# Sustainable farming in Serbia – FADN data exploration

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**Abstract**

**This paper explores the economic, ecological, and social dimensions of sustainability in Serbian agricultural holdings, using FADN data as the primary source. The analysis shows that economic viability has improved overall, with notable regional disparities—farms in Serbia North consistently outperforming those in the south. Sectoral differences were also evident, with horticulture and granivore farms achieving higher economic sustainability compared to dairy and grazing livestock farms. Ecological analysis focused on biodiversity revealed consistently low Shannon diversity index values on dairy farms, indicating limited crop diversity and highlighting the need for diversification. The study also addresses the social dimension of sustainability, emphasizing the lack of standardized indicators and the influence of farmers' experience, education, and gender on productivity and farm performance. These findings demonstrate the complexity of assessing farm sustainability and the importance of integrating economic, ecological, and social indicators. The results suggest that targeted support and tailored strategies are needed to enhance sustainability across all dimensions, especially in less developed regions and among vulnerable farm types.**

## Introduction

One of the earliest definitions of sustainability was introduced by Repetto, who argued that sustainability is grounded in the principle that present-day decisions must not jeopardize the potential for future generations to maintain or enhance their living standards (Repetto, 1985). Also, the widely accepted definition of sustainable development originates from the Brundtland Report (WCED, 1987), emphasizing development that meets present needs without compromising future generations. Harris (2009) expanded this view by suggesting that "the path to sustainable development is one where the overall stock of fixed assets is either stable or grows over time." Broadly speaking, sustainable development can be described as a process that seeks to harmonize diverse human activities with the capacity of the environment. Modern scientific and policy discourse generally agrees that sustainable development—seen essentially as system sustainability—arises from the interplay between ecological, economic, and social factors. Measuring sustainability often relies on the use of indicators, which help connect theory with practice. Indicators condense complex data into more accessible forms that facilitate decision-making and inform policy. According to Bossel (1999), such indicators must be easy to interpret, transparent in their meaning for all involved parties regardless of educational background and based on information that can be gathered without excessive complexity or cost. Ideally, data collection should be straightforward enough to integrate into daily observation and routine analysis.

When applied to agricultural holdings, sustainable agricultural systems can be described as those that produce goods and services (economic role), steward natural resources carefully (ecological role), and foster the vitality of rural communities (social role) (Diazabakana et al., 2014). A thorough evaluation of all sustainability dimensions is vital for ensuring the future progress of agricultural holdings. In line with this, a project funded at the Faculty of Agriculture in Novi Sad, Serbia was launched with the aim of assessing these indicators, and the purpose of this paper is to present some of the results obtained through this research. The FADN database was adopted as the basis for this analysis because it fulfils the key requirements for indicator selection outlined above. The Farm Accountancy Data Network (FADN) is the main European source of microeconomic data for agricultural holdings, aimed at evaluating farm income and business performance. Although primarily focused on economic data, FADN offers indirect insight into ecological and limited social factors. The European Union has recognized the limitations of the FADN system, particularly its strong focus on the economic dimension while largely neglecting the social and ecological aspects in the assessment of farm sustainability. As a result, a transition is currently underway from the FADN to the more comprehensive FSDN (Farm Sustainability Data Network), which aims to address these shortcomings.

The first research question in the project and this paper focused on identifying sustainability indicators that can be derived from the FADN database, which is presented in the paper through the tables 1, 4 and 6. Subsequently, further research was conducted to assess selected indicators, as shown in the tables 2, 3 and 5.

## Material and Method

Sustainability indicators for agricultural holdings were selected based on peer-reviewed international and domestic publications. Relevant keywords were used to search databases such as SCOPUS, Google Scholar, and ScienceDirect, covering economic, environmental, and social aspects of sustainability. When analysing the reviewed papers, the most frequently used economic indicators were ROA, ROE, and LTEV; ecological indicators often included biodiversity proxies like the Shannon Index; while social indicators remained scarce and inconsistent (Miljatović et al., 2025; Despotović et al., 2024). The analysis focused on Serbian family farms included in the FADN sample from 2015 to 2021, specifically those present throughout the entire seven-year period. After excluding farms with extreme values or missing data, the final sample included 527 holdings.

