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# The evolving landscape of farmland ownership in Europe: Implications for food system sustainability

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ABSTRACT

This study examines the evolving dynamics of farmland ownership in Europe, focusing on the implications of ownership changes, foreign direct investments (FDI), and land concentration on the sustainability and resilience of European food systems. A scoping review of academic literature, available data sources, and policy documents revealed a knowledge gap regarding the evolution of European farmland ownership and its sustainability impacts. To address this, a pan-European geospatial statistical analysis was conducted, identifying ownership patterns, temporal changes and related economic performance. Subsequently, the statistical analysis provides a foundation to assess how ownership transformations affect food system sustainability and resilience. Findings show that in 2020, family farms were the dominant landowners across Europe. However, between 2016 and 2020, a shift toward company-owned farms occurred, particularly in Central and Eastern Europe. Drawing on global research on land acquisitions and sustainable agriculture, the study underscores that while company-owned farms may offer economic efficiencies, family farm ownership is vital for food security and local control over land and production. The study calls for continued monitoring of ownership trends and deeper investigation into their benefits, risks, and consequences. It recommends policy measures that balance investment incentives in the European food system with protections for local communities, that promote transparency in land transactions, and safeguard the long-term sustainability of European agriculture by upholding labor and environmental standards.

## 1. Introduction

Sustainable agricultural production and resilient access to food and water is fundamental for human lives on this planet (FAO, 2018; World Bank, 2024; Matthews et al., 2022). Today's food system is highly complex and fraught with risks (Clapp, 2016; Rasva & Jürgensson 2022; Santangelo, 2018). It operates under challenging conditions, including occasional droughts, water shortages, pandemics, and diseases. These challenges are further compounded by rapid technological and digital advancements, as well as transnational trade involving extensive supply chains and stringent product quality controls. The involvement of multiple actors across different time zones and locations, often without the possibility of direct communication, adds another layer of complexity to the system. On a global scale, financial actors such as capital-rich nations and affluent corporations are dominant in the food and agricultural sectors, from procuring seeds, machinery and diesel to selling and marketing food products (Clapp, 2016; McMichael, 2014; Slätmo, 2018; van der Ploeg et al., 2015).

Moreover, the increase in farm size, both in terms of land per farm unit and capital turn-over per year, indicate the hardship to keep a stable food production in Europe (Eurostat, 2022). The traditional 'good farmer' who actively tilled the land, cleared ditches, maintained neat and tidy fields, and provided work and food for local and regional markets is less common today as fewer people pursue food production as their profession (Rasva & Jürgensson 2022; Teklemariam et al., 2015). This said, institutions such as WHO (2021) emphasize that traditional food markets continue to play a central role in communities and the food systems of the European Region. Further, the Russian invasion of Ukraine is impacting individual farmers, food sector supply chains, and societal food supply (EC, 2024a; 2024b; Kotykova et al., 2025). As a response, the European Commission has implemented sanctions aimed at crippling the Russian economy (EC, 2024a; Glauber and Laborde,

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2022). In this context, European self-sufficiency in food, as well as maintained ownership of land and resources, is becoming increasingly important (Rudloff et al., 2024; Slätmo, 2017).

This study aims to investigate how farmland ownership in Europe influences the sustainability and resilience of European food systems. Building on previous research in the field and a literature review of topics such as food security, transnational land acquisition, and land tenure in Europe, we use publicly available geospatial statistics at a pan-European level to analyse the farmland ownership patterns, changes in ownership over time, and the relationships between ownership types and farm economic performance.

Following this introduction, the next section provides the background to the study highlighting key trends in European food systems. This is followed by a presentation of the methods and approach used in the study. The results are then presented, followed by a discussion of the findings in relation to previous research. Finally, we summarise key insights and recommendations, particularly concerning the EU rural vision and EU's Common Agricultural Policy (CAP).

## 2. Background

This study examines the resilience and sustainability of European food systems through the lens of land tenure. It focuses on processes such as farmland concentration, foreign direct investments in agriculture, and farmland acquisitions. Given that European countries are under-researched in this area, the study therefore contributes to enriching our understanding of (European) food security and food sovereignty (Kay et al., 2015; van der Ploeg et al., 2015).

In 2018, agricultural land made up 39.1 % of the total area in the EU, for a total of 9.1 million agricultural holdings in 2020 (Eurostat, 2024). The number of farms in the EU declined significantly between 2005 and 2020, decreasing by approximately 37 % (equivalent to 5.3 million farms). However, during this period, the amount of land used for agricultural production remained stable (Eurostat, 2022), reflecting a phenomena of land concentration, defined as the process where large agricultural corporations increasingly purchase or lease land from smaller agricultural producers (Rasva & Jürgensson, 2022). This trend is exemplified by an increase in the number of large holdings, with fewer actors owning and controlling the majority of farmland in Europe. While most EU farms are small, just 7.5 % of farms—those 50 ha or larger—managed two-thirds (68.2 %) of the EU's farmland (Eurostat, 2022, 2024). The perception of (farm)land as a reliable investment (Lambin et al., 2001; Magnan, 2015; Saravia-Matus et al., 2013; Slätmo, 2018), combined with factors such as the financial struggles faced by many small and medium-sized farm businesses (Czekaj et al., 2020) and the EU's Common Agricultural Policy (CAP), which allocates support through direct payments to landowners, has contributed to farmland concentration in Europe (Burja et al., 2020; Gonda, 2019; Kay, 2016; and Rasva & Jürgensson, 2022). It is thus essential to expand the evaluation of land equality and its distribution in the context of sustainable agriculture (Cristoiu et al., 2007; Clapp, 2016; FAO, 2018; Primdahl and Swaffield, 2010; Robinson, 2024; Slätmo et al., 2017a; Velten et al., 2015).

This study focuses on exploring farmland ownership in Europe, analysing the geographical distribution of various ownership types, and assessing how these ownership structures affect economic performance. Here, we categorise land ownership based on the classifications available in the publicly accessible Eurostat database. These categories include: (i) natural persons, referring to family farms; (ii) legal persons, which encompass corporations, cooperatives, or associations; and (iii) group holdings, defined as farms owned, rented, or managed by multiple natural persons, legal persons, or a combination of both.

The implications of the observed patterns and changes in farmland ownership are discussed in light of various aspects of sustainable agriculture. These include social and environmental factors such as regional access to food, water and soil quality, and the impact of farmland ownership on biodiversity (Cristoiu et al., 2007; FAO, 2018; Saravia-Matus et al., 2013).

An important factor in understanding the relationship between farmland ownership and regional food access is foreign direct investment (FDI) in agriculture. FDI refers to investments made by entities from one economy to acquire lasting management influence (10 % or more of voting power) in enterprises operating in another economy (FAO, 2023; OECD, 2024). It establishes stable, long-term economic links and can take the form of mergers and acquisitions, or greenfield investments (FAO, 2023; OECD, 2024). In agriculture, FDI includes investments in crop farming, farm machinery, inputs, food processing, logistics, and land acquisitions –commonly referred to as "land grabs"—which have been extensively studied on a global scale (Antonelli et al., 2015; Bunkus and Theesfeld, 2018, Chiarelli et al., 2022, De Maria et al., 2023; Interdonato et al., 2022; Mechiche-Alami et al., 2019; Müller et al., 2021, Rasva & Jürgensson, 2022; Santangelo, 2018). These investments can significantly influence local food security and agricultural practices by introducing capital, technology transfer, and market access while also raising concerns about land governance and the displacement of smallholder (Hallam, 2011).

The trade in farmland often involves financially robust transnational companies investing in regions with favourable climates for food production and low economic risks (Magnan, 2015; Slätmo, 2018). According to Interdonato et al. (2022), the dynamics of global land trade predominantly reflect historical power asymmetries between the Global North and Global South, with G20 countries frequently investing in southern regions such as Sub-Saharan Africa, Latin America, and Southeast Asia. However, other patterns also exist, including South-South investments (e.g., Latin American countries investing in Africa) and those involving economies like the BRICS nations (Brazil, Russia, India, China and South Africa). (Interdonato et al., 2022, Mechiche-Alami et al., 2019; Teklemariam et al., 2017).

To address some of the pressing challenges from farmers perspective, such as cash flow difficulties, EU countries are permitted to advance higher levels of direct payments under the Common Agricultural Policy (CAP) (EC, 2024b). Additionally, the CAP for 2023–2027 has been reformed to reduce administrative burdens on farmers, ensuring a more efficient and supportive framework for agricultural activities (EU, 2024a; 2024b), and there are initiatives for enhancing direct dialogues with branch organisations (EC, 2024c).

In the EU, farmland markets are regulated at the Member State level, as there is no specific EU legislation governing land market transactions (Vranken et al., 2021) or farmland rentals (Ciaian et al., 2012). According to Vranken et al. (2021), there is significant variation between European countries in their agricultural land market regulations (cf. Ciaian et al., 2017). Measures implemented by individual Member States include protection for non-landowning farm managers, restrictions to prevent land fragmentation (e.g. minimum plot sizes for sale), requirements to publicly announce sale offers, procedures for selling public land, public actor approvals for share deals, pre-emptive rights for public bodies or family relatives, and moratoriums on transferring ownership after acquisition or selling public land. While some countries have heavily regulated markets, such as Croatia, Hungary, Poland and Romania, others adopt a more liberal approach, including Czechia, Denmark, Ireland and Finland (Vranken et al., 2021).

## 3. Methodology

### 3.1. Scope and analytical procedure

This study adopts a realistic yet eclectic theoretical approach, allowing the research problem to guide the selection of analytical perspectives used to conceptualise the real-world phenomenon under investigation (Sayer, 1984; May, 1997). The sustainability and resilience of European food systems remain a contested research field, as they are deeply intertwined with critical issues such as security, sovereignty,

territory, ownership, hunger, and access to resources (Primdahl and Swaffield, 2010). Because data collected in scientific research is often influenced by pre-existing conceptualisations –whether consciously or unconsciously (Sayer, 1984, p.49–50; May, 1997) - it is not immediately clear which methods or data should be created or sought to address the aims of this study. Investigating the sustainability and resilience of European food systems is particularly complex, as these terms carry normative dimensions. The values associated with "sustainability" and "resilience" can be seen as prescriptive, implying specific actions or outcomes. The aim here is not to prescribe a specific approach to agricultural practices. Instead, "the sustainability and resilience of European food systems" refers to a system that ensures societal access to nutritious food, supports a healthy environment, and secures the livelihoods of individual farmers, even amidst varying levels conflict within and around Europe. This vision seeks to achieve sustainable agricultural production while maintaining resilient access to food and water.

