much space in the barn	Likert scale (from 1 = totally disagree to 10 = totally agree)

Note: STEM = science, technology, engineering, and mathematics.

Given that our dependent variable is ordinal, representing the intention to adopt a loose-housing system rated on a Likert scale from 1 (totally disagree) to 10 (totally agree), it was imperative to select a model that appropriately handles this type of data. The dependent variable 'I will not implement a loose-housing system until it is mandatory' was reversed to enhance the clarity of interpretation in the regression outcomes, where higher values indicate a stronger intention to adopt a loose-housing system. We considered the following econometric models:

- *Negative binomial regression model*: We chose this as the primary model due to the presence of overdispersion in our dataset, where the variance of the dependent variable exceeds its mean. The negative binomial model is an extension of the Poisson model, introducing an additional parameter to account for this overdispersion. This makes it particularly suitable for count data or discrete outcomes that exhibit greater variability than what the Poisson distribution can capture.
- *The Poisson pseudo-maximum likelihood (PPML) estimator*: The PPML estimator is robust against misspecification of the distribution and remains efficient under various forms of heteroskedasticity. It is often used when dealing with non-negative dependent variables, providing consistent estimates even when the true distribution deviates from the Poisson distribution. The PPML estimator is particularly useful in dealing with heteroskedasticity, a common issue in survey data where variability in responses can differ across observations.
- *Ordered logit model*: Because our dependent variable is ordinal, with natural ordering but unknown distances between categories, we also considered the order logit model. This model is appropriate for cases where the outcome variable represents ordered categories, allowing us to estimate the probability of a respondent falling into a higher or lower category based on their characteristics. In addition, because the ordered logit model is explicitly designed for ordered outcomes, it captures the structure of ordinal data while not assuming a constant difference between levels. This flexibility is advantageous over simpler models that might ignore the ordered structure. Moreover, this model uses thresholds to distinguish between outcome categories. The probability of each category depends on where a particular score linked to predictors falls relative to these thresholds. This approach allows for flexibility in accommodating the non-linear nature of ordinal data and provides a unique probability for each category.

After comparing these models, we selected the negative binomial model as the main model (Model 1 in Table 3) due to its ability to handle overdispersed data effectively. We ensured the robustness of the results by comparing them with those obtained from the PPML estimator (Model 2 in Table 3) and the ordered logit model (Model 3 in Table 3), both of which produced consistent outcomes and qualitatively similar results.

The model can be formally expressed as:

$$\exp(y_i = \alpha + \boldsymbol{\beta_i SDV_i} + \boldsymbol{\beta_i FV_i} + \boldsymbol{\beta_i OV_i} + \varepsilon_i)$$

where y_i is the dependent variable, α denotes the constant term, $\boldsymbol{\beta_i SDV_i}$ is the vector of coefficients corresponding to the socio-demographic variables, $\boldsymbol{\beta_i FV_i}$ represents the coefficients associated with the farm variables, $\boldsymbol{\beta_i OV_i}$ pertains to the coefficients of the opinion variables, and ε_i is the error term.

To ensure the robustness of findings and to validate the assumptions underlying the negative binomial model, we also explored alternative model specifications. First, we incorporated the PPML estimator, which is recognised for its robustness against distributional anomalies and its preservation of efficiency, as underscored by Santos Silva, Tenreyro (2006). Additionally, we integrated an ordered logit model to cater to ordinal variables. Across these diverse econometric approaches, we found no significant differences.

To evaluate model fit, we performed several checks, including testing for multicollinearity by computing the variance inflation factor (VIF). The VIF consistently remained below the threshold of 5 (Hair *et al*., 2014; O'Brien, 2007), indicating no multicollinearity issues. We also employed the Akaike information criterion (AIC), log-likelihood, and pseudo R-squared to assess the model fit. We implemented the AIC and log-likelihood for the negative binomial and ordered logit models, and the pseudo R-squared for the PPML estimator.

Furthermore, to simplify the interpretation of results given the large number of questions in the survey, we applied a backward stepwise elimination method to refine the model by including only statistically significant regressors with a significance level of at least 80%. This process resulted in a final sample of 73 observations, starting from the original 98 respondents. The reduction in the sample size was due to the exclusion of incomplete responses and missing values, retaining only those respondents who answered all questions completely. This approach ensured the robustness and reliability of the econometric analysis, as shown in Table 3. For regression analyses, we used the 'glm.nb', '*glm*', and '*polr*' functions available in the MASS package of the R software (version 4.3.1).

4. RESULTS AND DISCUSSION

4.1 Descriptive statistics

Table 2 shows the descriptive statistics of the variables included in the analysis.

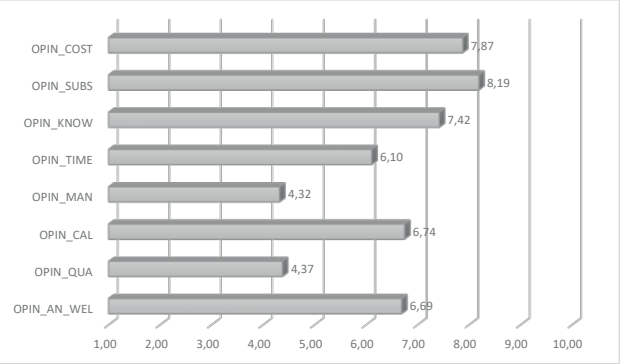
Regarding the socio-demographic variables, the majority of the respondents (79%) are male (based on DEM_SEX). The respondents are 23-77 years old (based on DEM_AGE), and most of them (87%) have over 30 years of experience as farmers (based on DEM_EXP).

For the farm-related variables, the majority of the interviewed farmers (92%) work full-time on their farms (based on FARM_OWNER). The high variability in average daily milk production per cow (FARM_MILK) reflects the inherently different productive performance of breeds, which is typically higher on farms located in the plains compared with those located in mountainous areas.

There is an interesting relationship between the FARM_UAA and OPIN_AN_WEL variables. Across all utilised agricultural area classes, the farms generally associate greater animal welfare with the use of a loose-housing system. Notably, small and medium-sized farms, with utilised agricultural area extensions up to 50 ha (classes 0-3), tend to have a more favourable opinion of a loose-housing system in terms of its perceived improvement in animal welfare.

Regarding the opinion variables, shown in Figure 1, the high mean OPIN_SUBS score (8.19) indicates a general consensus among the respondents on the importance of financial subsidies as a key prerequisite for the successful adoption of a loose-housing system on their farms. This view is supported by the high mean OPIN_COST score (7.87), which reflects the common perception that the upfront costs required to establish the necessary facilities and equipment are substantial.

Figure 1. Average values of the opinion variables (rated from 1 to 10).



Note: See Table 1 for the details on each variable.

The mean OPIN_KNOW score (7.42) suggests that the respondents generally believe they possess the necessary skills to implement a loose-housing system on their farms. Additionally, the majority of the respondents think that transitioning from a tie-stall to a loose-housing system would have a positive impact on timesaving and overall management effort. The mean OPIN_CAL (6.74) and OPIN_MAN (4.32) scores indicate that most of the respondents believe loose housing would make identifying animals in oestrus easier, thus requiring less management effort compared with a tie-stall system. Overall, 59% of the respondents somewhat or strongly

Table 2. Descriptive statistics.

Variables	Group description	Observation	Mean	Min	Max
DEP	Dependent	86	4.67	1	10
DEM_SEX	Socio-demographic	86	0.21	0	1
DEM_AGE	Socio-demographic	85	48.13	23	77
DEM_EXP	Socio-demographic	86	2.86	1	3
FARM_MILK	Farm-related	81	22.73	10	60
FARM_UAA	Farm-related	86	2.38	0	5
FARM_OWNER	Farm-related	86	0.92	0	1
OPIN_AN_WEL	Opinion	86	6.69	1	10
OPIN_QUA	Opinion	86	4.37	1	10
OPIN_CAL	Opinion	86	6.74	1	10
OPIN_MAN	Opinion	85	4.32	1	10
OPIN_TIME	Opinion	86	6.10	1	10
OPIN_KNOW	Opinion	86	7.42	1	10
OPIN_SUBS	Opinion	86	8.19	1	10
OPIN_COST	Opinion	86	7.87	1	10

Note: See Table 1 for the details on each variable. "Obs." defines the number of observations in the dataset.

agree with the statement that managing a loose-housing system would be less time-consuming than managing a tie-stall system (denoted by the mean OPIN_TIME score of 6.10).

Regarding the perceived impact of loose housing on FAW, the mean OPN_AN_WEL score (6.69) shows that most of respondents (70%) perceive this system as beneficial for cattle welfare. However, there is general disagreement with the statement that loose housing improves the quality of the milk produced (denoted by the mean OPIN_QUA score of 4.37).

4.2 Model results and discussion

The correlations among the variables did not indicate any issues with multicollinearity. However, to ensure the robustness of our analysis, we conducted additional tests to identify potential multicollinearity. This assessment involved calculating the VIF for each model. The results confirmed that multicollinearity was not a concern, as the VIF consistently remained below the threshold of 5, as recommended by Hair *et al.* (2014). Additionally, we utilised the AIC, log likelihood, and R-squared tests to assess the goodness of fit for the models. The stability of coefficients and the signs for the control variables across the different models demonstrated robust results, further confirming that multicollinearity is not a notable issue in these regressions (Table 3). The discussion of the results focuses on the negative binomial model due to the absence of significant differences among the three distinct models we analysed.

Among the socio-demographic variables, we found that DEM_SEX is significant. Specifically, women are more inclined to adopt loose housing compared with males. Various authors, including Jackson (1993) and Mazzocchi, Sali (2022), have noted that women often possess a unique and intimate connection with nature. Additionally, women tend to have a higher animal welfare attitudes than men (Randler *et al.*, 2021) and are more likely to reject livestock production systems that do not prioritise animal welfare (Jinjing, 2023). The protection of animal welfare is also considered to be slightly more important by women than by men (European Commission, 2023). To our knowledge, this study is the first to identify this female inclination towards FAW issues among farmers using this approach, which confirms the general trend of women being more concerned about FAW.

Older farmers are less likely to choose loose housing (DEM_AGE: coefficient = -0.009), possibly because they are more accustomed to using tie-stalls and have fewer years of work ahead, making them less interested in adopting new innovations compared to younger farmers (Mazzocchi *et al.*, 2019). The negative sign of the DEM_EXP coefficient supports this finding, as those with more

Table 3. Regression model results.

	Dependent variable (DEP)		
	Negative binomial (Model 1)	Poisson pseudo-maximum likelihood estimator (Model 2)	Ordered logit (Model 3)
Variables	Coefficients (standard errors)		
Constant	3.441***	3.441***	-
	(0.662)	(0.634)	-
DEM_SEX	0.387***	0.387***	1.788***
	(0.123)	(0.118)	(0.630)
DEM_AGE	-0.009*	-0.009*	-0.043**
	(0.005)	(0.005)	(0.022)
DEM_EXP	-0.717*	-0.717**	-15.820***
	(0.370)	(0.354)	(1.444)
FARM_MILK	-0.003*	-0.003*	0.017
	(0.002)	(0.001)	(0.029)
FARM_UAA	0.085**	0.085**	0.447**
	(0.042)	(0.040)	(0.200)
FARM_OWNER	-0.737***	-0.737***	-3.042***
	(0.177)	(0.169)	(0.899)
OPIN_AN_WEL	0.187***	0.187***	0.795***
	(0.028)	(0.027)	(0.147)
OPIN_QUA	-0.039*	-0.039*	-0.136
	(0.021)	(0.020)	(0.108)
OPIN_CAL	-0.046**	-0.046**	-0.270**
	(0.022)	(0.021)	(0.128)
OPIN_MAN	-0.061**	-0.061**	-0.386***
	(0.026)	(0.025)	(0.141)
OPIN_TIME	-0.051**	-0.051**	-0.350***
	(0.022)	(0.021)	(0.121)
OPIN_KNOW	-0.040	-0.040	-0.163
	(0.026)	(0.025)	(0.128)
OPIN_SUBS	0.061*	0.061*	0.279*
	(0.034)	(0.032)	(0.157)
OPIN_COST	-0.061**	-0.061**	-0.329**
	(0.029)	(0.028)	(0.148)
VIF max	3.44	3.44	3.44
VIF mean	1.87	1.87	1.87
Pseudo R squared	N.A.	0.55	N.A.
Log-Lik.	-160.78	N.A.	-125.32
Akaike information criterion	351.57	N.A.	296.64
Observations	73	73	73

Note: See Table 1 for the details on each variable. The asterisks indicate statistical significance (*** p < 0.01. ** p < 0.05. * p < 0.1).

than 30 years of experience generally do not consider loose housing to be a viable option for improving FAW. This resistance to change may be related to the cognitive 'status quo bias', which leads individuals to prefer maintaining the current situation rather than embracing change (Kahneman, 2011). Despite many actions under the Common Agricultural Policy (CAP) aimed at subsidising farmers to encourage FAW practices, the tie-stall system has not yet been prohibited and its use is not actively discouraged.

Among the farm-related variables, we found that FARM_MILK, FARM_UAA, and FARM_OWNER are statistically significant. Farmers with high milk production (FARM_MILK) are unlikely to adopt a loose-housing system, likely because those benefiting from high production may not feel the need to change their current farming system. On the other hand, farmers with large agricultural areas (FARM_UAA) are more willing to switch to loose housing, as they likely do not face the spatial constraints that could hinder the transition. Moreover, loose housing may allow for less labour-intensive practices, giving farmers more time to dedicate to other agricultural activities, such as cultivation, which could be more manageable on larger farms.

The FARM_OWNER results suggests that full-time farmers are less likely to choose a loose-housing system. In our sample, 92% of the respondents are full-time farmers, which created a bias in the results due to the sample structure. This finding indicates that part-time owners, who are more akin to hobbyists than professionals, are more likely to adopt a loose-housing system. These farmers may be interested in making their farm management more efficient through the adoption of such systems. Conversely, the large number of full-time farmers in the sample introduces variability, making it harder to generalise the findings within this group.

Among the opinion variables, OPIN_AN_WEL is strongly significant and positively related to the dependent variable (coefficient = 0.187). Farmers who firmly believe that loose housing positively influences the welfare of their herds are more likely to implement this system. This finding aligns with a qualitative analysis of Canadian farmers by Croyle *et al.* (2019), who found that farmers perceived an ethical duty to uphold high animal welfare standards, driven by 'pride' and a sense of 'self-responsibility of care'. There were similar sentiments in a previous study conducted in the United Kingdom (Leach *et al.*, 2010). Additionally, EFSA (2023) experts have recommended that cattle should not be continuously housed in tie-stalls. Although tie-stalls are still permitted in Italy, there is ongoing debate within the European Union regarding the legitimacy of this practice. Thus, the positive sign of the OPIN_AN_WEL coefficient reflects farmers' sensitivity to these issues, which is also supported by the emphasis on FAW actions in the new CAP for 2023-2027.

While some of the respondents believe that milk quality improves in a loose-housing system, those who hold this opinion do not necessarily adopt the technology (OPIN_QUA: coefficient = -0.039). This suggests that factors other than product quality, such as the need for subsidies and financial considerations, are more critical in the decision to adopt a different housing system.

We found that OPIN_CAL (coefficient = -0.046) and OPIN_TIME (coefficient = -0.051) are negatively related to the dependent variable, indicating that farmers who believe a loose-housing system allows for better detection of animals in oestrus and saves time compared with tie-stalls do not necessarily choose to adopt loose housing. This result suggests that the ability to recognise cows in oestrus is not a crucial factor in deciding to adopt loose housing, possibly because farmers can already identify oestrus in animals using tie-stall systems. Similarly, the time-saving aspect is not seen as a priority in adopting the technology. Our results indicate that other factors, such as management effort (OPIN_MAN), play a more significant role in the decision to adopt loose housing. The negative relationship between the dependent variable and OPIN_MAN (Table 3) indicates that farmers perceive a loose-housing system as requiring more management effort than tie-stalls, leading them to avoid this option to prevent increased workload.

Farmers who believe the upfront costs of implementing a loose-housing system are too high are less likely to adopt this system (OPIN_COST: coefficient = -0.061). The mean OPIN_COST score (7.87) is among the highest in Table 3, highlighting that economic constraints are a major barrier to adopting loose housing in our sample. The importance of economic viability has also been emphasised by Hansen *et al.* (2022), who found that, regardless of herd size, it is often more financially advantageous to continue using an upgraded tie-stall system rather than investing in a new loose-housing system. This is particularly true for farms with fewer than 30 cows, where investing in a new loose-housing system is typically not profitable.

The OPIN_SUBS result further underscores the economic aspect. With a mean score of 8.19 (Table 3), the highest among the explanatory variables, there is a strong level of agreement with the statement 'pursuing a loose-housing system requires subsidies' among the respondents. Thus, farmers who express a need for subsidies to support the investment in a loose-housing system are also more likely to adopt this technology (coefficient

= 0.061), probably due to their confidence in receiving public financial support for this type of agricultural investment.

