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ECONOMICS OF AGRICULTURE

CONTENT

FACTORS INFLUENCING THE PROFITABILITY OF SMES FROM THE REPUBLIC OF SERBIA: FOOD INDUSTRY

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A B S T R A C T

Drawing from an extensive literature review on the impact of microeconomic and macroeconomic variables on the profitability of food enterprises globally and within national markets, this research analyzes the performance of small and medium-sized food companies in the Republic of Serbia from 2014 to 2022. The objective of this paper is to analyze the influence of microeconomic and macroeconomic factors on their profitability. By applying panel regression analysis, the impact of various factors on profitability, measured by return on assets, was examined. The research findings indicate that both the current asset turnover ratio and the growth rate of gross domestic product exert a significant positive influence on the profitability of the examined enterprises, whereas factors such as indebtedness, average collection period, asset tangibility, and inflation demonstrate a significant negative impact.

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Introduction

Profitability serves as a fundamental indicator of business success and sustainability within today's economic landscape. The financial performance of a company is used as a means to measure its current development and growth potential (Kim et al., 2021). Profitability not only reflects a company's ability to generate profit (Alarussi & Gao 2021), but also provides insight into the efficiency of its operations, management strategies, and competitive position in the market. In the context of the Serbian economy, which faces numerous challenges and opportunities in the process of transition and integration into global economy, profitability becomes even more significant as a measure of economic growth and development. Profitability plays several key roles in a country's financial system. It provides the means for further development and investment in companies, contributing to business expansion, modernization of production processes and improvement of competitiveness. For the Serbian economy, which needs technological advancements and increased productivity, profitable companies form the basis for sustainable economic growth. Profitability contributes to job stability and increased employment. Companies that generate profits have a greater capacity to hire new workers and provide better working conditions for existing employees. In Serbia, where the unemployment rate remains high, profitable companies are vital in helping reduce unemployment and enhancing citizens' quality of life. Furthermore, profitability is a significant factor in attracting both domestic and international investments. Investors tend to favor companies with stable and robust profits, as this reduces investment risk and heightens the chances of returns. For Serbia, which is undergoing economic reforms and moving toward European Union integration, drawing in investments is essential to achieving sustainable economic growth. Profitability serves not only as a reliable measure of current business performance but also as a predictive tool for future success. It reflects shareholder value and is thus attractive to investors. This makes understanding the factors that influence profitability, whether directly or indirectly, a key area of research in fields such as economics, strategic management, accounting, and finance (Nguyen & Nguyen, 2020).

Identifying the determinants of profitability is fundamental for effective business decision-making and the formulation of appropriate economic policies. Analyzing these factors enables the identification of a company's strengths and weaknesses, as well as recognizing opportunities and threats in the business environment. Numerous factors influence a company's profitability, which, according to economic literature, can be divided into two groups: microeconomic (internal) factors and macroeconomic (external) factors that are beyond the company's control (Tekić et al., 2022).

The food and beverage industry represents one of the key traditional sectors that is vital for every economy. Economists often view it as a stable sector that better withstands economic cycles and fluctuations compared to other industries (Šimáková et al., 2019). Serbia has a long tradition in the food processing industry (Dakić & Mijić, 2018). As one of the largest sectors of the economy, it not only contributes to the country's GDP but also employs over 100,000 people (Statistical Office of the Republic of Serbia, 2024). This industry also plays a key role in Serbia's export strategy, contributing to the stability of the trade balance. Given Serbia's rich agricultural resources, the food industry has enormous potential for further development. The profitability of the food industry directly impacts Serbia's economic growth and development. Stable and profitable food enterprises facilitate long-term investments in innovation, enhance production capacities and contribute to the generation of new employment opportunities. This process strengthens the economy while simultaneously enhancing the quality of life for the population through the provision of a secure and stable food supply.

Given the importance of this sector, this study focuses on small and medium-sized (SME) food companies operating within the Republic of Serbia from 2014 to 2022. The main objective is to evaluate these enterprises' profitability and to analyze the effects of various microeconomic and macroeconomic factors on their financial standing. Accordingly, the research is guided by the following hypotheses:

H_1: Liquidity has a significant impact on the profitability of small and medium-sized food companies.

H_2: Leverage significantly influences the profitability of small and medium-sized food companies.

H_3: Indebtedness significantly affects the profitability of small and medium-sized food companies.

H_4: The average receivables collection period has a significant effect on the profitability of small and medium-sized food companies.

H_5: The current asset turnover ratio significantly impacts the profitability of small and medium-sized food companies.