Economic viability of farms was evaluated as the ratio of farm net income (FNI) and reference income (RI). Farm net income is calculated as the following (EC, 2022):

$$FNI = TO - IC + BCST - D + BSTI - EF$$

where TO is the total output, IC is the total intermediate consumption, BCTS is the balance of current subsidies and taxes, D is depreciation, BSTI is the balance of subsidies and taxes on investment, and EF is the total external factors (which are not the property of the farm: wages paid, rent paid, interest paid). Reference income represents the sum of oppotunity costs of own factors of production (labour, non-land capital and land). Opportunity cost of labour is the product of hourly average wage in national economy and the unpaid labour (family labour) hours for a year (O'Donoghue et al., 2016; Kołoszycz, 2020). Opportunity cost of non-land capital is the product of total equity minus value of agricultural land of the farm and the 5% rate of return (Frawley and Commins, 1996; Hennessy and Moran, 2015). Opportunity cost of land is the product of hectares of own land and average land rent in specific region (Coppola et al., 2020).

Share of economically viable farms (SEV) is estimated as the following ratio:

$$SEV = \frac{the\ number\ of\ farms\ where\ FNI\ \geq\ RI}{total\ number\ of\ farms\ in\ the\ sample}$$

For LTEV calculation farms were categorized by type of farming into: (1) specialist field crops, (2) specialist permanent crops (vineyards and fruits), (3) specialist milk, (4) specialist grazing livestock (cattle, sheep, goats), and (5) mixed farms—representing around 96% of all commercial farms in Serbia.

Economic viability was assessed using the opportunity cost approach, with a focus on long-term economic viability (LTEV), as it fully accounts for the opportunity costs of labor, capital, and land—the three key agricultural production factors (Hlavsa at el., 2020). The formula used to calculate economic viability is as follows:

$$LTEV = \frac{FNI}{TOC}$$

where FNI represents farm net income and TOC stands for total opportunity costs. Farms with an LTEV coefficient of 1 or higher are considered economically viable, as they use their resources efficiently and earn more from farming than they would by reallocating their production factors elsewhere. In contrast, farms with an LTEV below 1 cannot generate enough net income to cover the opportunity costs of their own resources, indicating insufficient profitability or a net loss (Miljatović et al., 2025).

The formula for calculating the Shannon Diversity Index is:

$$H' = - \sum_{\infty}^{s} (pi) * (lnpi)$$

Where: H' = Shannon diversity index; S = number of species in the area; pi = proportional share of the i-th species in the total area of all observed species, ln = natural logarithm.

For agricultural holdings, the Shannon index measures crop diversity and distribution as the absolute sum of each crop's share in total cultivated area multiplied by its natural logarithm. The Shannon index can be used to assess biodiversity in plant, animal, and microbial species, both above and below ground, as well as in aquatic environments (Ortiz-Burgos, 2016).

Given the aforementioned limitations of the FADN database with regard to social indicators, this paper presents only the potential indicators available within the database that could possibly be used for assessing the social sustainability of agricultural holdings.

## RESULTS WITH DISCUSSION

### ECONOMIC INDICATORS OF FARM SUSTAINABILITY

In the initial phase of our research, we first identified a set of potential economic sustainability indicators that could be extracted from the FADN database (Table 1). The aim was to establish a foundation of relevant indicators, some of which would later be applied in the assessment of farm economic viability. Defining the economic sustainability of agricultural holdings can be challenging. Savickiene et al. (2015) describe it effectively as "the ability of a farm to survive, live, and develop using available resources." Indicators for assessing economic sustainability largely rely on the FADN system, originally designed to monitor production and economic performance at the farm level. According to Latruffe et al. (2016b), the main economic indicators fall into four categories: profitability, liquidity, stability, and productivity. Table 1 presents the indicators that the authors considered potentially relevant for evaluating economic sustainability based on their theoretical significance and data availability within the FADN system.

