REA Italian Review of Agricultural Economics ONLINE FIRST

Manuscript was received 11/01/2024
Revised manuscript was received 22/07/2024
Manuscript was accepted for publication 06/08/2024
Corresponding editor: Filiberto Altobelli

Research article

A census-based sustainability indicator of agricultural holdings: the case of Italy

Roberto Gismondi
Italian National Statistical Institute – ISTAT, Rome, Italy
Corresponding author E-mail: gismondi@istat.it

Abstract

Sustainable agriculture is a critical issue globally. Evaluating it is often hindered by the complex, multidimensional nature of agricultural sustainability and the lack of statistical data at individual farm level. Ensuring the sustainability of Italian agriculture is vital for safeguarding both the survival of smaller agricultural holdings and the competitiveness of larger farms. In this context, the study proposes a methodology to estimate the degree of sustainability of Italian agricultural holdings. The methodology employs five indicators or *dimensions* – each representing a strategic farm feature related to sustainability – all derived from the Seventh Agricultural Census 2020. The number of sustainability dimensions each farm possesses forms the basis of the methodology. The findings indicate that, in 2020, 45% of holdings had at least one sustainability dimension; this share increases to 72% if the farm manager is under 40 years old. However, a significant sustainability gap remains between the north and south of the country.

Keywords: census, innovation, modernization, organic farming, sustainability
JEL codes: Q10, Q12, Q15

Highlights:

- Survival and the development of agricultural holdings depend on their degree of sustainability.
- Agriculture's sustainability is a complex and multidimensional concept, and its measurement is not an easy task.
- Sustainability evaluation requires the availability of several statistical indicators at the single farm level.
- The results of the 2020 General Census of agriculture census were used to calculate a farm sustainability indicator.

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record.

Please cite this article as:

Gismondi R. (2024). A census-based sustainability indicator of agricultural holdings: the case of Italy. *Italian Review of Agricultural Economics*, Online First.

DOI: 10.36253/rea-15056

1. What is sustainable agriculture?

The goal of sustainable agriculture is to meet society's food and textile needs in the present without compromising the ability of future generations to meet their own needs. Practitioners of sustainable agriculture seek to integrate three main objectives into their work: a healthy environment, economic profitability, and social and economic equity. When measuring agricultural sustainability, two interconnected challenges arise: i) defining the indicators to be considered at farm level, and ii) identifying the data sources to be used in their calculation. Undoubtedly, the selection of indicators lies at the heart of the methodology, irrespective of whether it is feasible to calculate them or not.

In 2015, the United Nations adopted the *Sustainable Development Goals* (SDGs) as a call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030. The key issue raised by the *SDGs* system is that sustainable development is a complex and multidimensional concept, based on three pillars: economic development, social development, and environmental protection. In particular, the FAO promotes the calculation of the SDG 2.4.1: Proportion of agricultural area under productive and sustainable agriculture. The SDG 2.4.1 includes the 11 sub-indicators in Table 1 (FAO, 2023).

Table 1. The 3 dimensions of agriculture sustainability according to FAO

Economic	Environmental	Social
1. Farm output value per hectare	4. Prevalence of soil degradation	9. Wage rate in agriculture
2. Net farm income	5. Variation in water availability	10. Food insecurity experience scale
3. Risk mitigation mechanisms	6. Management of fertilizers	11. Secure tenure rights to land
	7. Management of pesticides	
	8. Use of agro-biodiversity supportive practices	

Source: Elaboration based on FAO (2023).

Although the FAO requires the calculation of these indicators annually, this calculation is difficult even in most EU States because it implies the availability of numerous statistical variables at the single farm level with a yearly update. Actually, only during the agricultural censuses – therefore every ten years – it is possible to collect data concerning some of the indicators in Table 1 for each farm. The only statistical source capable of annually collecting a wide range of indicators on economic results and agricultural sustainability is the FADN survey, which however, does not include the smallest farms in the field of observation[1].

The new Common Agricultural Policy (CAP) 2023-2027 supports the transition towards more sustainable systems of food and farming, in line with the European Green Deal. The main goal of the CAP is supporting agricultural holdings in the EU. An agricultural holding – or farm – is "*a single unit, both technically and economically, operating under a single management and which undertakes economic activities in agriculture within the economic territory of the EU, either as its primary or secondary activity. The holding may also provide other supplementary (non-agricultural) products and services*". This definition (FAO, 2017, 43) is the same as that applied in the last agriculture census, as stated in Article 2(a) of Regulation (EU) 2018/1091 on integrated farm statistics. The 2020 agricultural census was an important step towards increased knowledge about the structure of agricultural holdings in the EU.

In this context, the study deals with the following question: is the information collected with the last general agricultural census able to evaluate the degree of sustainability of Italian agricultural holdings, at least with a certain degree of approximation? Following a brief literature review (Section 2), the paper examines the power of data collected from the latest agricultural census (Section 3.1.) to describe five fundamental sustainability dimensions of Italian farms (Section 3.2.). Section 4 presents the proposed classification methodology, the key results, and a comparison between 2020 and 2010. Section 5 offers a concise discussion of the findings, while Section 6 provides concluding perspectives.

[1] The Italian FADN (Farm Accountancy Data Network) does not observe farms with a yearly standard output lower than 8,000 euro. Based on the census 2020 results, they were 611,067 (53.9% of the total).

2. Short literature review

Several works commented on the need to focus on specific sustainability dimensions. Hansen (1996) underlined that agriculture sustainability can be interpreted according to two broad concepts: as an approach to agriculture developed in response to concerns about impacts of agriculture, or as a property of agriculture developed in response to concerns about threats to agriculture. However, even though interpreting sustainability as "an approach" should be useful for motivating change and improvements, conceptual and practical problems have limited its usefulness. In order for sustainability to be a useful criterion for guiding change in agriculture, its characterization should be quantitative and system-oriented. Blasi *et al.* (2016) showed that crops with negative environmental performances sustain farm income, while crops with a positive ecological balance bring a very limited contribution to economic profitability. Such results underline the *trade-off* between the economic and environmental consequences of farming activities in order to drive farmers towards more sustainable behaviour. More generally, evaluating farms' competitiveness may be a very different thing from evaluating their sustainability. Gilioli *et al.* (2020) analyse agriculture's sustainability from the point of view of biodiversity. Valorisation of agroecosystem biodiversity (spontaneous and cultivated flora, underground microbiota, habitat and landscape) support the transition of agricultural systems towards wider sustainability. Muie (2022) underlined that the use of novel approaches and practices such as smart agriculture, organic farming, biodynamic agriculture, sustainable intensification and regenerative agriculture has been proven to safeguard agricultural sustainability and should be implemented for ecological sustainability and food security. These goals lead to the keyword *innovation*, which is one of the indicators introduced in Section 3.2.