This study employs a multi-method approach to achieve both comprehensive and detailed insights. It combines a literature review with geospatial data analysis to provide a more realistic understanding of the issues at hand. The research began with a scoping review of literature and data. During this phase, we examined journal articles, research reports, book chapters, and information from official public and crowd-sourced online data platforms. This review helped us create a background based on clear questions about the materials. It also showed which data were best for studying European farmland ownership, and which calculations were most novel. Finally, the literature review guided our statistical analysis. We used it to examine farmland ownership and trade, farm economic performance, and the impacts on individual farmers as well as societal access to food.

### 3.2. Literature review

To identify limitations in existing knowledge and to address the research questions guiding this study, a scoping review was selected as the most appropriate literature review methodology. Scoping reviews are particularly well suited for mapping complex and underexplored fields of research where definitions, frameworks, and empirical applications vary across disciplines and contexts (Peters et al., 2015). Unlike systematic reviews that focus on testing interventions or providing narrow syntheses, scoping reviews can include many types of evidence. This includes peer-reviewed literature, policy documents, reports, and grey literature (Peters et al., 2015; Snyder, 2019).

The initial search for research literature was conducted on January 24, 2024, using the Scopus platform to incorporate insights from journal articles, books, book chapters, and conference papers into the study. Additionally, other relevant documents, reports and data were identified and included based on the Scopus findings and the Authors' prior knowledge in the field.

The process for identifying documents on Scopus is described hereinafter. On the Scopus search page, we conducted a search within the "Article title, abstract, keywords" field using the terms: 'land acquisition', 'agriculture', and 'Europe', which yielded 45 documents. To ensure the inclusion of relevant studies, we tested additional term combinations. For example, adding the term 'transnational' reduced the results to 4 documents, while adding the term 'food security' also narrowed it down to other 4 documents. To maintain broad results in the initial stage, we decided to proceed with the set of 45 documents.

To ensure the inclusion of the transnational component –specifically, the phenomenon of land ownership by actors from other countries—we also harvested documents using 'Transnational land acquisition' as search terms in the "Article title, abstract, keywords" field. A total of 77 documents was found, which was reduced to 27 when adding the term 'land grabbing'. To keep the scope as broad as possible at this stage, we opted to proceed with the 77 documents.

The search results of 45 and 77 documents were saved. To focus on European countries, the results were filtered in the Scopus database to include only studies centred on Europe. For example, documents covering Ghana, South Africa or Namibia were excluded, while those focusing on Italy, Spain, Germany, Sweden, or Switzerland were retained. This step reduced the results to 43 and 40 documents, respectively, for a total of 83.

The titles and abstracts of these 83 documents were manually reviewed to identify those relevant to the study's aim and research questions. Documents not directly related to the topic or geography of interest were excluded. If the title and abstract did not provide enough information, the document was included for further in-depth review to determine its relevance.

From the 43 documents retrieved using the terms: 'land acquisition', 'agriculture', and 'Europe', six were deemed relevant for further study. The high exclusion rate highlights that many studies focus on non-European countries or other aspects of agriculture unrelated to ownership and food security. Similarly, reviewing the 40 documents obtained with the term 'Transnational land acquisition' (limited to European countries) led to further exclusion due to duplicates or lack of relevance, leaving 14 suitable documents.

In total, 20 documents (6 from the first search and 14 from the second) were selected for detailed analysis to explore how large-scale land acquisitions for food production in Europe impact food sovereignty and security within the EU. Additional relevant literature was identified using chain-referral sampling by examining citations within these initial documents.

To ensure the inclusion of the European policy context, the JRC Publications Repository was searched on September 2, 2024. Using the terms "land AND tenure AND ownership", the search covered all science areas, publication groups, and years, yielding 105 results. These were manually reviewed to identify relevant reports for this study. Reports focusing on energy, soil degradation, specific countries, SDG guidelines or similar topics were excluded. Ultimately 20 reports from the JRC repository were selected to contribute to the background and policy context for this study. Including these sources allowed us to add a section on policy implications.

The results from the literature review informed the focus of the statistical analysis.

### 3.3. Statistical data and analyses

To analyse land concentration and transnational land acquisitions of agricultural land in Europe, data on farmland and farming from 2016 and 2020 were obtained from Eurostat (Eurostat, 2022;2024). This data source was selected after reviewing multiple datasets available at the pan-European level, including those from the OECD, FAO, Land Matrix, and other initiatives. Eurostat data was deemed most aligned with the study's objectives as it provides detailed information on farm holdings, changes over time, farmland size, turnover, and legal ownership structure. More details on the procedure and motivations behind this choice are included in Appendix A.

The Eurostat dataset includes metrics linking legal ownership to agricultural factors such as utilized agricultural area, economic size, and production inputs across NUTS-2 regions. This data serves as the foundation for analysing ownership patterns and their evolution during the period. For this study, land ownership is classified into three categories provided within the Eurostat database:

1) **Natural Person:** this refers to an individual, group, or legal entity responsible for operating an agricultural holding. In simpler terms, it primarily represents family farms;
2) **Legal Person:** this includes entities such as corporations, co-operatives or associations that are legally recognized as having rights and obligations separate from the individuals who own or manage them;
3) **Group Holding:** this refers to agricultural enterprises collectively owned, rented, or managed by multiple natural persons, legal

persons, or a combination of both. These holdings may involve partners jointly managing individual farms as a single operational unit or pooling resources to create a unified farm. Such cooperation can be formalised through legal agreements or written contracts, but in some Member States, informal arrangements like oral agreements or "de facto" associations are also recognised.

The following analyses were conducted for this study, with detailed methodologies provided in Appendix A:

**Farmland ownership share (2020):** the share of farmland ownership relative to total agricultural land was calculated to assess the distribution of ownership types in 2020 (cf. Fig. 1: Maps 1, 2, and 3). This process involved first quantifying the total farmland area in hectares by summing the areas associated with the three ownership types: Natural Persons (NP), Legal Persons (LP), and Group Holdings (GH). Once the total agricultural land was established, the percentage share of each ownership type was calculated by dividing the farmland area of each ownership type by the total agricultural land and multiplying by 100. This approach provided a clear understanding of the proportional contribution of each ownership category to the total agricultural land. The analysis of farmland ownership shares in 2020 faced limitations due to incomplete data reporting across NUTS-2 regions for each ownership type. For Natural Persons (NP), 2.35 % of the regions did not report the area dedicated to this ownership type in 2020. Legal Persons (LP) showed a satisfactory reporting, with 3.14 % of regions lacking data in 2020. Group Holdings (GH) exhibited the most substantial data gap, with 52.94 % of the regions not reporting in 2020. These gaps in the database highlight challenges in achieving comprehensive ownership data, particularly for group holding, which consistently shows the highest rates of non-reporting. This uneven availability of data limits the ability to fully understand the distribution and trends of farmland ownership across Europe.

**Land Ownership Index (2020):** this index was developed to measure the weighted difference between the proportions of land owned by legal and natural persons (in hectares per region in Europe). A positive index indicates a higher proportion of land owned by legal persons, while a negative index indicates a higher proportion owned by natural persons. Group Holding areas are represented separately as a percentage share out of the total farmland area, with proportional circles on the map. (cf. Fig. 2: Map 4); Normalization of the data was conducted for each land ownership type and region, to prevent bias from larger or smaller total areas. This was done by dividing the hectares of each land ownership by the total farmland area in hectares of the region.

Values adopted for elaborating the index were:

$\text{Land Ownership Index(LOI)} = \text{Wn} \times \text{n} \times \text{Wl} \times \text{l}$

Where:

Wn = -1 value for natural person areas

Wl = 1 value for legal person areas

n = hectares of natural person / total farmland hectares

$l$ = hectares of legal person / total farmland hectares

g = hectares of group holding / total farmland hectares

**Farmland Dynamics of Change (2016–2020, in hectares)**: this analysis illustrates changes in farmland ownership across NUTS-2 regions between 2016 and 2020, categorized by ownership types: Natural Persons (NP), Legal Persons (LP), and Group Holdings (GH) (cf. Fig. 3: Map 5); The analysis was conducted by comparing normalized ownership values for 2016 and 2020, allowing for the detection of trends such as increases, decreases, or stability in each ownership type. The classification approach applied the following specific rules to interpret the dynamics:

i. Regions where the 2016 ownership area was zero for a particular type are labelled as "None in NP," "None in LP," or "None in GH," representing the absence of ownership data in that category.
ii. For regions with existing ownership in 2016, an increase or decrease is determined based on whether the 2020 normalized value is higher or lower than the 2016 value.
iii. The label for regions showing no changes between the two years was created, but there was no occurrence of this classification in the dataset.

The combined analysis provides a comprehensive label for each region, summarizing the dynamics for all three ownership types.

**Economic Performance Analysis and Farmland Ownership**: This analysis links farmland ownership areas to the economic sizes of farms in Europe, measured in Euros (cf. Fig. 4: Map 6). The Economic Dynamics of Land Ownership Type (2016–2020) analysis evaluates the changes in the economic size of farms, measured in euros, for each ownership type: Natural Persons (NP), Legal Persons (LP), and Group Holdings (GH). The comparison identifies trends such as increases, decreases, or stability in economic size of the farm over the period.

The analysis applied the following labels based on specific criteria:

i. Regions with no recorded data for an ownership type in 2016 are labeled as "No data for NP" "No data for LP" or "No data for GH" representing the absence of information.
ii. For regions with available 2016 data, an increase or decrease is identified by comparing the economic size in 2020–2016.

i. The label for no changes between the two years was created, but there was no occurrence of this classification in the dataset.

Similar to the previous method for quantifying the changes in hectares, the resulting combined label for each region summarizes the economic dynamics for all three ownership types. This approach provides a view of shifts in the economic performance of farmland ownership, enabling the identification of regions where ownership types are increasing, declining, or stable economically. The labels facilitate a clear and comparative visualization of economic performance trends across regions together with the analysis of area (hectares) for each ownership type.

