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# The Agricultural Land Use Changes in Metropolitan Areas: A Case Study in Italy

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Received: 2 September 2024; Accepted: 29 October 2024; Available online: 1 November 2024

**ABSTRACT:** In recent decades, countries have experienced a widespread increase in population that has resulted in unorganized urban sprawl, problems with land use change and related threats to natural resources. On the other hand, this led to converting agricultural areas into urban spaces. This work aims to analyze land use changes in the metropolitan area of Rome, which has experienced significant urbanization in rural areas. In this context, the agricultural sector's contribution to the economic growth of peri-urban areas in the metropolitan area of Rome was verified. After showing the extent of agricultural land consumption, an economic evaluation of land use was provided through the analysis of the evolution of urban and peri-urban agriculture in Rome. The analysis was performed using the Italian FADN data for 2008–2020 and a set of structural and economic–financial indicators. Furthermore, the study analyzes the relationship between farm performance and agricultural resources, farmer demographics, and farm size. The analysis reveals that farms are mainly specialized in arable land and herbivores and are conducted prevalently by men with a high school education level and aged between 40 and 65 years. The economic results also show a good performance; however, they are yearly differentiated. Only a few farms resort to other gainful activities to increase the income produced. Therefore, a greater diversification of agricultural activities is desirable. The research provides interesting insights to stakeholders on the public support that needs to be designed and implemented to favor the survival of farms in rural areas.

**Keywords:** Land use changes; Land cover; Urban peri-urban areas; FADN; Rome



## 1. Introduction

Over the years, several countries have experienced population growth. Despite, in 2020, for the first time since 1950, the growth rate of the global population fell under 1% per year, the world's population reached 8 billion on 15 November 2022, and the latest projections by the United Nations suggest that the world's population could grow to around 8.5 billion in 2030 and 9.7 billion in 2050 [1]. Consequently, there is a rapid and disorganized urban expansion, with relative land use change also connected to the threats of depletion of natural resources, food and, finally, deficit and soil degradation [2–5]. Agricultural land use changes, i.e., the process by which human activities transform the natural landscape, together with climate change, represent one of the major environmental issues in the world [6,7]. The soil, as a natural resource, has become very limited. Agricultural land affects different domains of ecosystem services. In addition to providing food, they carry out their action by influencing the climate regulation through the storage of carbon, the cycle of water and the nutrients present in it and, therefore, the quality of the water itself. Further influences arise if one thinks, for example, of terraces, which offer services such as erosion reduction, mitigation of hydrogeological instability phenomena (if they are not abandoned by agricultural activity), slope stability and other cultural services with the maintenance of traditional landscapes and typical regional production systems, as well as being an historical and cultural testimony value [8]. However, in recent years, we have witnessed an intensification of soil degradation processes, particularly the consumption of agricultural land, due to incorrect land management (lack of balance between agricultural areas and built-up areas). By consumption of agricultural land, therefore, we must precisely understand the transition from agricultural and semi-natural roofs to urban ones. However, this contraction has not led to a loss of agricultural production due to the progressive introduction of new production techniques, which increased productivity per hectare and intensified livestock activities [9]. At the same time, there has been a change in the way of doing agriculture, moving from agriculture centered on the production of foodstuffs to a "multifunctional" agriculture which combines the primary function (production of food) with the production of secondary public goods and services, that have positive effects for the community (protection of biodiversity, landscape protection, water resource management, contributing to the socio-economic survival of rural areas, etc.). The adoption of multifunctionality in agriculture represents an important economic feature for farms when it becomes a strategy for diversifying business activities. However, the reduction of agricultural land leads to various effects, including the loss of organic matter, changes to the landscape, disruptions to ecosystems, impacts on climate, and alterations to hydrogeological structures. Therefore, the consumption of agricultural land arouses great interest due to the consequences and economic, environmental, and social costs that the phenomenon entails. Effective territorial planning, such as the conservation of agricultural land, is an important factor in environmental protection and the support of multifunctional agriculture [10]. On the other hand, as mentioned above, population pressure increases the demand for food globally. Indeed, the global scenario used to evaluate food security, projected to 2050, shows an increase in the demand for food from 35% to 56% between 2010 and 2050, with a consequent increase in the population at risk of hunger over the same period [11]. Meeting increased demands for food and feed without over-exploiting agricultural systems and encroaching on natural ecosystems will be a challenge for humans in the coming decades, especially considering the projected effects of climate change. The intensification of current agricultural systems is one way to increase crop yields, strengthening crop yields and strengthening food security.

Climate change and urbanization combine calls for urgent responses to improve cities' resilience. Agriculture in metropolitan areas plays an important role as a methodology for reducing the environmental impacts of urban food demand, providing several benefits to cities, including urban heat island mitigation, runoff reduction, air filtration and carbon sequestration. Nevertheless, suppose functions are not adequately managed, this leads to significant risks for human health and the environment, as agriculture in metropolitan areas competes with urban demands for natural resources, such as land use. This phenomenon is even more accentuated when natural resources are limited. Urban and peri-urban agriculture (UPA) can be defined as practices that yield food and other outputs from agricultural production and related processes on agricultural land within cities. It is not a new concept, as it has been practiced for decades. Consequently, a growing body of research has focused on this new model of agriculture and the urgent need to develop strategies that ensure food supply and security for people in urban areas. According to FAO et al. (2022) [12], the global population is projected to reach 9.7 billion by 2050, with approximately 70% of individuals living in urban areas, particularly in low- and middle-income countries across Africa and Asia. This shift underscores the critical importance of urban and peri-urban agriculture in supporting city growth. Not only does this form of agriculture help ensure adequate food production to satisfy local demand and feed increasing urban populations, but it also aims to reduce food waste. Additionally, it offers a wide array of benefits—social, educational, economic, and environmental—empowering residents of urban and peri-urban areas to achieve sustainable livelihoods.

Numerous researchers have examined the multifunctional nature of urban and peri-urban agriculture. For instance, Zasada (2011, 2012) [13,14] explored how agriculture adapts to urban pressures, socio-economic shifts, and developmental opportunities, emphasizing the importance of multifunctional benefits derived from agricultural practices close to urban centers. His work particularly focused on policy and planning strategies that support multifunctional agriculture in urban settings, contrasting these with rural agricultural practices and addressing the relationship with urbanization. This research also provided valuable insights into farmers' perceptions and strategic behaviors.

In a different approach, Lucertini and Di Giustino (2021) [15] utilized a Geographic Information System (GIS)-based methodology to identify and quantify agricultural land in urban and peri-urban regions. Their study highlighted the potential for climate change mitigation—such as $CO_2$ reduction and sequestration—as well as adaptation strategies, including alleviating urban flooding and heat islands through establishing new agricultural areas.

Lastly, Specht et al. (2014) [16] focused on the innovative aspects of urban and peri-urban agriculture. They investigated novel green urban architectural practices that integrate food production with design, allowing for large-scale food cultivation within and around urban buildings. Their analysis addressed the key benefits and challenges of these practices, highlighting that such agricultural systems serve multiple functions and generate a variety of non-food and non-market goods that positively impact the urban environment, including resource conservation, enhanced food security for local communities, and fostering connections between consumers and food producers.

The development of peri-urban agriculture is also a common phenomenon in Europe. Over the years, agricultural land near cities has been converted for urban purposes, leading to the adoption of urban lifestyles in rural areas.

Agriculture has responded to this by introducing a post-productive and consumption-oriented adaptation of agricultural activities [14,17].

In this framework, we want to analyze which type of farms and agriculture are spreading in the metropolitan area of Rome to verify the changes that have occurred in the structural and socio-economic characteristics of farms and to estimate the variations in farm performance and the economic value of agricultural land. Furthermore, we want to evaluate the impact of public support on the formation of agricultural income and verify if other gainful activities influence the formation of farm revenue and, therefore, whether it contributes to their survival over time.

In this regard, we used the Farm Accountancy Data Network (FADN) database, which represents the only source of data at the farm level, on agricultural structures, production, and economic results. Still, in recent years, other information, both of accounting and non-accounting nature (such as, for example, environmental and social information), has been added to this database.

This paper is structured as follows. Section two provides a literature review on land productivity and agri-environmental indicators. Section three describes the study area represented by the Metropolitan area of Rome, the database utilized for the analysis, and the methodology used, the fourth section shows results, and the fifth discusses the results. The main conclusions are summarized in the final section.

## 2. Literature Review

Though rapidly escalating urbanization positively affects economic growth and employment, its impact on agriculture in metropolitan areas needs to be analyzed. The analysis of agriculture in metropolitan areas generally falls within research on urban and peri-urban agriculture. This phenomenon has increasingly attracted the interest of various scholars in recent years. Rao et al. (2022) [18] highlighted that research on urban and peri-urban agriculture has increased exponentially since 2015, primarily involving countries in the Northern Hemisphere. Analyzing more than 4000 articles, they emphasized how studies on UPA have focused on six thematic outcomes of the UPA within three pillars of sustainability (environmental, social and economic): environmental sustainability; material well-being; work and livelihoods; land tenure and urban planning; food and nutrition security as part of economic sustainability; and subjective and relational well-being as well as gender and social differentiation as elements of social sustainability.

Despite considerable interest in UPA in recent decades, its contributions to urban sustainability and human well-being remain contested [18]. Some authors (for example, [19,20]) have demonstrated that metropolitan sustainability is associated both with the increase in wealth and with the state of public finances, as well as the relationship existing between the processes of urbanization and economic conditions during economic expansion than during recession periods [21–24].

In this work, however, we have concentrated exclusively on the transformations that have taken place in agriculture and farms located in metropolitan areas because of urbanization processes. Therefore, the object of our analysis is farms and their performance and evolution. In this perspective, this article focuses on the evaluation of agricultural land use in the metropolitan city of Rome.

Agricultural land in urban and peri-urban areas plays a strategic role by offering several benefits, including food provision for city residents, moderation of human impact, support for agrobiodiversity, enhancement of social and cultural relationships, and environmental support for urban areas [25].

Urban and peri-urban fabrics can be composed of several kinds of agriculture depending on spatiality (e.g., rooftop gardens and indoor farming), the actors involved (e.g., family farms and community-supported agriculture), and the organizational perspective (e.g., market orientation including urban farming or subsistence activities such as urban gardening) [26]. In Rome, this type of activity is spreading; however, very few attempts have been made to inventory urban agriculture areas, such as community gardens, residential gardens, school gardens, informal vegetable plots, and urban farms [27].

Generally, changes in agriculture in metropolitan areas are studied through model-based projections of future land use and land cover change [28–37]. These models are often used in environmental assessments to study the impact of land use and land cover change on environmental services and to provide support to policy makers. Land use changes are often non-linear, so it is essential to assess land use change trajectories and project possible future conditions based on certain assumptions. Both are crucial for ensuring sustainability.