The complexity of the sustainability concept implies the need to define which indicators should be calculated at the single farm level to assess the degree of sustainability. Velten *et al*. (2015) conducted a structured literature review in combination with a cluster analysis in order to identify the overall ideas and aspects associated with sustainable agriculture. Within the three broad dimensions (economic, social and environmental) the authors identified 16 main themes, divided into goal themes, strategy themes and action themes. Latruffe *et al.* (2016) commented that in the latest literature, the environmental pillar has undergone an "indicator explosion", due to the multitude of themes covered and the attention given by society to this dimension of sustainability. By contrast, economic indicators target a relatively small number of themes. Social indicators typically cover two main sustainability issues: the farming community and society as a whole, their measurement being challenging as they are often qualitative and subjective. Bathaei and Štreimikiene (2023) identified a total of 101 indicators found in previous studies for the three broad dimensions. In order to measure sustainable agriculture, the paper proposes a reclassification of the wide set of indicators according to eight main types: technology, market access, prices (economic dimension), farm structure, pollution, soil (environmental), quality of products, and farmers' rights (social).

Beyond indicator selection, there is the need to identify reliable data sources useful for their calculation. Many works are based on the database derived from the FADN survey – which contains many more indicators than the census – from both the Italian and European perspectives. However, the FADN survey does not observe the smallest agricultural units, i.e., the farms, which are probably those most dramatically characterized by sustainability problems, such as staying alive first. Zahm *et al*. (2008) applied the IDEA method, based on 41 sustainability indicators covering the three dimensions of sustainability, using French case studies. They used the FADN network as a possibility to assess the sustainability level of different farming systems. The conclusion was that there is not just one farm sustainability model, and therefore the indicators must be adapted to local farming before using the methodology. Longhitano *et al.* (2012) built up a set of 26 sustainability indicators derived from the FADN database, some of which are monetary-valued, while others are social and environmental. Based on a multi-criteria matrix, a sustainability farm index was calculated at the farm level. The methodology was applied to the regional FADN sample of Veneto as of 2009. Buttinelli *et al.* (2021) assessed the financial sustainability of organic farms compared to conventional ones. Based on the FADN data, the analysis showed that financial sustainability is greater for organic farms than conventional farms, and in several cases, the level reached by the former is very high, especially in mixed types of farming. Turchetti *et al.* (2021) underlined how the goal of transforming the FADN system into the new FSDN is oriented to better incorporate the three sustainability dimensions and will permit objectives to be reached covered only in part by the current FADN. Coppola *et al.* (2022) proposed a principal component analysis in order to build an economic sustainability index applied to 6,000 FADN farms and based on three indicators: an efficiency indicator; an indicator of the ability of the farm to remunerate the entrepreneur's production factors; an indicator of the farm's income capacity.

As regards the usefulness of agriculture census data, Wrzaszcz and Zegar, (2014) presented proposals for measuring the economic sustainability of farms in Poland based on agricultural census data. They used the indicators of economic sustainability: land productivity, labour profitability (all these indicators are *not available* based on the 2020 Italian census), farm market activity, and sources of households’ income and maintenance. The results show that economic and environmental goals are complementary at the farm level and that economically sustainable farms often conduct pro-environmental agricultural activities.

3. Materials and methodology

3.1. Data sources: the census of agriculture

The 2020 Census was mandatory in each European Union country and was coherent with recommendations by the FAO (2017). The census had the purpose of updating the structural data collected with the 2010 Census and enriching the available information assets. The most critical feature was the actual state of activity of the farms, in a historical context characterised by the concentration of farms and consequent decrease of very small agricultural units. The census included questions concerned with the degree of modernization and sustainability of farms.

The data used for elaborations in the next sections are definitive and coherent with the data available on the ISTAT website[2] at the municipality level. In this context, common lands have been excluded from elaborations, because some relevant census questions, – such as those concerned with innovation and multifunctionality – could not be addressed to common lands. The census counted 1,133,006 farms, including common lands. The census results outlined the sharp decrease in the number of agricultural holdings between 2010 and 2020 (-30.1%).

Available data does not include revenues. However, based on census data, ISTAT calculated the *standard output* (SO) for each active farm. The SO of an agricultural product (crop or livestock) is the average monetary value of the agricultural output at farm-gate price, in euros per hectare or per head of livestock. The standard output can be used to classify agricultural holdings by type of farming and economic size. The 2020 census questions derived rom the information needs that emerged at EU level, connected to multiple aspects of business management that are not always strictly connected with sustainability. However, the main census value added is the capability of collecting several indicators at the level of each active farm (*microdata*), without a relevant size threshold. On the other hand, the main limitation of agriculture censuses is periodicity (ten years in the EU, five in the USA).

Most of the works based on census microdata deal with the typological classification of agricultural holdings. Russo and Sabbatini (2005) were among the first researchers to point out the usefulness of census data in order to classify farms. Even if not in close connection with the theme of sustainability, Arzeni and Sotte (2014) proposed a methodology based on the 2010 agricultural census data. They highlighted how the majority of Italian agricultural units are not "businesses" in a strict sense, but pseudo-family entities with low economic size. The authors considered: altimetry, technical-economic orientation, self-consumed production, days of work, sub-contracting, age and education of the farm manager, other gainful activities beyond agriculture production, and share of direct payments from the EU on revenues.

According to this path, based on the 2020 agricultural census, we have identified five main *behaviours* of the farms – five *sustainability dimensions* – which can determine, even with some approximation, how many farms are sustainable and which are their main features. Broadly speaking, being sustainable means choosing a management model that is oriented to the principles of sustainable agriculture, integrated with the surrounding territorial and entrepreneurial context, able to guarantee a minimum economic well-being to those who manage the farm, and which can offer services additional to the basic agricultural production. The methodology proposed is founded on three main pillars.

1. It is applied to all farms active in Italy. This is an important peculiarity of census surveys, which collect microdata for each unit of the population and not just for those belonging to a sample. The vast majority of applications known in the literature are based on a larger number of indicators, but are calculable only for a small subset of farms. Furthermore, they are not always representative samples of the entire population of existing farms.

[2] https://esploradati.istat.it/databrowser/#/it/censimentoagricoltura.

2. The agricultural census guarantees the high quality of the data collected, which derives from the direct measurement of the indicators through a skilled data collection network. Estimates were used only in a few cases (outlier observations).
3. As explained in Section 3.2., the census-based indicators employed are constructed from a dichotomous perspective (i.e., whether a requirement is met or not). This approach is deliberately simple and helps to reduce information asymmetries arising from the particular distribution of the original variables, which are often highly concentrated in a few large units.

3.2. The five dimensions

The degree of sustainability of agricultural holdings depends on multiple factors, as outlined in Section 1. One of the major critical issues consists of the trade-off between the number and consistency of available statistical indicators and the availability of these indicators for the greatest possible number of agricultural holdings. In this context, five dimensions have been identified, probably not all those that could be listed, but all measurable through the agriculture census. The second and fifth factors were not mandatory based on EU legislation. The indicators selected are focused on particular managerial strategies and do not directly concern structural features of the farm (as hectares of surface or geographical localization) or the farm manager (as gender or age).