To give a more stable analysis the economic performance, the data was also investigated in relation to all regions with an increase in LP over the 2016–2020 time period, this to give an indication if the LP ownership type would increase the economic performance.

**Additional tests with the data**: The authors also explored additional analyses with the data that were used to validate the presented results. These include geospatial analysis of the percentage change in farmland ownership from 2016 to 2020 and examining regional disparities between ownership types using the standard deviation of Land Ownership Index (LOI) values. Appendix A provides more details on these methods. To investigate the potential implications of farmland ownership types, the authors also tested linking its spatial distribution to sustainability aspects at the regional level, including environmental and social factors. While there is potential for further research in this area, it requires accepting the limitations of using NUTS2-level data as a proxy for farm-level performance. Despite its coarseness for studying farming, this approach allows geospatial analyses to be conducted at the European scale. As an example, the authors tested relationships between land ownership types and environmental data (e.g. High-natural level farmland) to assess whether ownership type influences environmentally friendly farming practices. While the results were promising, they were excluded from this article due to the outdated nature of the environmental data (from 2012). Instead, the study focused on testing relationships between land ownership types and the sustainability indicator of economic farm performance (Fig. 4: Map 6).

### *3.4. Analysis*

The results of the statistical analysis presented in chapter 4 were

manually interpreted in the light of the insights from the literature reviewed. We looked at how different ownership structures affect economic performance and social and environmental factors, such as regional access to food, water and soil quality, and biodiversity. Chapter 5 then links trends of European farmland ownership to the sustainability and resilience of food systems. To keep the findings relevant for policy; –we compared our combined literature review and spatial analysis with current European rural policies, including the Common Agricultural Policy and (farm)land regulations.

## 4. Results: spatial distribution of farmland ownership, dynamics and economic performance

### 4.1. Farmland ownership distribution in Europe

The analysis of farmland ownership distribution in the EU reveals notable patterns and significant differences across Member States. In 2020, family farms, classified as "Natural Persons" (NP), were the dominant ownership type, accounting for approximately 70 % of agricultural land in Europe. This was followed by Legal Persons (LP), owning 25 %, and Group Holdings (GH), owning 5 % (Fig. 1: Map 1, 2, 3). The predominance of Natural Persons underscores the traditional structure of farmland management both within the EU and globally (Fig. 2: Map 4, Fig. 3: Map 5).

At the regional level, most European regions had over 60 % of farmland owned by family farms (i.e., Natural Persons). However, some countries, such as France, Czechia, Bulgaria and Germany stood out with regions where NP ownership was significantly lower, ranging between less than 35 % and 55 % (Fig. 1: Map 1).

The distribution of farmland owned by Legal Persons in 2020 shows a generally even spread across the EU but with clear regional disparities (Fig. 1: Map 2). At the national level, France led with 11.35 million hectares owned by private companies, representing 8.3 % of the EU's total agricultural land. Other countries also demonstrated relatively high levels of private ownership, including Spain (4.1 %), Romania (3.2 %), and Germany (2,1 %). At the regional level, France, Czechia, Romania, and Germany exhibited significant internal variations in LP ownership shares (Fig. 1: Map 2).

For Group Holdings, data limitations for several countries hinder a comprehensive understanding of their distribution in the EU (Fig. 1: Map 3). Among the countries reporting GH data for 2020, France displayed pronounced regional disparities, with GH ownership ranging from more than 40 % to less than 10 % of agricultural land. Germany showed similar but less extreme patterns, with shares varying between less than 10 % and 30 %. On the other hand, countries like Sweden, Finland, Denmark, and Spain exhibited more uniform distributions of GH ownership, generally between less than 10 % and 20 % of agricultural land (Fig. 1: Map 3).

### 4.2. Changes in farmland ownership over time (2016–2020)

The analysis of farmland ownership in Europe between 2016 and 2020 highlights significant shifts in ownership patterns, as illustrated by the Land Ownership Index (Fig. 2: Map 4) and changes in farmland ownership distribution (Fig. 3: Map 5).

Natural Persons remained the dominant ownership type, although their share on an European level decreased from over 72 % of farmland in 2016 to approximately 67 % in 2020 (Fig. 2: Map 4). NP ownership was particularly strong in countries like Austria, Italy, and Slovenia, where it consistently exceeded 90 %, reflecting a preference for family-owned farms. Similarly, Norway and the Netherlands maintained high NP shares of over 92 %. In contrast, NP ownership was significantly lower in countries such as Czechia and Slovakia, where it accounted for less than 30 %, indicating a stronger presence of other ownership types.

Legal Persons ownership is the dominant form in countries like Slovakia and Czechia, where LP consistently exceeded 70 % and 80 %, respectively. France experienced a notable decline in LP ownership, dropping from 65.4 % in 2016–41.5 % in 2020, suggesting a shift in ownership structures. Other countries, such as Portugal and Romania, exhibited a more balanced distribution, with LP holding around 35 %-40 % of farmland.

Group Holdings (GH) were generally less prevalent but showed notable increases in specific countries. For instance, GH shares in Germany rose slightly from 18.7 % in 2016–20.5 % in 2020. In France, GH

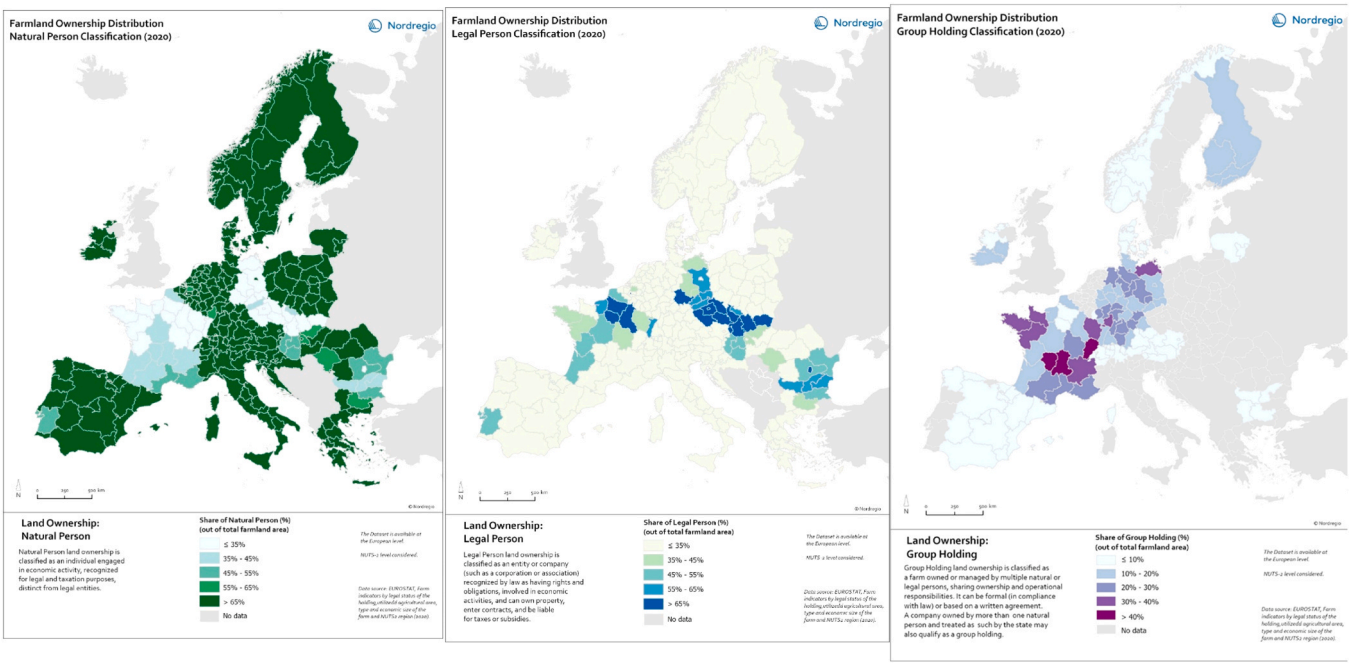


**Fig. 1.** Maps over Land Ownership of Farmland in Europe 2020. From the left the figure show Map 1: Farmland Ownership distribution in the category of Natural Persons for the year 2020 and on NUTS-2 regional levels. Map 2: Farmland Ownership distribution in the category of Legal Person for the year 2020 and on NUTS-2 regional levels. Map 3 Farmland Ownership distribution in the category of Group Holdings for the year 2020 and on NUTS-2 regional levels.