Over time, several authors, intrigued by land use change, which in turn highlights the change in the human-land relationship, have focused their efforts on analyzing agriculture in the metropolitan area of Rome. For example, Cavallo et al. (2016) [38] conducted a mapping and evaluation of urban agriculture in Rome, focusing on the relationship between agriculture and development in the metropolitan area within the framework of sustainable food planning. Starting with the relationship between food and city, they have mapped the foodscape, identifying several representative conditions of the metropolitan area of Rome. In particular, the authors highlighted how the land use analysis reveals a system of wedge-shaped agricultural areas, where short supply chain models can be used efficiently to manage and promote land use and landscape use. Instead, Pulighe and Lupia (2016) [27] have proposed a conceptual framework and a methodology for mapping urban agriculture through Earth observation techniques and using the concepts of photointerpretation, they have demonstrated the usefulness of integrating web services-mapping for the construction of urban agricultural land use datasets. Furthermore, they highlighted the policy implications of this analysis, which can support administrators in understanding the interactions between agricultural activities and the urban environment, thereby enabling the implementation of informed policies for managing green and open urban spaces. Given the uncontrolled expansion of cities into surrounding rural and natural areas, several countries have implemented laws and planning tools to preserve farmland on the urban fringe. In this context, Perrina et al. (2018) [39] analyze governance changes in peri-urban farmland protection following decentralization, comparing the cases of Montpellier (France) and Rome (Italy).Their results show how decentralization produced multiple decision-making authorities around Rome and Montpellier and increased the complexity of procedures. Nevertheless, farmland conversion has persisted. Although, decentralization processes have also changed ways of governing and favored local alternative initiatives for farmland protection and farming development on the urban fringe. In both cities, these new modes of governance have a positive but limited impact on the effectiveness of farmland protection instruments.

Tomao et al. (2021) [40] conducted an analysis of economic crises and land use changes in Rome through a spatial examination of urban transformations, utilizing a geographically weighted principal component analysis. Their study explores possible differences in the spatial direction and intensity of land-use change trajectories at two-time intervals (2006-2012, 2012-2018), identifying different patterns of land-use change depending on whether it is in an expansionary or a recessionary phase. Greening, defined as converting urban marginal areas into croplands, increased during the recession. At the same time, the rate of urban expansion into rural areas decreased, thus indicating a beneficial effect of economic downturns in reducing urban sprawl.

Marino et al. (2022) [41] within the research-action project “Construction of the Food Plan of the Metropolitan City of Rome Capital” that is part of the planning process strategy for the construction of the Strategic Plan of the Metropolitan City of Rome “Rome, Metropolis to the Future,” offer a cognitive picture of the territorial context of the metropolitan city of Rome. The work, based on the research of geographic information layers and sectoral reports from different sources, summarizes some results that describe the state of the environmental context, the strengths, some dynamics of transformation and the fragility of the metropolitan territory.

The analysis of the literature, though not exhaustive, highlights how agricultural land—a limited resource—is increasingly impacted by degradation due to urbanization, leading to its consumption and a loss of its essential functions over time. Nevertheless, metropolitan agriculture remains an economically important productive reality, offering several advantages: food security, environmental protection, landscape, and socio-cultural conservation, etc. These non-basic products are not always recognized by the free market even though they play an essential role in agricultural development [42,43]. Indeed, urbanization-induced land degradation may hamper metropolitan agriculture’s ability to provide food and agroecological services. However, multifunctional and profitable agriculture has been shown to help break the vicious circle of land degradation in urban and peri-urban cultivated areas [44].

## 3. Materials and Methods

### *3.1. The Study Area*

The study was conducted in the Metropolitan City of Rome, located in the Lazio region in Central Italy (Figure 1). It is a vast territorial entity that covers an area of over 5363 $km^2$, representing over 31% of the Lazio territory, and includes 121 municipalities. Four rivers cross the predominantly hilly territory for a total length of 255 km of route and 7 lakes for an area of 68.39 $km^2$. This area’s resident population is 4,222,870 inhabitants, of which 66% (2,786,434 inhabitants) reside in the municipality of the capital, Rome. The population density of this area is equal to 788.84 inhabitants/$km^2$, and the increment of the urban population between 2001 2022 was very rapid, with the average rate equal to 14.1%. The average age of the inhabitants is 45.1 years, and 25% of the population in the metropolitan city of Rome is over 65 years old [45].

The complexity of the provincial territory is not only due to the high number of individuals present but also to their distribution on the territory. The municipalities that fall within the province of Rome include, in fact, an extremely varied demographic consistency and distribution [46–48].

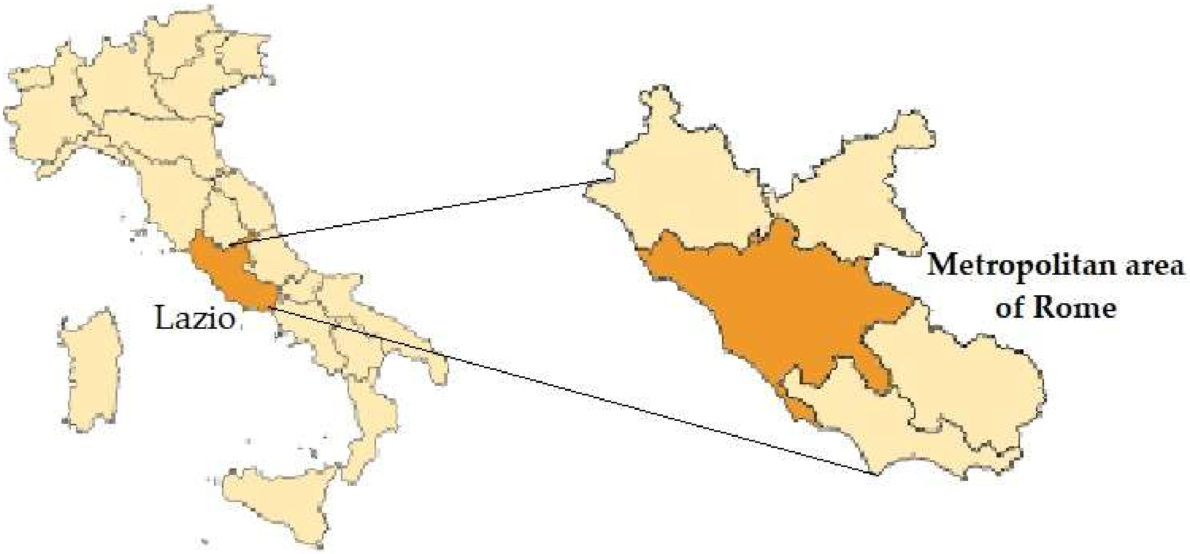


**Figure 1.** Metropolitan Area of Rome. Source: https://www.tuttitalia.it (Lazio, province of Rome).

The territory of the metropolitan area of Rome has been divided according to the degree of urbanization defined by ISPRA (the Italian Institute for Environmental Protection and Research), following the definition adopted in the context of the Global Agenda for Sustainable Development (objective 11). It considers the density thresholds of the covered artificial surfaces to distinguish three classes: urban areas (>50%); sub-urban (10–50%); and rural areas (<10%). Based on this classification, it emerged that urban centers with a high density of artificial soil cover 8% of the territory, while urban groups with a medium or low-density cover 26%. Conversely, the rural territory covers 66% of the area of the metropolitan city of Rome.

It is surrounded by a large agricultural region, historically linked to the city, and relevant from an economic and environmental point of view. This condition requires deeper reflections and specific actions regarding territorial planning and economic programming to ensure that it is efficiently framed in the metropolitan context [41].

The agricultural sector plays an important role in the metropolitan area of Rome. Recent data has shown that 40% of the municipalities (47 municipalities) record an agricultural extension of over 70% of the territorial area. However, in the last decade, there was a slight decrease in all the main indicators relating to the agricultural sector. Indeed, the Utilized Agricultural Area (UAA) decreased from 75,726 ha to 66,656 ha (−12%), and Livestock Units (LU) recorded a decrease, albeit more limited (−4%), while the added value of agriculture and Gross Salable Production (GSP) experienced a higher decrease (respectively −24% and −14%). From 2010 to 2020, there was also a small decrease in land productivity (−4%) and a consistent fall in terms of working units (−20%), but, on the other hand, there was an increase in labor productivity (+31%).

Among production systems (Figure 2), 31.4% of the municipalities of the metropolitan city of Rome (38) specialize in silvo-pastoral systems, which are mainly located on the area's borders. Other areas are specialized in intensive agriculture and animal husbandry, and this category represents 24% of the municipalities of the metropolitan city. While only 6% of municipalities specialize exclusively in intensive agriculture, a larger portion of the territory, including the municipality of Rome, specializes in extensive agriculture and animal husbandry, encompassing nearly 20% of municipalities.

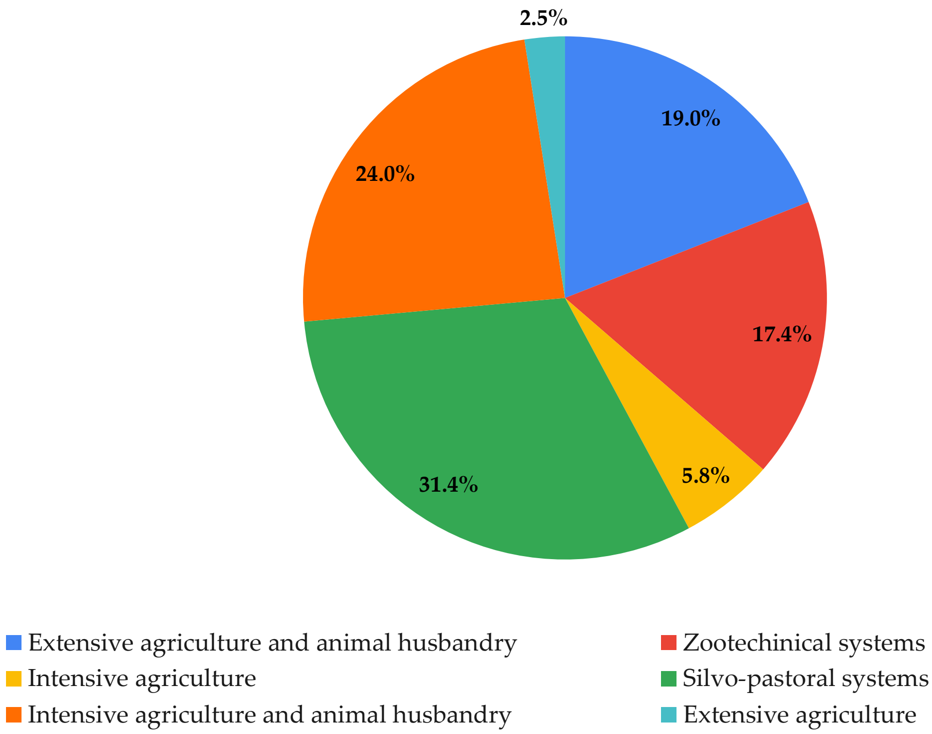


**Figure 2.** Distribution of different types of farming in the municipalities. Source: [41].

Furthermore, the Lazio region is of considerable importance in terms of the presence of certified productions, with 66 products (30 related to food and 36 for wine) for a total production value of 130 million euros. And the area of the metropolitan city of Rome is not an exception in this context, with various products of certified quality (5 PDO and 5 PGI for food and 20 PDO and 2 PGI for wine), for example olive from Gaeta or Frascati's wine [48,49].

### *3.2. Land Consumption in the Metropolitan Area of Rome*

The soil resource is fundamental for human existence and represents a very limited environmental resource as it is non-renewable. Over the years, soil degradation processes have intensified, particularly the consumption of agricultural land, largely due to improper land management and an imbalance between agricultural and built-up areas.

The consumption of agricultural land should, therefore, be understood as the transition from agricultural and semi-natural land covers (non-consumed land) to urban land covers (consumed land). The loss of agricultural land has obvious negative effects on the environment: decrease in organic matter (loss of fertility), loss of biodiversity, alteration of the landscape, ecosystem, climatic sphere and hydrogeological structure with increasingly frequent floods because of the sealing of the natural surface and, finally, desertification.

The consumption of agricultural land is of great concern due to its economic, environmental, and social costs, which appear to be linked to societal progress, demographic growth, and the evolution of modern society. In fact, the demographic trend of the resident population in Lazio shows a steady increase in the number of inhabitants: between 2001 and 2020, the population in the Lazio region grew by over 613,000 people.