H_6: Tangibility significantly influences the profitability of small and medium-sized food companies.

H_7: GDP significantly affects the profitability of small and medium-sized food companies.

H_8: Inflation has a significant impact on the profitability of small and medium-sized food companies.

Literature review

Various scholars worldwide have studied the factors influencing firms' profitability in the food sector. Some studies concentrate exclusively on microeconomic (internal) factors, while others incorporate macroeconomic (external) influences on profitability.

Pervan and Mlikota (2013) analyzed profitability determinants in Croatia's food and beverage industry from 1999 to 2009. Utilizing dynamic panel analysis and the Generalized Method of Moments (GMM), their findings revealed a statistically significant negative effect of indebtedness on profitability. Conversely, company size, industry concentration, and past performance had significant positive effects on current profitability. In Pakistan, Bhutta and Hasan (2013) examined profitability factors for food enterprises operating between 2002 and 2006. They found that asset tangibility, company growth, and inflation positively influenced profitability, while company size had a negative effect. This study considered only one macroeconomic factor, inflation, which proved to have a significant impact. The determinants of profitability for food industry companies in the EU were researched by Hirsch et al. (2014). The authors obtained data from companies in five countries (Belgium, France, Italy, Spain, and the UK) during the period from 2004 to 2008. Based on the results of the hierarchical linear model, they found that company size and concentration have a statistically significant and positive impact on profitability, while company risk, age and industry growth have a statistically significant and negative impact on profitability. Golas & Bieniasz (2016) researched how inventory management affects the financial performance of the food industry in Poland from 2005 to 2010. Panel regression models were applied in their analysis to examine the link between the length of the inventory cycle and company profitability, which was quantified by return on sales, assets, and capital. The results showed that shortening the overall inventory cycle, as well as individual inventory cycles, is positively associated with company profitability. The study emphasizes that efficient inventory management can significantly contribute to improving financial performance, especially in the food industry, where maintaining continuity of sales and production is essential due to the seasonal nature of raw material production. Mijić et al. (2016) conducted a study aimed at analyzing the profitability of the meat processing industry in Serbia for the period from 2011 to 2015. The study included 12 companies from this sector where profitability was measured by the return on assets (ROA). The panel regression analysis revealed that companies with a higher liquidity ratio and sales growth tend to achieve greater profitability, whereas a high level of indebtedness is associated with lower profitability. The analysis also revealed that company size, the ratio of fixed assets, and investment levels are not statistically significant determinants of profitability within the Serbian meat industry. The authors emphasize the need to reduce indebtedness and better utilize additional borrowings for adequate investments to improve profitability in this sector. Nuševa et al. (2017) investigated the performance of coffee processors and the coffee market in Serbia, utilizing market concentration analysis, profitability analysis and identification of profitability determinants. The research sample consisted of 40 coffee processors, which were classified into two groups: large processors and small processors. The results indicate that profitability is positively correlated with inventory turnover and negatively correlated with market share. An analysis of the factors influencing the profitability of companies engaged in fruit and vegetable processing in Serbia was conducted by Dakić & Mijić (2018). This study included 22 companies that operated from 2007 to 2015. Through the application of a panel regression model, the authors identified a statistically significant positive relationship between sales growth and profitability, while company size and capital turnover were found to significantly negatively affect profitability. An analysis conducted by Pervan et al. (2019) focused on 9,359 companies in Croatia's manufacturing industry during the period from 2006 to 2015. The study categorized the determinants of profitability into firm-specific factors, industry-specific factors and macroeconomic factors, applying the dynamic panel estimator General Method of Moments (GMM) to capture the dynamic aspect of profitability. The results showed that company age, labor costs, industry concentration, GDP growth and inflation significantly influence profitability. Specifically, older companies and favorable economic conditions positively impact profitability, while higher labor costs and industry concentration negatively impact it. Dakić, et al. (2019) analyzed the determinants of business success for companies in Serbia's food industry using multiple regression analysis on a sample of 73 companies from 2007 to 2015. The research results showed that sales growth has a significantly positive impact on profitability across all analyzed sectors of the food industry. In the meat processing sector, profitability is positively associated with the liquidity ratio, while company size, indebtedness and capital turnover ratio are negatively associated with profitability. In the fruit and vegetable processing sector, profitability is negatively associated with company size and capital turnover ratio. In the dairy processing sector, profitability is positively associated with the quick liquidity ratio and negatively associated with indebtedness. A study conducted by Blažková & Dvouletý (2019) examined the factors influencing the performance of food enterprises in the Czech Republic. Through the analysis of 1,804 enterprises spanning the period from 2003 to 2014, the authors utilized a panel regression model and identified labor productivity, company age, and size as having a statistically significant positive impact on profitability, whereas indebtedness was found to have a statistically significant negative effect. Grau-Reig et al. (2020) analyzed the profitability of small and medium-sized enterprises (SMEs) in the agri-food industry in Europe. The authors applied a hierarchical linear model (HLM) to decompose the variance in return on assets (ROA) into multiple levels: year, country, industry, and company. This analysis aimed to identify the factors that contribute most to profitability. The results indicate that company-level factors have a significantly greater impact on profitability than industry characteristics. Specifically, company size and industry concentration are key drivers, while company risk, age, and industry growth are negatively correlated with profitability. A study on the factors influencing the profitability of meat processing companies in Serbia was conducted by Dakić & Mijić (2020). Using data from 24 companies over the period 2007–2016, the authors employed panel regression analysis to determine the influence of various factors on profitability. The results revealed that company age, debt levels, and capital turnover negatively affect profitability, while both sales growth and liquidity are positively correlated with profitability. In their study, Andrés González-Moralejo et al. (2021) examined the factors affecting the profitability of food industry enterprises in the Valencia region from 2006 to 2015. Based on the results of panel regression analysis, the authors concluded that company size and exports were essential for profitability, with macroeconomic conditions and location also significantly impacting financial outcomes. Tekić et al. (2022) analyzed the determinants of profitability for small agricultural and food companies in the Republic of Serbia. The panel regression analysis conducted on a sample of 123 food enterprises from 2010 to