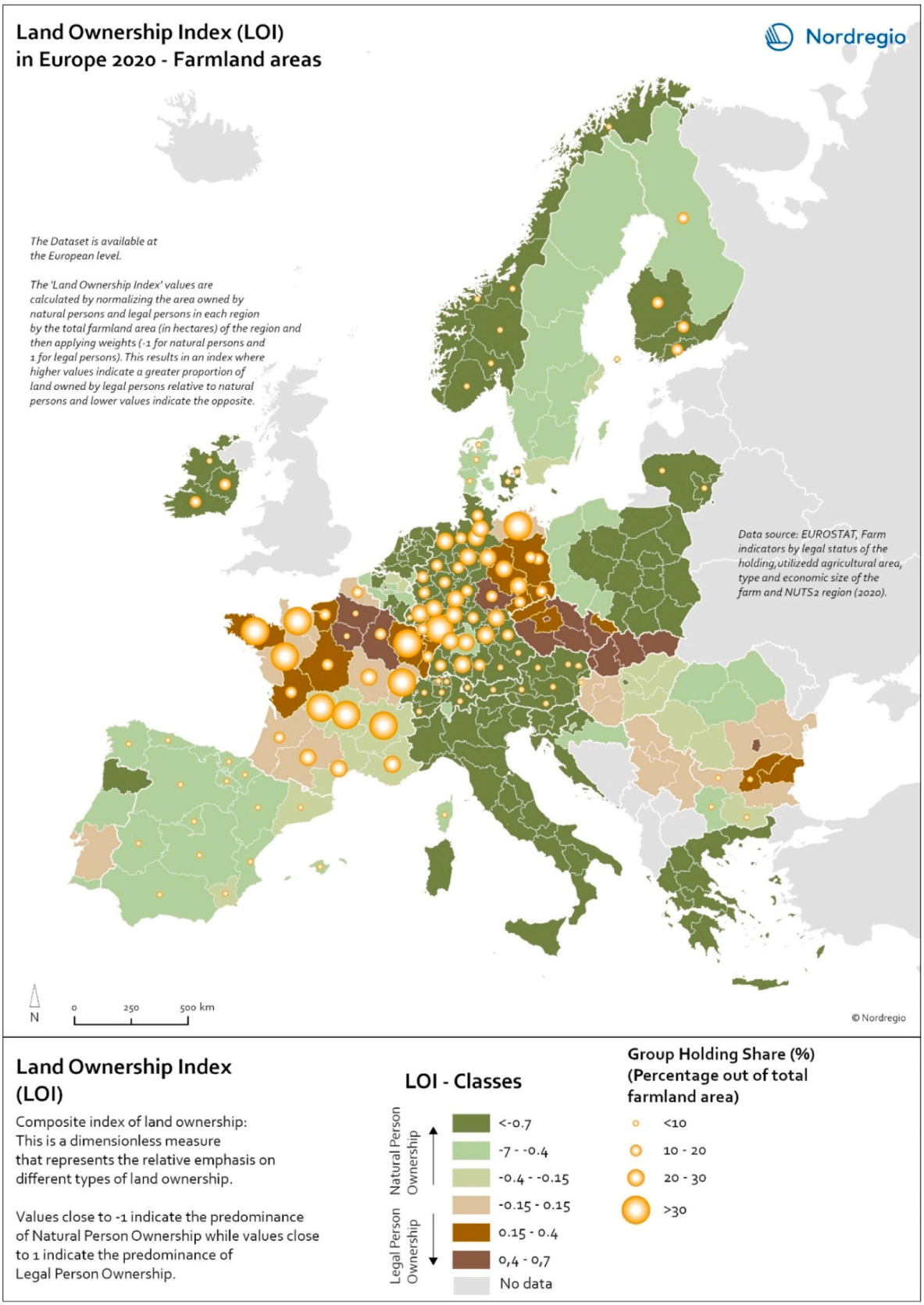


**Fig. 2.** The figure entails Map 4 which is the Spatial distribution of Land ownership index in Europe. The unit used to measure predominance: the number of hectares of ownership type out of total farmland area. As can be seen in the legend of the Map 4, the index specifies the predominance of the Natural or Legal Person ownership type. The greener colours indicate a predominance of Natural Person ownership, and the brown colours indicate the predominance of Legal Person ownership. Group Holding ownership is represented in a separate scale due to its lower shares across the regions. It is important to highlight that differences between land ownership types between countries can also be related to the reporting level or detail of each country for each year. In many countries, the data is not reported.

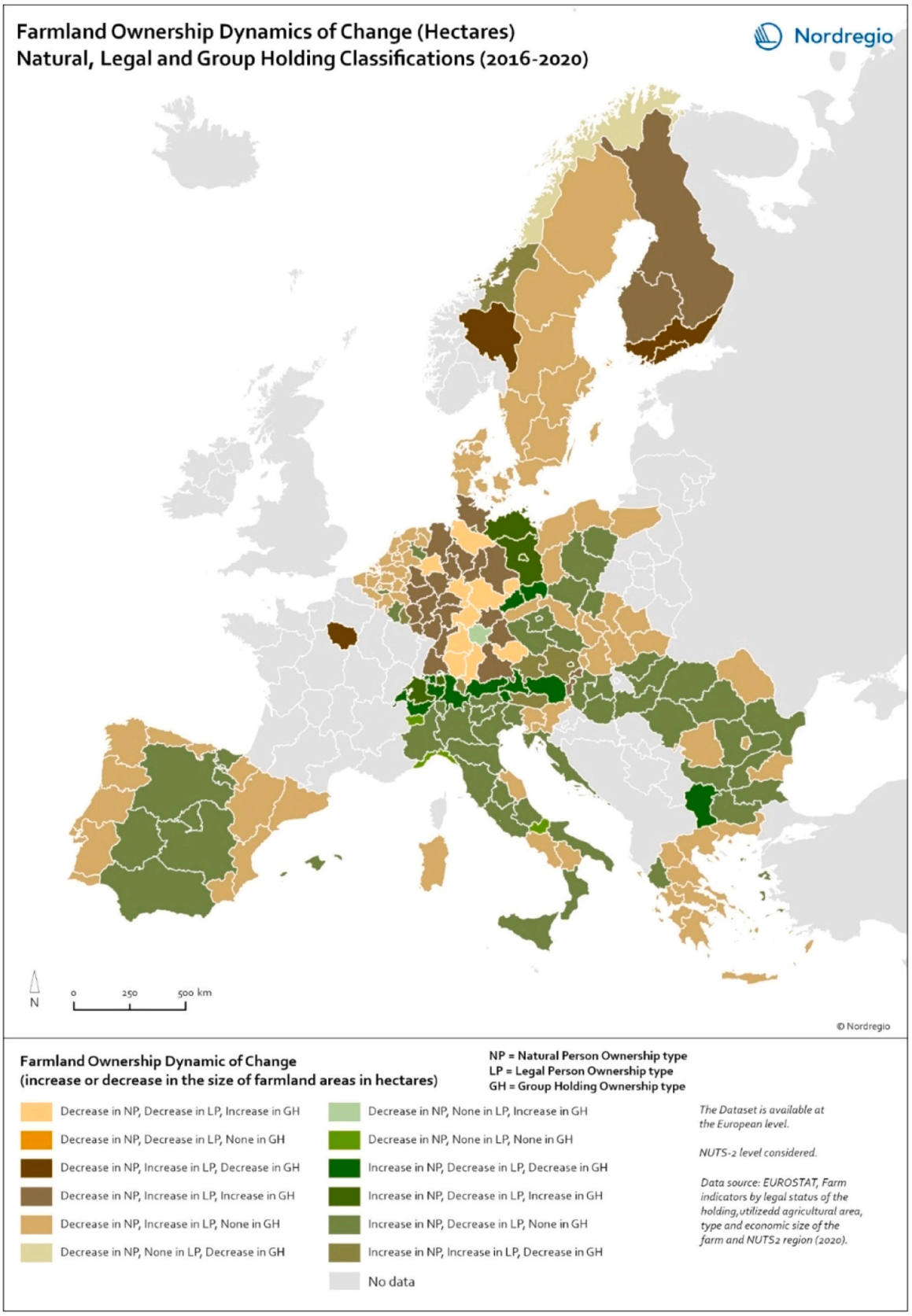


**Fig. 3.** The figure displays the Map 5: Farmland Ownership Dynamic of Change 2016 – 2020. To not only display the changes from one ownership type to another, but to give a dynamic understanding of ownership changes, all possible changes are displayed as different categories in the legend.

ownership increased significantly from 5.8 % in 2016–25.5 % in 2020, highlighting a growing trend toward collective or corporate landholding arrangements.

Over the four years, 2016–2020, there were shifts in farmland ownership patterns across Europe. Countries such as Austria and Norway have seen increases in natural person (NP) ownership, which reflects their strong emphasis on family landholding. Finland and Sweden, despite having a high proportion of natural person ownership, have experienced slight declines in NP ownership from 2016 to 2020, accompanied by small increases in legal person (LP) shares. GH shares have remained stable in most cases, except for significant increases in countries like France and Germany.

The geospatial analysis reveals dynamic changes rather than uniform trends (Fig. 3: Map 5). For instance, coastal regions in Spain, all of Denmark, most regions of Greece, and all regions of Sweden saw decreases in farmland owned by family farms, alongside increases in legal persons-owned farmland. On the other hand, central Spain, northern Italy, and mountainous regions of central Europe experienced increases in natural persons-owned farmland, while legal persons-owned farmland decreased. These findings underscore the evolving nature of farmland ownership across Europe, driven by regional dynamics, type of production, and varying national trends.

### 4.3. Implications of farmland ownership types on economic performance

To explore the potential impact of farmland ownership types on agricultural sustainability and resilient access to food, we analysed the economic performance of farms in European regions between 2016 and 2020 (Fig. 4: map 6). While map 5 (Fig. 3) depicts changes in land ownership types (in hectares), Map 6 (Fig. 4) focused on changes in the economic size of farms during the same period. For instance, regions labelled with red-yellow-brown colours on the map 6 indicate that the family farms in these regions had a negative economic performance 2016–2020, while regions with the green variations of colours in the map 6 are regions were the family farms had a positive economic performance over the same time period.

Regions in Europe show changing patterns of farmland ownership rather than steady trends (Fig. 3: Map 5 and Fig. 4: Map 6). To guide policy and legislation, we need further analysis regarding implications linked to different ownership types. As an example, we look at areas where ownership by legal entities rose from 2016 to 2020 and analyse farm economic performance in those regions.

A total of 118 regions across 20 European countries experienced an increase in legal person ownership during 2016–2020. Among these regions, 84.7 % showed positive economic performance associated with the expansion of LP-owned farmland, while 12.7 % demonstrated negative economic performance.

Countries with predominantly positive economic outcomes of the farms included 17 of the 20 analysed countries, indicating a broad trend of improved economic performance associated to LP-ownership (Fig. 4: map 6). Notably, Greece and Portugal emerged as top performers, with average economic performance increases of 73.8 % and 71.4 %, respectively. However, negative performance was concentrated in 7 countries: Germany, Greece, Spain, Czechia, France, Luxembourg, and Slovenia. Among these, the steepest declines were observed in Czechia (-48 %) and Germany (-23 %), while Slovenia (-7.2 %) and Spain (-8 %) experienced relatively moderate decreases.

At the regional level, disparities in economic performance were evident. In Germany, 14 regions reported positive performance with an average increase of 48 %, while seven regions experienced an average decline of 23 %, underscoring significant regional disparities within the country. In Czechia, three regions showed an average increase of 18.5 %, but one region faced a severe decline of 48 %. Regions with notable negative performance include Oberpfalz (Germany), where economic turnover fell from €8.1 million in 2016 to €3.4 million in 2020 (-58.4 %). Similarly, economic performance declined by 48 % in Moravskoslezsko (Czechia), and a decrease of 38.5 % was recorded in Anatoliki Makedonia, Thraki (Greece). Conversely; regions with significant positive economic performance include Algarve (Portugal), with a growth from €69.5 million in 2016 to €193.6 million in 2020 (+178.6 %), Dytiki Elláda (Greece), with an increase of 175.4 %, and Oberfranken (Germany), where the economic performance of the farming sector grew by 153.6 %. Other regions with strong growth include Centro (Portugal) (+111.4 %) and Detmold (Germany) (+111.3 %), alongside notable increases in other geographic areas, such as Burgenland (Austria) and Zeeland (Netherlands).