Crops diversification

According to CAP 2023-2027, crop diversification is one of the three good practices for the climate and environment that must be respected by farmers in order to receive the ecological payment, or *greening*[3]. Greening considers diversification only for farms whose arable land exceeds 10 hectares. In particular:

- farms with an arable land area between 10 and 30 hectares must cultivate at least two crops, the main one of which does not occupy more than 75% of the arable land;
- farms with arable lands area exceeding 30 hectares must cultivate at least three crops, the main one of which does not cover more than 75% of the arable land and the two main ones together do not cover more than 95% of the arable land.

If more than 75% of the arable land is occupied by grass or other herbaceous fodder plants or by land left fallow, the number of crops based on the arable land area must still be respected, but there are no maximum limits. The diversification commitments do not apply, in addition to farms with arable land of less than 10 hectares, in the following cases:

a) if the arable land is entirely covered by a submerged crop (rice);
b) if more than 75% of the arable land is used for the production of grass or other herbaceous fodder plants and/or is kept fallow, provided that the total area of arable land not subjected to such uses does not exceed 30 hectares;
c) if more than 75% of the eligible agricultural area consists of permanent grassland, used for

[3] The other two practices are: the maintenance of permanent pastures on the farms where they are present and the maintenance or establishment of an Ecological Focus Area.

the production of grass or other herbaceous fodder plants or for the cultivation of submerged crops (rice) or a combination of such uses, provided that the total area of arable land not subjected to such uses does not exceed 30 hectares.

The census collected the data necessary to evaluate which farms would have met the requirements to access the greening contribution because of diversification just in 2020 (diversification binary variable = 1). However, based on this criterion, we could not assign any diversification score to: 1) farms with arable land areas of less than 10 hectares; 2) farms that fall into the particular cases from a) to c) mentioned above; 3) farms without arable land; and 4) farms with livestock only. Therefore, the diversification indicator for farms of types 1), 2) and 3) was equal to 1 if these farms had at least 5 different crops of any kind, and equal to 0 otherwise. As regards farms with livestock only (type 4), the indicator was equal to 1 if the farms had at least two different animal species among those observed by the census.

Organic farming

Organic farming is a method of production that places the highest emphasis on environmental protection and, with regard to livestock production, on animal welfare. It avoids or largely reduces the use of synthetic chemical inputs such as fertilizers, pesticides, additives and medicinal products. The production of genetically modified organisms and their use in animal feed are forbidden. It is a part of a sustainable farming system and a viable alternative to the more traditional approaches to agriculture.

A sustainable food system is at the heart of the European Green Deal. The European Commission set a target of at least 25% of the EU's agricultural land under organic farming and a significant increase in organic aquaculture by 2030. The area used for organic agricultural production in the EU keeps on increasing: it passed from 14.7 million hectares in 2020 to 15.9 million in 2021, which is 9.9% of the total utilized agricultural area (UAA) in the EU. In Italy, in 2022, organic agricultural areas were 2.35 million hectares, or 18.9% of the whole UAA.

Even though organic farming is not the only dimension able to measure the attention to the environment on the part of farmers, it is an important variable measured by the census. Therefore, the second indicator taken into account is expressed through the binary variable, equal to 1 (yes) if the farm was organic (crops and/or livestock) and equal to 0 (no) otherwise.

Other gainful activities (OGAs), or multifunctionality

The gainful activities of the farm include activities beyond basic agriculture production that have an economic impact on the farm. The census questionnaire took into account other gainful activities where either the resources of the holding (area, buildings, machinery, etc.) or its products are used in the activity.

OGAs constitute an additional source of income to basic agricultural production. The diversification of income sources is important, especially in the presence of economic shocks or other undesired events such as climate change, natural disasters, or wars (Van der Ploeg *et al.*, 2009). OGAs respond to new demand needs and allow the valorisation of a territory's characteristics and traditions. According to the census results, in 2020, 65,126 farms had at least one OGA, or 5.7% of the total. This percentage had increased compared to 2010 (4.7%).

In this context, only some particular OGAs have been taken into account. Assessing sustainability means evaluating the propensity of agricultural holdings to offer services to customers, such as a) agritourism, b) educational farming, c) care farming, which express the degree of social and economic sustainability of the company. Furthermore, from the point of view of environmental sustainability, it is important to verify whether the farms self-produce energy from renewable sources: d) wind, e) biomass, f) solar, g) hydro energy, and h) other renewable energy sources. Therefore, the third dimension is expressed through the binary variable, equal to 1 (yes) if the farm had at least one OGA from a) to h) and equal to 0 (no) otherwise. In 2020, there were 33,881 farms with at least one OGA from a) to h), or 3.0% of the total.

Innovation

Innovation in the agricultural and forestry sectors can be described as the introduction of something new (or renewed) that turns into an economic, social, or environmental benefit for rural practice. Innovation may be technological, non-technological, organizational, or social, and based on new or traditional practices. Moreover, innovations are often related to agriculture's sustainability (Fontana, Fiorillo, 2023). The trend towards increasing support for innovation was reinforced within the CAP 2023-2027. Introducing innovation is a cross-cutting goal that must be integrated into priorities adopted by Member States in their rural development plans.

The last agriculture census collected two kinds of information related to innovation. The first one consists of the answers to the question: "*In the last three years (2018-2020), has the farm made investments aimed at innovating the technique or production management?*" The second information source derives from the record linkage between census microdata and AGEA microdata. AGEA is the Italian authority that manages EU subsidies to farmers. Among the wide set of subsidies, we selected those more concerned with sustainability issues, based on the assumption that many rural development measures can have a positive impact on the sustainability of agricultural holdings (Moulogianni, Bournaris, 2021), The rural development measures selected are: quality regimes for agricultural and food products; investments in tangible assets; aid for starting up entrepreneurial activities for non-agricultural activities in rural areas; aid for starting up entrepreneurial activities for the development of small agricultural businesses; support for investments in the creation and development of non-agricultural activities; agro-climate-environmental payments; biological agriculture; Natura 2000 payments and payments related to the Water Framework Directive; animal welfare.

The fourth feature taken into account is expressed through the binary variable, equal to 1 (yes) if the farmer answered "Yes" to the question on innovation, and/or if the farmer received at least one of the EU subsidies listed above, and to 0 (no) otherwise.

Economic size

The economic size is a basic indicator for each agricultural holding. The basic rationale is that each farmer has the right to ensure food security for himself and his household (Rocchi *et al.*, 2012). Even though the agricultural census did not pick up economic data, census data can be used in order to calculate the standard output (SO)[4]. The SO takes into account land and

[4] https://rica.crea.gov.it/APP/documentazione/?page_id=2153

livestock but does not consider other sources of income, such as EU subsidies and other gainful activities. The SO is a *proxy* for the true (but unknown) economic revenues of farms.