Land consumption in Italy continues to transform the national territory at great speeds. Last year, the new artificial covers affected 69.1 km$^2$, i.e., an average of about 19 hectares per day [50].

In Lazio, land consumption involved over 139,900 hectares (+407.42 hectares compared to 2020), equal to approximately 8% of the entire regional territory. Instead, at the level of the metropolitan area of Rome, the land consumed in 2021 is equal to over 70,000 hectares (+216.12 hectares compared to 2020). This loss represents approximately 13% of the regional territory, with an increase of over 4,117 hectares in the last 15 years.

The density of net changes in 2021, i.e., land consumption in relation to land area, shows that in Lazio (Figure 3), 0.71 square meters are consumed per hectare of land against a national average of 1.08 square meters per hectare. The metropolitan area of Rome shows a land take density of 0.31 square meters per hectare. In terms of land consumed per capita (Figure 4), the regional value is equal to 244 square meters per inhabitant, below the national average (366 m$^2$/inhabitant). In the metropolitan city of Rome, the present value is equal to 166 m$^2$/inhabitant, 78 square meters less than the regional average value [51,52].

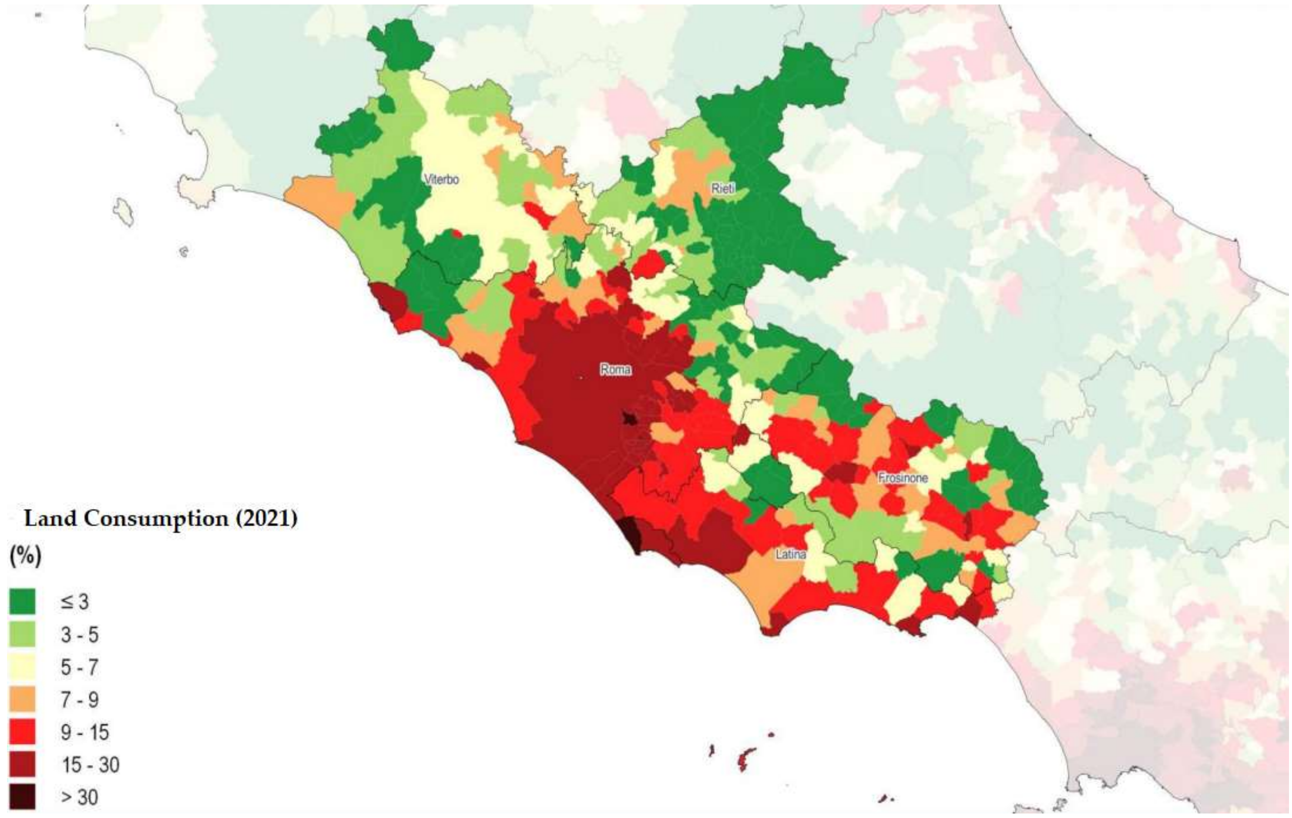


**Figure 3.** Percentages of land consumption in Lazio (2021). Source: [52].

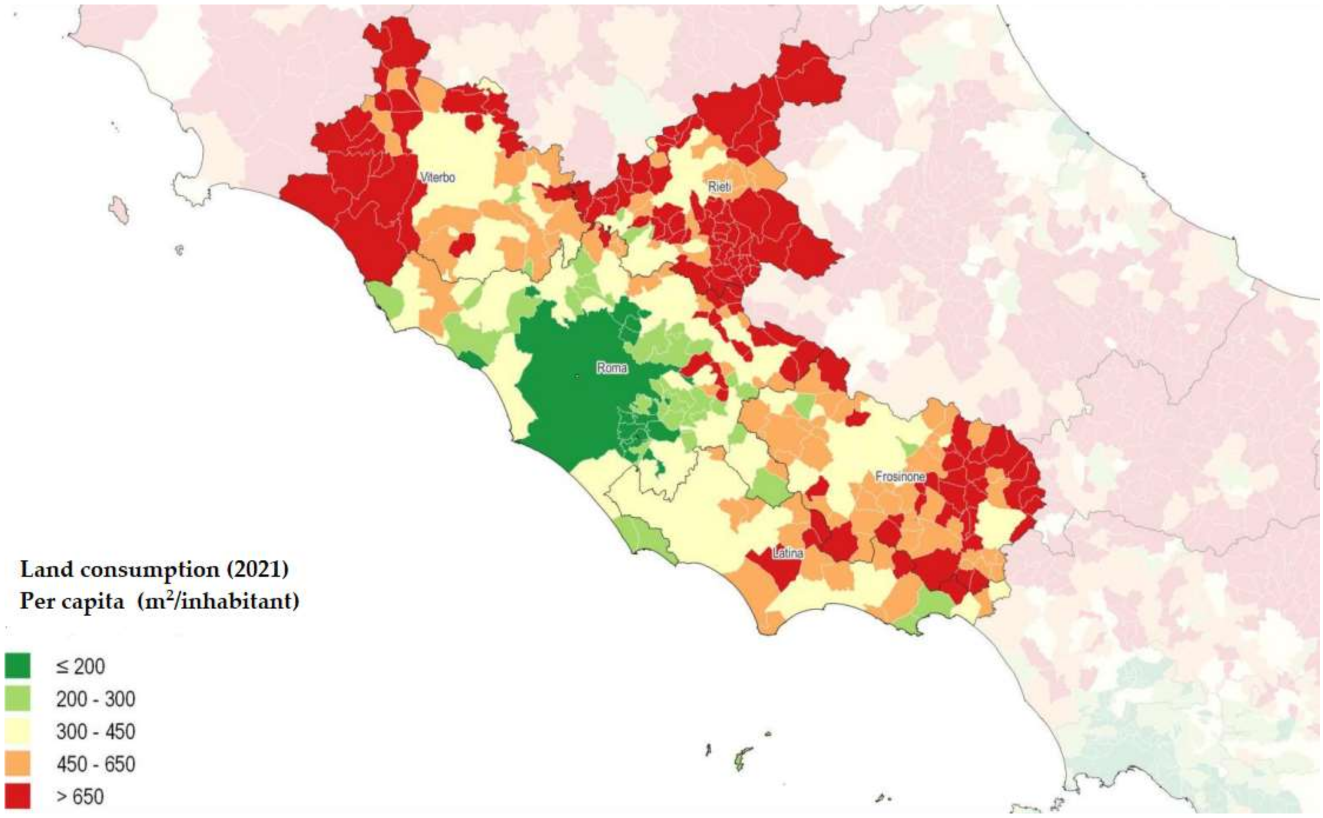


**Figure 4**. Per capita soil consumption ($m^2$/inhabitant) (2021). Source: [52].

### *3.3. The Economic Analysis*

To carry out this work, the information contained in the Farm Accountancy Data Network (FADN) database was used. FADN represents one of the main sources at the European level and collects data at the farm level on structures, production and, economic results, and many other information going beyond primary production.

It is a yearly sample survey whose field of observation in Italy is represented by farms with an economic size threshold equal to at least 8000 euros of Standard Output (SO), excluding smaller farms. The FADN aims to collect information useful for measuring the evolution of farmers' incomes and the functioning of farms in the EU. However, the new information added to the FADN database allows the monitoring of the evolution of agricultural incomes and the evaluation of the environmental impact of farms.

In this paper, the information relating only to farms in the metropolitan area of Rome has been used for the accounting years 2008–2020. In this way, 1198 farms were selected and subsequent analyzes were carried out on these (Table 1).

**Table 1**. Number of farms per year and percentage in Rome and Lazio.

| Year | Rome | | Lazio | |
|---|---|---|---|---|
| | Farms | % | Farms | % |
| 2008 | 103 | 8.6 | 449 | 6.8 |
| 2009 | 95 | 7.9 | 445 | 6.7 |
| 2010 | 81 | 6.8 | 500 | 7.5 |
| 2011 | 75 | 6.3 | 557 | 8.4 |
| 2012 | 83 | 6.9 | 524 | 7.9 |
| 2013 | 75 | 6.3 | 576 | 8.7 |
| 2014 | 140 | 11.7 | 712 | 10.7 |
| 2015 | 61 | 5.1 | 332 | 5.0 |
| 2016 | 67 | 5.6 | 359 | 5.4 |
| 2017 | 103 | 8.6 | 502 | 7.6 |
| 2018 | 101 | 8.4 | 507 | 7.7 |
| 2019 | 111 | 9.3 | 584 | 8.8 |
| 2020 | 103 | 8.6 | 578 | 8.7 |
| Total | 1198 | 100.0 | 6625 | 100.0 |

In particular, the analysis will be performed only for those groups (for example, year, type of farming, economic size) that include at least 5 farms. Those groups will be excluded from subsequent processing/analysis if their number is lower.

In economic theory, the land is considered a natural asset, pre-existing human activities, limited and it is non-transferable and irreproducible. It can only be modified to make it more functional. Thus, farmers have invested in the land, in a stable form, capital (buildings, irrigation systems, trees, etc.) whose value often exceeds that of the land itself and, therefore, in the agricultural sector, the term is used as fixed capital. The land, therefore, provides the necessary space for the location of economic activities, infrastructures, housing, and services of comfort and landscape-cultural value, etc. [53,54]. Consequently, land use results from choices made in economic, cultural, political, etc., terms governing land use planning. Indeed, land cover represents the biophysical attributes of soil that influence ecosystem functioning [55].

This leads to competition for land use. Several authors show that the closer the land is to the inhabited center, the more it is destined for urban use, and, therefore, agricultural activity is pushed to peripheral areas. In other words, the growth of cities, determined by an increase in population, tends to increasingly expel agriculture outwards, subjugating agricultural land to it. Therefore, land uses that provide low economic returns are effectively driven out of urbanized areas. Therefore, the agricultural area is reduced in favor of non-agricultural use of the land [56].