5. CONCLUSIONS AND LIMITATIONS

We have assessed the factors that influence the continuation of tie-stall systems in Italian dairy farms, considering both socio-economic and ethical aspects. The findings provide the foundation for outlining several theoretical implications regarding the relationship between the adoption of a loose-housing system and farmers' specific characteristics and opinions.

Certain variables related to farmers' opinions about their inclination to adopt a loose-housing system are notably significant. Specifically, the economic aspect is crucial, both in terms of the initial capital required for investment and the costs associated with transitioning from a tie-stall to a loose-housing system. The perception of improved animal welfare is also important. This sensitivity to FAW, coupled with the request for subsidies to support farm transitions, should be considered within the framework of the next CAP. In this context, specific measures focused on FAW have already been implemented, particularly through the inclusion of eco-schemes, albeit on a voluntary basis. Moreover, the issue of a mandatory shift from a tie-stall to a loose-housing system is on the national political agenda in several European Union countries, such as Denmark, indicating that this is a trending topic.

Another critical factor that influences the decision to adopt a loose-housing system is related to the demographic characteristics of the sample. Women, in particular, tend to be more receptive and predisposed to adopt this technology, while older, more experienced farmers exhibit less inclination towards innovation. In this regard, policies should encourage young farmers to adopt new animal welfare management practices, especially considering the greater propensity of women working in agriculture towards these issues. The CAP can play a role in addressing this, with policy instruments related to rural development that provide dedicated funding for young individuals and women.

However, as some authors have argued (Hansen *et al.*, 2023), it is crucial to proceed with caution and to avoid imposing change. For small farms, particularly in mountainous regions, pushing for the adoption of a loose-housing system could potentially lead to the abandonment of agricultural activities due to geographic constraints and limited space, which may hinder the transition. In specific contexts, especially in rural and mountainous areas, it is essential to maintain the production of small farms to contribute to agricultural resilience and the generation of various ecosystem services. Nonetheless, recommendations from the EFSA (2023), such as providing daily opportunities for free movement, should be implemented to enhance the welfare of dairy cows kept in tie-stalls while preserving traditional farming practices.

The limitations of this study primarily relate to the sample, which is representative of farms located only in Northern Italy and may not necessarily reflect a broader situation. However, many of the conditions faced by the interviewed farmers are common to other European regions. Additionally, qualitative research can raise concerns about the reliability of participants. Even when the data are meticulously collected and analysed by skilled experts, the construction of the survey can influence the results. Moreover, to consider temporal dynamics on this topic, the study could be repeated for several years to reach a wide understanding on this issue. Another limitation is related to the fact that the present study did not include broader control variables, such as local policies, government incentives, or even market conditions, which could be collected in future studies with an improved questionnaire. Future research could also involve additional investigations with farmers on other animal welfare practices, a highly debated topic with many facets. There are various practices for improving animal welfare on dairy farms, such as extending contact between the cow and calf at birth or implementing extensive cattle farming, which is funded by the CAP for 2023-2027. There are different analytical models available to investigate barriers to innovation acceptance, and they could also be applied to the context of improving animal welfare practices in farming.

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Conceptualization, Methodology, Writing – Review & Editing, Supervision, C.M.; Data collection, Data curation, Writing – Original draft preparation, L.Z.; Data curation, Software, Validation, L.O.; Supervision, S.M.; Data collection, Funding Acquisition, Supervision, M.B.

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Research article

The contributions of Rural Districts to the Long-Term Vision for Rural Areas: the case of the Tuscany Region

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Abstract. The Long-Term Vision for Rural Areas (LTVRA) pointed out that rural areas require an appropriate form of governance to avoid fragmentation and ensure the integration of rural policies. Recently, Italian law stressed the importance of Food Districts (FDs), including Rural Districts (RDs), to cope with rural challenges. Under the network governance perspective, this article explores internal and external barriers and the contribution of RDs to the LTVRA in the Tuscany Region. Following a desk analysis, the findings provide an overview of the main interventions contributing to the ten goals set by the LTVRA through different paths. The case study exhibits the flexibility of RDs in terms of geographical areas, predominant specialisations, actors involved, and fields of action, which characterise a clear ambition to promote a network-based and inclusive approach to rural development. The article suggests further investigation into the development of monitoring frameworks capable of optimising the structure of RDs and decision-making processes, capitalising on the inclusive capability network governance models to account for the needs and development visions of local actors.

Keywords: network governance, Rural District, LTVRA, rural areas.
JEL codes: R58, Q10, Q18.

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HIGHLIGHTS

- Territorial and institutional fragmentation leads to the need for coordination with institutions and territorial actors in rural areas.
- Network governance is a framework for supporting the Rural Districts as an alternative form of governance contributing to the Long-Term Vision of Rural Areas.
- The article showcases the different processes and efforts of Rural Districts to make their actions effective in defining their structure, actions, and strategies.

1. INTRODUCTION

Rural areas are considered crucial for the European Union's transition towards an environmentally sustainable society and food security (Joint Research Centre, 2021). As recently pointed out by the European Commission (2024), given the multisectoral nature of the challenges and opportunities to be addressed in rural areas (European Network for Rural Areas [ENRA] 2022), there is a need to target these issues through locally adapted strategies (Ahlmeyer, Volgmann, 2023). Revitalising[1] European rural areas require effective governance to guide the transition, prevent fragmentation in investment and impact, and coordinate policy instruments and actors at different levels (EC, 2021; ENRA, 2022).

These considerations raise the question of what the best ways are to address them, in terms of appropriate level of territory, and effective policy instruments to ensure institutional, governance, and integrated support for rural areas to contribute to the Long-Term Vision for Rural Areas (LTVRA). The LTVRA, set out by the European Commission in 2021 (European Commission, 2021, 2024), represents a common strategy outlining the multidimensional nature of rural development, based on the considerations of two main drivers: demographic change and different governance patterns. Indeed, the strategy recognises that the success of rural development is not just a matter of European policies but requires cooperation with national, regional, and local governments using a place-based approach (Territorial Agenda, 2030). As stated by Morrison (2014), rural governance is changed due to economic and social factors, but also as a result of privatised resource rights and networked management approaches that require, besides the involvement of institutions on several levels, a strong engagement on the part of the private sector and civil society in contributing to multilevel mechanisms (OECD, 2020; EC, 2021) and alternative forms of governance.

In Italy, an example of this process is defined Food Districts (FDs). The role of districts in the agricultural sector has been recently re-emphasised by National Law No. 205/2017[2] and the renewed attention of academia to the concept of FDs (Toccaceli, Pacciani, 2024; Tarangioli, 2024; La Sala, 2024). Nationally, Milan EXPO 2015 and Agenda 2030 positioned FDs as a strategic tool for revitalising rural territories[3]. To account for existing initiatives and territorial specificities, FDs represent a new macro-category aimed at: i) promoting territorial development, cohesion, and social inclusion; ii) fostering the integration of proximity-based activities; iii) ensuring food safety; iv) reducing environmental impacts; v) minimising food waste; and vi) preserving rural landscapes through agricultural and agri-food activities.

Among the eight recognised types, a specific form of FD is the Rural District (RD), which is recognised in Article 499 (National Law No. 205/2017) "*as local production systems referred to in Article 36, paragraph 1, of the Law of 5 October 1991, n. 317, characterised by a homogeneous historical and territorial identity resulting from the integration of agricultural and other activities', as well as from the production of goods or services of a particular nature, consistent with the natural and territorial traditions and vocations*".

The concept of RDs emerged in the 1990s from rich theoretical debate and the pivotal experience of the "Rural District" in Maremma and the "Wine District" in Piedmont (Toccaceli, 2012, 2015). However, RDs were officially recognised through Legislative Decree No. 228/2001[4] together with the "Quality agri-food districts" for the interest in the territorial relocation of agricultural production and endogenous development dynamics (Brunori, Rossi, 2007). In this regard, the territory appears to be a fundamental element for the agri-food system but also for the general dynamics of rural development (Lamine *et al*., 2023).

The new law has maintained an explicit link – through the notion of local production systems – with the devices already provided for Industrial Districts through Law No. 317/1991 (Toccaceli, 2013). Unlike the "Quality agri-food districts", characterised by interrelations and productive interdependencies between agricultural and agri-food enterprises, the qualification of "rural" emphasises the role of the context in terms of landscape, social and cultural character, despecialisation of the local production system, and integration of a plurality of economic activities and different uses of the territory, grafted on a set of specificities of that same territory (Meloni, Farinella, 2013; Zecca *et al*., 2015). Therefore, the territory becomes the space of interaction between rural development (as the integrated development of rural areas) and multifunctionality. On this basis, the concept of RDs allows the promotion and organisation of a new *meso* level of governance that includes different actors and territories.

Given the nature and mission of RDs and based on Murdoch's (2000) definition of horizontal networks, RDs

[1] The term refers to the process of moving from a poor and declining situation to a better state of rural areas (European Network for Rural Areas, 2022).

[2] National Law No. 205/2017, "Bilancio di previsione dello Stato per l'anno finanziario 2018 e bilancio pluriennale per il triennio 2018-2020", Art. 499.

[3] Text available at https://www.masaf.gov.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/14159#:~:text=I%20Distretti%20del%20cibo%2C%20istituiti,dei%20territori%20nel%20loro%20complesso.

[4] Legislative Decree No. 228/2001, "Orientamento e modernizzazione del settore agricolo", available at https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2001-05-18;228.

can be described as a "*horizontal network that explicates their process through the integration of non-agricultural rural economies into a set of processes that span both rural and urban spaces*". This definition allows RDs to be included in the dynamics of the network governance perspective as regards the interaction between formal and informal actors and their capacity to implement actions. Therefore, it becomes crucial to understand which factors and areas of intervention RDs are pursuing, which processes and actions[5] are to be put in place by local actors to address their governance challenges, and finally whether RDs can contribute to the revitalisation of European rural areas according to the common goals of the LTVRA.

This study describes the changes in governance models and systematically analyses the initiatives implemented by RDs in the Tuscany Region to collect detailed information on the existing governance structures. Sections 3 and 4 describe the research methodologies applied and insights for the analysis of RDs in the Tuscany Region focusing on territory, the process of institutionalisation, and their potential contribution to the LTVRA. Finally, Sections 5 and 6 discuss the main findings and provide final considerations, respectively.

2. THEORETICAL BACKGROUND

2.1 From government to governance

In recent years, governments have become more dependent on societal actors to achieve their goals due to the increasing complexity of the challenges that they face. This suggests that no single actor has the knowledge, resources, and capabilities to govern alone due to the nature of contemporary society and societal problems (Kooiman, 1993; Ansell, Torfing, 2022). Within this process, the shift from government to governance has become central in analysing the changes in the role of the nation state as the sole authority (Broto, 2017) and the processes of governing (Stoker, 1998). In accounting for the different strands of literature (Ansell, Torfing, 2022), the concept of "governance" can be defined as the process of guiding society and the economy through collective action in accordance with common goals (Torfing *et al*., 2012) to solve societal problems (Klijn, 2008). It includes the process where civil society (Goodwin, 1998) and business are involved and collaborate in a "diffused power context" (Shucksmith, 2010), making the boundaries between public and private sectors blurred (Stoker, 1998).

[5] By the term "action" the paper means all the different initiatives (projects, partnerships, etc.) that RDs organise.

2.2 Governance and network governance

In considering the process of change in governance models (understood as markets or hierarchies) and its environment (Lewis, 2011), a rapid rise of distinct organisational forms identified in network governance is highlighted (Powell, 1990). This governance model is also called *societal governance* due to the effort to compensate the limits and failures of state and market regulations through the formation of formal and informal networks such as public-private partnerships, strategic alliances, dialogue groups, consultative committees, and interorganisational networks (Sørensen, Torfing, 2007). Network governance recognises that policies emerge from governing processes beyond government control, offering an alternative to hierarchies and markets (Sørensen, Torfing, 2005), and it relies on formal and informal institutions to allocate resources and coordinate joint actions across organisations, addressing the limitations of sectoral policies (Kapucu, Hu, 2020; Müller, 2024).

The flexibility of network governance allows it to be applied across various fields and policy areas, European neighbourhood policy (Lavenex, 2008), energy transition (Termeer, Dewulf, 2012), transit stations (Müller, 2024), incident command systems (Moynihan, 2009), disaster relief (Pheungpha *et al*., 2019), national parks (Kluvánková-Oravská, Chobotová, 2006), sustainability (Romão, Najberg, 2023), democracy levels (Navdeep, Skelcher, 2007), and rural-urban synergies (Ovaska *et al*., 2021). In rural development, network governance promotes local empowerment and cross-sectoral collaboration through flexible, trust-based partnerships between governments, businesses, and civil society, enabling rural communities to shape decision-making and develop context-specific solutions.

2.3 Forms of governance and network in rural areas

The need for alternative governance and integration in rural policies is long-standing (EC, 2001; OECD, 2006). More integrated approaches enable decentralised decision-making and partnerships, addressing the limitations of sectoral policies. Locally, rural governance has evolved into a multilevel system involving diverse agencies and institutions (Goodwin, 1998). Alongside decentralisation and territorial reforms (OECD, 2017), this fragmentation underscores the need for greater coordination to prevent sectorisation and strengthen ties with local, national, and international authorities. As pointed out by Del Giudice (2024), the endorsement of some entities such as Districts represents an opportunity for integrating economic sectors and development paths. Within these processes, network governance provides valid sup-

port in addressing the complexity of cross-scale interactions and relations between formal and informal actors.

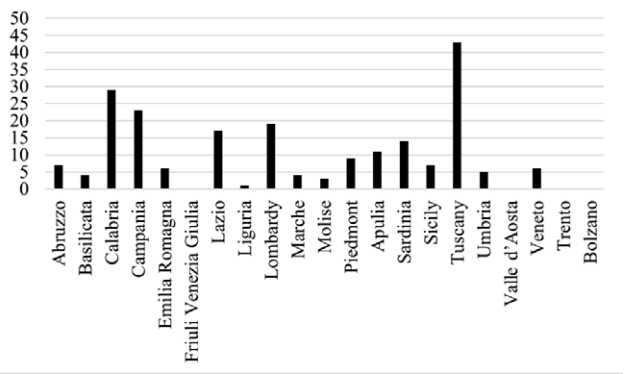
The focus on rural vitality is particularly evident in the LTVRA, which emphasizes the involvement of diverse actors, networks, and governance levels to foster collective action tailored to territory-specific needs (Tarangioli *et al*., 2024). As Pertoldi *et al*. (2022) highlight, regional and local players play a key role in linking their strategic efforts to broader policy agendas.

The current European vision is aligned with the concept of RDs. According to Berti et *al*. (2023), the concept emerged in the rural development, supported by the idea that a better territorial governance in rural areas can foster the design of development strategies based on: i) local resources, ii) integration between different dimensions of rurality, iii) the implementation of local actions, and iv) pushing the territory and local actors towards new forms of organisation.

2.4 Italian districts: a short overview of the legislation

The history of "Italian Districts" started with the introduction of the Industrial District by Law No. 317/1991[6], while in the field of agriculture, the district (Rural District and Quality Agri-food District) was recognised through Legislative Decree No. 228/2001 "*Orientamento e modernizzazione del settore agricolo*" with the aim of increasing the level of competitiveness of the primary sector in line with the Agenda 2000 reform of the Common Agricultural Policy (Toccaceli, 2013). Regions and Autonomous Provinces identified different typologies of district according to their territorial characteristics (especially for RDs) and production specialisation (Toccaceli, 2012). The same approach was also maintained in the new National Law. To cope with territorial challenges and to give new opportunities and resources to rural areas (Mazzocchi *et al*., 2021), the new National Law has recognised eight typologies of districts under the macro-definition of "Food Districts" (Art. 499 co. 2), namely Organic Districts, Rural Districts, Agri-food Districts, Districts with small and medium-sized enterprises, Interregional Districts, Urban and Peri-urban Districts, Proximity Districts, and "Sustainable Districts" (Fanfani *et al*., 2018). Moreover, it has assigned to the Regions and Autonomous Provinces the task of the identification and subsequent communication of FDs to the Ministry of Agriculture of Food Sovereignty and Forests (MASAF) where the National Register of FDs is established. Figure 1 shows the number of FDs (no. = 208) recognised at the national level as of 12/02/2024, with the Tuscany region as the first region for a number of FDs (no. = 43).

Figure 1. Number of Food Districts per Region/Autonomous province.



Source: Authors' elaboration based on National Register updated to 12/02/2024.

2.5 The Rural Districts in Tuscany

Tuscany has the highest number of RDs in Italy, totalling 12. In 2014, the Delrio Law (No. 56/2014) redefined the role of Provinces, altering the national and regional institutional framework. Under this new institutional setting, the Tuscany Region emphasised territorial self-organisation by revising Regional Law No. 21/2004, which assigned the role of organising and leading RDs to the Provinces, to better align with the socio-economic and normative context, thereby enhancing agricultural and rural opportunities (Regional Law No. 17/2017). Network governance helps highlight actions and connections among different actors, both formal and informal, to enable a better understanding of RD processes.