**Table 1.** Potential Economic Sustainability Indicators Derived from FADN Data

| Indicator group | | Indicators |
|---|---|---|
| FINANCIAL SUSTAINABILITY | Profitability | Return on Assets (ROA) |
| | | Return on Equity (ROE) |
| | | Return on Invested Capital (ROIC) |
| | | Return on Sales (ROS) |
| | Liquidity | Working Capital to Short-Term Liabilities Ratio |
| | | Total Liabilities to Net Cash Flow Ratio |
| | Stability | Debt to Equity Ratio |
| | | Share of Fixed Assets in Total Assets |
| | | Equity to Fixed Assets Ratio |
| PRODUCTIVITY | Partial Productivity | Value of Production per Annual Work Unit |
| | | Value of Production per Agricultural Land Used |
| | | Gross Profit per Annual Work Unit |
| | | Gross Profit per Agricultural Land Used |
| | | Net Added Value per Annual Work Unit |

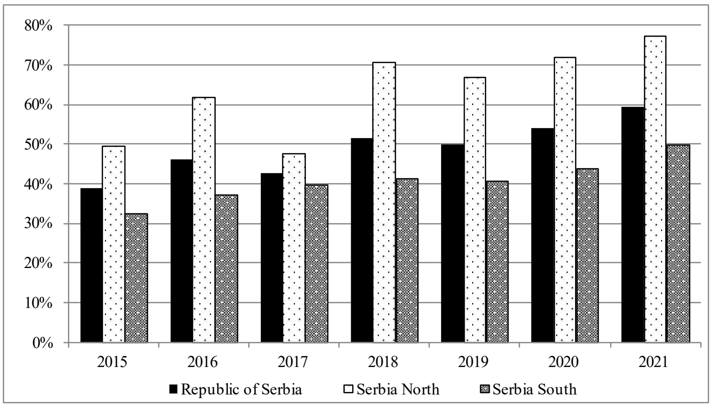
| Indicator group | | Indicators |
|---|---|---|
| | | Net Added Value per Agricultural Land Used |
| | | Net Profit per Annual Work Unit |
| | | Net Profit per Agricultural Land Used |
| | | Net Profit per Family Member |
| | Total Productivity | Technical Efficiency (TE) |
| | | Total Factor Productivity (TFP) |
| | | Opportunity Cost Approach |

Source: Authors

After identifying the potential indicators, the subsequent phases of the research focused on evaluating a selection of these indicators, with the results of these assessments presented in the following sections.

In our research, we performed various calculations following the described methodology, which led to several important findings. The results indicate that the share of economically viable farms in Serbia increased significantly over the observed seven-year period (Miljatović et al., 2024). By 2021, 59.4% of farms were economically viable—20.4 percentage points more than in 2015 (Figure 1). In the past four years, this share remained at or above 50%, indicating that over half of the farms were economically sustainable. Farms in the Serbia North region consistently outperformed those in the Serbia South region; in the North, the share of viable farms was above 50% almost throughout the entire period, peaking at 77.2% in 2021. In contrast, the South saw rates consistently below 50%, highlighting substantial challenges to achieving economic viability—likely due to lower levels of agricultural development driven by poorer climate conditions, limited human resources, and inadequate technical equipment.

**Figure 1.** Share of economically viable farms from 2015 to 2021




Source: Authors

The analysis by type of farming revealed that horticulture and granivore farms had the highest shares of economically viable holdings, at 66.5% and 65.5% respectively (Table 2). These farms demonstrated high asset turnover. As noted by Coppola et al. (2022), granivore farms, due to their production processes, operate similarly to industrial systems. This can be attributed to their relatively short production cycles—a feature also common in horticulture, where multiple crops can be grown in a season thanks to brief vegetation periods. This faster production leads to better economic performance. Conversely, farms specializing in other grazing livestock had the lowest share of viable holdings, at just 35.6%, with even worse results in Serbia South, where only 33.8% were economically sustainable. These findings align with Hloušková et al. (2022), who reported that grazing livestock farms were the least economically viable in the Czech Republic.