Instead, in this work, as will be seen, the methodological path followed tends to analyze and highlight the structural characteristics of the farms in the metropolitan area of Rome, as well as their evolution and economic performance. In this regard, the farm's net income, which measures the farm's ability to remunerate the inputs used in the production processes, is deduced from the analysis of the balance sheet results. However, the economic analysis is preceded by an assessment of the structural characteristics. For this purpose, structural indices have been used, which have allowed us to describe the farm structure [57]:

- Land Intensity (LI) is the ratio between fixed assets and utilized agricultural area (UAA).
- Operating Intensity (OI): given by the ratio between the operating capital and the UAA.
- Farm Intensity (FI) is the ratio between the sum of fixed assets, operating capital, and UAA.
- Owned-UAA: Percentage incidence of owned UAA.
- Rented-UAA: Percentage incidence of rented UAA.
- Irrigated UAA: Percentage incidence of irrigated UAA.
- Labor Intensity: given by the ratio between annual working units (AWU) and UAA. It indicates the availability of UAA per working unit.

- Family management index: is the ratio between family working units (FWU) and AWU. Therefore, it expresses the incidence of family work on the total work used on the farm.
- Degree of mechanization: it expresses the availability of machine power, measured in KW per hectare.
- New Investments: This represents the amount of new structural investments made annually on the farm, indicating the level of farm dynamism relative to the Utilized Agricultural Area (UAA). Furthermore, to complete the analysis of the farms with some considerations of an economic-financial nature, the following indices have been used [57]:
- Subsides on Total Farm Revenues (TFR): it is the ratio between public aid received by farms and TFR, therefore, it expresses the percentage incidence of them.
- Subsides on Farm Net Income: like the previous one but in this case, the aid is related to the farm net income.
- Farm Net Income (FNI) per hectare is given by the ratio between the FNI and the UAA. It represents the overall economic result of the farm, which, in addition to the economic result of the typical management, also includes the costs and revenues originating from activities not considered typically agricultural: non-typical management (financial management, extraordinary management, miscellaneous management and public transfers). It identifies the ability to remunerate all the production factors used on the farm.
- Farm Net Income per working unit: like the previous one but in this case, the FNI is related to the working unit (AWU).
- Liquidity ratio (Lr): represents short-term solvency, as it measures the farm's ability to fulfill its short-term financial commitments.
- Availability ratio (Ar): evaluates how many liquid resources and those that can be readily liquidated (availability) make it possible to meet the commitments undertaken. The financial balance is around 1.5–2, i.e., the short-term assets must be greater than the short-term liabilities.
- Coverage ratio (Cr): if $Cr > 1$, all durable goods have been financed with medium-long term sources. If $Cr < 1$, part of the resources used will have to be returned in the short term.
- Dependency ratio (Dr): expresses the share of external sources of financing compared to the total. It varies from zero to one depending on whether the farm is totally independent or dependent on external resources.
- Financial leverage (Fl) measures the balance or imbalance between the different sources of financing of the farm and allows the definition of how many times the borrowed capital (external lenders) is higher than the equity. Therefore, the more the farm is indebted, the more it is exposed to the risk of abandonment.

In defining the relationships between the various balance sheet items, the FADN follows the accounting principles used by the International Accounting Standards Board (IASB) [58,59]. Furthermore, the FADN reclassifies the income statement following a scaled value-added scheme to construct aggregates with a higher level of information that allows an analysis of the balance sheet and, therefore, builds several economic indices.

## 4. Results

### *4.1. Structural Aspects*

Even before evaluating the indices used in the analysis, it is necessary to provide some structural information on the farms making up the sample being analysed.

The first aspect examined is the breakdown of farms according to their physical size (classes of UAA).

In particular, Table 2 shows how 4 classes of Utilized Agricultural Areas have been identified:

- <5: includes farms with a UAA of less than 5 hectares;
- 5–15: farms with a UAA between 5 and 15 hectares fall within this class;
- 15–40: contains farms with UAA between 15 and 40 hectares;
- \>40: take in farms with a UAA of more than 40 hectares.

**Table 2.** Percentage distribution of farms and UAA by UAA classes and year.

| Year | UAA Classes (ha) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | <5 | | 5–15 | | 15–40 | | >40 | |
| | Farms | UAA | Farms | UAA | Farms | UAA | Farms | UAA |
| 2008 | 30.1 | 1.7 | 29.1 | 5.2 | 18.4 | 10.1 | 22.3 | 83.0 |
| 2009 | 27.4 | 1.6 | 28.4 | 5.2 | 16.8 | 9.5 | 27.4 | 83.6 |
| 2010 | 27.2 | 1.3 | 30.9 | 5.9 | 11.1 | 6.5 | 30.9 | 86.3 |
| 2011 | 26.7 | 1.1 | 29.3 | 5.8 | 12.0 | 7.0 | 32.0 | 86.0 |
| 2012 | 21.7 | 0.8 | 31.3 | 6.7 | 18.1 | 11.1 | 28.9 | 81.4 |
| 2013 | 26.7 | 1.1 | 20.0 | 4.2 | 22.7 | 11.3 | 30.7 | 83.4 |
| 2014 | 26.4 | 2.7 | 34.3 | 10.0 | 20.7 | 16.9 | 18.6 | 70.4 |
| 2015 | 27.9 | 2.3 | 37.7 | 8.3 | 16.4 | 11.2 | 18.0 | 78.2 |
| 2016 | 13.4 | 0.8 | 35.8 | 9.5 | 26.9 | 18.7 | 23.9 | 71.0 |
| 2017 | 11.7 | 0.7 | 32.0 | 7.4 | 33.0 | 20.6 | 23.3 | 71.3 |
| 2018 | 10.9 | 0.6 | 34.7 | 7.0 | 23.8 | 13.0 | 30.7 | 79.4 |
| 2019 | 12.6 | 0.8 | 36.9 | 8.6 | 23.4 | 14.6 | 27.0 | 76.0 |
| 2020 | 14.6 | 0.8 | 35.9 | 7.8 | 19.4 | 10.9 | 30.1 | 80.5 |
| Average | 21.0 | 1.2 | 32.2 | 7.0 | 20.5 | 12.5 | 26.2 | 79.3 |

The smallest class (UAA < 5 hectares), with 21% of farms, occupies an UAA equal to just 1.2% of the total; on the contrary, the largest class (UAA > 40 hectares) represents 26.2% of farms, but it concentrates as much as 79.3% of the agricultural area. The least numerous classes of UAA (20.5% of farms) are those of 15–40 hectares, 12.5% of the total UAA falls into this class. Instead, the 5–15 hectares UAA class is the most numerous (32.2% of farms) and concentrates a share of the utilized agricultural area equal to 7% of the total. The two intermediate classes are those that increase their numbers to the detriment of the two extreme classes. While Table 3 shows the division of farms according to their economic size defined by the SO.

**Table 3.** Distribution of farms by year and classes of economic size.

| Year | Small | Medium Small | Medium | Medium Large | Large | Total |
|---|---|---|---|---|---|---|
| 2008 | 19 | 10 | 21 | 27 | 26 | 103 |
| 2009 | 14 | 11 | 18 | 30 | 22 | 95 |
| 2010 | 14 | 9 | 17 | 34 | 7 | 81 |
| 2011 | 12 | 9 | 12 | 37 | 5 | 75 |
| 2012 | 18 | 9 | 17 | 32 | 7 | 83 |
| 2013 | 16 | 7 | 13 | 35 | 4 | 75 |
| 2014 | 40 | 37 | 27 | 32 | 4 | 140 |
| 2015 | 19 | 18 | 9 | 13 | 2 | 61 |
| 2016 | 16 | 10 | 12 | 26 | 3 | 67 |
| 2017 | 13 | 20 | 17 | 48 | 5 | 103 |
| 2018 | 9 | 21 | 16 | 48 | 7 | 101 |
| 2019 | 20 | 24 | 18 | 43 | 6 | 111 |
| 2020 | 17 | 24 | 15 | 42 | 5 | 103 |
| Total | 227 | 209 | 212 | 447 | 103 | 1198 |

In this way, 5 classes of the economic size of farms have been defined:

- small: with an SO of up to 25,000 euros (18.9% of the farms examined);
- medium small: the SO is between 25,000 and 50,000 euros. This group includes 17.4% of farms;
- medium: SO between 50,000 and 100,000 euros. (17.4% of farms);
- medium large: with a SO between 100,000 and 500,000 euros. This class includes the highest percentage of farms examined (37.3%);
- large: with the SO exceeding 500,000 euros. Only 8.6% of farms fall into this eco-nomic size class.

The average percentage of UAA owned in the farms in the metropolitan area of Rome is approximately 44.4%. The lowest percentage (33.7%) was found in 2017, and the highest percentage was for rented UAA (59.5%). Conversely, the highest percentage of UAA in ownership was recorded in 2008 (58.1%), which also records the lowest percentage of rented UAA (35.2%), as in 2010. Instead, the percentage of irrigated UAA is, on average, higher than 33%. The highest percentages occurred in 2011 (55%) and in 2010 (52.9%), while 2015 represents the year with the lowest percentage of irrigated UAA, just 17.7% (Table 4).

**Table 4.** Distribution of values of the main structural variables per year.

| Year | Average UAA (ha) | Owned UAA (%) | Rented UAA (%) | Irrigated UAA (%) | Livestock Units | Power of Machines (KW) |
|---|---|---|---|---|---|---|
| 2008 | 49.1 | 58.1 | 35.2 | 39.5 | 72.8 | 175.2 |
| 2009 | 47.1 | 55.1 | 37.3 | 39.2 | 78.0 | 181.8 |
| 2010 | 44.8 | 56.9 | 35.2 | 52.9 | 111.4 | 202.2 |
| 2011 | 44.3 | 56.5 | 36.2 | 55.0 | 99.8 | 206.5 |
| 2012 | 44.8 | 55.5 | 38.6 | 45.3 | 142.5 | 223.4 |
| 2013 | 48.2 | 42.9 | 51.8 | 36.9 | 143.4 | 219.9 |
| 2014 | 31.9 | 37.8 | 57.8 | 25.7 | 92.2 | 167.0 |
| 2015 | 39.6 | 37.5 | 54.6 | 17.7 | 77.9 | 208.0 |
| 2016 | 37.3 | 39.6 | 57.2 | 21.7 | 75.6 | 200.1 |
| 2017 | 43.7 | 33.7 | 59.5 | 26.0 | 72.0 | 222.9 |
| 2018 | 48.1 | 37.1 | 54.6 | 27.1 | 82.0 | 227.4 |
| 2019 | 39.8 | 36.3 | 57.2 | 25.7 | 74.8 | 201.1 |
| 2020 | 43.1 | 37.6 | 56.2 | 26.8 | 79.4 | 193.9 |
| Average value | 42.9 | 44.4 | 49.1 | 33.3 | 90.1 | 200.2 |
| Year | Mechanization index (KW/UAA) | Annual working units | Family working units | Labour intensity (AWU/UAA) | Family managment index (FWU/AWU) | |
| 2008 | 13.7 | 2.3 | 1.2 | 0.3 | 0.8 | |
| 2009 | 14.6 | 2.0 | 1.1 | 0.2 | 0.8 | |
| 2010 | 19.7 | 2.1 | 1.1 | 0.3 | 0.8 | |
| 2011 | 26.4 | 2.0 | 1.1 | 0.4 | 0.8 | |
| 2012 | 21.5 | 2.2 | 1.2 | 0.4 | 0.8 | |
| 2013 | 25.8 | 2.4 | 1.3 | 0.4 | 0.7 | |
| 2014 | 14.7 | 1.6 | 1.1 | 0.2 | 0.9 | |
| 2015 | 16.5 | 1.6 | 1.2 | 0.2 | 0.9 | |
| 2016 | 12.4 | 1.6 | 1.2 | 0.2 | 0.8 | |
| 2017 | 12.6 | 2.6 | 1.2 | 0.2 | 0.8 | |
| 2018 | 14.5 | 2.1 | 1.2 | 0.2 | 0.7 | |
| 2019 | 13.5 | 1.9 | 1.3 | 0.2 | 0.8 | |
| 2020 | 13.5 | 1.9 | 1.3 | 0.2 | 0.8 | |
| Average value | 16.4 | 2.0 | 1.2 | 0.3 | 0.8 | |

The comparison between owned and rented UAA highlights how, over time, recourse to the rental of UAA represents the solution adopted by farmers to increase the agricultural area of their farm. The analysis of Figure 5 clearly shows how, starting from 2013, the percentage of rented UAA is higher than the percentage of owned UAA.