These findings highlight a complex interplay of factors influencing farm economic performance beyond ownership type alone. While many regions benefited economically from increased LP-ownership, others faced challenges likely tied to broader structural or regional conditions rather than ownership type alone.

## 5. Analysis: implications of ownership types on the sustainability and resilience of European food systems

This section analyses the results presented in light of prior research, focusing on the implications of farmland ownership types and foreign direct investments for the sustainability and resilience of European food systems.

### 5.1. Dominant type of ownership, trends and economic performance

The geospatial analysis (Fig. 1: Maps 1–3) highlights that family farms, classified as Natural Persons (NP), remain the dominant ownership type across Europe. In 2020, NPs accounted for approximately 67 % of farmland, down from 72 % in 2016. Despite this decline, NPs continue to play a vital role in ensuring food security due to their localised “control over” land and food production. Theoretical risks associated with “distant ownership” and negative impacts of land acquisitions further underscore the importance of family farms in maintaining regional and national control over agricultural resources.

The analysis of land ownership changes (Figs. 2 and 3: Maps 4 and 5) show regionally diverse trends between 2016 and 2020. While there is a general decline in NP ownership, opposite trends are observed within individual Member States. For instance, some regions experienced increases in NP-owned farmland, while others saw growth in LP or GH ownership. These findings highlight that ownership transitions are dynamic and not uniformly directional across Europe.

The analysis on GH ownership is challenged by data limitations for several countries, however the high share of group holdings in certain regions in France in 2020 can partly be explained by the special status of group farming (GAEC), which has been in French law since 1962 and this type of voluntary group farming can have some positive outcomes for viable livelihoods within agriculture (Agarwal and Dorin, 2019).

The analysis of economic performance (Fig. 4: Map 6) demonstrates a general positive correlation between increased LP ownership and farm economic performance at the European level. However, significant regional disparities exist. While many regions with rising LP ownership reported economic growth of the farming sector, others faced declines due to various enabling or hindering factors beyond ownership type alone. For example, Greece and Portugal showed strong economic gains linked to LP ownership; Germany exhibited mixed outcomes, with some regions achieving substantial economic growth while others faced declines; and Czechia experienced both positive and severe negative economic changes depending on the region. These disparities suggest that additional factors—such as local policies, infrastructure, environmental conditions, and market dynamics—play a crucial role in determining farm performance (Busck, 2002; Primdahl et al., 2013; Setten, 2002; Slätmo, 2016; Slätmo et al., 2017).

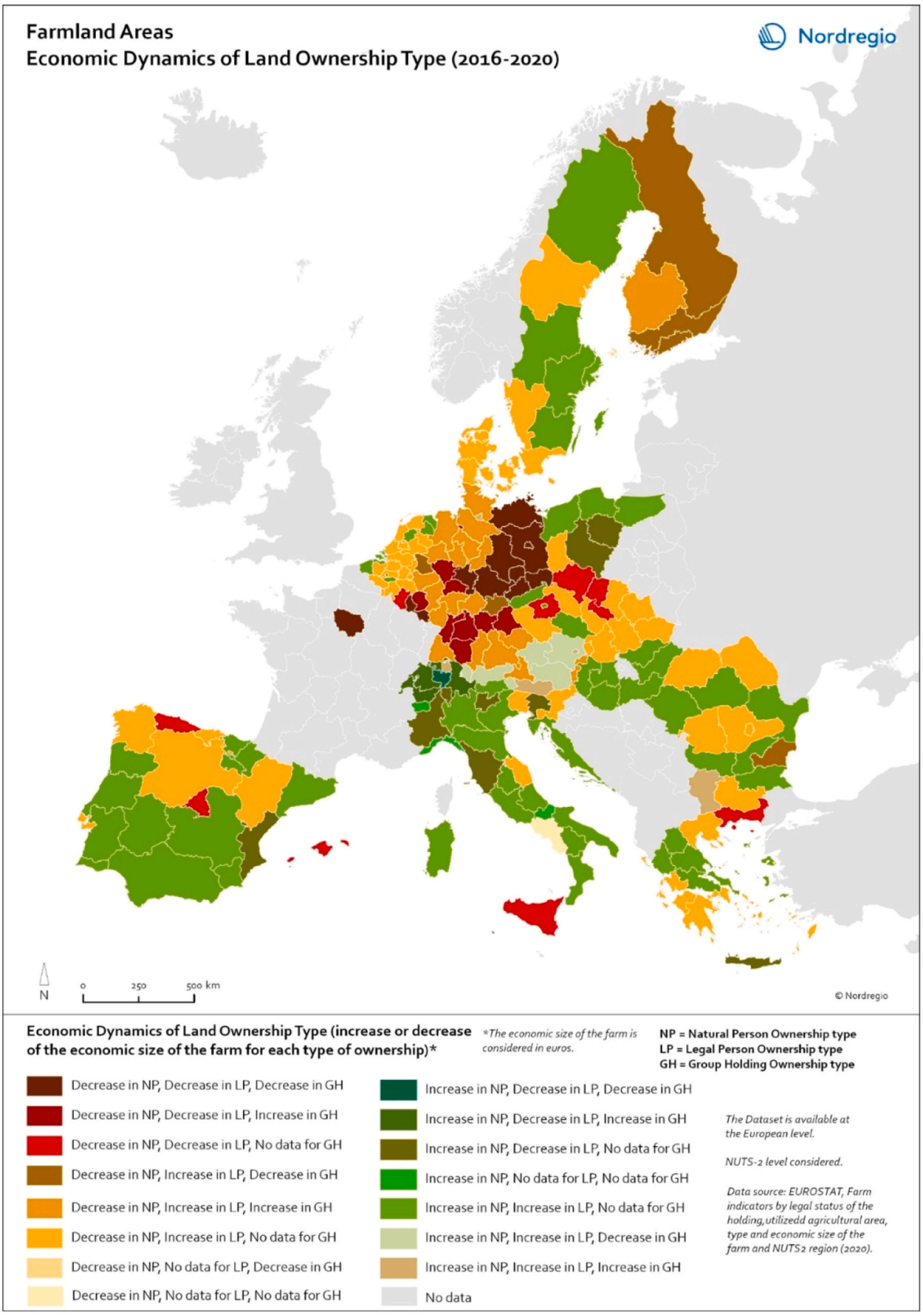


**Fig. 4.** The figure depicts the Map 6 which show the Economic Performance of European Farms linked to Ownership Type 2016 −2020. Using the legend it is possible to observe the distribution of the economic performance, with the red-yellow-brown colors indicating a decrease in the economic size of the farm owned by Natural Persons, and the green variation colors indicating the opposite trend, that is an increase in NP economic performance (i.e. economic size of the farms in the specific region). The purpose of the map is to show the economic performance dynamics of the European regions taking NP as a reference and looking into the other two classifications' dynamics.

### 5.2. Drivers of change in farmland ownership

The dynamics of farmland ownership in Europe are shaped by multiple drivers, including the separation of ownership from farm management, the role of foreign direct investments (FDI), and the increasing involvement of non-agricultural actors. These factors have significant implications for food security, food sovereignty, and the sustainability of European food systems (cf. Saturnino et al., 2011).

One notable trend is the increasing separation between farmland ownership and its management, particularly among Legal Persons and Group Holdings. While this separation can be seen as a strategy to increase liquidity for individual farmers or businesses by selling land to sustain operations, it also introduces risks. For instance, capital gains from land sales can help farmers maintain active farms and continue food production in the short term. This strategy can support food security by keeping farmland productive (Rasva & Jürgensson, 2022). However, detaching ownership from day-to-day management may reduce adaptability to local conditions and weaken oversight of farm operations. Non-local owners, especially those not involved in agriculture (e.g., investment funds), may lack awareness of regional needs and responsibilities, creating uncertainties about land use, food production and resilient provision of food (Antonelli et al., 2015; Burja et al., 2020; Sippel et al., 2017; Teklemariam et al., 2015).

The type of non-local actor acquiring farmland significantly influences outcomes. Non-local agricultural owners with tenancy arrangements can face challenges in adapting to local contexts and ensuring effective farm management due to physical distance (cf. Bunkus and Theesfeld, 2018), while investment funds or financial institutions acquiring farmland often detach ownership from agricultural production entirely (Sippel et al., 2017). This creates risks for food sovereignty, as control over farmland shifts away from local communities (Gunnoe, 2014; McMichael, 2014; Berchoux et al., 2019). In times of conflict or economic turbulence, such arrangements may exacerbate uncertainties about land use and food supply (Burja et al., 2020; Sippel et al., 2017).

FDI plays a growing role in European farmland ownership, with agribusinesses, financial institutions, and other industries increasingly viewing farmland as an attractive investment opportunity (Mechiche-Alami et al., 2019). While FDI can bring capital into the agricultural sector, it also raises concerns: FDI-driven acquisitions contribute to land concentration, potentially displacing small-scale family farms and reducing opportunities for young or aspiring farmers to enter agriculture (cf. Magnan, 2015; Slätmo, 2018); and in countries like Romania, large-scale land acquisitions by foreign investors have sparked fears about losing control over national food production bases, threatening long-term food security (Constantin et al., 2017).

Farmland concentration and "land grabbing" are further exacerbated by EU policies such as the Common Agricultural Policy (CAP), which inadvertently favour large-scale operations over small farms. CAP subsidies often disproportionately benefit large landowners, reinforcing barriers for smaller farmers and young entrants into the sector (Franco and Borras, 2013; Kay et al., 2015; van der Ploeg et al., 2015). This dynamic undermines Europe's traditional model of family farming and its associated multifunctional agriculture.

### 5.3. Foreign Direct Investments (FDI) in European Agriculture, Forestry, Fishing

The global research community has extensively studied the implications of Foreign Direct investments (FDI) and large-scale land acquisitions, particularly in the Global South. These studies often debate whether such investments are beneficial or detrimental to the agricultural sector (Dell'Angelo et al., 2017a,b; Saravia-Matus et al., 2013). On one side, proponents argue for the benefits of capitalist restructuring in agriculture, while critics highlight the need for small-scale farming and land redistribution to local owners (Dell'Angelo et al., 2017a).