2019 showed that the total asset turnover ratio and inflation significantly and positively impacted profitability, while liquidity, indebtedness, tangibility, and the GDP growth rate had a significant negative effect on profitability. Additionally, Nuševa et al. (2024) examined how sales growth affects the profitability of manufacturing companies in the Republic of Serbia. The panel regression results for a sample of 200 enterprises operating from 2018 to 2021 indicated that inventory exerted a statistically significant negative impact on profitability, whereas sales growth was found to have a statistically significant positive effect on profitability in the Serbian manufacturing sector.

Materials and methods

This research utilizes data derived from companies' financial reports. According to the Serbian Business Registers Agency, there were 3,911 active food enterprises in Serbia as of the end of 2022. Out of this total, 591 were categorized as small, and 149 as medium-sized enterprises. Initially, companies that were inactive during the study period were excluded from the sample. Furthermore, companies that did not adhere to the regular submission of financial reports, in addition to those in bankruptcy or liquidation, were excluded from the study. Following this, the Tukey-Fence rule (Zijlstra et al., 2007) was applied to eliminate enterprises with extreme values in profitability indicators. This process yielded a final sample of 311 enterprises, which were then analyzed using panel regression techniques.

The review of existing literature indicates that the return on assets (ROA) is the most frequently used profitability metric. Calculating this indicator involves comparing the net result with the average total assets, thereby revealing the net profit generated from the company's assets. Additionally, this metric serves to assess the effectiveness with which the company employs its investments to generate profit (Alshatti, 2015). Therefore, return on assets (ROA) will be incorporated as the variable being explained in the panel regression model. Various financial performance indicators (liquidity, leverage, indebtedness, receivables collection period, current asset turnover ratio and tangibility) were used as microeconomic determinants of profitability (independent variables). Ehiedu (2014) states that an enterprise lacking adequate liquidity may be considered nonviable, highlighting the critical importance of sustaining an appropriate liquidity level. Additionally, it is fundamental to recognize overabundant liquidity, as it may lead to the accumulation of unproductive inventory that fails to generate profit. Excessive borrowing can also place an enterprise in a precarious position and there must be a balance between the level of borrowed funds, the sources designated for debt repayment and the total available assets. Consequently, leverage and indebtedness have been incorporated into the analyzed indicators. The receivables collection period is a key aspect of a business's cash flow management, particularly for SMEs within the food sector. A reduced receivables collection period facilitates the timely collection of payments from customers, thereby enhancing cash flow. The current asset turnover ratio reflects the ability to convert current assets, such as inventory and receivables, into sales. A higher ratio indicates that the company is effectively managing its assets, which can lead to increased sales relative to the investments. Tangible assets, such as machinery, equipment, and real estate, are vital for food production and distribution. High levels of tangible assets can enhance operational efficiency, allowing companies to increase output and consequently, profitability. The independent variables (regarding macroeconomic determinants of profitability) were the gross domestic product (GDP) growth rate and inflation (CPI). While rising GDP can enhance profitability through increased consumer spending and market expansion, inflation presents a more nuanced challenge by affecting input costs and consumer behavior. SMEs must remain vigilant and adaptable to these economic conditions to sustain and enhance their profitability in a dynamic economy. The variables incorporated into the panel regression models are outlined in Table 1.