**Table 2.** Share of economically viable farms by type of farming, 2015-2021

| TF 8 | Type of farming | Share of economically viable farms (%) | | |
|---|---|---|---|---|
| | | Republic of Serbia | Serbia North | Serbia South |
| [ 1 ] | Fieldcrops | 58.6 | 65.6 | 44.1 |
| [ 2 ] | Horticulture | 66.5 | 65.3 | 66.9 |
| [ 3 ] | Wine | 52.4 | 33.3 | 60.3 |
| [ 4 ] | Other permanent crops | 52.8 | 64.4 | 48.5 |
| [ 5 ] | Milk | 41.8 | 73.8 | 36.8 |
| [ 6 ] | Other grazing livestock | 35.6 | 49.6 | 33.8 |
| [ 7 ] | Granivores | 65.5 | 70.0 | 63.5 |
| [ 8 ] | Mixed | 42.5 | 59.7 | 35.8 |
| | Total | 49.8 | 64.7 | 41.4 |

Source: Authors

In another part of our research, we evaluated the long-term economic viability (LTEV) indicator as a measure of overall farm sustainability (Miljatović et al., 2025). The LTEV demonstrated positive values throughout the analysed period, with average coefficients exceeding one across all farming types—indicating that farms were able to cover the opportunity costs of production factors from their net income (Table 3). As expected, results varied by farming type: field crop farms recorded the highest LTEV value (2.91), while grazing livestock farms had the lowest (1.03). Overall, livestock farms demonstrated lower average economic viability coefficients compared to crop farms, consistent with findings from a Czech study (Hlavsa at el., 2020).

**Table 3.** Descriptive statistics of the LTEV indicator for various types of farming

| Descriptive statistics | Field crops | Permanent crops | Milk | Grazing livestock | Mixed |
|---|---|---|---|---|---|
| Mean | 2.91 | 2.49 | 1.60 | 1.03 | 1.30 |
| Median | 1.59 | 1.44 | 0.96 | 0.68 | 0.85 |

| | | | | | |
|---|---|---|---|---|---|
| Lower Quartile | 0.37 | 0.49 | 0.50 | 0.16 | 0.36 |
| Upper Quartile | 4.16 | 3.39 | 1.75 | 1.40 | 1.82 |
| Standard Deviation | 5.35 | 3.88 | 2.44 | 2.03 | 1.53 |
| n | 254 | 48 | 103 | 56 | 66 |
| T | 7 | 7 | 7 | 7 | 7 |
| N | 1778 | 336 | 721 | 392 | 462 |

Source: Miljatović et al., 2025.

As expected, the median values of the observed indicator are lower, highlighting the significantly reduced economic viability of farms in Serbia. The situation is especially concerning for milk, mixed, and grazing livestock farms, where the median coefficient falls below one. Grazing livestock farms are the most at risk, consistent with Hloušková et al. (2022) they show the lowest average and median economic viability coefficients and consistently have less than 50% of farms classified as economically viable.

### Ecological and social indicators of farm sustainability

As with the economic dimension, the initial phase of the research also aimed to identify potential ecological and social indicators that could be derived from the FADN database. Although FADN is primarily designed to capture economic data, its structural and production-related components provide a basis for extracting certain environmental and social indicators. Table 4 presents a set of ecological indicators that the authors considered potentially relevant for assessing environmental sustainability, based on data availability and alignment with established frameworks. The environmental impacts of agriculture are often difficult to measure directly (Bockstaller et al., 2008). Over the past 35 years, numerous agro-ecological indicators have been developed to assess negative effects on water, air, soil, biodiversity, greenhouse gas emissions, and other environmental issues associated with farming. The OECD was among the first to propose such indicators (Spânu et al., 2022), defining them as summary measures that combine data to describe environmental conditions, risks, changes, and pressures partly or fully caused by agriculture. These indicators are commonly structured according to the Pressure-State-Response (PSR) model. While FADN primarily targets economic performance, its supplementary data allow for indirect insight into environmental pressures and responses (Table 4).