In contrast to the Global South, countries in the Global North, including Europe, are considered attractive for FDI due to their "low-risk environments", characterised by stable governments, strong property rights, and well-established investment laws (Bunkus and Theesfeld, 2018; De Maria et al., 2023; Gunnoe, 2014; McMichael, 2014; Magnan, 2015; Slätmo, 2018). However, data on FDI in European agriculture remains limited, particularly regarding its linkages to land tenure and farmland ownership.

From 2018–2022, several European countries ranked among the top global recipients of FDI inflows to agriculture: Norway ranked fourth globally after Indonesia, Brazil, and the United States; Ukraine and Romania were also among the top ten global recipients (FAO, 2023; FAO, 2024). Inward FDI stocks in agriculture, forestry, and fishing for 2022 reveal significant investments in Spain, Italy, France, and Poland (USD 1.2–2.0 billion); Latvia, Hungary, and Estonia (USD 0.8–1.0 billion); Lithuania, Czechia, Austria, Belgium, Greece, Germany, and Slovakia (USD 0.2–0.6 billion); while Sweden and Denmark reported lower levels of FDI stocks for the same period (OECD, 2024). Despite these investments, Europe's share of global FDI inflows has declined significantly—from 30 % in 2013 to just 6 % in 2022—indicating a shift toward Asian (49 %) and American (38 %) markets as more attractive destinations for foreign capital (FAO, 2023; FAO, 2024).

European private actors, public institutions, and NGOs are key players in land acquisitions outside Europe. These investments often target regions with weak governance but high agricultural potential, such as Africa and Southeast Asia (Mechiche-Alami et al., 2019). This aligns with global trends showing most land deals being led by companies rather than governments. Globally, China led FDI outflows to agriculture from 2013 to 2022 with USD 1.71 billion annually—three times more than any other country; Norway ranked second globally as an agricultural FDI provider during this period; and USA followed as the third-largest contributor (FAO, 2023).

Reliable data on land acquisitions within Europe is scarce. While platforms like the Land Matrix Global Observatory (2024) and the Global Atlas on Environmental Justice (2024) provide some insights, the former only focuses on low- and middle-income countries, and the latter solely emphasises cases involving environmental justice conflicts. Studies based on these datasets have examined farmland acquisitions in Eastern and Central Europe—particularly in Romania, Bulgaria, Hungary, Poland, Slovakia, Czechia, Lithuania, and Latvia—highlighting decreasing numbers of farms but unclear ownership patterns due to a mix of owned and rented farmland (Rasva & Jürgensson, 2022). Limited research exists for Northern and Western Europe (e.g Sweden [Slätmo, 2018], Norway [Skog and Bjørkhaug, 2020]), where land trades are often underreported due to business confidentiality and the complexity of the trade relations.

The reliance on foreign capital flows raises questions about food sovereignty and control over agricultural resources within Europe. While FDI can bring financial benefits to the sector, it risks concentrating farmland ownership among large-scale investors and may reduce opportunities for small-scale farmers or new entrants into agriculture. Addressing these challenges requires improved monitoring of land acquisitions within Europe and greater transparency in reporting investment activities.

### 5.4. Positive and negative impacts of FDI and non-family farming

Foreign Direct Investments (FDI) in farmland have been promoted globally as a mechanism to enhance agricultural productivity, rural development, and economic growth. First, FDI provides much-needed capital to modernize farming practices, improve infrastructure, and boost productivity (Bunkus and Theesfeld, 2018; Davis et al., 2022). Second, investments often introduce advanced agricultural techniques and technologies, potentially increasing crop yields and efficiency (Santangelo, 2018). Third, large-scale agricultural enterprises can create employment opportunities in rural areas, supporting local economies

(Saravia-Matus et al., 2013). Finally, larger farm units, such as those under group holdings, may leverage superior bargaining power in concentrated agricultural markets, improving profitability (Saravia-Matus et al., 2013). In some cases, FDI has shown a positive impact on food security in host nations by increasing cropland and production capacity. However, the extent of these benefits depends on the investor's corporate code of conduct and the local context (Santangelo, 2018; Müller et al., 2021).

Despite its potential benefits, FDI in farmland is often associated with significant risks and negative outcomes (Teklemariam et al., 2015). Non-local investors may introduce farming techniques that negatively impact cropland and biodiversity. Studies show that large-scale land acquisitions often lead to substantial losses in species richness due to changes in land use rather than land cover (Davis et al., 2023). Moreover, foreign investors may prioritize export-oriented crops over local food production, reducing food availability for local populations (Müller et al., 2021; Mills et al., 2020). Furthermore, land acquisitions can result in dispossession, forced evictions, land tenure disputes, and reduced water access for local farmers. In a study of transnational land deals across 39 countries, 67 % of trades led to water scarcity for local populations due to irrigation infrastructure changes (Chiarelli et al., 2022; Siciliano et al., 2017). Finally, farmland concentration limits opportunities for younger generations to buy or lease land, making it difficult for them to enter agriculture. This also centralizes decision-making about rural development in the hands of a few large landowners (Burja et al., 2020; Bunkus and Theesfeld, 2018).

FDI presents a paradox where it can simultaneously increase agricultural productivity and threatening local food systems. While crop production may rise due to new investments, the focus on export-driven agriculture can undermine regional food cultures and local market supply chains (Mills et al., 2020). Moreover, the environmental impact varies depending on the investor's practices. For example, developed-country investors may implement environmentally friendly technologies that reduce emissions or degradation, but this is not guaranteed universally (Santangelo, 2018). In Europe, farmland concentration through FDI poses unique challenges. The lack of reliable data on land acquisitions complicates monitoring and regulation, since existing platforms like the Land Matrix Global Observatory focus on low- and middle-income countries. Furthermore, land trade processes are often opaque due to business confidentiality practices(Slätmo, 2018).

In conclusion, while FDI can bring financial resources and technological advancements to agriculture, its impacts are highly context-dependent. Positive outcomes require strong governance frameworks that enforce corporate accountability, protect local farmers' rights, and ensure sustainable farming practices. Without these safeguards, FDI risks exacerbating social inequalities, environmental degradation, and threats to food sovereignty.

### 5.5. Policy implications

Public authorities play a critical role in farmland transactions, particularly in ensuring that land trades align with social, environmental, and economic sustainability goals. Within the EU, this involves balancing the principles of free-market trade with the need to protect agricultural land and rural communities. EU institutions have incorporated references to social and environmental sustainability criteria in various policies and directives, especially for land investments outside Europe. These measures aim to ensure responsible investment practices that safeguard human rights and environmental standards (Antonelli et al., 2015; Nanni et al., 2020). While the EU lacks specific secondary legislation regulating land transactions within its own territory, Member States are permitted to impose restrictions on foreign investments in farmland. These restrictions must align with EU free-market principles but can address legitimate public interests like preserving agricultural communities, reducing land concentration, or strengthening local farmers' positions (Vranken et al., 2021).

Individual Member States have implemented measures to regulate land sales, such as limiting foreign ownership or addressing land fragmentation. For example, studies show that Eastern Germany has faced challenges such as legal irregularities and centralized decision-making in large-scale land acquisitions, necessitating government intervention (Bunkus and Theesfeld, 2018; Vranken et al., 2021). National governments also play a role in protecting farmers' access to land markets. For instance, the Common Agricultural Policy (CAP) includes measures to strengthen farmers' positions in the food supply chain and promote fair trading practices.

Despite existing frameworks, enforcement often falls short. Studies highlight that institutional measures to protect human rights and common lands are often not implemented effectively in practice. Governments frequently grant exclusive land concessions to foreign investors without adequate safeguards (Dell'Angelo et al., 2021a,b). Within Europe, a lack of transparency and reporting on land acquisitions complicates efforts to monitor and regulate farmland trades. This is particularly evident in Northern and Western Europe, where business confidentiality often obscures the details of transactions.

To address these challenges, improved data collection and transparency are essential for tracking land acquisitions and ensuring compliance with sustainability goals and resilient provision of food. This could help advocacy groups in proposing an EU directive on agricultural land to regulate transactions, combat speculation, prevent land concentration, and promote agroecological practices. Such a directive would set binding objectives while allowing Member States flexibility in implementation. In summary, public authorities at both EU and Member State levels are crucial in shaping farmland governance. Their responsibilities include enforcing sustainability criteria, protecting local farmers' rights, and promoting equitable access to land markets while addressing gaps in implementation and data availability.

## 6. Conclusions

This study has explored the dynamics of farmland ownership in Europe, focusing on the implications of ownership changes, foreign direct investments (FDI), and land concentration on the sustainability and resilience of European food systems. The findings underscore both opportunities and challenges associated with evolving ownership patterns and highlight the need for targeted policy interventions to ensure sustainable rural development.

The analysis reveals that family farms, classified as Natural Persons, remain the dominant form of farmland ownership across Europe, reflecting traditional preferences for localised and family-based landholding. However, there is a clear trend toward increased ownership by Legal Persons and Group Holdings, particularly in Central and Eastern Europe. While these shifts can bring economic benefits, such as improved productivity and infrastructure through large-scale investments, they also pose significant risks to food security, sovereignty, and rural livelihoods.

Farmland concentration and distant ownership by non-local or non-agricultural actors –such as investment funds or corporations— raise concerns about the disconnect between land rights, local communities, and agricultural production. This trend can lead to reduced access to land for small-scale farmers and younger generations while centralising decision-making power in the hands of a few large entities. Furthermore, the lack of transparency in land transactions within Europe complicates efforts to monitor and regulate these changes effectively.