3. METHODS AND METHODOLOGIES

Based on the National Register of FDs[7], a desk analysis was developed on the specific case study of Tuscany RDs to identify the initiatives that can contribute to the rural development goals set by the LTVRA. We used a

[6] As described by Toccaceli (2013), the first definition of an industrial district offered by L. 317/1991 was modified with L. 140/1999, which, by introducing the notion of a Local Production System, paved the way for the extension of the district to different fields, such as rural, agri-food, and fisheries, as was already the case in those years with the extension of negotiated programming tools to agriculture and fisheries, services, and tourism. Similarly, as described by Toccaceli (2015), negotiated planning instruments were being used to cover these sectors.

[7] Available on the official website of MASAF (https://www.politicheagricole.it).

case study approach to capture and understand complex social phenomena and support to generalise findings (Yin, 2003). Indeed, the large number of Districts and RDs and the opportunity to recognise RDs on different territorial scales (no minimum territorial limits were set) made the Tuscany Region a compelling case in understanding the complex synergies between RDs and the LTVRA.

To identify and describe the dynamics of RDs in Tuscany, the official annual reports, available for each RD and for the years 2019, 2020, 2021, and 2022 in the regional database[8], were used. In addition, to integrate some information, annual RD reports were consulted in the period January–February 2024. According to Regional Regulation No. 14/2018[9], each RD must report annually on: (i) the actual participation of each member in the activities of the RD, (ii) a description of the activities carried out and the objectives achieved according to the Territorial Economic Plan (TEP), (iii) problems concerning the implementation of the TEP, and (iv) the updated action programme. The annual RD reports were preferred to the TEPs[10], since they represent the main operative tool for monitoring the concrete actions of the RDs.

Under the network governance perspective, in line with the structure of the annual reports, the analysis also included three elements: territory, actors, and synergies. Based on the annual reports, the territorial scale, the preliminary governance structure, and internal and external actors (e.g. universities and technical actors) are identified. Moreover, 55 RD initiatives, their levels of action, and funding sources are highlighted (Supplementary Material, Table A.1).

To identify the potential contribution of the RD initiatives to the LTVRA, the analysis involved examining annual reports, which were systematically classified into 15 main categories[11] to gain a deeper understanding of the content of each initiative. These categories were derived through an inductive and deductive path (Saldaña, 2013), taking into consideration both the themes and scopes of RD initiatives and the goals of the LTVRA. In the second stage of the research, each initiative was mapped against the ten shared goals of the LTVRA to explore their alignment and contribution, as Table 1 shows. In some cases, the same categories may be part of different goals of the LTVRA, while the initiatives refer to a predominant goal of the European strategy. Additionally, the material was also analysed to identify the limitations in the scope of action of the RDs and their strategies to address these challenges.

4. INSIGHTS FROM RURAL DISTRICTS IN TUSCANY

The initiatives implemented by the Tuscany RDs are influenced by the territory, the composition of the network of actors (e.g. local government bodies, community organisations, educational and research institutions, etc.), and the process of RD institutionalisation.

4.1 Heterogeneity of territorial scale

As a result of the autonomy that the Tuscany Region left to the territories in terms of self-organisation, RDs differ due to geographical areas and portions of territory involved in terms of numbers of Municipalities (Figure 2[12]). The territory of some RDs matches that of a single municipality (e.g. the RD of Montalcino-San Giovanni d'Asso), while for other districts it extends over large territories (e.g. the RD of Southern Tuscany).

This diversification generates territorial overlapping, enclaves, or proximity among RDs. For example, the RD of Southern Tuscany embeds the RD of Montalcino-San Giovanni d'Asso, vocationally specialised in wine production (Brunello di Montalcino) and therefore capable of implementing territorial development strategies independently from the surrounding territory[13]. In other cases, the territorial vocation allowed some territories to belong to multiple RDs. Examples include the Interprovincial Floriculture District of Lucca and Pistoia; the Rural Forestry District of the Pistoia Mountain, covering Uzzano, Pieve a Nievole, and Pescia; and the Vivaistic Ornamental Rural District of Pistoia, which includes the municipalities of Pistoia, Montale, and Serravalle P.se.

[8] Available at: https://www.regione.toscana.it/ricerca-atti#/searchAttiGiunta.

[9] "Regolamento di attuazione della legge regionale 5 aprile 2017, n. 17", Art. 6, "Contenuti necessari della relazione annuale".

[10] The Tuscany Region called the District Plan the "Territorial Economic Plan"; Art. 7 (RL No. 17/2017) establishes the main aim and elements.

[11] The categories identified below: (1) Cultural regeneration and tourism; (2) Knowledge exchange; (3) Landscape; (4) Territorial integration; (5) Governance; (6) Sustainability; (7) Natural resources management; (8) Research (territorial needs); (9) Networking; (10) Harmonization; (11) Food valorisation; (12) Organic production; (13) Supply chains; (14) Prevention (workplace); (15) Education.

[12] Rural District with high organic vocation of Fiesole (2019) was ended and recognised as an Organic District in 2021 with Decree No. 13483 by the Region.

[13] Camera di Commercio Maremma e Tirreno, "Istanza di riconoscimento del Distretto Rurale della Toscana del Sud", 2017. Available at https://www.lg.camcom.it/sites/default/files/media/5859_Progetto%202017-2022.pdf.

Table 1. RD initiatives classified by categories and LTVRA goals.

Initiatives	Categories	LTVRA goals
LIFE Subsed project	*Knowledge exchange*	
Exchange with Rural District of Val di Cecina	*Knowledge exchange, networking*	
"Pole for the economy of the mountain" in Campo Tizzoro	*Territorial integration*	
Joint proposal of contract with Rural Forestry District of Pistoia Mountain	*Territorial integration, sustainability*	Attractive spaces
Research project on GIAHS[1]	*Landscape*	
Proposal for "Vivaismo per un futuro sostenibile"	*Sustainability*	
"Piccoli Borghi storici"	*Cultural regeneration and tourism*	
Networking with Vivaistic Ornamental District of Pistoia	*Networking*	
Action for consistency of administrative acts	*Harmonization*	
Joint proposal of contract of District with ornamental nursery of Pistoia for overlap and territorial contiguity	*Territorial integration*	Engagement in multilevel governance
Interest in Forest calls and SNAI[2]	*Natural resources management*	
"A tavola con i prodotti della Val di Cecina" project	*Food valorisation*	
"Regional Food Roundtable of Tuscany"	*Food valorisation*	
"Competence Centre of Traditional Agri-Food Products"	*Food valorisation*	
Path of realization of the brand "Eccellenze di Montalcino"	*Food valorisation*	
Virtual experiential path through "Patto territoriale Interregionale VATO"	*Food valorisation*	
Promotion of events and festivals on food	*Food valorisation*	
Memorandum of understanding to promote organic production	*Organic production*	
Interest in calls like MASAF (District contract), Region (IDP and ICP[3])	*Supply chains*	
Proposal submitted for IDP 2019 Southern Tuscany	*Territorial integration*	Provision of food security
District Contract Agreement Southern Tuscany	*Territorial integration*	
Participation in a study on the role of RD and food as subjects capable of organising the demand for investment and use of public resources	*Territorial integration*	
Proposal submitted for IDP 2019 "Vino e territorio"	*Territorial integration*	
Proposal submitted for IDP 2019 "M.A.W. (Montalcino: Also, of Wine)"	*Territorial integration*	
Support activities for the enhancement of local livestock	*Supply chains*	
Memorandum of understanding for collective catering	*Supply chains*	
"E-food community" project	*Supply chains*	
Interest in supply chain and district contracts (IDP and ICP)	*Supply chains*	
"ProValCecina" project	*Supply chains*	
Mercatale's and Mercatale Figline Valdarno renovation	*Supply chains*	
"Le Terre PIsano LIvornesi, un territorio da assaporare lentamente"	*Supply chains*	
District as "technical" (prevention) through activities	*Prevention (workplace)*	Dynamic communities and well-being
"Conosciamoci meglio: il vivaismo pistoiese per il benessere dei cittadini, spiegato ai giovani" initiative	*(Nursery) education*	
Contratto di Fiume	*Natural resources management*	
"Green Community Lunigiana"	*Natural resources management*	
Table for integrated design (agro-irrigation system) and experimentation activities for wastewater reuse	*Natural resources management*	
IBIS project	*Sustainability*	
Various collaborations with research centre	*Sustainability*	Flourishing sources of nature
Project "Actions in support of the Circular Economy"	*Sustainability*	

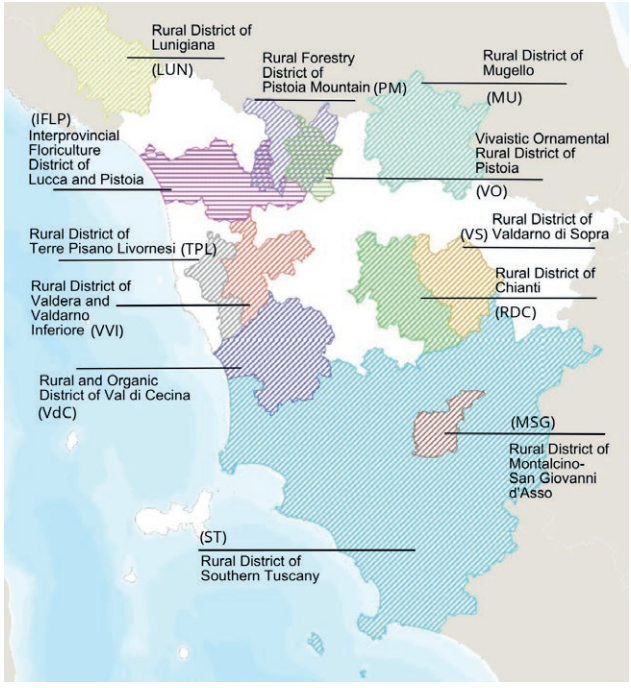
(Continued)

Table 1. (Continued).

Initiatives	Categories	LTVRA goals
Cycle of meetings to analyse European objectives and future strategies	*Knowledge exchange, networking*	
"HUB for the marketing of flowers and plants grown within the district according to compatible methods"	*Sustainability, supply chain*	
"Vivaismo per un futuro sostenibile"	*Sustainability*	
Protocol of understanding for the introduction of good practices in nursery cultivation	*Sustainability, education*	
Initiative to create a "self-control laboratory"	*Sustainability, prevention*	
Survey on the Digital Divide and analysis of the territory	*Research (territorial needs)*	Benefiting from digital innovation
Project for the Citadel of the training of agri-food Partnerships	*(Agri-food) Education* *Knowledge exchange, networking*	Entrepreneurial and innovative people
Meetings with other subjects by setting up an RD in Bolzano	*Knowledge exchange, networking*	
GRANULAR[4] project	*Governance*	Places equipped with services

Notes: To avoid repeating the same initiatives promoted by various RDs, only 49 are listed here.
The goals "*Inclusive Communities*" and "*Places of diversity*" are not included since no initiatives were implemented by the RDs.
Source: Authors' elaboration from Rural Districts Annual Reports and the LTVRA
[1] Globally Important Agricultural Heritage Systems.
[2] National Strategy for Inner Areas.
[3] Respectively Integrated District Projects and Integrated Contract Projects (supply chain).
[4] Giving Rural Actors Novel data and re-Useable tools to Lead public Action in Rural areas, hereinafter GRANULAR.

Figure 2. Rural Districts in Tuscany.



Source: Tuscany Region (accessed in February 2024).

4.2 Composition and process of institutionalisation

Depending on the territorial characteristics and the respective TEPs[14], RDs define integrated territorial strategies pursuing socio-economic development and resources valorisation consistent with the protection of the environment, landscape, historical-cultural traditions, and agricultural policies in the territory. The scope and the effectiveness – the ability to generate tangible impacts on the territory – of the RD strategies and actions are mainly influenced by the composition of the members, the skills and influence of RD actors (e.g. expertise, network, and technical expertise), and governance structures (Table 2). In this regard, the compositions of the actors of Tuscany RDs in terms of the presence of local government bodies, a community organisation, a Local Action Group (LAG), and other district typologies exhibit substantial differences, starting from the District's leaders (*soggetto referente*). Indeed, District leaders, who, according to Art. 6 (Law No. 17/2017), must prepare and implement the TEP, and organise and report on the district's activities, encompass

[14] As stated by RL No. 17/2017, the TEP is "the instrument by which the district defines the integrated territorial strategies. The project pursues objectives of socio-economic development and valorisation of local resources consistent with the protection of the environment, the landscape, the historical and cultural tradition and with the agricultural policies operating in the territory".

ad hoc created associations (four cases), public authorities (four cases), LAGs (two cases), and private entities (two cases) (Table 2). This echoes the regional choice of granting full freedom of typologies and legal form to RD leaders, even if it can affect the possibility of accessing funding opportunities. Moreover, among the RD members, the most represented actors are Municipalities and Municipality unions, LAGs, consortia, Food Districts and Organic Districts, and agri-food and farmers' associations. Four RDs consider crucial the presence of scientific committees, advisory boards, universities, and specific working groups to support the leaders in the planning and management of the initiatives, and for fundraising activities.

The activities of RDs have mostly focused on: i) the integration of the TEP, ii) direct actors' participation and

Table 2. Rural District structures.

Tuscany RDs	Leader (referent)	Members	Governance	Technical and scientific support
Rural and Organic District of Val di Cecina (VdC)	Association of Rural and Organic District of Val di Cecina	Municipalities, Unions of Municipalities, agricultural associations, private entities, LAG	Assembly, President, Board of directors, Supervisory board	-
Rural District of Southern Tuscany (ST)	Chamber of Commerce Maremma and Tirreno	Municipalities, Unions of Municipalities, agricultural associations, private entities, LAG, Food District	Assembly	Internal working group to support the activity of the District and Fondazione del Polo Universitario Grossetano with technical assistance
Rural District of Chianti (RDC)	Ad hoc Association established	Municipalities, private entities	Assembly, Board of directors	-
Interprovincial floriculture district of Lucca and Pistoia (IFLP)	Interprovincial floriculture association	Municipalities, private entities	Assembly, Steering committee	Scientific Committee as an Advisory Body of the Steering Committee
Rural District of Montalcino-San Giovanni d'Asso (MSG)	Foundation of Brunello Montalcino	Municipality,private entities	Assembly	-
Rural District of Valdarno di Sopra (VS)	Bucine Municipality	Municipalities	Assembly, Board of Directors (public and private actors), Assembly	Technical Committee, Scientific Committee (presence of University of Florence), mixed public-private working groups
Rural District of Lunigiana(LUN)	Union of Municipalities Montana Lunigiana	Municipalities, Unions of Municipalities, agricultural associations, private entities, LAG	Assembly, Supporting group for the Referent subject, Operational secretariat	-
Rural Forestry District of the Pistoia Mountain (PM)	LAG Montagnappennino	Municipalities, LAG	Assembly	-
Vivaistic Ornamental Rural District of Pistoia (VO)	Association of Vivaisti Italiani	Municipalities, Unions of Municipalities, agricultural associations, private entities	Assembly, Committee, Secretariat	Working groups
Rural District of Mugello (MU)	LAG Start srl	Municipalities, LAG	Assembly	-
Rural District of Valdera and Valdarno Inferiore (VVI)	Union of Municipalities Valdera	Municipalities, Unions of Municipalities, agricultural associations, Organic District	Assembly	-
Rural District of Terre Pisano Livornesi (TPL)	Association of Rural District of Terre Pisano Livornesi	Municipalities, agricultural associations	Assembly	-

Source: Authors' elaboration from Annual Reports and Regional Law.

awareness-raising actions in the territory, and iii) the structuring of a formal dialogue process with regional authorities. These three main actions allow RDs to better identify challenges, set priorities, distinguish strategies to achieve them, and start the institutionalisation process.

In this regard, the Tuscany Region not only recognises, controls, and funds RDs but also supports their activities through the Regional Table of Rural Districts. This platform gathers needs, serves as an interlocutor with MASAF and the State-Regions Conference, and provides a networking space for RDs. Additionally, the Tuscany Region facilitates RD participation in regional initiatives to promote food valorisation through the Competence Centre of Traditional Agri-Food Products. Another key external actor is the National Council of Food Districts, established in 2021 at MASAF with the objectives of: (i) addressing local challenges and optimising resource management, (ii) connecting with institutions and economic and social bodies to call for laws and funding, (iii) fostering synergies with academia, and (iv) promoting sustainable territorial growth (La Sala *et al*., 2023). Finally, MASAF plays a crucial role by allocating financial resources to Food Districts through instruments such as "*District Contracts*" and "*Integrated District Plans*".

4.3 Characteristics of initiatives

Most of the identified initiatives are aimed at improving the capacity to identify and mobilise economic resources and promote partnerships and networking activities. For initiatives targeting the involvement, or awareness raising, of local actors (public, private, and civil society) in RD activities, the most frequently used tools are specific collaborations, territorial actions (*Contratto di Fiume*), regional actions (Regional Food Roundtable of Tuscany), or the "*Memorandum of understandings*", usually with Municipalities and other public authorities (e.g. Municipalities' unions). Frequently, RD interests and project proposals are associated with specific funding schemes at the regional (e.g. Rural Development Plan [RDP] or Development and Cohesion Fund [DCF]) and national levels (e.g. National Recovery and Resilience Plan [NRRP], *District Contract Agreement* or *Integrated District Projects*).