**Table 4.** Potential Environmental Sustainability Indicators Derived from FADN Data

| PSR Concept | Indicators |
|---|---|
| Pressure | Livestock density |
| Pressure | Greenhouse gas emissions |
| Pressure | Use of mineral fertilizers |
| Pressure | Use of pesticides |
| Pressure | Water usage |
| Pressure | Energy usage |
| Response | Environmentally friendly practices (e.g., organic farming, subsidies for agro-environmental measures) |
| Pressure-State | Biodiversity |
| State-Response | Area of legumes |
| Pressure-State | Area of pastures and meadows |

In the subsequent phases of the research, the assessment of ecological sustainability was conducted using a selected indicator – Shannon Diversity Index. One of the focuses of our study was dairy farms. The results showed that, on average, during the period from 2015 to 2021, dairy farms had low biodiversity. The Shannon diversity index did not exceed 2.5 for any farm in any observed year (Table 5). Moreover, dairy farms grew only a small number of crop types, with uneven distribution across cultivated areas. Typically, Shannon index values range from 1.5 to 3.5, rarely exceeding 4.5 (Ortiz-Burgos, 2016). Therefore, the biodiversity of dairy farms, measured by the presence and diversity of cultivated crops, can be considered extremely low.

**Table 5.** Shannon Diversity Index

| Year | Mean value ± standard deviation | Minimum | Maximum | Number of farms with monoculture |
|---|---|---|---|---|
| 2015 | 1.14±0.49 | 0 | 1.93 | 10 |
| 2016 | 1.16±0.48 | 0 | 2.11 | 7 |
| 2017 | 0.84±0.40 | 0 | 1.59 | 9 |
| 2018 | 1.16±0.47 | 0 | 1.87 | 8 |
| 2019 | 1.16±0.47 | 0 | 1.80 | 8 |
| 2020 | 1.14±0.45 | 0 | 1.80 | 8 |
| 2021 | 1.13±0.45 | 0 | 1.94 | 7 |
| Average | 1.10±0.47 | 0 | 2.11 | 8.14 |

Source: Despotović et al., 2024.

For the 49 dairy farms analysed, the average biodiversity rate measured by the Shannon index decreased by 2.93%. Five farms showed no change in biodiversity during the period, while 40 farms recorded an average annual increase of 2.65% from 2016 to 2021. The remaining farms had at least one year of monoculture (Shannon index value of 0), preventing calculation of chain indices and average annual change rates for these holdings.

When it comes to the social dimension of farm sustainability, Janker and Mann (2020) point out that clear indicators or measurement tools are still lacking. Many authors (Binder et al., 2010) emphasize that the social aspect has been largely neglected in research and continues to lag behind the economic and ecological dimensions. In the context of this study, only a potential list of social sustainability indicators was identified based on available FADN data, while their actual evaluation has not yet been carried out due to significant methodological limitations and data constraints. This highlights the complexity of assessing social sustainability and suggests that more comprehensive data—such as that anticipated in the forthcoming FSDN system—may be better suited for such assessments. Although some frameworks have been proposed to make the concept of social sustainability more operational, there is still no consensus on what this dimension should encompass or how it should be measured. Key questions remain regarding how policymakers, researchers, and stakeholders define the social aspect and how it can be translated into concrete, measurable indicators.

**Table 6.** Potential Social Sustainability Indicators Derived from FADN Data

| Indicator Group | Indicators |
|---|---|
| Field | Age of the farm holder |
| | Age of the farm manager |
| Work Experience | Experience of the farm holder |
| | Experience of the farm manager |
| Agricultural Training | Practical experience |
| | Basic training |
| | Full training |

Coppola et al. (2020) emphasize that farmers' work experience is vital, as more experienced producers are likely to make better decisions, positively affecting their farms' economic sustainability. Some researchers (Seok et al., 2018) connect this experience with the age of farm decision-makers. Education and training levels can also influence producers' innovativeness and productivity. Additionally, studies suggest that farm productivity may differ based on the gender of the owner or manager (Udry et al., 1995; Doss and Morris, 2000).

## Conclusion

This study highlights the complexity of assessing agricultural sustainability and the importance of simultaneously considering economic, ecological, and social dimensions. The findings reveal pronounced regional and sectoral disparities in economic viability, with dairy and grazing livestock farms facing particular challenges. Ecological analysis, based on the Shannon diversity index, pointed to low biodiversity on dairy farms, underscoring the need for diversification to strengthen environmental resilience. Regarding the social dimension, only a preliminary set of potential indicators could be identified due to limitations in the FADN database, emphasizing the need for more suitable data frameworks, such as the forthcoming FSDN. Overall, the results support the use of integrated, multidimensional assessment approaches and point to the need for better-aligned data systems and targeted policy measures to promote sustainable development of agricultural holdings in Serbia.

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