To address these challenges and promote sustainable food systems, this study offers several recommendations. First, farmland should be recognized as an asset of fundamental importance for food security and sovereignty. Policies must balance the benefits of liquidity and investment with safeguards to protect local farming communities from speculative practices and land concentration. Second, public data collection on farmland trades is essential to monitor ownership dynamics and FDI impacts. Greater transparency would help prevent speculative practices

that undermine rural development and ensure accountability in land acquisitions. Third, legal protections must ensure that labour rights, tenancy agreements, and environmental standards are upheld when ownership shifts to non-local actors or corporations. Member States should also consider implementing restrictions on land sales to preserve access for local farmers while remaining compliant with EU free-market principles. Fourth, broader stakeholder involvement in decision-making processes related to farmland governance is crucial. This includes engaging producer organizations, rural communities, and regional governments in participatory governance frameworks to ensure equitable outcomes. Fifth, barriers preventing young farmers or new entrants from accessing farmland must be addressed. Reforms to the Common Agricultural Policy (CAP) should ensure subsidies do not disproportionately benefit large-scale investors at the expense of smaller farms. Sixth, strengthened oversight of FDI inflows is necessary to ensure long-term resilience rather than short-term economic gains. To uphold the 'low-risk environments' for investments, host governments should regulate financial actors through tax systems, lease terms, contract obligations, and environmental regulations. Finally, future research should further explore the connections between land ownership changes and sustainability in terms of environmental (e.g., soil health, biodiversity), social (e.g., gender equity, rural livelihoods), and societal (e.g., food security) aspects.

The findings align with the EU's long-term vision for stronger, connected, resilient, and prosperous rural areas. Initiatives such as "Supporting the role of producer organizations" could benefit from integrating knowledge about farmland governance presented in this study. Additionally, fostering dialogue between the European Commission, producer organizations, interbranch organizations, and rural ministers could improve market transparency for agricultural investments while safeguarding rural livelihoods.

This study highlights the complex interplay between farmland ownership dynamics, foreign investments, and sustainability in Europe's food systems. While non-local ownership models can offer economic opportunities under certain conditions, they must be carefully managed to avoid negative consequences for food security, sovereignty, and rural livelihoods across Europe. By prioritizing transparency, participatory governance, sustainability metrics, and support for small-scale farmers, policymakers can foster a resilient and sustainable food system that balances economic growth with equitable development across Member States. Finally, ensuring sustainable farmland governance is not only critical for addressing immediate challenges but also for securing long-term resilience in Europe's agricultural sector amidst evolving global pressures.

## CRediT authorship contribution statement

**Karina Berbert Bruno:** Writing – review & editing, Visualization, Methodology, Formal analysis, Data curation. **Tristan Berchoux:** Writing – review & editing, Writing – original draft, Funding acquisition. **Elin Slätmo:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. : Choice and characteristics of the Statistical Data, and details on the methods applied for the georeferenced statistical analysis

*Data on farmland trade deals*

As described in the methodology sections, the literature review in this study identified a knowledge gap regarding the implications of farmland trade and changes in farmland ownership in Europe. Therefore, the authors searched and assessed data to cover this insufficiency. The procedure applied to identify relevant data for a European study is explained in the following sections.

Inspired by previous research studies such as those by Antonelli et al. (2015); Bunkus and Theesfeld, (2018), Chiarelli et al. (2022), De Maria et al. (2023); Interdonato et al. (2022); Mechiche-Alami et al. (2019); Müller et al. (2021) the researchers searched The Land Matrix Global Observatory, a global and independent land monitoring initiative led by the International Land Coalition (ILC), which collects information on large-scale land deals in low and middle-income countries since 2000. On The Land Matrix Global Observatory, data on land deals for European countries include only deals for Eastern European points.[2] Santangelo (2018) states that land deals on The Land Matrix Global Observatory are probably underestimated in Eastern Europe (cf. Dell'Angelo et al., 2017a). The Eastern European contact point on The Land Matrix Global Observatory was contacted via e-mail correspondence during the first weeks of February 2024, to get a deeper understanding of the lack of deals in other European countries, than Eastern European ones. The contact point refers to the focus of low- and middle-income countries for the Land Matrix Global Observatory as one of the reasons to way some countries in the European region are not covered. Also, a lack of contributors from other European countries and language are mentioned as reasons for why not other central, western, or northern European countries are included. This indicates that it is not necessary so that it is no land deals in other European countries, rather that those potential land deals are not included. This is off course respected, the database is based on a set definition and delimitation, but also in higher income countries, the trade in farmland can potentially cause trouble for food sovereignty and food security for the local and regional inhabitants. With the ambition to cover the whole of Europe, the data from The Land Matrix Global Observatory was not used in this study.

Further, and inspired by previous research studies, such as the one from Dell'Angelo et al., 2021a,b, the possibility of using data from The Global Atlas on Environmental Justice was also considered for this study (The Global Atlas on Environmental Justice, 2024). The atlas is based on a Direction and Coordination Group (DCG) of five members and a large network of collaborators and advisors. The 30 European cases of potential interest to this

[2] Eastern European countries integrated in the initiative and database of The Land Matrix Global Observatory: Albania, Belarus, Bosnia & Herzegovina, Bulgaria, Kazakhstan, Lithuania, Macedonia, Moldova, Romania, Russian Federation, Serbia, Ukraine, and Uzbekistan.

study, categorized as Biomass and Land Conflicts (Forests, Agriculture, Fisheries and Livestock Management) on the webpage of the atlas where manually accessed to judge the relevance for the farming and agricultural focus of this study. The cases that are reported on this platform are categorized as 'conflicts' needed to be 'solved' from an environmental justice perspective. This notion of conflicts as a basis for reporting cases indicate that other cases, for instance those that are perceived as positive land use change or developments, are not included in the database and this bias makes us reluctant to use the data on the open access The Global Atlas on Environmental Justice for this study (Dell'Angelo et al., 2021; the Global Atlas on Environmental Justice, 2024).

The above assessment of data led the authors to further search for public data on land ownership for the whole of Europe. Subsequently, data from Eurostat were considered as suitable for the scope of the study. To utilize publicly funded and available data can enable further comparable studies and monitoring. In the following sections in this appendix the meta-data in terms of concepts and definitions for the included Eurostat data sets, as well as the details regarding the methods utilised are presented.

Concepts and definitions in the dataset provided by Eurostat regarding farm holding ownership

The definitions below can be found in the official documents and metadata of Eurostat (EUROSTAT, 2010; Eurostat, 2024; EUROSTAT, n.d.)

*Agricultural holdings*

The holder of a farm is the person or entity legally and economically responsible, bearing its financial risks. Holders can own, rent, lease, or manage the holding under various legal arrangements. This flexible framework allows farms to be identified based on either their legal status or specific agricultural thresholds, accommodating diverse practices and legal systems across Member States (EUROSTAT, 2010; Eurostat, 2024).

The Eurostat dataset serves as the foundation for analysing ownership patterns in this study. For clarification, land ownership is classified into three categories provided within the Eurostat database:

*Natural Person*

A Natural Person classification in the Eurostat database refers to an individual, group, or legal entity responsible for operating an agricultural holding. The holder manages the holding in their name, assumes its legal and economic responsibilities, and accounts for its financial risks. Holders may own, rent, lease, or manage the holding through agreements such as usufruct or trusteeship.

Holders can either manage the holding ("holder/manager") or delegate daily financial and production decisions to a manager ("holder/not manager"). In the case of sole holder holdings, which are independent holdings operated by one natural person, the holder is typically also the manager, although this is not always the case. For group holdings, only the main holder is recorded.

The term farmer includes any individual, group, or entity conducting agricultural activities within the EU, regardless of their legal status under national law. Sole holder holdings are classified in agricultural statistics based on variables like area, livestock, labor force, and economic size.

*Legal Person*

A Legal Person refers to an entity, such as a corporation, cooperative, or association, that is recognized by law as having rights and obligations independent of the individuals who own or manage it. Unlike holdings operated by natural persons, which are tied to individual ownership or familial arrangements, legal person holdings are owned and managed by the entity itself. This structure enables collective ownership, centralized decision-making, and separation of the farm's legal and financial identity from that of its stakeholders. Legal person holdings differ from sole holder holdings, which are operated by a single natural person, and from shared ownership holdings, which involve joint management by a natural person and family members. They also differ from holding-groups, where partnerships of natural and legal persons operate the holding. In the case of legal persons, the responsibilities and risks of the holding are carried by the entity, governed by its constitution and the legal framework of the Member State.

*Group Holding*

A Group Holding is an agricultural enterprise collectively owned, rented, or managed by multiple natural persons, legal persons, or a combination of both. It may involve partners jointly managing their individual holdings as a single operational entity or pooling resources to create a unified farm. This cooperation must be recognized either through formal legal agreements, written contracts, or, in some Member States, informal arrangements such as oral agreements or "de facto" associations. Group holdings differ from sole holder holdings, where a single natural person operates the farm independently, and from legal holdings, which are owned and managed by a legal entity. Unlike these categories, group holdings emphasize shared ownership and operational responsibilities among multiple stakeholders, fostering collaboration to share risks, compile resources, and leverage collective expertise. By accommodating diverse collaborative structures, this classification recognizes agricultural operations that go beyond individual or corporate ownership. Group holdings are thus characterized by their collective approach, allowing participants to benefit from economies of scale and joint management within a unified framework.

*Farmland Ownership Definitions*

Considering the above concepts adopted by Eurostat, agricultural holdings are classified based on the holder's status, which can include sole holder holdings (operated by one natural person), shared ownership holdings (jointly managed by a natural person and a spouse or family member), group holdings (operated by a group of natural persons as partners), or legal holdings (owned and operated by a legal person). This classification has evolved over time, and until 1997, only sole holdings and legal entities were recognized, but from 2000, group holdings were added in some countries, and by 2020, shared ownership holdings were introduced. Despite these classifications, the legal and economic responsibilities of an agricultural holding are ultimately defined by the rules of each Member State. Within this flexible framework, a farmer is broadly defined as a natural or legal person, or a group of either, conducting agricultural activities within the EU, regardless of their legal status under national law.

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*Method for Farmland Ownership Share in 2020*

The farmland ownership shares relative to the total agricultural land were calculated for the distribution of the three ownership types in 2020. This process involved first quantifying the total farmland area in hectares by summing the areas associated with the three ownership types: Natural Persons (NP), Legal Persons (LP), and Group Holdings (GH). Once the total agricultural land was established, the percentage share of each ownership type was calculated by dividing the farmland area of each ownership type by the total agricultural land and multiplying by 100. This approach provided a clear understanding of the proportional contribution of each ownership category to the total agricultural land in Europe. The formula used for this calculation is as follows:

$$\textit{Percentage Share of Ownership Type} = \left(\frac{\textit{Area of Ownership Type}(ha)}{\textit{Total Farmland area}}\right) \times 100$$

Where:

- Area of Ownership Type (ha) is the farmland area for NP, LP, or GH.
- Total Farmland Area (ha) is the sum of farmland areas for NP, LP, and GH.