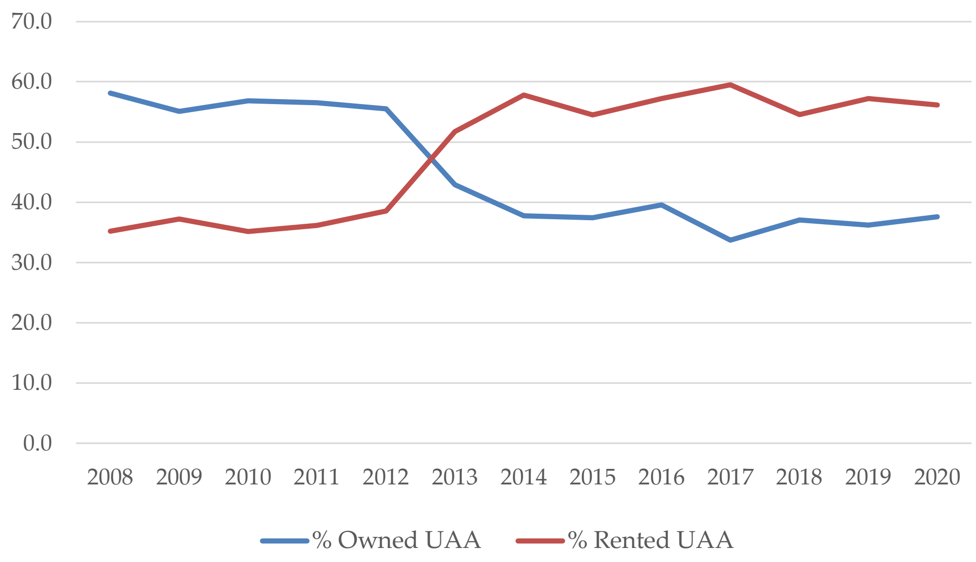


**Figure 5**. Percentage of owned and rented utilized agricultural area.

The quantity of work used on the farm is, on average, equal to two annual working units (AWU) per year. As many as 1.2 work units are represented by the tenant and/or his family (family working units—FWU). In fact, in almost all agricultural holdings, the peasant family provides farm work (over 70% in all years).

The availability of UAA per employee (intensity of the work) is, on average, equal to 0.3 hectares. In particular, the highest intensity of the labor factor (0.4) is found in the years 2011–2013.

Finally, the farms have a high degree of mechanization (Table 4) they have an endowment of machines with an average power of over 200 kW, which remained the same over the years, and a degree of agricultural mechanization (available power), that accounts for 16.4 kW per hectare. This confirms another typical feature of Italian farms, namely the possession of an excessive fleet of machines compared to the real physical size of the farms.

The breakdown of farms by legal form shown in Table 5 highlights that over 80% of the farms examined have the form of individual farms, and about 19% are companies that increased during the last years, while cooperative farms are almost completely absent (0.5%).

**Table 5.** Percentage distribution of farms by year and legal form.

| Legal Form | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Average (Total) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Individual | 88.3 | 85.3 | 81.5 | 81.3 | 75.9 | 81.3 | 78.6 | 86.9 | 79.1 | 76.7 | 77.2 | 77.5 | 75.7 | 80.1 |
| Cooperatives | 1.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.9 | 1.0 | 0.5 |
| Companies | 10.7 | 13.7 | 18.5 | 18.7 | 22.9 | 17.3 | 20.0 | 9.8 | 20.9 | 22.3 | 21.8 | 21.6 | 23.3 | 18.9 |
| Other | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 1.3 | 1.4 | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |

According to the form of management, over 93% of the farms examined are managed directly by the entrepreneur. Within this form of management, 51.5% of farms are managed directly by the entrepreneur with the help of his family and 31.6% with external workers. Only in 10% of farms does the use of workers not belonging to the entrepreneur's family prevail. Lastly, the farms managed with the exclusive use of hired employees represent 5% of the sample examined.

The analysis of the type of farming (Figure 6) shows that almost all the farms examined (93%) are specialized, while the remaining 7% practice mixed agriculture. The specialized systems most represented are arable crops (30.7%) and herbivorous breeding (28.4%).

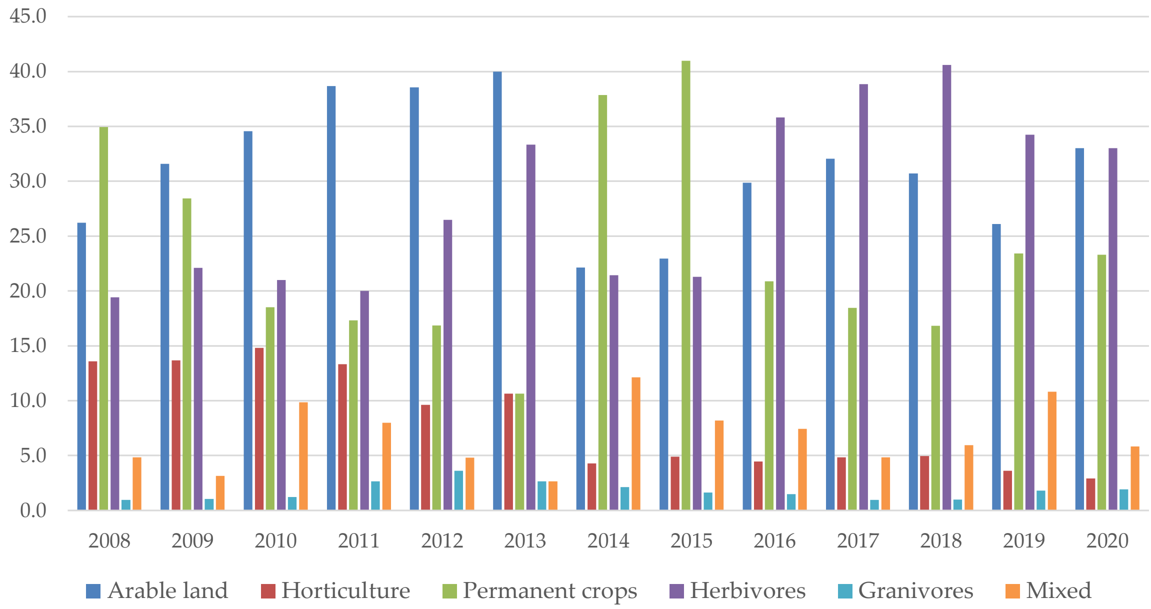


**Figure 6**. Percentage distribution of farms by type of farming and year.

Furthermore, during the period under examination (2008–2020), there was a reduction of 30% in the area dedicated to the cultivation of arable crops and a reduction of 53% in the area dedicated to horticulture. In contrast, the area dedicated to permanent crops remained unchanged when comparing the two periods. Granivorous farms experienced a reduction of 6% in their area, while farms specialized in herbivores saw their agricultural area increase by 22%. Finally, during the same period, the agricultural area of non-specialized (mixed) farms nearly doubled, showing an increase of 94% (Figure 7).

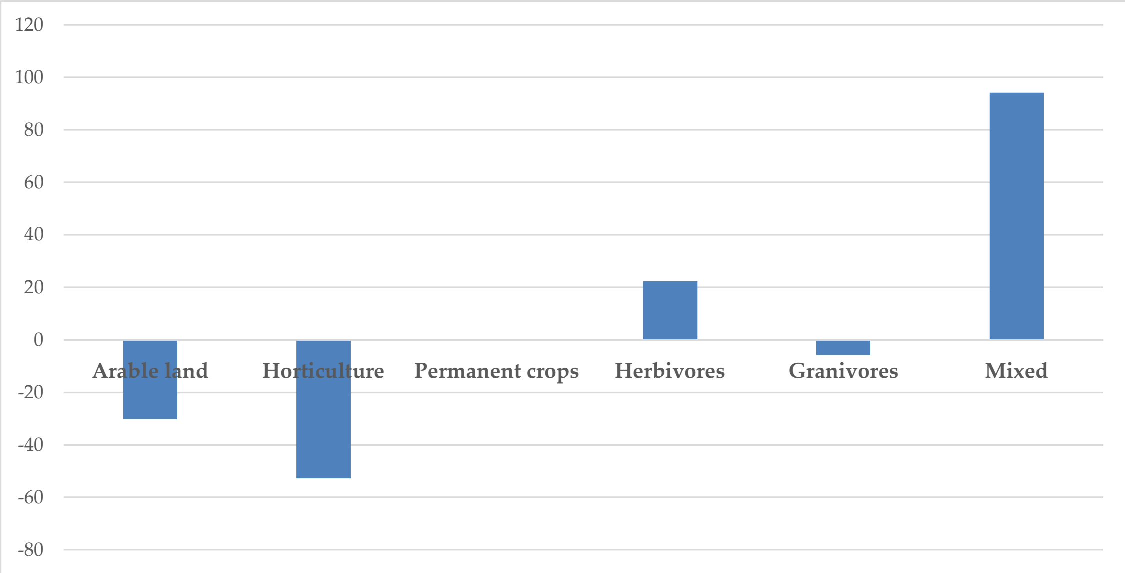


**Figure 7**. Percentage variation of area (2020–2008) by type of farming.

Table 6 summarizes the indices relating to the investments made by farms in the metropolitan area of Rome. It highlights that land intensity index (LI) is equal, on average, to just over 19,400 euros per hectare. The highest value of LI, equal to approximately 28,000 euros, occurred in 2011. Instead, the operating intensity index (OI) is lower (just under 11,600 euros per hectare). OI shows the highest values in 2011 (about 17,500 euros).

**Table 6**. Farms investments by year.

| Year | Land Intensity (€/ha) | Operating Intensity (€/ha) | Farm Intensity (€/ha) | New Investiments (€/ha) |
|---|---|---|---|---|
| 2008 | 21,318 | 9806 | 31,124 | 219 |
| 2009 | 16,911 | 11,397 | 28,308 | 507 |
| 2010 | 20,527 | 13,814 | 34,341 | 981 |
| 2011 | 28,168 | 17,460 | 45,629 | 8880 |
| 2012 | 24,579 | 12,359 | 36,938 | 2701 |
| 2013 | 25,263 | 16,939 | 42,202 | 2610 |
| 2014 | 22,251 | 12,263 | 34,514 | 1240 |
| 2015 | 21,285 | 8636 | 29,922 | 4133 |
| 2016 | 14,415 | 8340 | 22,754 | 1204 |
| 2017 | 13,743 | 8916 | 22,659 | 1407 |
| 2018 | 15,977 | 8639 | 24,616 | 471 |
| 2019 | 15,544 | 10,766 | 26,310 | 1532 |
| 2020 | 15,777 | 12,126 | 27,902 | 410 |
| Average value | 19,425 | 11,565 | 30,990 | 1210 |

The farm intensity (FI), given by the sum of the two previous indices, reflects the trend. In this case, the average total investment per hectare is just under 40,000 euros. Instead, the trend of the investment index appears more interesting, which represents a measure of the farms' dynamism as it estimates the value of new investments per hectare. What immediately appears interesting is to see how, on average, only 25% of the farms in the metropolitan area of Rome make investments with an average value of the investment index equal to 1210 euros per hectare. It shows the low propensity of farms to make structural investments during the entire period under review. In 2011, the index recorded its highest value (just under 8900 euros per hectare), while the lowest value was found in 2008, at only 219 euros per hectare.