RD initiatives cover different topics ranging from (short) supply chain, food and landscape valorisation, encompassing the promotion of organic production, and sustainable resources management to actions on cultural regeneration, tourism, and governance. Also, education (agri-food or nursery), networking and knowledge exchange, (research on) territorial needs, (administrative) harmonisation and prevention (on workplace) are involved in RD activities. The RD actions related to (short) supply chains include supporting actions for the valorisation and promotion of local food products in collective catering (e.g. RD of Val di Cecina), or the renovation of market areas such as in the case of Mercatale (e.g. RD of Valdarno di Sopra). Cultural regeneration and tourism activities are mostly arranged around the "*Piccoli borghi storici*" initiative (NRRP, M1C3 – Investment 2.1 "*Attractiveness of villages*") based on an integrated local project to improve the attractiveness of the "*borghi*". Moreover, sustainable resources management activities are often promoted through integrated territorial planning instruments such as the "*Contratto di Fiume*", which targets the sustainable management of water resources and the reduction of hydrological risks. Several collaborations within a single RD, between RDs, and with external actors are established to optimise RD activities on local, district, interdistrict, regional, interregional, European, and international scales. These collaborations are more structured among RDs that are geographically close and that share the same challenges (e.g. RD of Pistoia Mountain and the Interprovincial Floriculture District of Lucca and Pistoia). In other cases, cooperation became a mandatory strategy to access financial resources (e.g. the RD of Southern Tuscany and the RD of Montalcino-San Giovanni d'Asso). An example of these collaborations is the "E-food community" project, promoted by three different RDs (the RDs of Val di Cecina, Lunigiana[15], and Terre Pisano Livornesi), the Wine Street of Colline Pisane, and the Food Community of Crinale, with the aim of creating an agri-food marketing digital platform to connect local producers from different districts to new markets across the whole Region.

This heterogeneous situation allowed local communities (e.g. municipalities, local institutions, enterprises, associations, etc.) to design different pathways of actions – elaborated in the TEPs – capitalising on potentialities and overcoming barriers to ensure actions that contribute to the LTVRA. Table 3 shows that almost all RDs focused their initiatives on four goals of the LTVRA, namely "*attractive spaces*", "*engagement in multilevel governance*", "*provision of food security*", and "*flourishing of nature*", while the remaining categories of the LTVRA are partially or not covered in the RD actions.

RDs contribute to the objectives of the LTVRA through the implementation of various initiatives covering a wide range of objectives in different fields (e.g. from supply chain and food valorisation to water management and cultural regeneration) and territorial levels and involving various local and external actors. Detailed

[15] Also, in this case, the report (2022) highlighted the problem of identifying firms available to create the "business network" (Rete d'impresa).

Table 3. RD contribution to the LTVRA goals.

RDs	Attractive spaces	Engagement in multilevel governance	Provision of food security	Dynamic communities and well-being	Flourishing sources of nature	Benefiting from digital innovation	Entrepreneurial and innovative people	Places equipped with services
VdC	x		x		x			x
ST	x		x				x	
RDC			x			x		
IFLP	x	x			x			
MSG			x				x	
VS	x	x	x					
LUN	x		x		x			
PM	x	x			x			
VO	x	x		x	x			
MU			x		x			
TPL			x					

Notes: No RD initiatives have been recorded for the LTVRA goals "*Place for diversities*" and "*Inclusive communities*". The Rural District of Valdera and Valdarno Inferiore (VVI) is not included since it was formed in 2023.
Source: Authors' elaboration from Rural Districts Annual Reports and the LTVRA.

information on the initiatives and the actors are provided in Table A1 as supplementary material.

To achieve RDs' objectives, the capacity of each territory to design and enforce actions and synergies for the development of the territory beyond specific sectors needs to be considered. This capacity characterizes the RD of Montalcino-San Giovanni d'Asso, which promotes various actions aimed at the valorisation of food products (e.g. truffles, oil, honey, pecorino cheese, saffron, and wheat) through the new brand *Eccellenze di Montalcino*, and of the entire territory through, for example, the IDP project M.A.W. Montalcino. In addition, this RD is promoting an educational project in the agri-food sector (*Cittadella di formazione per l'Agri-food* in San Giovanni d'Asso) and several town twinning projects both at the European and international level.

Moreover, the analysis reveals the intention of RDs to connect their activities with other territorial development strategies, such as the National Strategy for Inner Areas (e.g. RD of Pistoia Mountain), and the need to align them with environmental protection interventions, as in the IDP proposal "*Vivaismo per un future sostenibile*", focusing on the introduction of good practices to reduce the use of glyphosate, enforced by the Vivaistic Ornamental RD of Pistoia.

5. DISCUSSION

The analysis captures the territorial heterogeneity, institutionalisation process, and key initiatives of RDs in Tuscany. As part of FDs, RDs promote multilevel, place-based governance by fostering integrated development strategies. Addressing local needs through multiscale actions, RDs serve as a platform for: developing flexible and inclusive network governance models for sustainable resources management, enhancing integration along the (short) supply chain, guaranteeing attractive spaces, and improving access to public and private services. RD initiatives are aligned with LTVRA objectives, supporting food security, rural attractiveness, multilevel governance, natural resources valorisation, innovations, and rural well-being.

Territorial diversity results in overlapping, enclaves, or proximity among RDs, reflecting Tuscany's self-organisation vitality. This heterogeneity spans production, history, society, and culture but does not hinder collective actions linked to the need to strengthen networks for collaborative funding (e.g. the case of the E-Food Community project), create territorial synergies (e.g. the Vivaistic Ornamental RD of Pistoia and the Interprovincial Floriculture District of Lucca and Pistoia), and integrate broader development strategies (e.g. the RD of Pistoia Mountain). Additionally, RDs must structure internal governance models by regional law, sometimes involving technical and scientific actors in the implementation of their activities. At the same time, a broader process of institutionalisation and governance needed to address the barriers and needs that RDs and FDs may face has been outlined at the regional and national level.

In this context, RDs encounter several internal and external barriers that could impact the development of their networks, activities, and network governance per-

spective. These are mainly represented by the difficulties in finding the necessary financial resources for the start-up phase and thus promote a network-based governance model, which requires the engagement of different actors. Examples of internal limitations are represented by the lack of interest of actors – especially private companies – in participating in planned initiatives (e.g. in the RD of Southern Tuscany), or internal governance arrangements that can delay the District actions (e.g. Rural Forestry District of the Pistoia Mountain). This highlights the importance of the members, especially the capacity of the *Soggetto referente* to organise the internal action, including the need for technical support, involve stakeholders, and establish external relations.

Additionally, acquiring financial resources for the preliminary design and initiation of actions is also recognised as a significant hurdle. The main sources of financial support that RDs use are represented by "*Integrated District Projects*" (IDP) and, at the regional level, "*Measure 16.4*" of the RDP. At the national level, instruments borrowed from "*Supply Chain Agreements*" and "*Integrated Supply Chain Plans*" – "*District Contracts*" and "*Integrated District Plans*" – are established to align agricultural and rural development in a traditional set of sectorial policy tools[16] (Toccaceli, Pacciani, 2024). Limited access to funds can be mitigated, as stated by Hertting and Vedung (2012), through the support of Regions, the National Council of Food Districts, and MASAF. Moreover, the participation in projects under other European funding schemes such as Horizon Europe (e.g. the RD of Val di Cecina's participation in the GRANULAR project) represents a potential solution to overcome these barriers, and a useful means to engage local actors and reinforce collaborations with academia and research institutions.

Finally, the screening of the main activities promoted by RDs in Tuscany made it possible to outline some trends in relation to the ten goals of the LTVRA and revealed the heterogeneity of RDs, in terms of geographical areas and the predominant specialisation, but also the typology of actors involved and fields of action. These factors reveal the high degree of flexibility of the RD model to accommodate the complexity of local actors' (public, private, and non-profit entities) needs and visions, and thus facilitate an approach to resource management and territorial (rural) development based on networks and inclusive governance models. However, not all RD initiatives cover the full range of objectives, especially those related to the management of resources, an integrated strategy (e.g. "*attractive spaces*" *and* "*engagement in multilevel governance*"), and social innovation aspects (e.g. "*inclusive communities*" and "*place of diversity*"), with the exception of the "*entrepreneurial*" dimension. Despite this apparent limitation, it seems encouraging that RDs are active on issues aimed at revitalising rural areas. This aspect could support future discussions and stimulate reflection within the recent debate on the role of social innovation in rural areas (Bock, 2016; Del Giudice, 2024) and their governance (Georgios, Barraí, 2023).

6. CONCLUSIONS

The LTVRA outlines the European ambition for a multidimensional nature of rural development (EC, 2021). The success of this vision requires cooperation at all different governance levels and implies the involvement of different actors in order to overcome the "New Rural Paradigm" in favour of "Rural Well-being: Geography of Opportunities" (OECD, 2020). This ambition requires coherent and effective policies developed according to place-based and territorial cooperation approaches (Territorial Agenda, 2030). FDs are one of the main approaches identified in Italy to cope with the need for integration and territorial cooperation.

Through the analysis of annual reports, this article showcases the characteristics in terms of territory, actors, and initiatives of RDs in Tuscany. Based on the premise that this analysis is not exhaustive, due to the limited content available in the annual reports and the recent recognition of the RDs, this study represents a starting point for further investigating the governance arrangement models capable of supporting effective place-based and participatory approaches to rural development in line with the strategic ambitions of the LTVRA. In this regard, a robust network governance approach can contribute to consolidating relationships both within and outside the RDs, strengthening the ties among agricultural enterprises, institutions, associations, and other actors operating in different sectors, and aligning distinct visions and initiatives in different fields.

Beyond the annual reports, it is valuable to assess the processes and impacts of RDs, accounting for their contribution to the development of the rural territory and the integration of economic and territorial policies.

[16] The National Law 2002 No. 289, Art. 66 co. 1, establishes the Supply chain and District Contracts, and the subsequent implementation and changes led to the Decree of 22 December 2021 published in General Series No. 61/2022 (available at the following link) with the definition of criteria and procedures for the implementation of supply chain contracts provided for by the supplementary fund to the NRRP (Mission no. 2 Green revolution and ecological transition, component 2.1, Sustainable agriculture and circular economy) and subsequent call for Bando IV and V (for further info check https://www.masaf.gov.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/17917).

Further research is necessary to better design RD activity monitoring and evaluating tools – for example, by reshaping and applying the four indicators proposed by Morrison (2014) in the context of regional governance and accounting for the contextual factors reproposed by Wegner and Verschoore (2022) – but also to understand whether RDs can be an effective reference point for the development of the territory.

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AUTHOR CONTRIBUTIONS

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Review article

The role and challenges of women in agriculture: a bibliometric review

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Abstract. This paper presents a bibliometric analysis of women's role in agriculture from a global perspective, with a particular focus on the Global South, emphasising the challenges women face. It identifies key research trends and thematic developments by analysing 3,304 records from the Web of Science database from 1991 to 2024 with the Biblioshiny app and the VOSviewer software. The findings reveal a notable increase in publications between 2022 and 2023, particularly in the *Journal of Rural Studies* and *World Development*. Influential authors, such as C. Leukefeld, R. Meinzen-Dick, and A. Quisumbing, are identified based on citation metrics (H-index and G-index). In the last decade, researchers from India and China have notably increased their focus in this field. Thematic mapping highlights core areas, including food security, rural development, and women's empowerment, with emerging topics such as gender equity, climate change resilience, and agricultural productivity. The co-occurrence keyword network analysis underscores an intense research focus on women's empowerment, particularly in the Global South. Additionally, analysis of the 50 most cited studies in the field reveals that regression analysis is the predominant research method used to explore complex relationships between variables, especially in the context of women's empowerment and food security.

Keywords: women, agriculture, Global South, co-occurrence analysis, Thematic Map.
JEL codes: C89, J16, Q10.

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HIGHLIGHTS

- The analysis underscores growing research on women's role in agriculture, highlighting barriers such as limited access to resources, land ownership, and decision-making power.
- A stronger focus on women's empowerment, food security, and climate change emphasises the need to address gender inequalities in agriculture.
- Overcoming barriers faced by women in agriculture is important for enhancing livelihoods, promoting food security, and advancing sustainable development.

1. INTRODUCTION

Agriculture is important in sustaining the global population. Nearly 45% of the world's population, or 3.1 billion people, live in rural areas, and approximately 2.5 billion people rely on agriculture for their livelihoods. Women, who constitute a significant portion of rural dwellers, make up 43% of the agricultural workforce in the Global South, contributing substantially to food security, particularly in regions such as sub-Saharan Africa (Food and Agriculture Organization of the United Nations [FAO], 2012). Despite being vital resources in agriculture and the rural economy, statistics indicate that less than 15% of all landholders are women; they typically hold smaller shares of total land, are less likely to possess legal documentation proving ownership than men, and own fewer agricultural assets (FAO, 2024). Empowerment of rural women is essential for achieving the Sustainable Development Goals (SDGs), particularly in areas such as gender equality and poverty reduction (Pérez-Escamilla, 2017).

In the Global North, women's participation in agriculture has steadily increased, with policy reforms contributing to greater gender inclusion. By 2016, women managed approximately 30% of farms in the European Union, with even higher representation in Eastern European countries. Similarly, women account for 28% of farmers in Canada and comprise 32% of the agricultural workforce in Australia (European Commission, 2019; FAO, 2024; Statistics Canada, 2025). Despite these advancements, gender disparities persist, particularly in wages, career opportunities, and cultural norms that limit women's full participation in farming (Fisher *et al*., 2022).

According to Timu and Kramer (2023), women worldwide face social, institutional, and economic constraints that exacerbate their vulnerability to climate-related production or income shocks. The existing literature also highlights that women control fewer productive assets (Doss *et al*., 2020), have fewer opportunities, and perform more unpaid domestic work (Dinkelman and Ngai, 2022).

The role of women in agriculture varies depending on a country's stage of economic development. In developed nations, most tasks are performed by men. In contrast, in developing countries, women often handle tasks that involve less physical labour alongside their primary homemaker roles. Although women may not engage in heavy physical work, they typically work longer hours and manage more tasks than men. Japan is an exception, as women also operate mechanised agricultural equipment there. In India, agricultural modernisation has had mixed effects on women. Approximately 74% of the female workforce in India is engaged in agriculture, but their roles and levels of participation differ significantly across regions. Additionally, while male farm workers enjoy more free time during the off-season, women continue to work during these periods (Satyavathi *et al*., 2010).

Boserup (1970) suggests that gender disparities in roles originated in pre-industrial times and became entrenched social norms. In the agricultural sector, activities such as ploughing have led to significant gender gaps in the labour market. Societies with plough agriculture and a gender-based division of labour have reinforced the idea that women's natural place is in the home. These cultural beliefs persist even as economies transition from agriculture, affecting women's participation in market employment, entrepreneurship, and political engagement (Nunn, 2012).

In many communities, farming is regarded as the responsibility of men, while women are primarily expected to focus on household duties such as childcare and livestock management. Men are often perceived as more knowledgeable and capable of adopting new agricultural technologies. In contrast, women's roles tend to be confined to less labour-intensive tasks such as seed distribution and weeding. Technologies that require more excellent land or financial investment, such as irrigation systems or cereal farming, are typically deemed unsuitable for women, who are more frequently assigned tasks within the homestead. Furthermore, cultural restrictions on women's mobility hinder their ability to attend agricultural training or meetings, limiting their participation in agricultural activities (Choudhry *et al*., 2019).

Despite continuous institutional efforts to support women in agriculture, gender disparities persist, underscoring the need for sustained research and targeted interventions. This study provides a comprehensive bibliometric analysis of global research on the role of women in agriculture, identifying key trends and emerging topics that influence the discourse in this field. It includes four research questions:

- Research Question 1: Which authors, journals, and geographic areas dominate the literature on the role of women in agriculture?
- Research Question 2: What are the primary topics investigated in the literature concerning the role of women in agriculture?
- Research Question 3: How has the literature on women's role in agriculture evolved?
- Research Question 4: What are the predominant research methods used to assess the status of women in agriculture in the most cited documents?

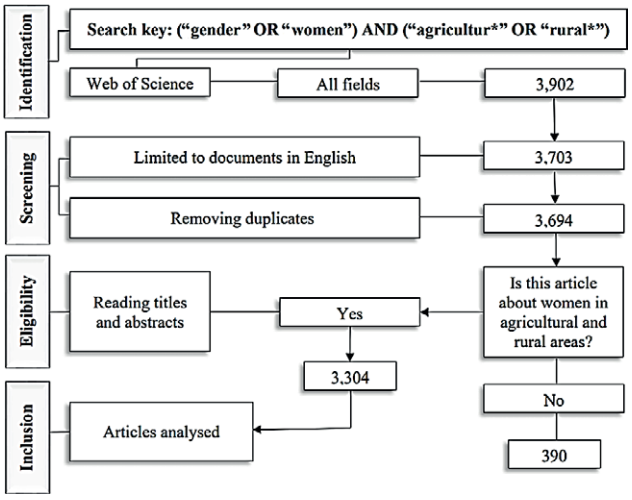
The rest of this paper is structured as follows: Section 2 delineates the data and methodology employed in our

study. Then, Section 3 presents the analysis. Finally, Section 4 summarises the findings and concludes the paper.