The analysis of European farmland ownership shares in 2020 faced limitations due to incomplete data reporting across NUTS-2 regions for each ownership type. For Natural Persons (NP), 2.35 % of the regions did not report the area dedicated to this ownership type in 2020. Legal Persons (LP) showed a satisfactory reporting, with 3.14 % of regions lacking data in 2020. Group Holdings (GH) exhibited the most substantial data gap, with 52.94 % of the regions not reporting in 2020. These gaps in the database highlight challenges in achieving comprehensive ownership data, particularly for group holding, which consistently shows the highest rates of non-reporting. This uneven availability of data limits the ability to fully understand the distribution and trends of farmland ownership across Europe.

*Method for Land Ownership Index*

The Land Ownership index use data for European regions in 2020 to showcase the weighted difference between the proportions of land owned by legal and natural persons (in hectares). The calculations were made with the purpose to depict regional patterns in the ownership across Europe(in hectares). A positive index indicates a higher proportion of land owned by legal persons relative to natural persons, while a negative index indicates the opposite. Normalization of the data was conducted for each land ownership type and region, to prevent bias from larger or smaller total areas. This was done by dividing the hectares of each land ownership type by the total farmland area in hectares of the region. Values adopted for elaborating the index LOI regarding Natural and Legal Person are as follow:

$$\text{Land Ownership Index}(\text{LOI}) = \text{Wn} \times \text{n} \times \text{Wl} \times \text{l}$$

Where:
Wn = -1 value for natural person areas
Wl = 1 value for legal person areas
n = hectares of natural person / total farmland hectares
$l$ = hectares of legal person / total farmland hectares
g = hectares of group holding / total farmland hectares
LOI Interpretation:
If there are a higher number of areas classified as Natural Person (n), the values will be close to $-1$;
If there are a higher number of areas classified as Legal Person ($l$), the values will be close to 1;
Group Holding areas are represented separately as percentage share out of the total farmland area, with proportional circles on the map.

*Strengths of the approach*

- Normalization by the total farmland area of the country/region allows for comparison across regions of different sizes.
- Weighted Index captures the relative importance of different ownership types based on the assigned weights – which are in the same proportion (-1 and 1).

*Improvements and considerations*

While the Land Ownership Index as here developed and presented provides valuable insights into the relative dominance of legal versus natural person ownership, several considerations and potential issues should be noted. First, the choice of weights (-1 for natural and 1 for legal) is subjective, is made for the purpose only to depict patterns and does not reflect the true significance of one ownership type being better than the other, nor those this choice reflect impact of each ownership type in relation to a specific aspect (e.g., social, economic, etc.). Adjustments to weights may be necessary if one ownership type needs emphasis. Additionally, the exclusion of group holdings from the calculation omits potentially important data, even if group holdings are less substantial in overall regional distributions. Finally, the index measures relative differences but does not account for absolute ownership values, meaning regions with similar indices could have vastly different total land areas and ownership scales, which might limit comparative interpretation in absolute numbers.

*Farmland Dynamics of Change (2016–2020, in hectares)*

The Farmland Dynamics of Change (Hectares) Map illustrates the shifts in farmland ownership across NUTS-2 regions from 2016 to 2020, categorized by ownership type: Natural Persons (NP), Legal Persons (LP), and Group Holdings (GH). The analysis was conducted by comparing normalized ownership values for 2016 and 2020, allowing for the detection of trends such as increases, decreases, or stability in each ownership type. The purpose of the calculations and categorizations behind the map is to investigate the changes of European farmland ownership over time. The classification approach applied the following specific rules to interpret the dynamics:

i. Regions where the 2016 ownership area was zero for a particular type are labeled as "None in NP," "None in LP," or "None in GH," representing the absence of ownership data in that category.
ii. For regions with existing ownership in 2016, an increase or decrease is determined based on whether the 2020 normalized value is higher or lower than the 2016 value.
iii. The label for regions showing no changes between the two years was created but there was no occurrence of this classification in the dataset.
iv. The combined analysis provides a comprehensive label for each region, summarizing the dynamics for all three ownership types.

*Method for Economic Dynamics of Land Ownership Type (2016–2020)*

To explore the implications of land ownership on the sustainability and resilience of the European farm system a number of calculations and tests have been developed. One of these are the Economic Dynamics of Land Ownership Type (2016–2020) which evaluates the changes in the economic size of farms, measured in euros, for each ownership type: Natural Persons (NP), Legal Persons (LP), and Group Holdings (GH). The comparison identifies trends such as increases, decreases, or stability in economic size of the farms in each European region over the period.

The analysis focused on assessing the economic performance of land ownership patterns in European regions based on data from two geospatial datasets: Economic Dynamics of Land Ownership Type (2016–2020) and Farmland Dynamics of Change (Hectares). Both datasets provide region-level information, with Farmland Dynamics of Change (Hectares) detailing changes in land ownership types (Natural Person, Legal Person, and Group Holding) and Economic Dynamics of Land Ownership Type (2016–2020) describing economic performance metrics (value of the farm in euros) for the same ownership types. The datasets referred to the same EU countries and regions, enabling integration and comparative analysis. The input data were structured as geospatial tables containing region codes, country names, and columns for various ownership and economic performance metrics.

The analysis applied the following labels based on specific criteria:

i. Regions with no recorded data for an ownership type in 2016 are labeled as "No data for NP" "No data for LP" or "No data for GH" representing the absence of information.
ii. For regions with available 2016 data, an increase or decrease is identified by comparing the economic size in 2020–2016.
iii. The label for no changes between the two years was created but there was no occurrence of this classification in the dataset.

Similar to the previous method for quantifying the changes in hectares, the resulting combined label for each region summarizes the economic dynamics for all three ownership types. This approach provides a view of shifts in the economic performance of farmland ownership, enabling the identification of regions where the change of ownership types are related to economic performance regarding increase, decrease or stable economic performance The labels facilitate a clear and comparative visualization of economic performance trends across regions together with the analysis of area (hectares) for each ownership type.

To gain more insights into the relations between the change of ownership and economic performance, the data was used to investigate if an increase in the LP ownership type would increase the economic performance of farms on a regional level. To classify economic performance for this purpose, the Farmland Dynamics of Change (Hectares) dataset was filtered by regions where the Classification column indicated an increase in the Legal Person (LP) ownership area. These filtered regions were then cross-referenced with the Economic Dynamics of Land Ownership Type (2016–2020) dataset to evaluate their corresponding economic performance. Regions were labelled based on whether the increase in LP ownership area corresponded to:

1. An increase in LP economic performance (Positive economic performance),
2. A decrease in LP economic performance (Negative economic performance), or
3. Insufficient economic data (Not applicable) – when no data for legal person was available for that region.

After classification, the results were summarized by country. This involved calculating the number of regions in each country, determining the proportion of regions classified under each performance label, and identifying the countries with the highest number of regions exhibiting both positive and negative economic performance. This analysis facilitated a comparative ranking of countries and regions based on their economic outcomes and ownership trends.

To evaluate the economic performance of regions classified as having "Positive economic performance" and "Negative economic performance" considering the increase of Legal Person ownership (in hectares) between 2016 and 2020, it was calculated the percentage change in economic metrics (economic size of the farm in euros) between these years. The calculation used the formula:

$$Percentage\ of\ Change = \left( \frac{LP(euros)\quad 2020 - LP(euros)\quad 2016}{LP(euros)\quad 2016} \right) \quad \times 100$$

This approach measures the relative increase or decrease in economic value (in euros) from 2016 to 2020 for the combined farms in each region. By normalizing the difference to the 2016 baseline, the analysis captures proportional changes, allowing for direct comparison across regions with varying absolute economic values.

This methodology integrates geospatial analysis with categorical classification to provide insights into regional economic dynamics concerning land ownership trends, leveraging structured regional data for systematic comparison.

*Additional tests with the data*

For transparency and further potential development the below methods are included as examples of tests that the authors performed with the Eurostat datasets to describe any potential patterns. However, due to limited space, the detailed results are not included in the study.

*Method for Regional Disparity compared to National level*

A Regional Disparity Map was developed to visualise the relationship between the farmland ownership types within the regions in a European member state, and to determine how dispersed or aligned the ownership type are within a country. The measure represents the overall standard deviation of Land Ownership Index (LOI) values. It measures the dispersion or variability of the LOI values among different regions within the same country – comparing regional LOI to the overall LOI's mean for that country. A lower standard deviation indicates that the regional LOI values are closely clustered around the national mean, suggesting uniformity across regions. A higher standard deviation suggests greater variability or disparity between the LOI's regions within a country. This is valid regarding Natural and Legal ownership types. Group Holding was represented on a different scale: percentage share of group holding area out of the total national farmland area.

*Method for Farmland Ownership Percentage of Change 2016–2020*

A calculation of the Farmland Ownership Percentage of Change for Natural Persons (NP), Legal Persons (LP), and Group Holdings (GH) from 2016 to 2020 was performed to evaluate shifts in farmland ownership distribution across the EU. The percentage change for each ownership type was computed based on normalized ownership values (areas divided by the total farmland area per region) to ensure comparability across regions. For NP and LP, the percentage change was calculated using the formula:

$$Percentage\ of\ Change = \left(\frac{Value2020 - Value2016}{Value2016}\right) \times 100$$

This measures the relative increase or decrease in farmland ownership proportions over the period. For GH, additional logic was incorporated to handle cases where both 2016 and 2020 normalized values were zero, ensuring the percentage change was set to 0 in these scenarios to avoid undefined results or division by zero errors. This procedure was necessary since Group Holdings (GH) ownership data presented the highest percentage of missing values among the ownership types. In 2016, 75.29 % of NUTS-2 regions did not report the area dedicated to GH ownership, highlighting significant gaps in data availability. While reporting improved in 2020, the missing data remained substantial, with 52.94 % of regions failing to provide information on GH ownership. The calculations provided insights into ownership trends by quantifying relative changes in land distribution for each ownership type, helping to identify patterns of growth, decline, or stability across the EU regions.

## Data availability

Data will be made available on request.

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