### *4.2. Socio-Economic Aspects*

Approximately 73% of the farms selected are run by men and 27% by women, but, over time, there is also an increase in female-led farms. In fact, in 2020, the percentage of farms headed by a woman is about double that was recorded in 2008 (15.5%) (Figure 8).

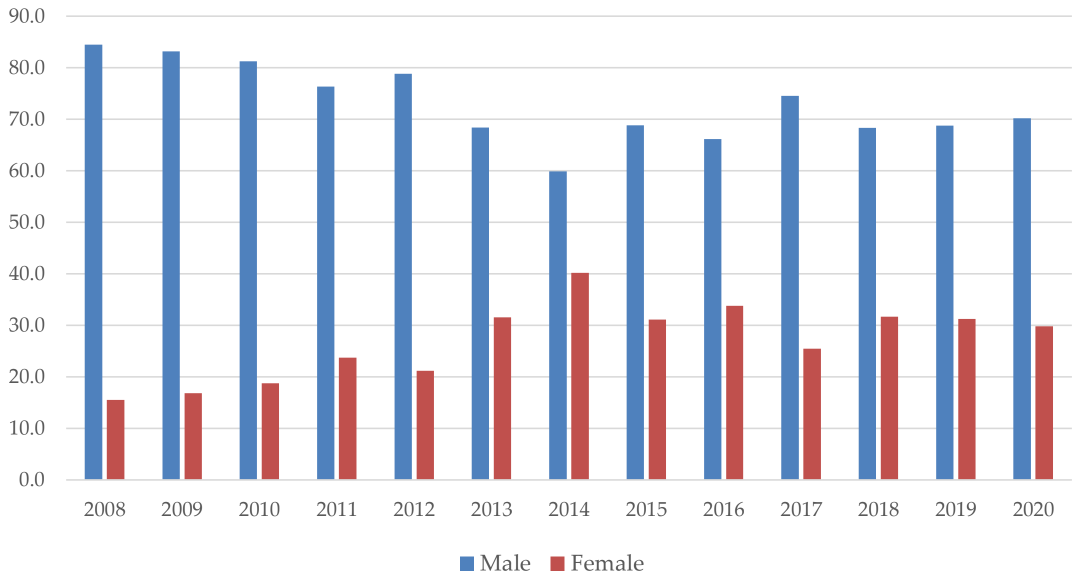


**Figure 8**. Percentage distribution of farms by gender of farm manager and by year.

In terms of age of the farm manager, we divided this information into 3 classes (less than 40 years; 40–65; over 65). Data reveals that farms are primarily managed by mature individuals: 59.3% of tenants are aged 40 to 65, while younger tenants (under 40) make up 20.2%, and those over 65 account for 20.5%.

The education level is not too high indeed only 12.2% of the entrepreneurs have a degree, whereas about 79% have a middle school and/or high school diploma, and those with only primary school education represent 6.9% of the total tenants (Figure 9). Among graduate entrepreneurs, there is a large disparity between men and women. Specifically, the percentage of male farms managers (78.2%) is always higher than that of female tenants (21.8%) each year. The distribution of farm managers by qualification varies according to the age class. The highest percentages of graduate farm managers are found in the intermediate age class (40–65 years), even though, in recent years, the under 40 graduates are growing. Farm managers with a high school qualification represent the highest percentage within the over-65 age group.

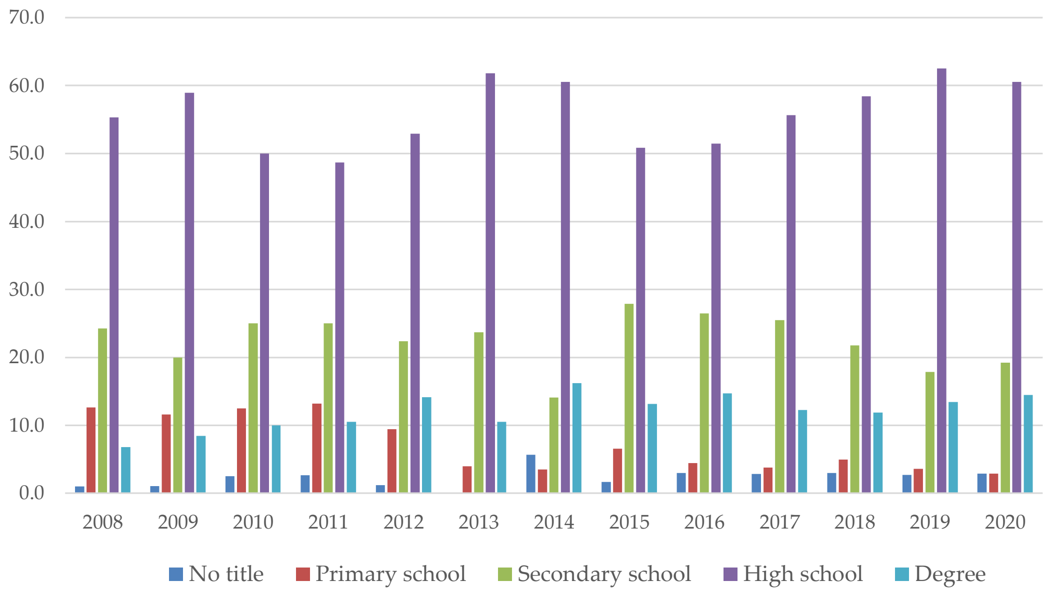


**Figure 9**. Percentage distribution of farms by qualification of tenants and by year.

The availability in the FADN database of information related to the diversification and differentiation of agricultural production allowed a reclassification of the farms in the FADN sample, defining a new farm typology defined as a strategic profile [1], that considers the intensity of the activity of qualitative differentiation of the product and the production diversification. It is a method of aggregation of farms into homogeneous groups, both in terms of gross salable production (GSP) levels and of revenues deriving from non-strictly agricultural activities carried out by the farms (agritourism, processing, and other related activities) and of the qualitative differentiation of agricultural productions (processes and products with quality certification) [60,61].

Table 7 shows the percentage distribution of FADN farms in the metropolitan area of Rome per year, according to the reclassification just described. The table shows a wide fluctuation in the distribution of farms both among strategic profiles and overtime. The highest percentage of farms is placed in the farm profile called Conventional small (37.1% of total farms), reaching the highest percentage in 2016 (47.8% of farms) and the lowest value in 2020 with 31.1% of farms. This is followed by the farms that fall under the Conventional large profile (31.6%). The other strategic profiles include a lower percentage of farms. The Diversified profile includes 16% of the farms and the remaining apart are the Micro profiles (12.2%), Differentiated and Diversified (1.7%). Finally, the Differentiated farm profile includes only 1.3% of farms.

**Table 7**. Percentage distribution of farms by strategic profile and by year.

| Year | Micro | Conventional Small | Conventional Large | Differentiated | Diversified | Differentiated and Diversified |
|---|---|---|---|---|---|---|
| 2008 | 11.7 | 36.9 | 32.0 | | 19.4 | |
| 2009 | 11.6 | 34.7 | 32.6 | | 21.1 | |
| 2010 | 12.3 | 38.3 | 34.6 | 1.2 | 12.3 | 1.2 |
| 2011 | 12.0 | 45.3 | 32.0 | | 10.7 | |
| 2012 | 10.8 | 42.2 | 33.7 | | 12.0 | 1.2 |
| 2013 | 6.7 | 41.3 | 40.0 | | 12.0 | 0.0 |
| 2014 | 21.4 | 32.1 | 21.4 | 0.7 | 22.1 | 2.1 |
| 2015 | 23.0 | 34.4 | 19.7 | | 18.0 | 4.9 |
| 2016 | 14.9 | 47.8 | 29.9 | | 7.5 | |
| 2017 | 5.8 | 37.9 | 31.1 | 6.8 | 16.5 | 1.9 |
| 2018 | 11.9 | 37.6 | 37.6 | 0.0 | 10.9 | 2.0 |
| 2019 | 9.9 | 32.4 | 35.1 | 2.7 | 15.3 | 4.5 |
| 2020 | 6.8 | 31.1 | 33.0 | 3.9 | 22.3 | 2.9 |
| Total | 12.2 | 37.1 | 31.6 | 1.3 | 16.0 | 1.7 |

The economic indices of farms in the metropolitan area of Rome were also analyzed, and the performance of farms compared to UAA and employment was compared (Figure 10). It emerges that the economic index relating to the working units presents the highest values. The "farm net income" index was chosen as representative since it summarizes the technical-commercial choices and the organization of production within the farm. It is the set of incomes due to the farmer for the remuneration of the production he brings (for example, agricultural land, work) and to remunerate his "organizer" function of the production process. Therefore, this index measures the farm's ability to remunerate all the production factors used in the production cycle.

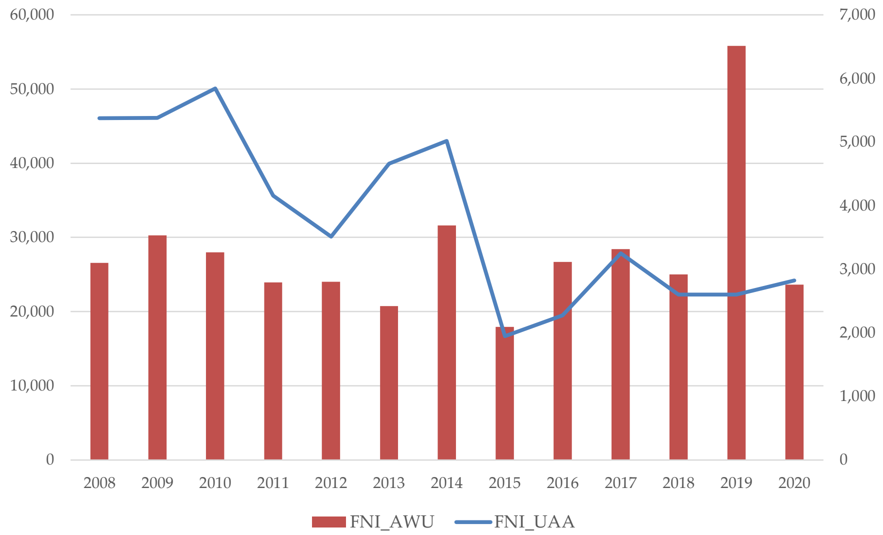


**Figure 10**. Economic indices (Farm Net Income—FNI) of farms by utilized agricultural area (UAA), by annual working units (AWU) and by year.

The highest value of the FNI/UAA index was recorded in 2010, just over 5800 euros per hectare, and it was followed by 2014, with an index value of around 5000 euros per hectare. While the worst performance was recorded in 2015 (about 1950 euros per hectare). When analyzing the index per working unit (FNI/AWU), the best performance was recorded in 2019, with an FNI of just over 55,800 euros per AWU. This is followed by 2014 with an index value of approximately 31,600 euros and then, 2009 where the index assumes a value of 30,276 euros. In this case, 2015 recorded the lowest value of the index, with just under 18,000 euros per working unit.