The economic dimension of farms is fundamental in the framework of FAO Sustainable Development Goal 2.3: by 2030, double the agricultural productivity and revenues of small-scale food producers (FAO, 2019). Even though small-scale food producers should be identified according to the combination of the three dimensions given by agricultural land, livestock and net revenues, Gismondi (2024) showed that very similar results could be obtained using the SO in place of the three above-mentioned indicators.

Each modern farm must have a yearly SO larger than a given threshold. Of course, thresholds may be determined in different ways. In this context, we preferred not to use subjective thresholds, or to refer to percentiles of the SO cumulative distribution, which is strongly influenced by very large farms. Instead, we used the concept of *poverty threshold*, strictly connected with the old question about poverty and the richness of rural households. ISTAT updates this indicator annually; it represents the monetary value, at current prices, of the basket of goods and services considered essential for each family to avoid serious forms of social exclusion in the reference context[5]. In this framework, the threshold T used depended on the territorial area in which the agricultural holding was located, and was based on the standard household composition of three adults. On average, the poverty threshold was found to be T=17,562 euro. So, the fifth dimension taken into account is expressed through the binary variable, equal to 1 (yes) if the farm had SO≥17,562 euros and equal to 0 (no) otherwise.

4. Results

4.1. Sustainable and not sustainable farms

The core idea involves classifying agricultural holdings based on the number of sustainability dimensions they possess, ranging from 0 to 5. Naturally, this means that two farms may receive the same score even if their sustainability features differ partially or entirely.

For each reference domain, n is the number of agricultural holdings, while $n(i)$ is the number of agricultural holdings that have i sustainability dimensions (binary variable = 1) – e.g. i "Yes", for i=0,1,2,3,4,5. Moreover, we define:

number of sustainable farms: $n(1) + n(2) + n(3) + n(4) + n(5) = n - n(0)$ (4.1)
number of "high sustainability" farms = $n(4) + n(5)$ (4.2)
number of "medium sustainability" farms = $n(2) + n(3)$ (4.3)
number of "low sustainability" farms = $n(1)$ (4.4)
number of not sustainable farms = $n(0)$. (4.5)

Table 2 summarizes the $n(i)$ frequencies defined above and the main results of the farm classification based on the number of sustainability dimensions they possess (*sustainability score*). In 2020, 45 farms out of 100 were sustainable (more than 508,000). High sustainability characterized 2.1% of farms, while low sustainability farms were 22.2%. On the other hand, 55 farms out of 100 were not sustainable at all (more than 622,000).

[5] https://www.istat.it/it/files//2023/10/REPORT-POVERTA-2022.pdf

In detail, the scores in Table 3 summarise the frequencies with which the individual dimensions examined characterise agricultural holdings. Economic size is the most frequent sustainability dimension, since it is present in 358,133 farms, or 31.7% of the total (Table 3). The second most important sustainability dimension is diversification (20.4% of farms), while the least common dimension is multifunctionality (3.0%). The contribution provided by each dimension to the general level of sustainability can also be measured based on a second indicator. It is the number of farms with "yes" for that particular dimension and with "no" for all the remaining 4 dimensions (*exclusive "yes"*).

For instance, the economic dimension was the only sustainability dimension for 125,267 farms. We define *exclusive effect* as the percentage ratio between the number of exclusive "yes" and the number of "yes" for that particular dimension. As regards the economic dimension, the exclusive effect was 35% (125,267/315,133x100). The larger the exclusive effect is, the greater the relative importance of that dimension for the overall sustainability level, because without that dimension, the farm would not be sustainable at all. Even though innovation characterizes 188,827 farms, more than double compared to organic farming (79,053), the exclusive effects of these two dimensions are almost the same (18.0% and 17.9%, respectively).

Table 2. Degree of sustainability of farms by number of "Yes" (from 5 to 0) – 2020

Number of "Yes"	Classification	Number of farms	%
Total	Whole population	1,130,513	*100.0*
>0	**Sustainable**	**508,303**	***45.0***
4 or 5	High sustainability	23,862	*2.1*
2 or 3	Medium sustainability	233,905	*20.7*
1	Low sustainability	250,536	*22.2*
0	**Not sustainable**	**622,210**	***55.0***

Source: Elaboration on ISTAT data – Census of agriculture 2020.

Table 3. Number of farms with certain sustainability dimensions (5 dimensions) – 2020

Dimension	Number of "Yes"	% of total farms	Exclusive "Yes"	Exclusive effect
Diversification	230,716	*20.4*	72,983	31.6
Organic farming	79,053	*7.0*	14,178	17.9
Multifunctionality	33,881	*3.0*	4,063	12.0
Innovation	188,827	*16.7*	34,045	18.0
Economic size	358,133	*31.7*	125,267	35.0

Source: Elaboration on ISTAT data – Census of agriculture 2020.
Number of "Yes" %: % ratio between number of "Yes" and the whole population (1,130,513).
Exclusive "Yes": number of farms with "Yes" for that particular dimension only.
Exclusive effect: % ratio between exclusive "Yes" and number of "Yes".

The degree of sustainability of agricultural holdings is quite correlated with their main dimensional characteristics (Table 4). Not sustainable farms have on average 2.5 hectares of

UAA, 0.1 adult livestock units, 0.22 annual working units, and slightly more than 4000 euros of standard output. On the other hand, as regards sustainable farms (those with at least one sustainability dimension), these figures rise to 20.6 hectares, 18.2 adult livestock units, 1.23 annual working units and more than 105,000 euros of standard output.

Table 4. Dimensional indicators by degree of sustainability (average per farm) – 2020

Number of "Yes"	Classification	Standard output (1)	Utilized agricultural area (2)	Adult livestock units (3)	Annual working units - AWUs (4)
Total	Whole population	49,740	10.6	8.3	0.67
>0	**Sustainable**	**105,474**	**20.6**	**18.2**	**1.23**
4 or 5	High sustainability	253,617	52.6	44.3	2.71
2 or 3	Medium sustainability	147,928	28.9	27.0	1.58
1	Low sustainability	51,729	9.8	7.5	0.76
0	**Not sustainable**	**4,209**	**2.5**	**0.1**	**0.22**

Source: Elaboration on ISTAT data – Census of agriculture 2020.
(1) Euro. (2) Hectares. (3) Indicator that summarizes in a single number the different animal species present on the farm. (4) AWUs have been obtained by dividing the overall amount of hours worked by the standard daily work length, set equal to 8 hours, as recommended by EUROSTAT.