2. MATERIALS AND METHODS

This study systematically reviewed the global academic literature on the roles and challenges faced by women in agriculture. The earliest identified research dates back to 1991, so the analysis covers the period from 1991 to 2024. Data for this study was sourced from the Web of Science database. The search criteria included articles with the keywords ("gender" OR "women") AND ("agricultur*" OR "rural*"). The asterisk (*) serves as a truncation symbol, capturing all variations of words beginning with "agriculture*" (e.g. "agriculture", "agricultural research") and "rural" (e.g. "rural areas"). A comprehensive search conducted on 2 September 2024 identified 3,902 relevant documents on the research topic worldwide, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach illustrated in Figure 1.

Figure 1. The PRISMA flow chart.



Source: Prepared by author. Data compiled from the Web of Science database.

The PRISMA guidelines were followed, in accordance with the Guidelines for Systematic Reviews and Meta-Analyses (Hutton *et al*., 2016; Page *et al*., 2021). The PRISMA approach comprises four stages – identification, screening, eligibility, and inclusion – to ensure the reliability of the data.

The raw data underwent bibliometric analysis using the "Analyse Results" tool within the Web of Science platform. Further, the frequency analysis was employed to examine the distribution of the top 10 authors' keywords, track the cumulative growth in the number of publications, and assess annual scientific production.

This study used the Biblioshiny app, supported by the Bibliometrix package in R Studio, to identify future research pathways and to map potential author collaborations. The Bibliometrix package offers extensive tools for bibliometric analysis, enabling comprehensive science mapping of scientific literature (Aria and Cuccurullo, 2017).

Co-occurrence network analysis was conducted using the VOSviewer software (Van Eck and Waltman, 2010), which provides various types of visualisations. Network and overlay visualisations were utilised for this study. Network analysis was performed to examine keyword co-occurrence, while overlay analysis was used to illustrate the evolution of the research focus based on the frequency of keywords in recent studies.

VOSviewer and Bibliometrix rely on a similarity matrix for visualisations and map construction. Both tools use association strength, a proximity index, to measure similarity. This matrix is derived from a co-occurrence matrix through normalisation, adjusting for occurrence variations (Van Eck and Waltman, 2007; Aria and Cuccurullo, 2017). It quantifies how often two keywords or authors appear together and accounts for their co-occurrence probability under independent assumptions. This method helps identify keyword patterns, author collaborations, and future research directions.

The similarity s_{ij} between two items i and j based on the association strength is given by the following general equation:

$$s_{ij} = \frac{c_{ij}}{w_i w_j} \quad (1)$$

where c_{ij} represents the number of co-occurrences of items (keywords or authors) *i* and *j*, and w_i and w_j denote the total number of occurrences of items *i* and *j*, respectively, or the total number of co-occurrences of these items.

A mapping technique is provided based on the similarity matrix. Let n denote the total number of items (keywords or authors) that should be mapped. The result of the mapping technique is a two-dimensional map, in which all items ranging from 1,...,*n* are located on this map reflecting the similarity between two items *i* and *j*. The VOS mapping technique aims to minimise a weighted sum of squared Euclidean distances between all item pairs, with the weight of their squared distance increasing based on their similarity. The minimised function is

given by the general equation 2, while the minimisation is provided under the constraint represented by equation 3 (Van Eck and Waltman, 2010).

$$V(x_1, \ldots, x_n) = \sum_{i<j} s_{ij} \|x_i - x_j\|^2 \quad (2)$$

where the vector xi = (x_{i1}, x_{i2}) represents the location of the item i in a two-dimensional map and ||•|| denotes the Euclidean norm.

$$\frac{2}{n(n-1)} \sum_{i<j} \|x_i - x_j\| = 1 \quad (3)$$

The software positions similar items (keywords or authors) closer together while placing less similar ones farther apart. This arrangement reflects the strength of relationships, with more frequent co-occurrences given greater weight. By minimising the Euclidean distance based on co-occurrence frequency, the mapping technique visually represents relationship structures, providing insight into author collaborations and the evolution of research topics over time.

Finally, a thorough analysis of the 50 most cited documents relevant to the subject matter is conducted.

3. RESULTS

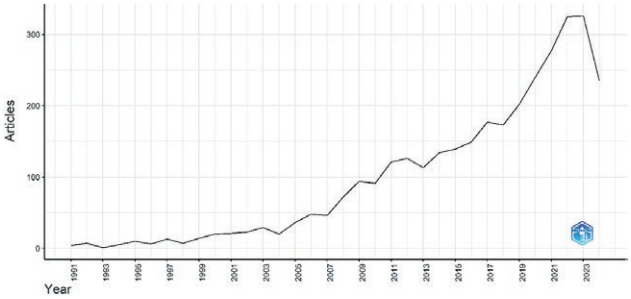
First, to provide insights into the development of the analysed scientific research, Figure 2 illustrates the annual scientific production.

The use of keywords such as "gender", "women", and "rural" is reflected in the notable increase in annual scientific output, particularly over the last two decades. The annual growth rate of scientific production is measured by the average number of articles published during the analysed period. The annual growth rate of the analysed dataset was 13.14%. The most significant volume of submitted papers to date was recorded in 2023, with 326 papers, followed by 325 papers in 2022. The increasing number of publications indicates a rising interest from both academia and industry in the challenges and issues related to women's role and challenges in agriculture.

3.1 The dominant authors, journals, and geographic areas in the literature on the role of women in agriculture

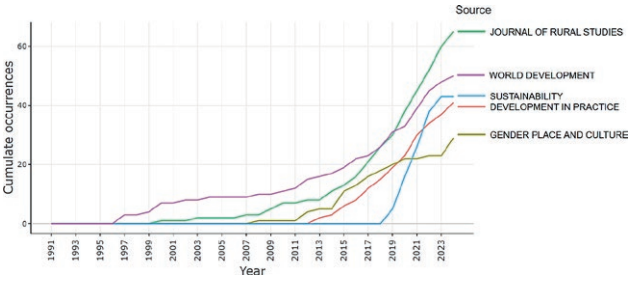
The annual growth of publications can vary across different sources. Analysing the cumulative growth of documents in the top 5 related sources in the dataset, as displayed in Figure 3, shows the greatest number of publications in the *Journal of Rural Studies* (60 papers), *World Development* (48 papers), and *Sustainability* (38 papers). Notably, since 2019, the *Journal of Rural Studies* has been the leading publication in this research area, followed closely by *World Development*. All other sources have published 29 or fewer articles throughout the entire study period.

Figure 2. The annual scientific production.



Source: Prepared by author. Data compiled from the Web of Science database.

Figure 3. Cumulative growth in the number of publications for the top 5 sources.



Source: Prepared by author. Data compiled from the Web of Science database.

As stated, the analysed dataset comprised 3,304 documents. Among these, the top 10 pertinent sources accounted for 10.87% of the total, equal to 359 documents, which suggests that there is greater diversity among the sources of publications rather than the concentration.

In addition to publication volume, a variety of metrics allows for a comprehensive assessment of source impact and productivity within the field of women in agriculture. Table 1 presents five distinct metrics for the most pertinent journals, encompassing the H-index, the G-index, the number of publications (NP), total citations (TC), and the inaugural publication year (PY start). Notably, while the *Journal of Rural Studies* exhibits the most substantial cumulative growth in publication numbers, it commenced its growth trajectory in 2000, in contrast to the second most prolific journal, *World Development*, which began its publication history in 1997.

Table 1. The top 5 influential sources on women in agriculture.

Source	H-index	G-index	NP	TC	PY start
Journal of Rural Studies	24	35	65	1,374	2000
World Development	24	50	50	2,949	1997
Food Policy	17	17	17	1,233	1995
Social Science & Medicine	16	21	21	1,071	1994
Agricultural Economics	13	18	18	545	2002

Source: Prepared by author. Data compiled from the Web of Science database.

Table 2. The top 10 contributing authors on women in agriculture.

Author	H-index	G-index	TC	PY start
C. Leukefeld	8	8	260	2003
R. Meinzen-Dick	8	9	1,114	2013
A. Quisumbing	8	10	1077	2010
L. Badstue	7	7	243	2013
L.A. Simmons	7	8	242	2007

Source: Prepared by author. Data compiled from the Web of Science database.

The most significant sources, as discerned from the analysed metrics, are those with the highest publication rates. These journals exhibit remarkably similar values across the analysed metrics. While the *Journal of Rural Studies* leads in publication volume within the specified timeframe, *World Development* stands out with the highest G-index. This index is derived from the distribution of citations received by an author's publications and the total citation count. The H-index, which represents an author's productivity and impact in terms of both paper output and citation count, is the same for the *Journal of Rural Studies* and *World Development*. Although some sources have a longer publication history, they register considerably lower values across all indices.

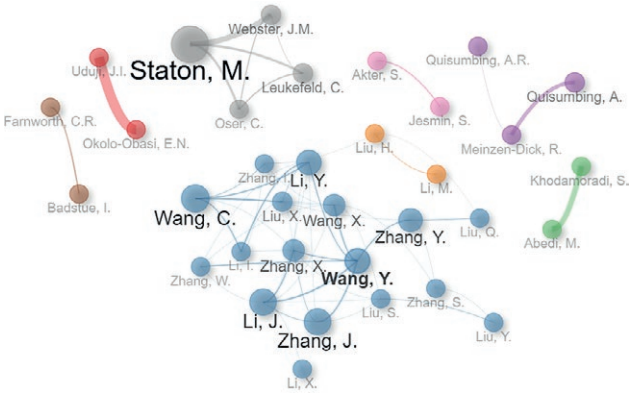
In the subsequent analysis, we identified the top contributing authors, institutions, and countries. Around 92.29% of authors (9,443 out of 10,232) displayed an article fractionalisation of less than 1, questioning the extent of individual contributions versus collaborative efforts.

The analysis of the top authors in women's role in agriculture utilised metrics such as H-index, G-index, TC, and PY start. C. Leukefeld stands out with the longest publication history among the top 10 authors; it began in 2003. However, author rankings vary based on specific indicators. While C. Leukefeld has the highest H-index (8), J. Zhang leads in the G-index (12). R. Meinzen-Dick has the most citations (1,114), followed closely by A. Quisumbing (1,077). The results are presented in Table 2.

Notably, among the most relevant authors ranked by the H-index, more than half (specifically, 55 out of 100) are women, highlighting a significant trend of increasing participation and a growing commitment among women to enhance their impact and influence within the field.

Although the lowest fractionalisation values indicate low collaboration between authors, the analysis of scientific collaboration depicted in Figure 4 presents the authors who collaborate most frequently. The nodes represent authors in the collaboration network, while the links indicate co-authorships. The size of the node represents the number of publications. The blue cluster, displaying the highest betweenness centrality values ranging from 28.16 for X. Wang to 0.18 for W. Zhang, highlights the most collaborative authors. According to the results, X. Wang plays a crucial role in connecting different groups or clusters of authors. The orange cluster follows, also with significant betweenness centrality values. Additionally, two authors in the red cluster exhibit the highest closeness centrality, signifying efficient access to resources from others in the network.

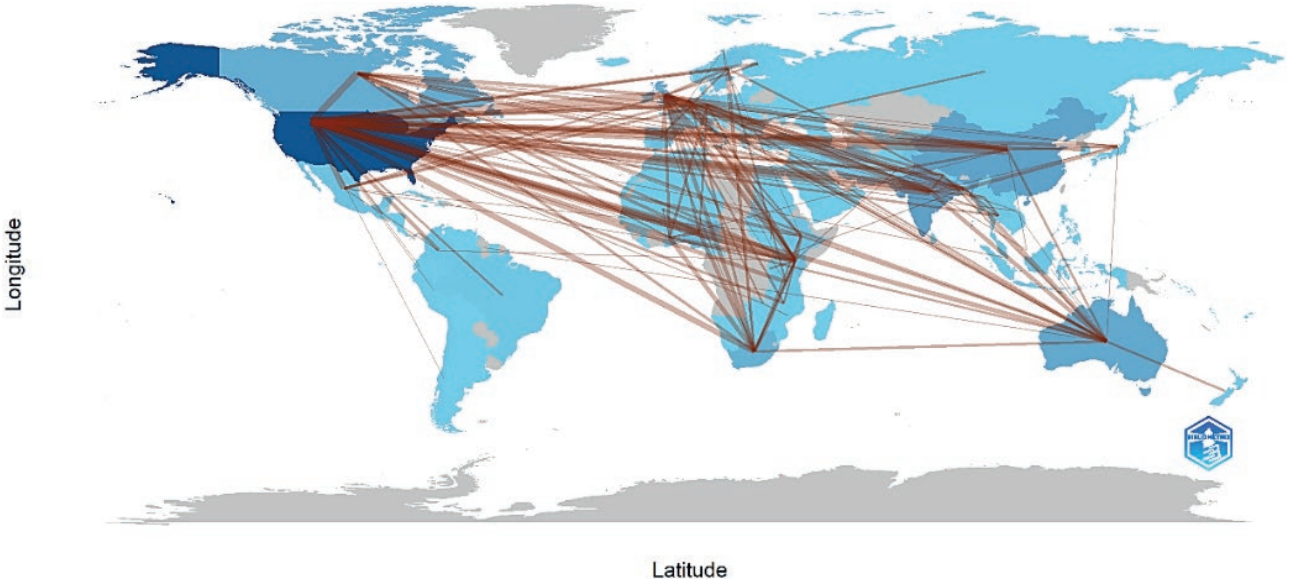
Figure 4. Collaboration among authors in the field of women in agriculture.



Source: Prepared by author. Data compiled from the Web of Science database.

Throughout the analysed period, most authors have originated from the United States, underscoring its leading role in research output. Meanwhile, both India and China have increasingly focused on gender equality and women's empowerment in agriculture. In China, the 2003 Rural Land Contracting Law (RLCL) was introduced to safeguard rural land rights and to ensure equitable distribution for women. Other programmes aimed at supporting women's income security and resilience have also been implemented, attracting scholarly interest in their impact on women's roles in agriculture (Gong *et al.*, 2022; Shi *et al.*, 2024). Similarly, India has launched

Figure 5. Collaboration between countries in the field of women in agriculture.



Source: Prepared by author. Data compiled from the Web of Science database.

several initiatives to enhance women's participation in agriculture, including the Mahila Kisan Sashaktikaran Pariyojana (Women Farmer Empowerment Program), a centrally funded scheme to strengthen women's roles in agricultural activities. Other programmes further promote women's representation and engagement in farming (Barooah *et al*., 2023).

From the standpoint of collaboration between countries shown in Figure 5, the most extensive collaboration is between the United States and China, with 52 published documents. Additionally, the United States collaborates significantly with India (41 papers), the United Kingdom (40 papers), Kenya (31 papers), and Canada (27 papers). Other collaborations have resulted in 20 or fewer papers. Collaborations usually involve a country with a robust research base on one side and a country addressing the examined problem on the other.

3.2 The main topics researched in the literature on women position in agriculture

Two metrics are utilised for displaying the analysis of authors' keywords: keyword frequency visualisation and co-occurrence network analysis.

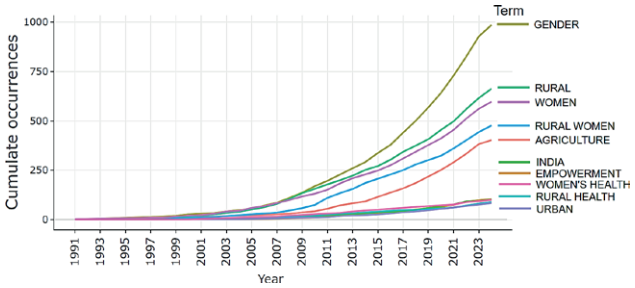
As shown in Figure 6, among the top 25 most frequently used keywords, those with the highest occurrences include "gender" (985 occurrences), "rural" (662 occurrences), "women" (597 occurrences), "rural women" (476 occurrences), "agriculture" (402 occurrences), "India" (104 occurrences), and "empowerment" (101 occurrences). Other keywords have 99 or fewer occurrences. Additionally, the frequency of the top 10 authors' keywords has not significantly changed over the analysed period.

The thematic analysis illustrated in Figure 7 leverages clusters of authors' keywords and their interrelationships to identify key themes, which are then visualised on a thematic map with vertical and horizontal axes.

The upper left quadrant contains specialised yet isolated topics such as women's health and depression. The large node size indicates extensive research, but their peripheral position suggests a limited connection to broader themes. Chandra *et al.* (2020) note that rural women face unique health challenges, gender discrimination, poverty, and inadequate healthcare, emphasising the need for further study. Despite their comprehensive exploration, these topics could benefit from greater integration with mainstream research to increase their relevance and impact.