Figure 11 shows the percentage incidence of public aid received by farms on total farm revenues (TFR) and farm net income (FNI).

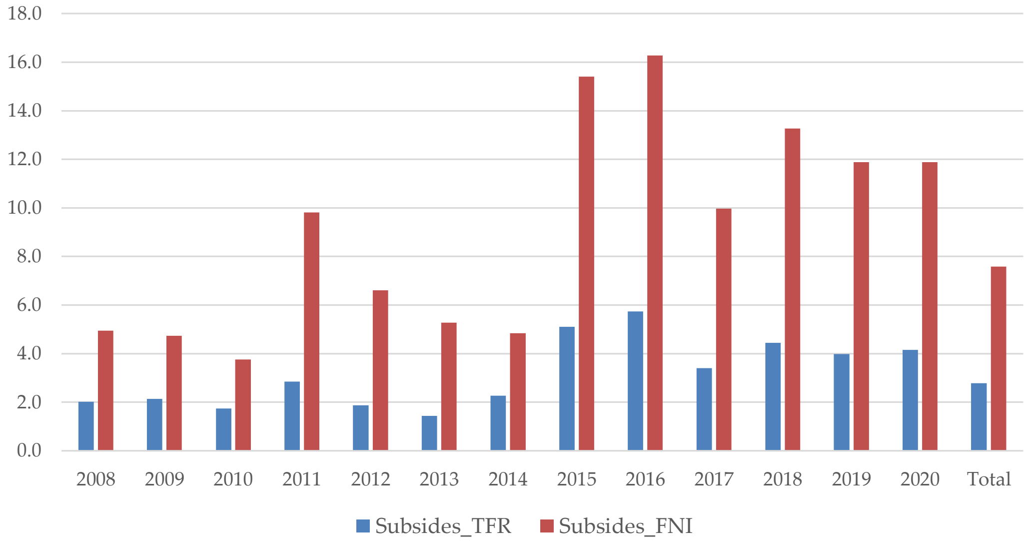


**Figure 11**. Percentage incidence of subsidies on TFR and FNI by year.

The figure shows that the average incidence of aid on the farms' total revenues is equal to around 3%, while that on the farms' net income is over 8%. This leads us to deduce that farm performance is significantly conditioned by the amount of public aid received. Analyzing different years, it seems that 2016 had the highest percentage of incidence (16.3%), followed by 2015 with 15.4%, whereas the lowest percentage of incidence occurred in 2010 at 3.8%.

The analysis of the economic aspects of the farms belonging to the metropolitan area of the city of Rome has highlighted how, in these farms, there is little presence of other gainful activities (OGA) related to the multifunctionality of the farms. The income from other profitable activities is almost entirely insignificant. Slightly less than 11% of farms engage in other gainful activities. On average, the revenues deriving from OGAs equal 3057 euros per hectare, but they show a large fluctuation over the period under review. However, in recent years, an increase in their value has begun to be observed. In 2020, revenues from related activities amounted to just under 2600 euros per hectare (they were 1596 euros in 2008).

Over the years, farms have incorporated an increasing variety of activities into their operations beyond strictly agricultural production. In fact, at the beginning (in 2008), agritourism represented the only gainful activity, but it has left more and more space for other activities. In 2020, agritourism represented just under half (46.7%) of the other gainful activities present in farms in the metropolitan area of Rome.

This is further confirmed by the analysis of Table 8, where the various other gainful farm activities are detailed. Direct sales, hospitality, and catering activities, typical of agritourism, have consistently been present over time, while additional income-generating activities, such as contract work (machinery hire and contract labor), educational farming, and renewable energy production, have gradually been incorporated.

**Table 8**. Percentage distribution of farms by year and type of OGA.

| Year | Direct Sale | Hospitality | Catering | Hire of Machinery | Educational Farms | Renewable Energies | Craft Activities | Local Rental | Environmental Services | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | 33.3 | 33.3 | 33.3 | | | | | | | |
| 2009 | 28.6 | 28.6 | 28.6 | 14.3 | | | | | | |
| 2010 | 22.2 | 33.3 | 33.3 | 11.1 | | | | | | |
| 2011 | 25.0 | 25.0 | 37.5 | 12.5 | | | | | | |
| 2012 | 33.3 | 22.2 | 33.3 | | | 11.1 | | | | |
| 2013 | 25.0 | 12.5 | 37.5 | 12.5 | | 12.5 | | | | |
| 2014 | 12.9 | 6.5 | 9.7 | 22.6 | 9.7 | 29.0 | | | 3.2 | 6.5 |
| 2015 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | | | | 14.3 |
| 2016 | 16.7 | 16.7 | 33.3 | 16.7 | | | | | | 16.7 |
| 2017 | 9.1 | 9.1 | 27.3 | 18.2 | 9.1 | 9.1 | | | | 18.2 |
| 2018 | 7.1 | 21.4 | 21.4 | 7.1 | 14.3 | 7.1 | | 7.1 | | 14.3 |
| 2019 | 7.1 | 21.4 | 21.4 | 7.1 | 14.3 | 7.1 | 14.3 | | | 7.1 |
| 2020 | 6.7 | 20.0 | 20.0 | 13.3 | 13.3 | 6.7 | 13.3 | | | 6.7 |
| Average value | 15.9 | 17.9 | 23.4 | 13.1 | 7.6 | 11.0 | 2.8 | 0.7 | 0.7 | 6.9 |

Comparing farms carrying out other gainful activities and farms without other gainful activities in terms of farm net income per hectare, it emerges that, on average, the value of farms with OGA is higher than the FNI of farms without OGA (4648 euros vs. 3780 euros) and this appears to be more evident in recent years, due to the increase and greater diversification of other gainful activities.

Finally, using the UAA of the various crops and the gross margin value of each crop in the FADN database, an estimate of the value of the land used for cultivation in the metropolitan area of Rome was made. Each production process's gross margin (GM) is calculated by subtracting the variable costs, i.e., the production costs referred to the production process, from the total gross production. The gross margin thus calculated provides information on the profitability of the agricultural phase and the values have been normalized by dividing them by the hectares cultivated to be able to compare the crop results regardless of the farm's physical size. From the analysis of Figure 12, where the results of 2008 and 2020 are compared, there is an increase in the value of agricultural land in each type of farming.

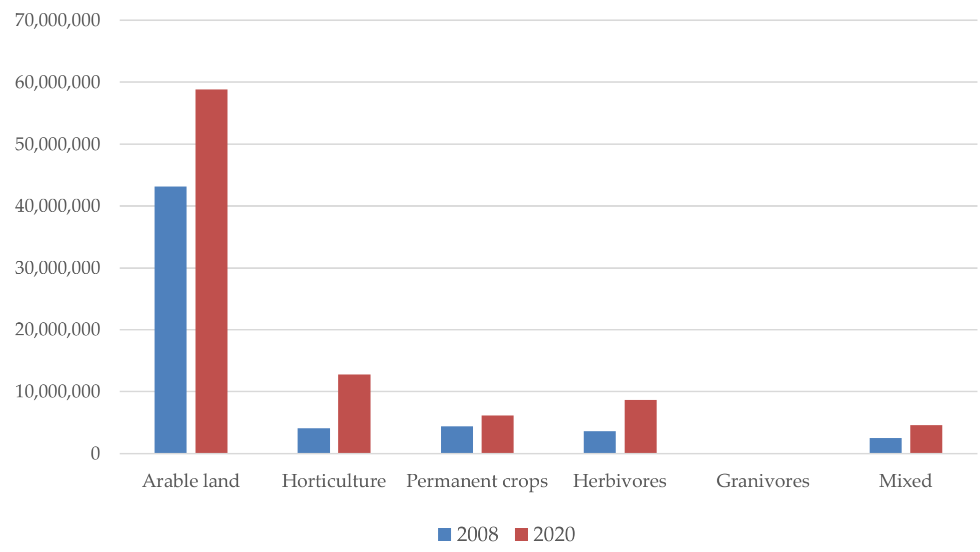


**Figure 12**. Estimate of agricultural land value by type of farming.

The financial ratios measure the ability of the agricultural holding to meet its commitments economically, i.e., its short-term solvency, they represent balance sheet quotients aimed at providing elements of judgment on the farm's liquidity situation in operation. This type of indices should be analyzed, at least at the end of the year, to understand what and how (possibly) to improve farm management. We compared the liquidity ratio (Lr) and the availability ratio (Ar), to verify the farm's capital solidity conditions (Figure 13), and it shows how the farms analyzed can adequately deal with short-term liabilities. In particular, the value assumed by the 2 indices is, on average, significantly higher than the reference values of the same considered optimal. Furthermore, there is a Lr lower than Ar, this is due to the calculation methodology. The former compares short-term assets net of inventory with short-term debts and expresses the degree of coverage of short-term debts with immediate and deferred liquidity. By not considering inventories, i.e., the riskiest asset items, as collections because they are still to be sold (instead taken into consideration by the availability ratio), the result obtained prudentially establishes what certain future collections will be.

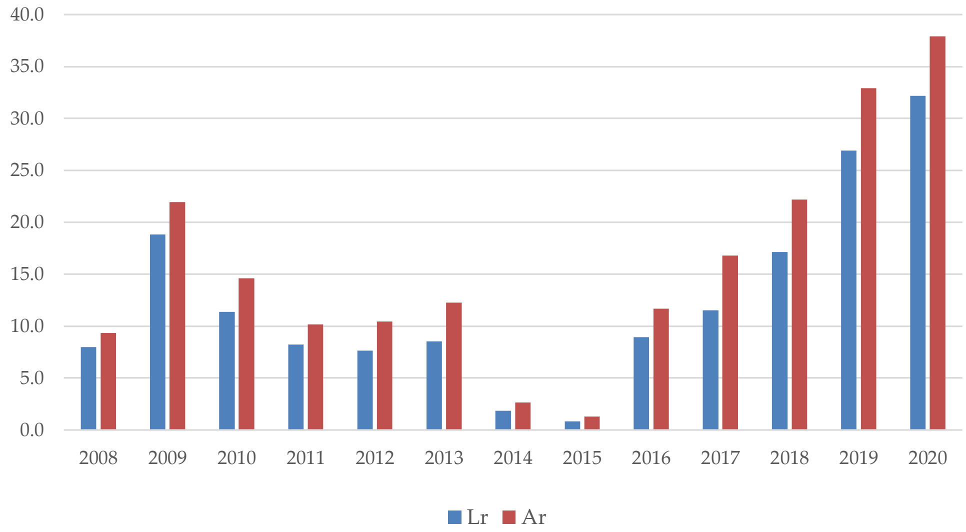


**Figure 13**. Liquidity ratio (Lr) and availability ratio (Ar) of farms per year.

The analysis of the medium-long term financial situation (Figure 14) is monitored through the coverage ratio (Cr), which makes it possible to recognize the presence, or otherwise, of the balance between medium-long term sources and uses. For the medium-long term financial equilibrium to be guaranteed, the Cr index must always be greater than unity, which occurs in all years.