4.2. Post-stratification criteria

Features of the farm manager

According to the data collected by the census, it was possible to verify which factors most influence farm sustainability. These *post-stratification factors* belong to three main types: manager characteristics, type of production (crops and/or livestock), and territory (plains/hills /mountain and disadvantaged or not disadvantaged municipality). The use of data on disadvantaged municipalities[6] was possible through the linkage with the census database at municipality level. The main control indicator is the percentage of sustainable farms out of the total. The main difference with respect to Section 4.1. is that, in this context, the sustainability level is calculated within the particular sub-population identified through each post-stratification factor. For instance, as regards the *management* factor "How long have you been running the farm?" the farms can be distinguished between those with management of less than 3 years and those with management of at least 3 years. Farms managed for less than 3 years (Table 5) are more sustainable (54.9%) than those managed for a longer time (44.5%). The larger the difference in sustainability referred to strata identified by the post-stratification factor, the greater the importance of that factor for influencing farm sustainability.

[6] https://www.istat.it/it/files//2022/07/FOCUS-AREE-INTERNE-2021.pdf

Table 5. Sustainable farms according to some post-stratification criteria – 2020

Breakdown	Sustainable farms (1)	Farms with the dimension (2):				
		Diversifi-cation	Organic farming	OGAs	Innovation	Economic size
Management < 3 years	*54.9*	*23.1*	*9.2*	*2.8*	*21.4*	*38.7*
Management ≥ 3 years	*44.5*	*20.3*	*6.9*	*3.0*	*16.5*	*31.3*
Young (< 40 years)	*71.8*	*30.4*	*15.3*	*5.3*	*37.2*	*57.4*
Not young	*42.5*	*19.5*	*6.2*	*2.8*	*14.8*	*29.3*
Male	*48.2*	*21.4*	*7.2*	*3.0*	*18.9*	*35.2*
Female	*37.8*	*18.3*	*6.6*	*2.9*	*11.9*	*24.0*
Basic education	*40.4*	*18.0*	*4.7*	*1.9*	*13.2*	*28.1*
Diploma/degree	*53.8*	*25.0*	*11.4*	*5.0*	*23.4*	*38.6*
Crops and livestock	*73.4*	*33.5*	*10.4*	*7.2*	*34.4*	*60.0*
Only cultivations	*39.4*	*18.0*	*6.4*	*2.2*	*13.2*	*26.1*
Only livestock	*34.5*	*0.1*	*3.8*	*1.2*	*17.1*	*22.7*
Plains	*44.0*	*17.7*	*4.9*	*2.4*	*15.0*	*36.4*
Hills	*43.5*	*21.8*	*7.7*	*2.8*	*15.4*	*28.8*
Mountain	*51.0*	*21.4*	*8.8*	*4.6*	*23.8*	*31.0*
Disadvantaged	*39.2*	*21.2*	*7.6*	*1.0*	*12.6*	*24.2*
Not disadvantaged	*46.7*	*20.2*	*6.8*	*3.6*	*17.9*	*33.9*

Source: elaborations on ISTAT data.

(1) % ratio between sustainable farms and total farms. (2) % share on total farms.

The most important factor is the age of the farm manager: 71.8% of farms managed by a "young" manager (with less than 40 years) are sustainable, compared to 42.5% of farms with a "not young" manager. These results confirm the fundamental role played by new generations in modernizing agriculture (Proctor, Lucchesi, 2012). Young managers develop organic farming and innovation more than twice that compared to not young managers: these sustainability dimensions characterize, respectively 15.3% and 37.2% of farms managed by young managers, against 6.2% and 14.8% of farms managed by not young managers.

Further factors discriminate significantly against different sustainability levels: farms with both crops and livestock are much more sustainable (73.4%) than those with only cultivations (39.4%) or only livestock (34.5%); farms whose manager has a diploma or degree are more sustainable (53.8%) than those whose manager has only basic education (40.4%).

It is undoubtedly comforting to note that the gender of the manager does not discriminate too much in the sustainability level, although for female-run holdings, the sustainability is lower than for male-run ones (37.8% versus 48.2%). In particular, the gender gap is almost null as regards other gainful activities and organic farming.

As regards territory, it is not surprising that the sustainability level of farms located in disadvantaged municipalities is lower than that of those operating in non-disadvantaged municipalities (39.2% against 46.7%). On the other hand, the higher sustainability level of mountain farms (51.0%) is surprising, at least in part. This may be due to the fact that the lower accessibility of mountain sites may lead to the need to organize their own production according to schemes that are basically sustainable and integrated with the surrounding area. This profile is confirmed by the larger propensity of mountain farmers to practice organic farming, carry out other gainful activities and introduce innovations.

Regional aspects

The geographical breakdown represents one of the most important post-stratification criteria. The persistence of geographical gaps in the degree of evolution of Italian agriculture is well known. In 2020, while in the north-west area the percentage of sustainable farms was 64.2%, it was only 34.6% in the south (Table 6). Sustainability decreases from north to south, even though the average sustainability of the two major islands (Sicily and Sardinia) is more similar to that of the centre than south. Compared to other areas, southern regions are penalized above all by their small economic size and poor propensity to introduce innovations. In the south, other gainful activities are also not very widespread, being practiced by only 1% of farmers, a share that is very close to that of the islands (1.2%). In the south only organic farming shows diffusion similar to the national average (6.5% of farms against 7.0%).

The territorial heterogeneity of sustainability is further highlighted by regional analyses. Figure 1 shows the ranking of Italian regions based on the percentage of sustainable farms on the regional total (horizontal axis) and the ISIC indicator (vertical axis). ISIC[7] is a synthetic indicator of regional agro-food competitiveness, which summarizes the four competitiveness dimensions: cost competitiveness, gross profitability, foreign markets and innovation. Both indicators have been calculated with reference to their national averages (equal to 100).

Table 6. Sustainable farms by geographic area – 2020

Geographic area	Sustainable farms (1)	Farms with the dimension (2):				
		Diversification	Organic farming	OGAs	Innovation	Economic size
North-West	*64.2*	*27.9*	*5.3*	*5.9*	*26.6*	*50.1*
North-East	*57.8*	*22.3*	*7.2*	*5.7*	*27.6*	*45.9*
Centre	*46.4*	*24.7*	*9.0*	*5.7*	*15.9*	*28.9*
South	*34.6*	*16.5*	*6.5*	*1.0*	*10.3*	*22.3*
Islands	*45.7*	*20.0*	*7.1*	*1.2*	*17.0*	*33.1*
ITALY	***45.0***	***20.4***	***7.0***	***3.0***	***16.7***	***31.7***

Source: elaborations on ISTAT data.
(1) % ratio between sustainable farms and total farms. (2) % share on total farms.