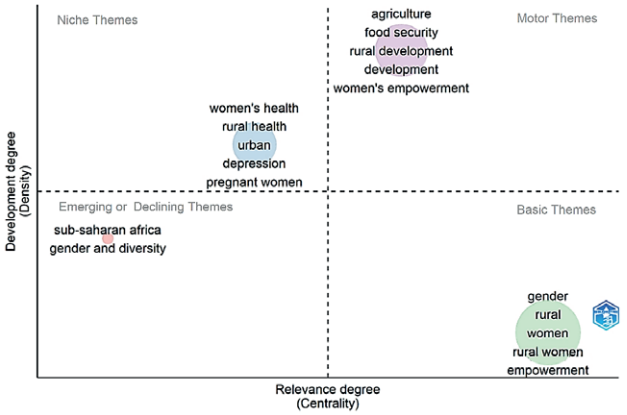
In contrast, the upper right quadrant highlights well-developed and critical themes such as food security, rural development, and women's empowerment. These issues have been the focus of numerous studies exploring the intersection of food insecurity and gender disparities, with an emphasis on empowering women in agricultural production to improve food and nutrition outcomes (Rahman and Islam, 2014; Pandey *et al*., 2016; Jones *et al*., 2017; Johnston *et al*., 2018). The thematic mapping and existing literature reflect the centrality and

Figure 6. The frequency of the top 10 authors' keywords over time in the field of women in agriculture.



Source: Prepared by author. Data compiled from the Web of Science database.

Figure 7. Thematic mapping of the authors' keywords in the field of women in agriculture.



Source: Prepared by author. Data compiled from the Web of Science database.

density of this topic, indicating its strong connections with other themes and the sustained interest it garners among researchers.

The lower left quadrant, characterised by low density and centrality, includes topics such as gender, diversity, and Sub-Saharan Africa. The small node size indicates that these themes are either emerging research areas with limited scholarly traction or declining topics. While various organisations have made efforts to improve the quality of life for women in Sub-Saharan Africa, significant challenges persist, including vulnerable employment, gender disparities in education, and the gender gap in agricultural productivity. Given the underdeveloped nature of this research area, further academic exploration of women's economic empowerment in Sub-Saharan Africa is crucial. Strengthening their economic position could enhance household dietary diversity, increase income levels, and contribute to poverty reduction (World Bank Group, 2023).

The lower right quadrant highlights key yet emerging themes, such as the empowerment of rural women within the agricultural sector. The large node size reflects significant academic interest and a growing body of research in this area. Although these themes are gaining prominence they remain underdeveloped, underscoring the need for further research and integration with established fields to unlock their full potential. Empowering rural women enhances their social and economic roles, contributing to societal development. Research indicates that empowering women improves decision-making power, increases household income, and strengthens community resilience (Doss, 2006; Akter and Chindarkar, 2020), highlighting the importance of further analysis.

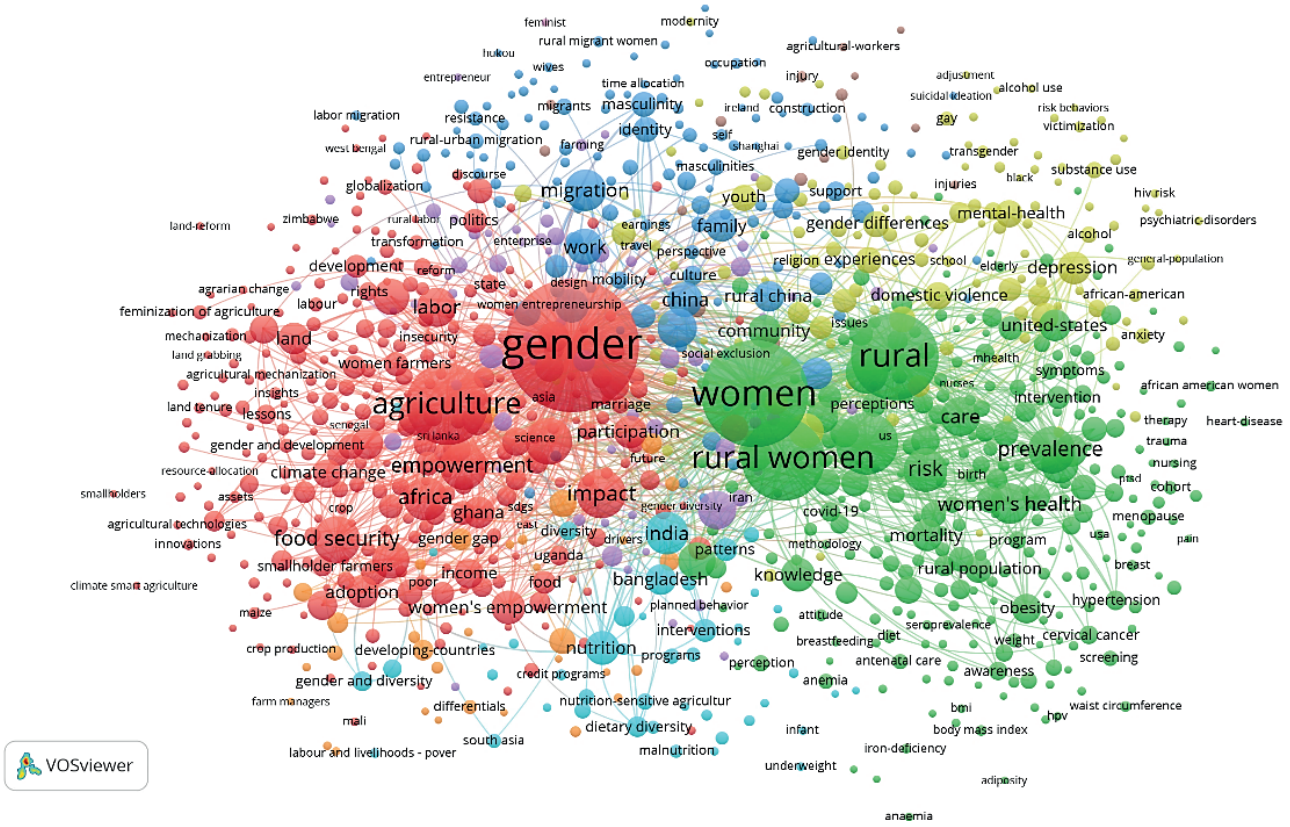
The co-occurrence analysis of keywords was conducted using the VOSviewer software; it provides insights into the interconnections and relationships between individual terms associated with the position of women in agriculture. Figure 8 displays the results of the keyword analysis: 1,047 keywords met the threshold of a minimum of five occurrences. These keywords were divided into nine clusters and formed 42,543 links, with a total link strength of 79,824. In the subsequent analysis, the size of the circles indicates keyword frequency, and the thickness of the lines indicates the strength of co-occurrence within and between clusters.

The largest red cluster, consisting of 296 items, prominently features the terms "gender" (907 links, link strength 8,279) and "agriculture" (633 links, link strength 3,325), underscoring the importance of gender-related issues in agriculture. Additionally, terms such as "food security", "empowerment", and "poverty" frequently co-occur within the same cluster, highlighting their interconnectedness.

Women's empowerment is vital, as empowered women drive social change, amplify marginalised voices, and improve overall well-being (Akter and Chindarkar, 2020; Hossain *et al.*, 2019). However, there are significant differences across countries. In the Global North, policy reforms have contributed to progress in women's empowerment, yet gender disparities persist in wages, farm incomes, and work identities, particularly within the agricultural sector (Fisher *et al.*, 2022). While some countries, such as Lithuania, offer more equitable opportunities, marginalised groups, such as Latina farmworkers in the United States, still face barriers due to social and economic inequalities (Quandt *et al.*, 2020).

The co-occurrence network analysis emphasises the more significant gender gap in agriculture in the Global South, where women face deep-rooted economic, politi-

Figure 8. Co-occurrence network analysis of authors' keywords in the field of women in agriculture.



Source: Prepared by author. Data compiled from the Web of Science database.

cal, and social inequalities. Despite their key role in agriculture, women encounter barriers such as land and livestock ownership discrimination, unequal pay, and limited access to credit and decision-making. Studies show that women hold a small share of land, often without legal ownership, and own fewer assets (FAO, 2024). Empowering women in the Global South is important for improving food security and achieving the SDGs which link sustainable agriculture, small farmer empowerment, and gender equality (Pérez-Escamilla, 2017). Gender equality and women's empowerment also support eliminating poverty and promoting health and well-being (Olumakaiye *et al*., 2019).

The second cluster, shown in green, highlights 272 key terms related to "women" (891 links and 5,568 link strength), "rural" (717 links), and "rural women" (608 links), underscoring the importance of health issues affecting rural women. The co-occurrence network analysis further confirms a strong association between women's health and empowerment. Empowering women in agriculture enhances health outcomes by addressing gender disparities in resource access and mitigating risks specific to women, such as age, time constraints, and social expectations (Anderson *et al*., 2019).

Health risks and challenges increase as income levels decline, disproportionately impacting rural women. Financial barriers, especially gaps in health insurance, force many to pay their expenses out-of-pocket, deterring them from seeking essential care (Onah and Govender, 2014). This issue is especially prominent in the Global South, where rural women struggle to access basic healthcare. A 2015 International Labour Organization (ILO) report found that 83% of Africa's rural population lacks adequate healthcare access. Similarly, recent data from 174 countries highlight significant disparities, with the most severe gaps found in developing nations (ILO, 2015).

Rural women face significant health challenges, including high rates of malaria, malnutrition, anaemia, and reproductive health issues. These are exacerbated by inadequate health education, cultural dietary habits, frequent pregnancies, and lack of rest (Houdegbe, 1985). Such factors contribute to high mortality rates in the Global South, where preventable conditions such as

maternal complications and infectious diseases remain deadly due to delayed or inaccessible care. Maternal mortality in low-income countries is nearly 40 times higher than in high-income nations, highlighting the urgent need for healthcare improvements (McCauley *et al*., 2020). However, rural health disparities persist globally. In the United States, rural women experience higher rates of chronic diseases and maternal complications due to provider shortages in their areas (Kozhimannil *et al*., 2019). Indigenous and rural populations in Australia and Canada face similar barriers (Bourke *et al*., 2012). Meanwhile, rising obesity rates throughout the world, increasing diabetes and cardiovascular diseases, further strain rural healthcare systems (Harrington *et al*., 2020).

The blue cluster of 135 keywords explores the connections between "migration", "gender", "agriculture", "education", and "work", a critical issue impacting rural women worldwide. In China, migration significantly shapes agricultural responsibilities to women, altering labour patterns and gendered economic impacts (Tong *et al*., 2018). Rural-to-urban migration also promotes more egalitarian gender attitudes, as exposure to modern workplaces boosts women's skills, economic status, and confidence, fostering gender equality (Yuan and Zhang, 2023). However, young, educated rural women face institutional barriers such as limited social security and career opportunities (Luo, 2006), while female migrant workers often take low-paying jobs and return to rural areas after marriage, limiting their economic mobility (Kocabicak, 2021).

Leder (2022) connects rural migration in Africa and South Asia to the "Feminization of Agriculture", emphasising how it reshapes gender norms and power structures. Migration impacts women's roles in accessing resources and decision-making, yet deep-rooted inequalities linked to caste, class, and social norms often limit their empowerment. In Europe, rural depopulation often leads young women to migrate for education and employment (García and Sánchez, 2005), although recent trends show more educated women choosing to stay or return to rural areas for career opportunities (Carbó *et al*., 2013). In Spain, gender-sensitive policies are crucial for retaining young women and supporting their professional goals, especially in areas with improving infrastructure (Bayona and Gil, 2013). There are similar trends across Europe, where such strategies aim to empower women and combat regional depopulation (Bock, 2004).

The fourth cluster, highlighted in yellow, contains 131 authors' keywords centred on mental health topics, highlighting women's mental health challenges in agricultural and rural settings. The prevalence of mental disorders varies geographically, differing not only between countries but also within them, with notable distinctions between urban and rural areas (Yoshioka *et al*., 2021).

Rural areas often face poverty and limited resources, which significantly impact women's mental health. The lack of mental health services exacerbates this issue, leading to higher rates of depression and other mental disorders. Poverty affects women differently throughout their lives, with challenges such as underpaid labour, early marriage, sexual abuse, and discrimination. Women in rural communities of the Global South often live in extreme poverty, lacking essentials like food, water, shelter, and healthcare (Marandure, 2024). In rural parts of the United States, women also experience health disparities due to limited access to primary and mental health services, resulting in delayed diagnoses and inadequate treatment. Cultural factors, including self-reliance and stoicism, influence healthcare-seeking behaviour, leading many rural women to rely on self-care or delay professional help until conditions worsen (Simmons *et al*., 2014). Furthermore, women with severe mental illnesses experience greater physical and social isolation compared with men, with cultural norms often reinforcing these gender-specific challenges (Ghebrehiwet *et al*., 2020).

The fifth cluster, marked in purple, focuses on economic empowerment and financial opportunities for women, particularly in rural or agricultural settings. Women's entrepreneurial behaviour is influenced by institutions, which play a significant role regardless of whether the women entrepreneurs reside in developed, emerging, or underdeveloped economies. The highest concentration of female participation in the business environment is found in emerging and developing economies, where women often establish businesses to balance work and family responsibilities or due to limited opportunities in the formal labour market. In Latin America, for example, women tend to close their businesses and transition to the traditional labour market as the economy improves (Giménez *et al*., 2018). Merrett and Gruidl (2004) find that rural female entrepreneurs face more obstacles to business success than their male or urban female counterparts.

Women's empowerment is closely linked to access to credit, as Hashemi *et al*. (1996) emphasise. Microcredit programmes have helped women gain financial independence, expand their social networks, strengthen decision-making power, and increase mobility (Pitt *et al*., 2006). Despite these benefits, significant formal barriers still hinder women's entrepreneurial efforts. Organisations such as the World Bank, United Nations, and Organisation for Economic Co-ordination and Development (OECD) collect data on gender wage inequality and

economic participation (Lee *et al.*, 2011), yet these obstacles persist. Moreover, gender roles shape formal and informal institutions, embedding biases that discourage women from starting businesses (Giménez *et al.*, 2012).

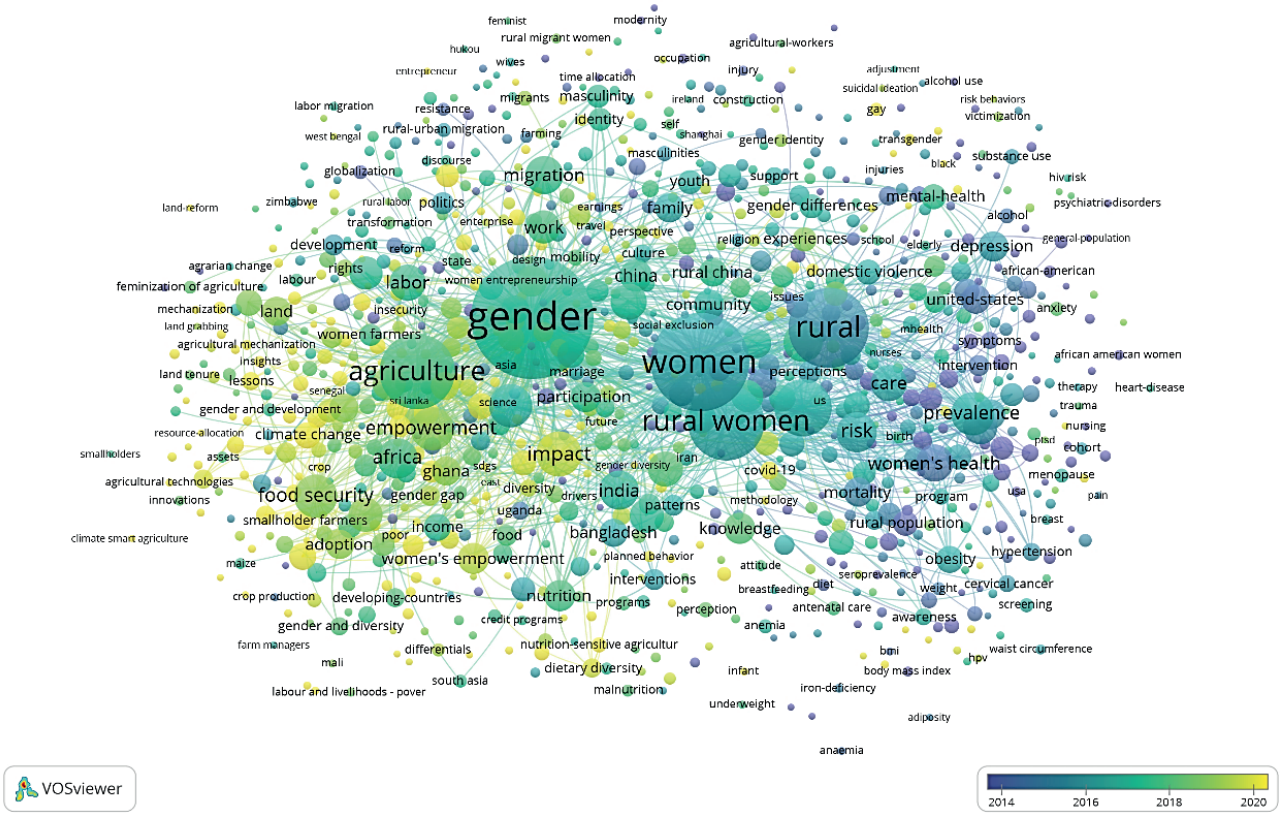
The sixth light blue cluster highlights "food security", "nutrition", and "dietary diversity" with a focus on India and Bangladesh. Despite economic growth, India has the highest burden of child undernutrition (43% of children under 5 years of age) and lags behind sub-Saharan Africa in human development indicators. Investments, including the $2.4 billion Integrated Child Development Scheme, failed to meet the 2015 hunger reduction goal, leaving 33% of children undernourished (Sinha *et al.*, 2017). Bangladesh also faces high undernutrition rates despite progress in food production. Women, comprising 46% of the farming population, play a key role but face gender-based discrimination that limits their economic participation and access to food (Talukder and Anik, 2016). To address these issues, national and international efforts focus on nutrition improvement, including the Adivasi Fisheries Project and programmes like "One House, One Farm" (Rahman and Islam, 2014).