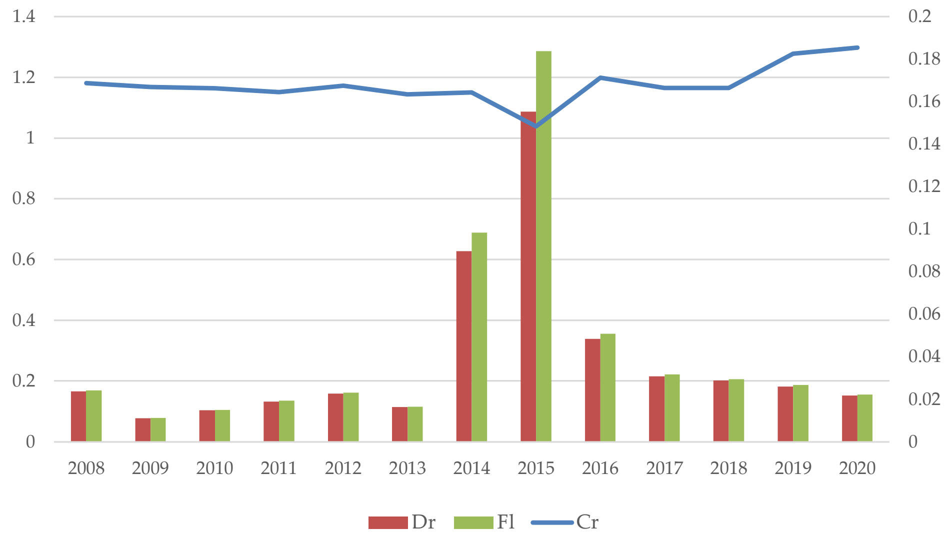


**Figure 14**. Coverage ratio (Cr), dependency ratio (Dr) and financial leverage (Fl) of farms by year.

Finally, to define the financial structure of farms in the medium-long term, reference was made to:

- the dependency ratio (Dr), which expresses the farm's recourse to external sources of financing;
- the financial leverage (Fl), which represents the degree of indebtedness of the farm or the extent to which it uses third-party capital to finance itself. Therefore, it expresses the degree of equilibrium of financial sources, if it is high (greater than 1) it can indicate an excess of farm debt. Conversely, a value lower than 1 indicates a well-balanced debt/equity relationship. The Fl index makes it possible to evaluate how much a farm is exposed to the risk of default.

From the comparison of these 2 indices, it emerged that, in all years analyzed, the values assumed by the financial dependence index are well below the unit and, therefore, denote a "good" financial structure of the farms. This is also confirmed by the financial leverage ratio, which assumes values close to zero in all years and highlights a scarce use of third-party capital to meet farm investments by the farms examined.

However, it is impossible to establish reference levels for these quotients as it would be necessary to establish the financial needs of a farm by farm and evaluate the opportunities offered by the market. In general, the extreme values are to be considered negative as total financial autonomy cannot fully exploit the financial leverage mechanism, conversely, the massive recourse to external financing would cause the farm to become dangerously dependent on external subjects which, if few, would be capable of heavily influencing farm choices (as in the case of a single supplier and/or client).

## 5. Discussion

The importance of farms is well-established and recognized in metropolitan areas. The study of farms in the metropolitan area of Rome highlights their role in promoting sustainable development, ensuring food security and stability, and helping to mitigate climate change [57]. Recently, changes in land use have diminished the capacity of ecosystems to provide goods and services, resulting in economic consequences for society. In response to these challenges, the Metropolitan City of Rome commissioned the University of Molise to develop a strategic plan for the area. This study aims to ensure the continued provision of essential goods and services crucial for human well-being by implementing governance tools designed to enhance the understanding of natural capital and its interactions with social and economic capital and promote its conservation.

Numerous agricultural and social-agricultural initiatives take place in the Metropolitan City of Rome. Many of these serve as experimental laboratories for best practices in land management and the creation of inclusive social environments, with some establishing continuous and structured collaborations. Social agriculture, in particular, plays a significant role by offering new models of territorial welfare to disadvantaged groups, providing opportunities for employment, reintegration into society, and rehabilitation through targeted employment offers and support programs. Additionally, several initiatives focus on innovation, aiming for a more integrated and systemic approach to reduce the use of conventional pesticides and expand the area of organic farming.

The economic evaluation results indicate that the interaction of natural, economic, and social capital in the Metropolitan City of Rome generates a flow of benefits exceeding 9 billion euros, representing 6.45% of the region's value added. When this flow of benefits is considered in relation to the population and land area, it translates into an estimated per capita benefit of 704 euros per year and a per hectare benefit of 5601 euros per year [https://pianostrategico.cittametropolitanaroma.it/piani/contabilita-ambientale-dei-servizi-ecosistemici-della-citta-metropolitana-di-roma-capitale].

Several studies have focused on urban and peri-urban farms and their production activities. These studies highlight how population growth and non-agricultural employment, which impact land use, pose significant social challenges in metropolitan areas. These challenges include food security, climate change, biodiversity loss, resource efficiency, land management, social cohesion, and economic growth. Such issues influence farmers' behavior and the way they conduct their activities. Consequently, metropolitan areas' economic and social development must strike a balance between existing resources and how they are managed (e.g., [62–66]).

For instance, de Oliveira Alves and de Oliveira (2022) [67] demonstrate that agriculture and peri-urban farming contribute to environmental sustainability by affecting land use, ecosystem conservation, biodiversity, climate, and urban landscapes. These activities are essential for the local production of sustainable food, which helps alleviate pressures on conventional agriculture and contributes to addressing global challenges. Similarly, Pradhan et al. (2024) [68] highlight that urban and peri-urban agriculture can generate social, economic, and environmental benefits by adopting sustainable practices. However, the specific practices for promoting urban agriculture may vary across different urban areas, indicating the need for further research and innovation.

The literature analysis highlights how the various authors focus on analyzing, in general, those factors (economic, environmental, and social) that govern the land use change processes to pursue sustainable development. In this article, agriculture in Rome's metropolitan area is analyzed; therefore, we focused more on the Italian scientific literature. Several Italian authors have studied the agriculture of metropolitan areas (e.g., [13,21,27,38,40,41,47,69]). However, we want to focus only on some of them [38,41] that analyzed the same study area. These studies explore the agricultural context of Rome, focusing on its relationship with development in the metropolitan area in the context of sustainable food planning. It is demonstrated how, despite the strong urban planning pressure, it caused a reduction of the UAA between the 90s and 2000s, but then followed by a trend reversal, which led to a recovery of the UAA. The transformation processes affecting the agricultural sector in metropolitan areas highlight a type of agriculture that produces new landscapes and creates new functions connected to the historical value of agriculture in urban and peri-urban areas. The metropolitan area of Rome is characterized by the presence of many short-chain farms, which, in many cases, practice the diversification of production that is typical of multifunctional agriculture. Such a system represents a resilient device for the city, where flows, material and immaterial relationships, and the processes that are established between the various subjects become increasingly sustainable.

## 6. Conclusions

In the proposed analysis, based on information from the FADN database, the structural and economic characteristics of the farms in the metropolitan city of Rome were highlighted. Through the proposed indices, it was possible to underline the differences in the structural characteristics and economic results of the farms over the various years. More than 32% of them have a UAA between 5 and 15 hectares however, around 80% of the total UAA is concentrated in the farms with a UAA of over 40 hectares. From the point of view of economic size, over 37% of farms are positioned in the medium-large class. Farms specialized in arable crops and herbivores are the most represented and followed by those specialized in permanent crops. In contrast, granivores represent the type less numerous in the FADN database. In terms of labor force, the farms investigated imply both family (in prevalence) and non-family works. Farm managers, mostly men, are between 40 and 65 years old, and their main qualification is high school, while only a small percentage of them have college degrees. These are, therefore, generally quite large farms from an economic point of view. Still, they are small in terms of physical size (over 50% have less than 15 hectares of UAA). Furthermore, the data shows the prevalence of herbivorous livestock activities, implying the strong presence of arable land.

The economic results are quite good, even if the farms show different performances during the years, and the indicators that show the highest value are those relating to labor productivity. Furthermore, all farms selected show a discreet incidence of public contributions to the farms' net income, highlighting how the public aid received by farms plays an important role in the formation of the farms' net income.

Finally, the analysis revealed that a crucial role in maintaining the network made up of farms in the metropolitan city of Rome is played not only by the geographical location of the farm (in particular, proximity to important urban markets) but also by public contributions that the farms receive, and which allow their greater survival within this urban context.

Additionally, the resilience and survival of farms amid changes in land use and urban pressures largely depend on the entrepreneur's ability to diversify agricultural income, enhance competitiveness, and promote agricultural sustainability. In other words, it is the ability to adopt multifunctional agriculture. In the sample of farms analyzed, it was seen how the other gainful activities of farms increased over time, underlining a growing orientation of these farms towards diversification strategies (traditional as agrotourism or more innovative like the production of renewable energies).

An analysis of the economics of land use change in metropolitan areas must consider these areas' economic and social development process to plan a balanced use of existing resources. A sustainable approach to growth in metropolitan areas requires integrated economic, social, and environmental actions to improve overall well-being. Hence, farmers must be able to take advantage of the proximity to the urban area. They must maintain agricultural activity, diversify production and services, make the rural environment appealing to attract tourism, and leverage their proximity to urban consumer markets.

For future development of this work, we intend to carry out further studies that could provide more evidence and more details on the trends and development patterns of farms in the metropolitan area of Rome by addressing some of the limitations of this study, including, for example, the use of a single database for the analysis. It would be advisable to cross the data from the FADN survey with those from the agricultural census covering all the farms insisting on the national territory. This merging can also lead to an expansion of the metropolitan areas to be studied. Therefore, it should be possible to make a comparative analysis of the various metropolitan areas of Italy. Thus, when the new data from the general census of agriculture will be available, we intend to carry out new work both to broaden the knowledge of farms in the metropolitan area of Rome and to extend this analysis methodology to other metropolitan areas to provide useful suggestions to political decision-makers who will have to define the agricultural policy interventions to be implemented in support of farms located in metropolitan areas. However, it should be underlined that, even if we were able to use the census data, this would allow us to make a structural framework of the context of companies also in other metropolitan areas but since the FADN (the only database containing economic information) is a sample survey, the economic analysis would in any case always be limited to only the companies belonging to the sample. Another risk we may face is that, since it is always a sample, we may not find enough farms in the metropolitan areas we want to analyze.

## Author Contributions

Conceptualization, C.C. and O.C.; Methodology, C.C. and O.C.; Software, O.C.; Validation, C.C.; Formal Analysis, C.C. and O.C.; Investigation, C.C. and O.C.; Resources, C.C. and O.C.; Data Curation, O.C.; Writing—Original Draft Preparation, C.C. and O.C.; Writing—Review & Editing, C.C.

## Ethics Statement

Not applicable.

## Informed Consent Statement

Not applicable.

## Funding

This research received no external funding.

## 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.

## Footnotes

1. Micro: includes very small farms that have a gross salable production (GSP) of less than 15,000 euros; Diversified: these are farms that have a GSP equal to or greater than 15,000 euros, and at least 30% of which derives from revenues from other gainful activities (OGA); conventional: these are farms that do not use of activities for the diversification and differentiation of their production or use it a limited one. The GSP has a component of less than 30% both for the fraction deriving from revenues from OGA and for that deriving from quality production. In turn, they are divided into small and large according to whether the GSP is between 15,000 and 100,000 euros or if it is greater than 100,000 euros; Differentiated: includes farms whose total GSP value derives for a percentage equal to or greater than 30% from revenues from quality production (Protected Designation of Origin—PDO, Protected Geographical Indication—PGI, organic products, etc.); Differentiated and Diversified: it is a residual group, in which all those farms converge that do not have the requisites to be classified in the other categories. Therefore, they are farms that adopt both differentiation and diversification activities, without however that these individual categories of activities exceed the threshold of 30% of the GSP.

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