Table 1. List of indicators

Indicator	Notation	Explanation
Return on asset	ROA	Net income/Average total assets
Liquidity	LIQ	Current assets/Short-term liabilities
Leverage	LEV	Total liabilities/Total capital
Indebtedness	DEBT	Total liabilities/Total assets
Receivables collection period	RCP	365/Accounts receivable turnover ratio
Current asset turnover ratio	CATR	Sales revenue/Average current assets
Tangibility	TANG	Fixed assets/Total assets
GDP	GDP	Growth rate of GDP
Inflation	CPI	Growth rate of CPI

Source: Author's review (based on: Fernández-Lopez et al., 2020; Tekić et al., 2022)

The panel regression model was utilized to evaluate the factors affecting the profitability of small and medium-sized food enterprises operating in the Republic of Serbia from 2014 to 2022. This model combines cross-sectional and time series data, encompassing both spatial and temporal dimensions. In this study, a classical linear panel regression model was used on balanced data, with a previously selected set of variables. The regression model was calculated according to:

$$ROA_{it} = \beta_{it} + \beta_{1\,LIQ} + \beta_{2\,LEV} + \beta_{3\,DEBT} + \beta_{4\,RCP} + \beta_{5\,CATR} + \beta_{6\,TANG} + \beta_{7\,GDP} + \beta_{8\,CPI} + u_{it}$$

In this specification, *i* denotes the individual company (*i*= 1,2,3…, n), *t* refers to each year (t= 1,2,3…,9), and u_{it} is the error term, assumed to have a mean of zero and constant variance for all *i* and *t*.

Following the formulation of the initial model, the key assumptions necessary for the application of panel regression models were assessed, namely multicollinearity, heteroskedasticity, autocorrelation, and cross-sectional dependence.

Prior to selecting the final model specification, it is essential to assess the presence of individual and/or time effects within a fixed or random effects framework. Hypothesis testing examines the presence of unobserved heterogeneity in the panel regression model, and if heterogeneity is confirmed, it is determined whether it is fixed or random. Then, the F-test is used to determine whether a fixed-effects model or an OLS model is more appropriate. For comparing the OLS model and the random-effects model, Lagrange Multiplier (LM) tests are used. If no test rejects the null hypothesis, the OLS model is applied. The Hausman specification test is most commonly used to compare fixed and random effects models, assuming that individual effects are not correlated with the regressors. If the null hypothesis is rejected in favor of the alternative hypothesis, it is necessary to apply the fixed-effects model (Das, 2019).

Results and discussion

The results of the descriptive statistical analysis for the business performance indicators of the observed food enterprises are shown in Table 2.

Table 2. Descriptive data analysis

Indicator	Med	Min.	Max.	Std.dev
ROA	5.85	-41.37	61.08	6.92
LIQ	2.93	0.06	93.74	5.11
LEV	2.31	0.00	297.49	7.34
DEBT	0.49	0.00	1.29	0.25
RCP	47.73	0.93	461.91	13.88
CATR	3.13	0.09	39.45	2.63
TANG	0.43	0.00	0.97	0.21
GDP	2.63	-1.60	7.70	2.66
CPI	3.24	1.10	12.00	3.22

Source: Authors' calculation

During the observed period, the median value of the ROA indicator was 5.85%, which suggests an average level of profitability, slightly above the 5% benchmark typically seen as indicating good profitability. The median liquidity ratio of 2.93 indicates that these companies have sufficient current assets to meet their short-term liabilities. The median financial leverage of 2.31 suggests a substantial reliance on liabilities in the capital structures. The median indebtedness ratio was 0.49, meaning that 49% of the enterprises' assets were financed by debt, while the remaining 51% were financed by equity. The median day of the receivables collection period was 47.73, indicating that, on average, it took enterprises about 48 days to collect their receivables. This indicator showed a high degree of variability, with some enterprises collecting receivables immediately, while others took up to 462 days. The median current asset turnover ratio was 3.13, meaning that the average current assets turned over or converted back to cash was 3.13 times. The median tangibility was 0.43, indicating that 43% of total assets were fixed assets. This indicator also showed a low standard deviation, implying a low level of variability among the enterprises in the sample. Throughout the observed period, the median GDP growth rate was 2.63%, while the average CPI rate stood at 3.24%. The GDP growth rate reached its lowest point in 2014 at -1.6%, and its highest in 2021 at 7.7%. The CPI rate was at its lowest in 2016, at 1.1%, and at its highest in 2022, at 12%.