Urban food insecurity is also a significant issue in the Global North, where urban and peri-urban agriculture are increasingly recognised as key to food security. While urban agriculture mainly meets household food needs, peri-urban agriculture provides larger quantities and broader distribution pathways, making it more impactful. Both face challenges from urbanisation, underscoring the need for targeted urban food planning to unlock their full potential (Opitz *et al.*, 2016).

Clusters 7-9 provide focused insights into distinct themes within the field. The seventh cluster, in orange, highlights strategies for addressing gender gaps in agriculture, with key terms such as "strategies" (237 links) and "Nigeria" (135 links) taking precedence. The eighth cluster, shown in brown, features 16 keywords, including "farm," "exposure," and "safety", with link counts of 129, 121, and 81, respectively. Lastly, the ninth cluster centres around the term "feminist", which has 26 links. Due to the relatively small size of these clusters, they will not be examined in further detail.

The overlay visualisation of co-occurrence analysis in Figure 9 highlights the evolution of the research

Figure 9. Co-occurrence overlay analysis of authors' keywords in the field of women in agriculture.



Source: Prepared by author. Data compiled from the Web of Science database.

focus, with the more recent keywords in yellow and earlier ones in purple. Recent research emphasises keywords including "food security", "empowerment", "climate change", "productivity", and "gender equality", underlining the growing recognition of climate change's impact on food security and the empowerment of women in agriculture. In contrast, terms such as "women's health", "rural population", and "prevention" have become less common, indicating a shift in research priorities. The increasing use of keywords such as "food security", "climate change", and "gender equality" shows that climate change is now one of agriculture's most pressing challenges.

Climate change significantly impacts food security, with women in both the Global South and North bearing a disproportionate burden. In the Global South, particularly in Sub-Saharan Africa, women make up 55%-87% of agricultural production but face barriers such as limited access to land, technology, and financial resources, heightened by climate impacts like droughts and floods (International Monetary Fund, 2003). Climate change, including irregular rainfall and extreme weather events, leads to crop losses and increases hunger, with women at higher risk of malnutrition than men (Agarwal, 2018).

In the Global North, there are significant climate impacts on agriculture, with changing weather patterns affecting crop yields. For example, Australia saw a 27% decline in water-limited yield potential from 1990 to 2015, worsened by rising temperatures and reduced rainfall. In Europe, wheat and barley yields have decreased by 2.5% and 3.8% since 1989, with Italy facing the worst declines due to a drying trend (Mbow *et al.*, 2019). Despite having more resources to mitigate climate effects, farmers in the Global North, particularly women, still face challenges adapting to these changes. In contrast, subsistence farmers in the Global South, lacking resources, often rely on community-based adaptation which, while helpful, can reinforce existing gender biases.

The keyword analysis and thematic mapping highlight a shift towards central themes such as food security, climate change, and women's empowerment in agriculture, emphasising their growing relevance. Research indicates that female farmers often adapt more effectively to climate-related challenges than their male counterparts (Quisumbing *et al.*, 2017).

3.3 The predominant research methods used to assess the status of women in agriculture in the most cited documents

This section synthesises the predominant research methods employed in the 50 most cited documents, highlighting their methodological trends and implications for understanding women's roles in agriculture. Most of these studies employed various types of regression analysis to explore complex relationships between variables. Regression analysis is favoured for its ability to handle large, representative datasets, often drawn from national or cross-country surveys. Key themes identified through keyword analysis – such as gender, agriculture, health, and empowerment – are essential for evidence-based policy formulation, with regression analysis revealing significant patterns and relationships. For example, Sraboni *et al.* (2014) used regression analysis to examine the link between women's empowerment and food security in Bangladesh, finding that higher empowerment scores corresponded with increased calorie availability and household dietary diversity. Conversely, Malapit and Quisumbing (2015) investigated women's agricultural empowerment in northern Ghana, noting that while empowerment is linked to improved dietary diversity, it does not consistently correlate with broader nutritional indicators like body mass index. These differing findings can likely be attributed to national contextual factors, such as Bangladesh's recent growth in female employment and reduction in the gender wage gap.

Some studies have combined thematic approaches, such as qualitative interviews paired with regression analysis. For instance, Savy *et al.* (2005) utilised both qualitative and quantitative methods, revealing inadequate overall dietary quality through a domestic survey that included questionnaires and anthropometric measurements. They identified significant relationships between food variety scores, dietary diversity scores, and key nutritional indices. Similarly, Alkire *et al.* (2013) integrated interviews and decomposition methods to analyse women's empowerment across different regions. The analysis revealed regional differences in empowerment: wealth influences empowerment in Bangladesh and Uganda but not in Guatemala, while education has a variable effect across countries. Age also plays a role in Bangladesh and Guatemala, with middle-aged women showing greater empowerment, whereas age has no significant impact in Uganda.

Other studies have solely relied on interviews. For example, Logan *et al.* (2005) used six focus groups conducted in rural and urban areas to gather insights into individual motivations and barriers related to community-supported agriculture. In contrast, Meiselman *et al.* (2010) employed a commercially available internet system for data collection to gain personal insights into survivors' experiences accessing services.

Literature reviews and comparative analyses are the third most frequently used methods. Ruel *et al.* (2018)

summarise current research on how agriculture can influence nutritional outcomes, while Quisumbing and Pandolfelli (2010) provide a critical review of interventions and policy changes aimed at increasing women farmers' access to resources in South Asia and Sub-Saharan Africa. They note that, in contrast to interventions aimed at enhancing human capital investment, only a minority of initiatives or policy changes aimed at increasing female farmers' access to productive resources have undergone rigorous evaluation. Pandey *et al.* (2016) show that agricultural interventions, such as producing nutrition-rich crops, establishing homestead gardens, and diversifying systems with fruits, vegetables, and aquaculture, can improve nutritional outcomes in South Asia. They also emphasise the importance of women's empowerment and nutritional knowledge in enhancing these results.

Among the comparative analyses, Doss (2006) explores crops in Ghana through the lens of gender roles, finding minimal distinctions between "men's" and "women's" crops. Maharjan *et al.* (2012) examine agricultural interventions, revealing that while both genders benefit, a persistent gender-asset gap highlights ongoing gendered barriers. Meiselman *et al.* (2010) focus on food neophobia and demographic trends, demonstrating the varying impacts of age, education, and income. Lastly, Carr (2008) contrasts mainstream and feminist post-structuralist approaches in Ghana, illustrating how theoretical differences influence practical outcomes in gender development.

Other analytical approaches, such as longitudinal survey analysis, content analysis, case studies, ethnographic research, and cost-benefit analysis, were utilised infrequently in the 50 most cited documents. Table 3 shows a summary of the predominant research methods

Table 3. Summary of data analysis research methods used in the literature.

Methods	Sources
Surveys (questionnaire, interviews)	Rahman (1999), Cone and Myhre (2000), Conway *et al.* (2003), Logan *et al.* (2005), Savy *et al.* (2005), Meiselman *et al.* (2010), Maharjan *et al.* (2012), Alkire *et al.* (2013), Liu (2016), Akter *et al.* (2017)
Regression analysis	Udry *et al.* (1995), Wawer *et al.* (1997), Martorell *et al.* (2000), Wingood *et al.* (2000), Sellen and Smay (2001), Bentley and Griffith (2003), Wilson *et al.* (2003), Ekici *et al.* (2005), Savy *et al.* (2005), Yip *et al.* (2005), Deininger and Castagnini (2006), Hannum *et al.* (2009), Vyavaharkar *et al.* (2010), Ragasa *et al.* (2013), Takagi *et al.* (2013), Ali *et al.* (2014), Sraboni *et al.* (2014), Malapit and Quisumbing (2015), Johnson *et al.* (2016)
Structural equation modelling	Huddleston *et al.* (2009), Berkel *et al.* (2009)
Decomposition methods	Alkire *et al.* (2013), Kilic *et al.* (2015)
Reviews	Hilson *et al.* (1997), Bryld *et al.* (2003), Deininger and Castagnini (2006), Ruel *et al.* (2018), Quisumbing and Pandolfelli (2010), Pandey *et al.* (2016)
Longitudinal survey analysis	Hannum *et al.* (2009), Perez *et al.* (2015)
Comparative analysis	Doss (2006), Carr (2008), Meiselman *et al.* (2010), Maharjan *et al.* (2012), Quisumbing *et al.* (2015), Doss (2017)
Content analysis	Bryld (2003)
Case studies	Rahman (1999), Cone and Myhre (2000), Liu (2014)
Other	Yip *et al.* (2000), Ambrose *et al.* (2003), Jost *et al.* (2015)

Source: Prepared by author. Data compiled from the Web of Science database.

4. CONCLUSION

A bibliometric analysis was conducted of the role of women in agriculture worldwide. After filtering out duplicates, non-English records, and irrelevant articles, the final dataset comprised 3,304 records. The analysis offered valuable insights into the research questions. Notably, the most significant increase in publications occurred between 2022 and 2023, reflecting heightened interest from academia and industry. Over the past two decades, the number of publications has surged, with the *Journal of Rural Studies* and *World Development* leading the growth. The analysis shows that top-ranking authors (C. Leukefeld, R. Meinzen-Dick and A. Quisumbing) are central to collaboration networks, aiding researchers in identifying key experts. Moreover, both India and China have shown growing attention to gender equality and women's empowerment in agriculture, further enriching the global discourse. Strengthening author collaboration could further advance research on women's roles in agriculture.

Thematic mapping reveals well-established topics such as food security, rural development, and women's empowerment, which were prominently discussed between 2014 and 2018 and continue to be central to research and policy dialogues. Based on the co-occurrence network analysis of authors' keywords, climate change has emerged as a critical issue, reflecting its increasing impact on agricultural productivity and gender disparities. The growing frequency of keywords such as "food security", "climate change", and "gender equality" in recent years underscores the urgency of address-

ing climate-related challenges in agriculture, particularly their disproportionate effects on women. Conversely, emerging topics such as gender diversity, Sub-Saharan Africa, and rural women's empowerment are gaining attention but remain underexplored. Expanding research in these areas is essential for their integration into broader agricultural and gender studies, enabling more effective policy interventions.

The co-occurrence network analysis of author keywords shows that while some clusters address global issues, others are more region-specific, highlighting their significance in specific contexts. While the literature indicates that women in the Global North face deep-rooted economic, political, and social inequalities, migration and health disparities remain persistent challenges for rural women worldwide, albeit with varying regional patterns.

The most common approach involves collecting primary data through surveys or interviews and applying regression analysis to explore complex relationships. This method has provided more profound insights into women's agricultural roles, leading to more targeted policy recommendations. Comparative analysis highlights contextual differences, such as the impact of wealth, education, and age on empowerment. Although less frequent, integrating diverse analytical approaches offers a valuable perspective on gender and agriculture, enhancing evidence-based policy development.

While this study provides insights into the role of women in agriculture, it has several limitations that future research could address. Expanding the scope to include publications from national institutions and policy reports may provide a more comprehensive understanding of efforts to improve women's positions in agriculture. Additionally, although the findings offer a global perspective, specific topics – such as the empowerment of rural women in Africa or the nutrition of rural women in Bangladesh and India – are analysed more frequently, reflecting regional research priorities. Given these patterns, segmenting the analysis and comparing the results could yield more profound insights. A comparative approach between the Global North and South could further illuminate regional differences and identify effective policies that may be adapted across contexts. Future research could also place greater emphasis on the economic empowerment of rural women, particularly regarding access to land, technology, and financial resources. Moreover, linking research findings to practical policy recommendations aimed at promoting gender equality and improving living conditions in agriculture would contribute to the broader global effort to empower women in the sector.

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Short Communication

Note on carbon sequestration policies in the European Union

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Abstract. This note examines the state of carbon farming (CF) policies in the European Union (EU), highlighting their potential to deliver significant public benefits, such as improved soil health, air quality, and climate mitigation. The existing mechanisms for encouraging carbon sequestration and evaluating alternative support scenarios are assessed, starting from analysing the regulation on carbon sequestration certification adopted by the European Parliament and the Council following a proposal from the European Commission. This note analyses the integration of CF into the EU's Common Agricultural Policy (CAP) through cross-compliance measures, eco-schemes, and Rural Development programmes. Additionally, it explores potential CF support frameworks, including exclusive reliance on the first CAP pillar, the voluntary carbon market, and mixed approaches. The analysis highlights several trade-offs: balancing CAP budget limitations with the need for stronger environmental measures, mitigating market uncertainty in the voluntary carbon market, and ensuring that certification costs do not deter farmer participation. Despite these challenges, the findings suggest that including CF within CAP, either as an alternative or complement to the voluntary carbon credit market, could enhance carbon sequestration and align EU agriculture with climate neutrality goals, particularly when supported by a structured certification system.

Keywords: carbon farming, carbon credits, soil carbon accounting, climate neutrality goals, CAP budget, carbon sequestration certification.
JEL codes: Q18.

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HIGHLIGHTS

- The European Union is currently adopting a regulation for the certification of carbon sequestration in the farming sector.
- Remuneration for carbon farming could be part of the next Common Agricultural Policy reform.
- Balancing public support between paying for carbon farming practices and fostering the market for carbon credits is crucial.

1. INTRODUCTION

In a world where demographic and economic growth have led to a steady increase in food consumption, there has been significant pressure on natural resources, as global agricultural production has intensified over the years (Hu *et al*., 2020). Consequently, greenhouse gas emissions have increased, necessitating appropriate environmental policies aimed at countering the sector's impact (Vojtech, 2010). In the European Union (EU), considering data published by the European Commission (EC) and contained in the Emissions Database for Global Atmospheric Research (EDGAR), from 1990 to 2021, the total greenhouse gas emissions from the agricultural sector decreased from 485 Mt CO_2 equivalents to 378 Mt CO_2 equivalents, representing a 22% reduction (EC, 2023). This decline signals an improvement and indicates the partial, yet limited, effectiveness of the tools adopted in relation to the budget allocated for the ambitious goal of achieving climate neutrality by 2050 (European Court of Auditors, 2021).

Among the strategies for climate change mitigation and adaptation, carbon farming (CF) is defined as a green business model that rewards land sector actors for adopting better land-management practices that result in carbon sequestration in living biomass, dead organic matter, and soils, thereby increasing carbon capture and/or reducing carbon release into the atmosphere (EC, 2021a). Based on this definition, it is clear that environmental objectives can be achieved through the adoption of two main CF practices: (1) reducing greenhouse gas emissions and thus the carbon footprint of agricultural, forestry, and livestock activities (De Boer *et al*., 2011), and (2) increasing soil carbon absorption, such as the preservation of peatlands (Joosten *et al*., 2014) and increasing organic matter in agricultural soils and the biomass of crops, both intercropping annual crops (Francaviglia *et al*., 2017) and multi-year arboreal and forestry crops (Bernal *et al*., 2018).

The purpose of this note is to briefly outline the status of CF policies in the EU, considering the instruments currently in place and comparing alternative scenarios for supporting carbon sequestration activities implemented by farmers.

2. THE STATE OF THE ART OF CARBON FARMING POLICIES IN THE EUROPEAN UNION

In its communication on "Sustainable Carbon Cycles – Carbon Farming", the EC (2021a) reiterated the need to remunerate entrepreneurs who, through their activities, demonstrate carbon dioxide absorption, thus generating carbon credits. At present, direct remuneration for CF activities in the agricultural sector occurs through the voluntary carbon market, where farmers can generate and sell carbon credits. Certification is required to validate these credits, which must be obtained through accredited entities (Michaelowa *et al*., 2019; Criscuoli *et al*., 2024). This voluntary market is different from the EU-regulated carbon market, known as Emission Trading System (ETS), which was established under the provisions of the Kyoto Protocol (United Nations Framework Convention on Climate Change, 1998).