ISIC considers parameters such as economic performance and openness with respect to international markets not available from the 2020 census and therefore not included in the sustainability indicator proposed here. On the other hand, even though ISIC is a competitiveness

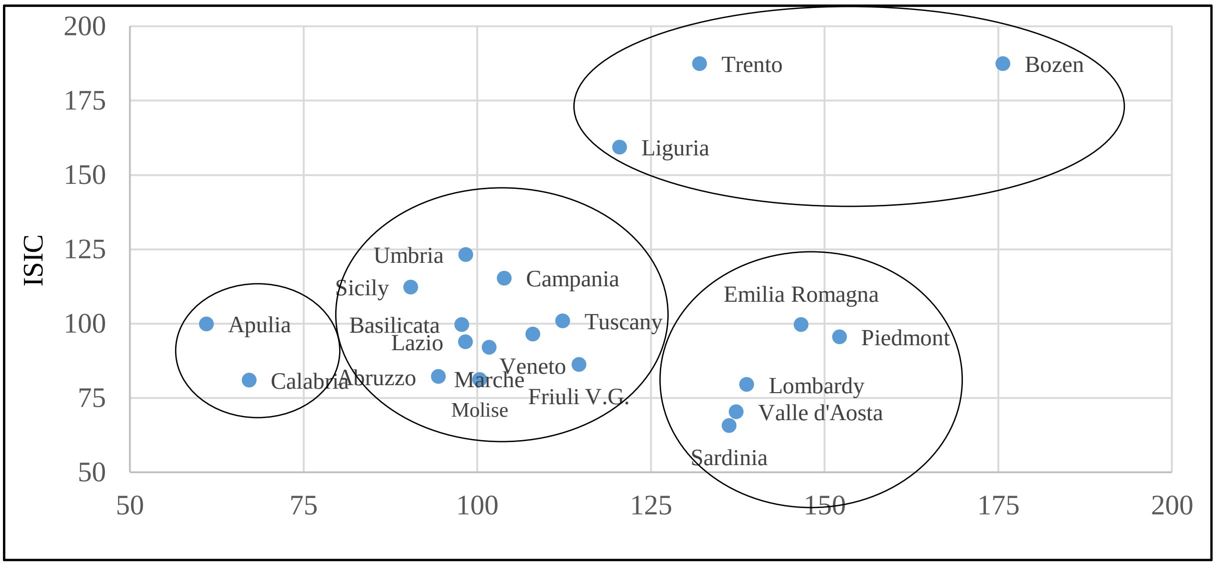
[7] The ISIC indicator (*Indicatore SIntetico di Competitività*) taken into consideration refers to the agricultural component only (with the exclusion of food manufacturing). It is the synthesis of aggregate data on a regional scale and could not be calculated starting from data referred to each active agricultural holding, such as occurs instead for the sustainability indicator (ISMEA, 2021).

and not a sustainability indicator, it also takes into account some aspects related to sustainability. Joint analysis of the sustainability index and ISIC leads to the identification of four regional clusters.

1. Regions with levels of agro-food competitiveness and agricultural sustainability close to their respective national averages. Most of the regions belong to this cluster; in order of increasing sustainability, they are Sicily, Abruzzo, Basilicata, Lazio, Molise, Marche, Campania, Veneto, Tuscany and Friuli Venezia Giulia.
2. Regions with ISIC index and agricultural sustainability significantly higher than the respective national averages: Liguria and the autonomous provinces of Trento and Bolzano.
3. Regions with high agricultural sustainability but levels of agro-food competitiveness equal to or lower than the national average: Sardinia, Valle d'Aosta, Lombardy, Emilia Romagna and Piedmont.
4. Regions with low environmental sustainability and ISIC index levels equal to or lower than the national average: Apulia and Calabria, which are the Italian regions with the lowest sustainability levels.

These results confirm that economic competitiveness is important, but does not necessarily imply sustainability, and vice versa. At regional level, the linear correlation between ISIC and sustainability is poor (*r*= 0.33) and 7 regions out of 21 (those belonging to clusters 3 and 4) are characterized by very discordant levels of the two indices.

Figure 1. Sustainability and agriculture competitiveness by Regions – 2020



Source: elaborations on ISTAT and Rete Rurale Nazionale data. Italian average = 100.

4.3. Comparison with 2010 Census

Each census includes partly or entirely new questions. Therefore, the 2020 census collected data that was not available with the 2010 census. For example, the propensity to introduce innovations, which is one of the dimensions used for assessing the sustainability level as regards 2020.

Overall, the 2020 data are substantially comparable with those of 2010, even though the two censuses used different size thresholds. In order to estimate the changes in the degree of sustainability of Italian farms over the decade, we applied a classification methodology similar to that described in Section 4.1., even though the innovation dimension has been excluded. Both for 2020 and 2010, starting from the availability of data for each farm, the other four dimensions (diversification, organic farming, multifunctionality and economic size) are measurable.

The main consequence is that, to allow comparison between 2020 and 2010, the sustainability classification of farms changes as follows: according to the symbols introduced in Section 4.1., $n(i)$ is the number of agricultural holdings which have i sustainability dimensions (binary variable = 1) – e.g. i "yes", for i=0,1,2,3,4. Moreover, we define:

number of sustainable farms: $n(1) + n(2) + n(3) + n(4) = n - n(0)$ (4.6)
number of "high sustainability" farms = $n(4)$ (4.7)
number of "medium-high sustainability" farms = $n(3)$ (4.8)
number of "medium-low sustainability" farms = $n(2)$ (4.9)
number of "low sustainability" farms = $n(1)$ (4.10)
number of not sustainable farms = $n(0)$. (4.11)

Of course, the results referring to 2020 reported in Tables 7 and 8 are slightly different from those already seen in Section 4.1. because they are based on four sustainability dimensions rather than five. With reference to 2020, the exclusion of the innovation dimension led to a reduction in the share of sustainable farms: 42.0% (Table 7), compared to 45.0% obtained including innovation (Table 2).

Table 7. Degree of sustainability of farms by number of "Yes" (from 4 to 0) – 2020 and 2010

Number of "Yes"	Classification	2020		2010	
		Number of farms	%	Number of farms	%
Total	Whole population	1,130,513	*100.0*	1,620,884	*100.0*
>0	**Sustainable**	**474,258**	***42.0***	**525,817**	***32.4***
4	High sustainability	3,593	*0.3*	5,322	*0.3*
3	Medium-high sustainability	32,317	*2.9*	31,254	*1.9*
2	Medium-low sustainability	152,112	*13.5*	160,477	*9.9*
1	Low sustainability	286,236	*25.3*	328,764	*20.3*
0	**Not sustainable**	**656,255**	***58.0***	**1,095,067**	***67.6***

Source: Elaboration on ISTAT data – Censuses of agriculture 2020 and 2010.

The main result deriving from comparison with 2010 is that, over the decade, farms' sustainability increased significantly, since it was only 32.4% in 2010. While the share of "high sustainability" farms remained the same (0.3% both in 2010 and 2020), the relative importance of "medium sustainability" farms increased: from 1.9% to 2.9% as regards "medium-high" and from 9.9% to 13.5% as regards "medium-low". Even "low sustainability" farms increased: they rose from 20.3% to 25.3%, probably because over the decade a share of non-sustainable farms have become sustainable, albeit at a low level. A comparison between 2010 and 2020 shows that the share of farms with at least one sustainability dimension increased (Table 8). The largest increase characterizes the economic dimension (8.1 percentage points, from 23.6% to 31.7%), while the share of farms adopting organic farming has more than doubled (from 3.1% to 7.0%).