The application of panel data assumes that the independent variables are not excessively correlated, which in turn implies the lack of multicollinearity. For the formulated model, the variance inflation factors (VIF) and tolerance values were calculated first to determine the presence of multicollinearity (Table 3).

Table 3. Multicollinearity among the independent variables

Variable	VIF	TOL
DEBT	1.51	0.66
LIQ	1.30	0.77
CATR	1.18	0.85
LEV	1.18	0.85
TANG	1.13	0.88
RCP	1.06	0.94
GDP	1.02	0.98
CPI	1.02	0.98

Source: Authors' calculation

According to the VIF and TOL (1/VIF) results, none of the variables have a VIF value exceeding 5, and all TOL values are above the threshold of 0.2. This leads to the conclusion that multicollinearity does not adversely affect the developed model. Daoud (2017) states that VIF values should be between 1 and 5 to consider the variables moderately correlated, which is desirable in regression analysis.

The next phase of the analysis focused on testing additional assumptions for panel regression, including heteroskedasticity, autocorrelation, and cross-sectional dependence (Table 4).

Table 4. Analyses of heteroskedasticity, autocorrelation and cross-sectional dependence

Test	Test statistics	p-value
Breusch-Pagan / Cook-Weisberg test	448.91	0.00
Wooldrige test	278.52	0.00
CD Pesaran test	21.43	0.00

Source: Authors' calculation

Heteroskedasticity was tested using the Breusch-Pagan / Cook-Weisberg test. At the 1% significance level, the results indicate a rejection of the null hypothesis of homoskedasticity, providing evidence in support of the alternative hypothesis of heteroskedasticity ($p < 0.01$). Autocorrelation was examined using the Wooldridge test, which confirmed its presence at the 1% significance level ($p<0.01$). Furthermore, Pesaran's CD test results indicate significant cross-sectional dependence ($p < 0.01$), which suggests that the dependent variable is affected by underlying common factors.

In the subsequent phase of the research, tests were performed to assess the presence of individual and/or temporal effects. The F-test for fixed effects and the Breusch-Pagan LM test for random effects were employed to test for the presence of individual and/or time effects (Table 5).

Table 5. Tests for individual and/or time effects

Test	Test statistics	p-value
F-test (individual effects)	6.54	0.00
F-test (time effects)	5.34	0.00
Breusch-Pagan LM test (individual effects)	1470.90	0.00
Breusch-Pagan LM test (time effects)	28.13	0.00

Source: Authors' calculation

The F-test results for individual effects confirm the presence of these effects at a 1% significance level ($p<0.01$). Similarly, the F-test for time effects supports the alternative hypothesis, indicating significant time effects in the model ($p<0.01$). The Breusch-Pagan LM test also confirms the presence of individual effects in the model ($p<0.01$), and further shows that time effects are statistically significant as well ($p<0.01$).

The subsequent step necessitates an analysis of the characteristics of individual and temporal effects, focusing on the determination of their status as either fixed or random. To choose the appropriate model specification, a modified Hausman test is applied. With a Hausman test statistic of 35.71 ($p = 0.00$), the null hypothesis is rejected at the 1% significance level, suggesting that a fixed-effects model is appropriate for capturing both individual and time effects.

In order to address the violations of the initial assumptions for panel regression, an alternative fixed-effects model with panel-corrected standard errors (PCSE) was employed. The outcomes of this specification are displayed in Table 6.

Table 6. Model estimation with fixed individual and time effects for analyzing the profitability of food SMEs

	Coeff.	Std. Error	t-ratio	p-value
Const	16.895	1.519	11.121	0.000**
LIQ	-0.062	0.039	-1.611	0.109
LEV	0.017	0.027	0.644	0.524
DEBT	-15.549	2.125	-7.322	0.000**
RCP	-0.004	0.001	-2.808	0.005**
CATR	0.817	0.144	5.655	0.000**
TANG	-11.329	1.679	-6.754	0.000**
GDP	0.180	0.035	5.090	0.000**
CPI	-0.067	0.032	-2.091	0.037*
n	311			
t	9			
N	2799			
R^2	0.53			
F- test	16.77**			

*Note: ** - level of significance 1%; * - level of significance 5%*

Source: Authors' calculation

Based on data from 311 food companies over a nine-year period, the panel regression model was developed, generating a total of 2,799 observations. The F-test results indicate that the model is highly significant ($p < 0.01$), and the coefficient of determination reveals that 53% of the variability in profitability can be explained by the factors included in the model.