The ETS imposes legally binding caps on greenhouse gas emissions for sectors such as energy and industry, requiring participants to trade allowances within a strictly regulated framework. In contrast, the voluntary market provides non-regulated entities – such as individual farmers and smaller landowners – with the opportunity to contribute to climate change mitigation efforts by adopting carbon sequestration practices (Criscuoli *et al*., 2024; Gołasa *et al*., 2025). However, this market is volatile and has not yet been widely exploited by farmers (Battocletti *et al*., 2023). Given that this voluntary market is more volatile and less attractive than a regulated market (Battocletti *et al*., 2023; Marchewka-Bartkowiak, 2023), it is necessary to standardise carbon sequestration quantification methodologies to determine the amount/number of credits that can be generated by farmers based on the activities performed (Smith *et al*., 2020; Van der Vort *et al*., 2023; Van Hoof, 2023).

For this reason, the EC has published a draft regulation, enacted recently by Regulation No. 2024/3012, which outlines the minimum criteria for classifying farmers' activities as carbon sequestration practices, summarised by the acronym QU.A.L.ITY., which stands for Quantification, Additionality, Long-term storage, and Sustainability (EC, 2022; Günther *et al*., 2024). The QU.A.L.ITY. system is at the core of the EU's effort to establish a robust certification framework for carbon sequestration practices, aiming to address some of the key challenges related to measuring and verifying carbon sequestration, ensuring credibility and consistency across EU Member States:

1. QUantification: activities must be measured accurately and provide unequivocal sequestration benefits. The additional sequestration generated by an activity compared with a baseline scenario should exceed the greenhouse gas emissions caused by its implementation across the entire life cycle. The net carbon sequestration benefit should be validly and accurately quantified.

2. Additionality: sequestration activities must go beyond standard practices and legal requirements. To demonstrate additionality, it is necessary to define a "normalised" baseline scenario that accurately reflects standard practices, regulatory frameworks, and market conditions in which the activity takes place. This baseline scenario allows for objective and cost-effective demonstration of additionality and recognises the early commitment of land managers and industries that have already undertaken carbon sequestration activities.
3. Long-term storage: CF activities must ensure that the absorbed carbon is stored for as long as possible, with minimal risk of release. Certificates will specify the duration of storage and distinguish between permanent and temporary storage.
4. Sustainability: CF activities must leave other environmental goals, such as biodiversity, climate change adaptation, greenhouse gas emission reduction, water quality, zero pollution, or a circular economy, unaffected or generate additional benefits.

The importance of this framework – although at present it is general and will be regulated in detail through future delegated acts – reflects the EC's clear intent to make progress on certification while remaining within the voluntary market. Indeed, the report produced as a conclusion for the "Strategic Dialogue on the Future of European Agriculture" (Strohschneider, 2024) reiterated that this could represent "a market-based opportunity to reward sustainable agricultural practices", and pays close attention to uncertainties associated with this sequestration, which should not fall solely on the farmer.

3. CURRENT CARBON-FARMING-RELATED MEASURES IN COMMON AGRICULTURAL POLICY

Currently, in the EU, the Common Agricultural Policy (CAP) provides payments to farmers for voluntarily adopting agricultural practices aimed at reducing emissions, such as conservation agriculture, cover crops, sowing of crops for ecological purposes, fallowing of arable land, and the promotion of forestry and afforestation practices (EC, 2021b; Criscuoli *et al*., 2024). These measures are part of the first CAP pillar, specifically under cross-compliance of direct payments and eco-schemes. While these are designed and financed at the EU level, their application and specific measures depend on national strategies. Italy's CAP Strategic Plan serves as an example of how EU policies are translated into national-level interventions, offering practical insight into CF implementation in a specific country. Concerning conditionality, CF-related activities include Good Agricultural and Environmental Conditions (GAEC) standards 1, 2, 3, 6, 7, and 9, which relate respectively to "maintenance of permanent grassland", "protection of wetlands and peatlands", "ban on stubble", "minimum soil coverage", "crop rotation", and "ban on conversion or ploughing of permanent grasslands in Natura 2000 sites". Regarding voluntary measures, and referring to the Italian case as an example, carbon sequestration is promoted through eco-schemes 2, 3, and 4, which include "greening of arboreal crops", "protection of landscape olives", and "extensive forage systems with crop rotation", respectively (Italian CAP Strategic Plan, 2023).

In the second pillar, several CF practices are included under Italy's Rural Development measures "typology A – commitments related to the environment, climate, and other management commitments" and "typology D – investments" (Italian CAP Strategic Plan, 2023). These are mainly agronomic and forestry interventions whose direct consequences include medium-and long-term carbon footprint reductions (Willard, 2023), either through emissions avoided or carbon accumulated via afforestation or the addition of organic matter (McDonald *et al*., 2021). What is remunerated is the agricultural practice itself, as the farmer provides an ecosystem service through its execution. The increasing benefits of the practices come from actions that do not alter land use, such as no-tillage, or more impactful practices like afforestation (Dumbrell *et al*., 2016). Specifically, no area-based measures or other incentives are tied to a specific quantity of carbon absorbed per surface; rather, carbon storage is considered a consequence (Italian CAP Strategic Plan, 2023).

While Italy represents a relevant case study, it is important to recognise that CF policies and their effectiveness vary across the EU Member States due to differences in agricultural systems and soil types. For example, northwestern Member States, such as France and the Netherlands, emphasise carbon sequestration through peatland restoration (Carbon Connects, Care Peat, 2023), while southern Member States, including Spain and Greece, focus on afforestation and soil organic matter enhancement due to their arid climates (Lilas4soils, 2025). These regional differences highlight the need for more flexible CAP measures tailored to the local contexts to maximise CF adoption and effectiveness.

4. CARBON FARMING: COMMON AGRICULTURAL POLICY OR VOLUNTARY (OR REGULATED) MARKET?

With the commencement of Regulation No. 2024/3012, a legal basis was created for a certification protocol of agri-

cultural practices, albeit still generic. If CAP intervenes, should CF support remain under the second pillar, or could dedicated first-pillar payments accelerate mitigation? Five scenarios are proposed (Table 1).

Scenario 1 – The current situation ("status quo")

Currently (Scenario 1, Table 1), remuneration is guaranteed through a variety of tools (direct payments, eco-schemes, and second-pillar measures) which, despite providing flexibility, lead to fragmented resources and overlapping measures (Alabrese, Saba, 2023). In this scenario, the only way for a farmer to sell carbon credits is to adhere to the fulfilments of a voluntary certification scheme, without CAP coverage for the costs related to the implementation of such a scheme (i.e., certification and related costs).

Scenario 2 – Only the first pillar

In case of enhanced CF remuneration through the first-pillar direct payments – cross-compliance and eco-schemes (Scenario 2, Table 1) – a larger group of beneficiaries would be reached, because many practices that contribute to sequestration are part of the CAP 2023-2027 cross-compliance (in detail, GAECs), which represents a tool that reaches more farmers than the second pillar (Soussana *et al*., 2010; Olson *et al*., 2014; Willard, 2023; Márquez-García *et al*., 2024). The second pillar, on the other hand, only provides support to incentivise adherence to a certification scheme, allowing the credits to be placed on the voluntary market. This scenario offers a strong incentive to comply with conditionality, also from the perspective of credit commercialisation, and practices would not be perceived solely as a requirement for receiving income support but as an opportunity to diversify income, encouraging farmer participation (Block *et al*., 2024; EC, 2025).

Scenario 3 – Only voluntary carbon credit market

Transferring CF remuneration from the CAP payments to the voluntary market (Scenario 3, Figure 1) could optimise policy spending for environmental outcomes (European Court of Auditors, 2021), as the monetary amount earned from the sale of certificates would provide a diversification of income beyond primary agricultural production and related activities. On the other hand, a lack of sufficient demand for credits (Wongpiyabovorn *et al*., 2022) could lead to price volatility (World Bank, 2023), resulting in high market uncertainty and low stability of support for farmers' income (EC, 2023).

There is also uncertainty about certification costs, whether they should be borne by farmers or whether they could be subsidised by CAP. In Scenario 3, if costs are high, then they could be a barrier to adopting and maintaining certified CF practices (Mayer *et al*., 2022; Paul, 2023). In general, and aside from Scenario 3, it should be noted that only the establishment of a proper incentive system for certifying credits would allow environmental targets to be met more effectively by farmers (Verschuuren *et al*., 2024).

Scenario 4 – Mixed and additional

In this scenario, in addition to CAP support that incentivises CF practices, the farmer can benefit from the voluntary market of carbon credits, obtained through the European certification system (Reg. No. 2024/3012). Accordingly, there would be double remuneration for commitments, as the farmer would receive compensation from CAP for CF activities beyond the income guaranteed by the market (Günther *et al*., 2024). This is very favourable for farmers, but is difficult to realise, considering the current Multiannual Financial Framework (MFF) aimed at a reduction of the CAP budget, unless increased public goods justify additional spending (Lötjönen *et al*., 2024).

Scenario 5 – Reduced Common Agricultural Policy support and guaranteed market for credits

This scenario envisages CAP support only to cover the costs of CF certification, unlike in Scenario 2. This option may generate a reduction in the MMF budget allocated to the CAP, an option that is particularly favoured by detractors of the CAP and the need to direct MMF to other EU policies. However, this option would be totally opposed by farmers' organisations, which at least demand the invariance of CAP support. The loss of CAP support is compensated through revenues generated by a guaranteed market for credits.

Table 1 illustrates potential implications of the five scenarios and hypothesises how stakeholders influence the decision-making process of CAP. Farmers, through their organisations, can slow down or speed up the process of embedding CF into CAP, based on their readiness to implement the practices and generally advocate for maintaining current MFF budget (Scenarios 1 and 4). Environmentalists, on the other hand, are citizens and organisations who want a greener CAP, supporting

Table 1. Scenarios for supporting carbon farming (CF).

Scenario	Description	Possible impacts/implications	Supporters	Opponents
1 – Status quo	CF is supported by both CAP pillars, while certification of credits is not supported	– Flexibility due to the presence of multiple tools, both mandatory and voluntary (Strohschneider, 2024) – Widespread practices throughout the territory as baseline commitments – High fragmentation of financial resources – Low synergy between CAP and credits certification	– Farmers that comply with Good Agricultural and Environmental Conditions standards and Rural Development measures	– Environmentalists – Farmers interested in carbon credits
2 – Only the first pillar	CF is supported only by the first CAP pillar (partially rearranging the current direct payments system, based on cross-compliance and eco-schemes), while there is also budget in the second CAP pillar to incentivise a harmonised certification scheme for CF	– Compliance would be perceived by farmers not as cross-compliance but as an incentive for CF – More beneficiaries are reached for CF, that is, the current receivers of Basic Income Support for Sustainability and eco-schemes – Increasing the total agricultural area on which carbon removals are conducted – The budget increase for first pillar of CAP can support segments of the farming population that have not yet adopted practices that goes beyond the minimum commitments of cross-compliance (Phelan *et al.*, 2024) – Reluctance of farmers and their representatives to abandon the current system of direct payments	– Environmentalists	– Farmers interested in income support without cross-compliance (adopters of second-pillar commitments) – Non-agricultural stakeholders
3 – Only voluntary carbon credit market	CF is paid only by the market, while the European Union supports a certification scheme only from a regulatory point of view	– If properly regulated, selling credits could be remunerative when the unit prices (€/t CO2 equivalent) are higher than the unit costs incurred for practices – This situation accelerates the trend of reduced CAP support, providing farmers with alternative income to remunerate actions with positive environmental effects (Lötjönen *et al.*, 2024) – Diversification of income sources (Gołasa *et al.*, 2025; EC, 2025) – High market uncertainty for farmers due to price volatility (€/t CO2 equivalent) – Need for additional incentives for certification and related transaction costs – Concern of farmers about a reduction of support from the public and private sectors	– Environmentalists – The Frugal Four (Austria, Denmark, the Netherlands, and Sweden) – Non-agricultural stakeholders	– Farmers and agricultural organisations – Environmentalists
4 – Mixed and additional (Scenarios 1 and 3)	CF is supported by both CAP pillars (which get the same amount of resources), while farmers also receive remuneration from a voluntary carbon credit market	– Double remuneration for European farmers (Paul *et al.*, 2023; Günther *et al.*, 2024) – Introduction of the voluntary credit market for agriculture – Need to develop outcome-based measures (McDonald *et al.*, 2021) – Mixed support hardly justifiable in negotiations among European Union institutions	– Farmers and agricultural organisations	– The Frugal Four (Austria, Denmark, the Netherlands, and Sweden)
5 – Reduced CAP support and guaranteed market for carbon credits	The CAP budget decreases (e.g., from the current 32% of the Multiannual Financial Framework to 25%) and the loss of CAP support is offset by a guaranteed market for carbon credits	– Welcomed by political factions who look favourably on CAP budget reduction – The demand for credits must be constant; otherwise, there is no certainty of farmers' income stabilisation	– The Frugal Four (Austria, Denmark, the Netherlands, and Sweden) – Non-agricultural stakeholders	– Farmers and their organisations

Note: CAP, Common Agricultural Policy.
Source: Authors' elaboration based on the consulted bibliography.

stricter environmental measures. They usually advocate the reduction of public support for intensive farms in favour of less intensive ones, following the statement "public money for public goods" (Scenarios 2 and 3).

Other stakeholders who aim for a budget reduction are representatives from non-agricultural sectors (members of civil society and representatives of organisations of workers in non-agricultural sectors), who lean towards increasing the funding for other policies, such as social and cohesion policies, environmental policy, defence and security policies, energy policy, enlargement policy, etc. However, it is also possible to consider another category of stakeholders, namely the "Frugal Four", a group of four fiscally conservative states – Austria, Denmark, the Netherlands, and Sweden – that advocate for strict budget discipline, reduced EU spending, and careful allocation of funds. These countries have been particularly active during budget negotiations, often pushing back against large financial transfers to economically weaker Member States and favouring financial responsibility and efficiency in the use of EU resources. Representatives from non-agricultural sectors and the Frugal Four are the two groups of stakeholders in favour of Scenarios 3 and 5, where the budget for CF within the CAP decreases.

Finally, although not present in Table 1, it is also possible to identify the neutral stakeholders, those who have little influence over CAP's CF decisions: they are consumers, workers' unions, and international trade institutions such as the World Trade Organization. CF remuneration does not determine changes to product availability and price, and at the same time does not distort international trade. Even regarding labour in agriculture, which is protected and monitored by workers' unions, there would be no substantial deviation, as CF practices would still be adopted with varying degrees of diffusion by the farms themselves, regardless of employment.

5. CONCLUSIONS

As McDonald *et al.* (2021) highlighted, the environmental mitigation potential of the CAP is already considered limited by the European Court of Auditors (2021). To avoid further undermining its effectiveness and to prevent greenwashing (Scherger, Sharma, 2024), it is essential to strengthen incentives for farmers to adopt CF practices (Wongpiyabovorn *et al.*, 2022; EC, 2025). This can be achieved by leveraging the flexibility offered by CAP Strategic Plans, particularly in the upcoming 2028-2034 programming period.

It should be noted that ensuring sufficient financial resources for these objectives will be a critical topic of debate among political parties, and this can be an obstacle to the pursuit of effective CF policies (Wreford *et al.*, 2017). A trade-off will likely arise between the current measures under the second pillar and the potential measures dedicated to CF under the first pillar, thus necessitating an increase in policy resources. This has been mentioned in a recent study on the possible pathways of the 2028-2034 CAP Reform (Guyomard *et al.*, 2024) and in the EC's Communication on its "Vision for Agriculture and Food" (EC, 2025).

It would therefore be more appropriate to reconfigure existing tools to enhance carbon storage to effectively meet environmental objectives, including the intermediate target of reducing net internal greenhouse gas emissions (net emissions) by at least 55% compared with the 1990 levels by 2030, as required by the European Climate Law (Regulation No. 2021/1119). In addition, the numerous national initiatives related to carbon storage, which are based on a variety of mechanisms (Van Hoof, 2023; Raina *et al.*, 2024), could complement and stimulate the design of effective EU-wide measures, also in relation to other environmental policies. In addition, a recently published study conducted in Poland (Gołasa *et al.*, 2025) has shown that when farmers are not fully aware of CF practices, there is reduced adoption of CF and, consequently, reduced effectiveness of the carbon sequestration policy itself. Further research should focus on identification of the most suitable mechanisms for CF remuneration, also building on the most effective national initiatives that received positive feedback from the farmers regarding the implementation.

Expanding CF practices to a greater number of farmers through the CAP is an appropriate path to generate significant quantitative effects in the primary sector's mitigation strategy in the EU. This would also justify the presence of specific subsidies to citizens – the policy funders – given the existence of environmental objectives and the involvement of public-interest resources, such as soil and air quality, which are public goods connected to and influenced by CF activities (Cooper *et al.*, 2009; Strohschneider, 2024).

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AUTHOR CONTRIBUTIONS

A.F.: Conceptualization, Writing – Review & Editing, Supervision, Project administration, Funding acquisition. P.E.B.: Writing – Original Draft. S.C.: Writing – Review & Editing, Supervision, Validation.

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