Overall, the results confirm that Italian agriculture is becoming more sustainable over time, emerging from the essentially rural context that characterized it at least until the 1990s. However, sustainability levels still depend too much on farm size and location.

Table 8. Number of farms with certain sustainability dimensions (4 dimensions) – 2020 and 2010

Classification	2020		2010		Difference 2020-2010
	Number of farms	%	Number of farms	%	
Diversification	230,716	*20.4*	255,798	*15.8*	4.6
Organic farming	79,053	*7.0*	50,092	*3.1*	3.9
Multifunctionality	33,881	*3.0*	27,424	*1.7*	1.3
Economic size	358,133	*31.7*	382,195	*23.6*	8.1

Source: Elaboration on ISTAT data – Censuses of agriculture 2020 and 2010.

5. Discussion

As already mentioned in Section 3.2., the main limitation of the methodology proposed is the low number of sustainability indicators available. This limit derives from the characteristics and purposes of the agricultural census, which was carried out in Italy, having to respect the rigid constraints imposed by the EU regulations on the matter. The census collected a lot of data on production tools, but only a few indicators strictly related to sustainability. Each of the indicators used (Section 3.2.) is connected with specific sustainability dimensions (Table 1).

- Crop diversification and organic farming refer to the environmental dimension.
- Economic size refers to the economic dimension.
- Other gainful activities refer to the economic dimension (because they represent a source of additional revenue), but also to the environmental dimension (regarding the production of energy from renewable sources) and the social dimension (educational and care farming).
- Innovation is a transversal characteristic connected to all three sustainability dimensions.

We used the five above indicators for these main reasons. 1) They are available for 100% of farms. 2) As just seen, they are connectable to SDG 2.4.1. 3) They can be easily expressed through binary variables (possession or not of the characteristic).

A potential limitation of the methodology is that the dimensions have the same weight in the synthesis procedure that allows the classification of agricultural holdings. This choice derives from the intrinsic multidimensional nature of the sustainability concept, which attributes the same importance to environmental, economic and social dimensions. Moreover, based on the analysis of the exclusive effect of each dimension (Table 3), the five indicators do not have the same relative importance: diversification and economic size are much more relevant indicators than the others. This evidence largely derives from the fact that in 2020, there were still relatively few farms dedicated to organic farming or multifunctionality.

The proposed methodology considers the five dimensions individually and therefore analyses them separately. Even though the advantage of this approach is the possibility of easily understanding why a certain farm is more or less sustainable, the main risk is to lose pieces of the correlation between the variables and the dimensions themselves. Gómez-Limón and Sanchez-Fernandez (2010) proposed a methodology applied to two Spanish agricultural systems based on calculating 16 sustainability indicators that cover the three main components (economic, social and environmental), and their subsequent aggregation into nine different types of composite sustainability indices. Reig-Martínez *et al.* (2011) built up a composite indicator at the farm level to assess social, economic and environmental issues, combining Data Envelopment Analysis and Multi-Criteria Decision-Making methods. Dos Santos and Ahmad (2020) proposed a cluster analysis of EU countries based on 22 indicators derived from the FADN, founded on the calculation of composite indicators, where the weight of each original indicator is derived from a factor analysis. In our context, the number of basic indicators is quite low (5). Their normalization consisted of the use of binary variables equal to one if the farm possessed that particular feature and to zero otherwise. The aggregation criterion was the not weighted sum of indicators because of two main reasons. First, the main goal was to assess whether the farm reached each target (yes or no). Second, the degree of linear correlation among the five indicators is quite low: the average correlation between each couple of indicators is 0.167, and the highest correlation referred to the couple 1 (diversification) and 5 (economic dimension) is still rather low (0.308). Both these pieces of evidence and the very low number of indicators taken into account discouraged the use of composite indicators.

Among the studies on agricultural sustainability, at least partly comparable with the one examined, we consider the results obtained by Longhitano *et al.* (2012), referring to the Italian case. The two analyses are not fully comparable because the authors used a much broader set of indicators derived from the FADN network and applied the methodology to the Veneto region for the accounting year 2009. One of the main results was the identification of three sustainability classes: low (44% of companies), medium (44%) and high (12%). It is useful to note that the methodology based on 2020 census data applied only to Veneto farms would lead to these percentages: 50.2% (low sustainability), 41.6% (medium) and 8.2% (high), data that is not very different, given that the methodology based on census data also includes very small farms (not included in the FADN observation field). Based on the 2010 Census of agriculture census results, Arzeni and Sotte (2014) showed that in 2010, 80.1% of agricultural units were “non-businesses”. It is plausible to assume that, based on the methodology proposed in this context, these “non-businesses” would have been classified as “not sustainable” or with “low sustainability”, classes that, with reference to 2020, included 77.2% of farms (Table 2); this percentage is slightly lower than the percentage of “non-businesses” estimated in 2010.

6. Main conclusions and future work

Increasing sustainability and modernizing the national agricultural system are two parallel, unavoidable processes that can also be speeded up by the National Recovery and Resilience Plan, defined in 2021. In this framework, the periodic measurement of the degree of agricultural sustainability becomes an essential objective.

The methodology proposed in this work aims to provide an overall evaluation of the sustainability of Italian farms. This approach requires the availability of indicators at farm level, typically sourced from agricultural censuses, which are conducted every ten years. Based on 2020 data, the methodology utilises five indicators reflecting specific farm dimensions related to sustainability. These dimensions include crop or livestock diversification, organic farming, additional gainful activities beyond basic agricultural production, innovation and economic size. The number of sustainability indicators possessed by each farm (ranging from 0 to 5) forms the basis of the classification. A farm is considered sustainable if it meets at least one sustainability dimension: in 2020, more than 508,000 farms (45% of active farms) met this criterion. Comparisons with 2010 are challenging due to the absence of innovation data in the Sixth Agricultural Census. Nevertheless, we estimate that the degree of sustainability increased by 9.6% over this decade.

The proposed system of indicators does not claim to be definitive or to establish a sustainability model that should remain unchanged. The five indicators only partially cover the three main dimensions of sustainability (economic, environmental and social) because the agricultural census was not designed with sustainability in mind. For instance, aspects such as the use of precision agriculture, the training levels of the workforce beyond the farm manager, additional environmental protection measures beyond organic farming, and most notably, the quantities of plant protection products and nutrients used in crop cultivation are not fully captured. Therefore, it is crucial to enhance collaboration between institutions that manage information databases, including administrative ones, related to agricultural holdings. This would enable the cross-referencing of indicators with high informational value at the individual farm level.

It is important to replicate these calculations at intervals of less than ten years. While the convergence process aimed at reducing the historical north-south divide is undoubtedly in progress, it is essential to monitor its pace and territorial reach. Agricultural systems, which remain divided into two major groups – predominantly modern market-oriented holdings and smaller, self-subsistence farms – are no longer sustainable.

Author Contributions
One author only.

Declaration of Competing Interest
The author declares no conflict of interest in this manuscript.

Data Availability

Data will be made available by the corresponding author upon request.

References

Arzeni A., Sotte F. (2014). Agricoltura e territorio: dove sono le imprese agricole? *QA Rivista dell'Associazione Rossi-Doria*, 1: 75-100. DOI. https://doi.org/10.3280/QU2014-001003.

Bathaei A., Štreimikienė D. (2023). A systematic review of agricultural sustainability indicators. *Agriculture*, 13, 241. DOI: https://doi.org/10.3390/agriculture13020241.

Blasi E., Passeri N., Franco S., Galli A. (2016). An ecological footprint approach to environmental-economic evaluation of farm results. *Agricultural Systems*, 145: 76-82. DOI: https://doi.org/10.1016/j.agsy.2016.02.013.

Buttinelli R., Cortignani R., Dono G. (2021). Financial sustainability in Italian Organic Farms: An analysis of the FADN Sample. *Economia Agro-Alimentare Food Economy - Open Access*, 23(3). DOI: https://doi.org/10.3280/ecag2021oa12766.

Coppola A., Amato M., Vistocco D., Verneau F. (2022). Measuring the economic sustainability of Italian farms using FADN data. *Agricultural Economics – Czech*, 68(9): 327-337. DOI: https://doi.org/10.17221/169/2022-AGRICECON.

Dos Santos M.J.P.L., Ahmad N. (2020). Sustainability of European agricultural holdings. *Journal of the Saudi Society of Agricultural Sciences*, 19(5): 358-364. DOI: https://doi.org/10.1016/j.jssas.2020.04.001.

FAO (2017). *World programme for the census of agriculture 2020. Programme, concepts and definitions*. https://www.fao.org/3/i4913e/i4913e.pdf.

FAO (2019). *Methodology for computing and monitoring the Sustainable Development Goal Indicators 2.3.1 and 2.3.2*, FAO Statistics Working Paper Series / 18-14.

FAO (2023). *Proportion of agricultural area under productive and sustainable agriculture.* https://openknowledge.fao.org/server/api/core/bitstreams/04c03eca-49d4-443c-b38e-16c9e16c01a5/content.

Fontana E., Fiorillo V. (2023). *Agricoltura tra sostenibilità e innovazione*. SDA Bocconi – Edagricole – Crédit Agricole. https://www.libreriauniversitaria.it/agricoltura-sostenibilita-innovazione-1-rapporto/libro/9788850656509.

Gilioli G., Orlando F., Ghiglieno I., Sperandio G., Simonetto A. (2020). Biodiversità e agricoltura sostenibile. *Equilibri*, 1: 69-76. DOI: https://doi.org/10.1406/97537.

Gismondi R. (2024). Who are small-scale food producers in Italy? Comparisons among different approaches. *Statistical Journal of the IAOS*, 40: 289-298. DOI: https://doi.org/10.3233/SJI-230085.

Gómez-Limón J.A., Sanchez-Fernandez G. (2010). Empirical evaluation of agricultural sustainability using composite indicators. *Ecological Economics*, 69(5): 1062-1075. DOI: https://doi.org/10.1016/j.ecolecon.2009.11.027.

Hansen J.W. (1996). Is agricultural sustainability a useful concept? *Agricultural Systems*, 50(2): 117-143. DOI: https://doi.org/10.1016/0308-521X(95)00011-S.

ISMEA (2021) *Il modello ISIC-regioni. Un indicatore sintetico di competitività dell'agroalimentare nelle regioni italiane*. Rete Rurale Nazionale, Roma.

Longhitano D., Bodini A., Povellato A., Scardera A. (2012). Assessing farm sustainability. An application with the Italian FADN sample. *1st AIEAA Conference: Towards a Sustainable Bio-economy: Economic Issues and Policy Challenges*, 4-5 June, Trento.

Latruffe L., Diazabakana A., Bockstaller C., Desjeux Y., Finn J., Kelly E., Ryan M., Uthes S. (2016). Measurement of sustainability in agriculture: a review of indicators. *Studies in Agricultural Economics*, 118: 123-130. DOI: http://dx.doi.org/10.7896/j.1624.

Moulogianni C., Bournaris T. (2021). Assessing the impacts of rural development plan measures on the sustainability of agricultural holdings using a PMP model. *Land*, 10(446): 1-13. DOI: https://doi.org/10.3390/land10050446.

Muie S.H. (2022). Novel approaches and practices to sustainable agriculture. *Journal of Agriculture and Food Research*, 10: 1-11. DOI: https://doi.org/10.1016/j.jafr.2022.100446.

Proctor F., Lucchesi V. (2012). *Small-scale farming and youth in an era of rapid rural change*. https://www.iied.org/sites/default/files/pdfs/migrate/14617IIED.pdf.

Reig-Martínez E., Gómez-Limón J.A., Picazo-Tadeo A.J. (2011). Ranking farms with a composite indicator of sustainability. *Agricultural Economics*, 42(5): 561-575. DOI: https://doi.org/10.1111/j.1574-0862.2011.00536.x.

Rocchi B., Stefani G., Romano D., Landi C. (2012). Are Italian farming households actually poorer than other not agricultural households? An empirical analysis. *Towards a Sustainable Bio-economy: Economic Issues and Policy Challenges*, 1th AIEAA Conference, Trento: 4-5 June 2012. https://ageconsearch.umn.edu/record/124128?ln=en.

Russo C., Sabbatini M. (2005). Analisi esplorativa delle differenziazioni strategiche nelle aziende agricole. *REA - Rivista di Economia Agraria*, 4.

Turchetti L., Gastaldin N., Marongiu S. (2021). Enhancing the Italian FADN for sustainability assessment: The state of art and perspectives. *Economia Agro-Alimentare Food Economy – Open Access*, 23(3). DOI: https://doi.org/10.3280/ecag2021oa12771.

Van der Ploeg J.D., Laurent C., Blondeau F., Bonnafous P. (2009). Farm diversity, classification schemes and multifunctionality. *Journal of Environmental Management*, 90/2009: 124-131. https://doi.org/10.1016/j.jenvman.2008.11.022

Velten S. Leventon J., Jager N. Newig J. (2015). What Is Sustainable Agriculture? A Systematic Review. Sustainability. 7: 7833-7865. DOI: 10.3390/su7067833

Wrzaszcz W., Zegar J.S. (2014). Economic sustainability of Farms in Poland. *European Journal of Sustainable Development*, 3(3):165-176

Zahm F., Viaux P., Vilain L., Girardin P., Mouchet C. (2008). Assessing farm sustainability with the IDEA method – from the concept of agriculture sustainability to case studies on farms. *Sustainable Development*. 16: 271–281. DOI: 10.1002/sd.380