The panel regression analysis results show that liquidity and leverage do not have a statistically significant impact on the profitability of small and medium-sized food companies, leading to the rejection of hypotheses H_1 and H_2. The analysis reveals a statistically significant negative effect of indebtedness on profitability, supporting hypothesis H_3. Similar conclusions were reported by Pervan and Mlikota (2013) for Croatian food enterprises, Mijić et al. (2016) for Serbian meat processing companies, and Tekić et al. (2022) for small food enterprises in Serbia. Additionally, the results indicate that the receivables collection period has a statistically significant negative impact on profitability, implying that longer collection periods are associated with reduced profitability. Consequently, hypothesis H_4 is accepted. These findings are consistent with previous research by Mathavu (2010), Ray (2012), and Pais and Gama (2015). The analysis reveals that the current asset turnover ratio significantly positively influences the profitability of the observed food enterprises, thereby supporting hypothesis H_5. An increase of 1 in this ratio corresponds to a 0.82% rise in profitability. These findings are consistent with the results reported by Akoto et al. (2013). Asset tangibility significantly negatively affects the profitability of the observed enterprises, thereby supporting hypothesis H_6. Specifically, an increase in tangibility by 1 resulted in an 11.34% decrease in profitability. This finding suggests deficiencies in the condition and management of fixed assets, highlighting the necessity for investments in new facilities and equipment. The negative correlation between tangibility and profitability was further confirmed by Tekić et al. (2022) in their research on food enterprises in Serbia. The results show that macroeconomic factors have a statistically significant impact on the profitability of the observed companies, where GDP growth positively influences profitability, while the CPI has a negative effect. Consequently, hypotheses H_7 and H_8 are accepted. The positive effect of GDP growth on profitability has also been identified by Pervan et al. (2019), Juszczyk et al. (2020) and Grau and Reig (2021). Additionally, the adverse impact of CPI on the profitability of food enterprises has been corroborated by Juszczyk et al. (2020) and Tekić et al. (2022).

Conclusions

This study analyzed the profitability of small and medium-sized food companies in the Republic of Serbia from 2014 to 2022, with an emphasis on identifying the microeconomic and macroeconomic factors that impact profitability. The findings indicate that the average profitability of the enterprises examined during this period was 5.85%.

Utilizing a panel regression model with fixed effects allowed for the identification of key factors that significantly influence the profitability of the enterprises studied. The analysis indicates that indebtedness, the period for collecting receivables, current asset turnover ratio, tangibility, GDP growth rate, and the CPI are statistically significant variables influencing the profitability of food enterprises. Specifically, indebtedness, receivables collection period, tangibility, and CPI were found to have a negative effect on profitability, while the current asset turnover ratio and GDP growth rate positively influenced it. The negative impacts of indebtedness and tangibility suggest a need for improved debt management and more efficient use of fixed assets. Similarly, the negative effect of the receivables collection period indicates a need for stronger credit policies, as longer collection periods mean a higher amount of financial resources are tied up, representing an opportunity cost for these companies. On the other hand, the positive influence of the current asset turnover ratio highlights the importance of effective working capital and liquidity management for achieving higher profitability. Regarding macroeconomic factors, the positive effect of GDP growth underscores the value of favorable economic conditions for the success of food enterprises, while the negative impact of the CPI rate emphasizes the necessity of price stability and a predictable economic environment for effective business planning.

This study offers a better understanding of the key factors impacting the profitability of food enterprises in Serbia and can serve as a basis for formulating adequate economic policies and management strategies that would improve the operations and competitiveness of this sector. It is particularly important to focus on reducing indebtedness, more efficient management of fixed assets and adapting business operations to macroeconomic conditions to achieve sustainable profitability and growth of food enterprises in Serbia. This research has certain limitations. First, since the sample comprises only small and medium-sized food enterprises from the Republic of Serbia, the results may not fully represent the broader food sector. Therefore, future research should include micro and large enterprises. Second, the period covered by the research is another limitation; in the future, the database should be expanded and the research should be repeated. Additionally, it is necessary to conduct studies in other industries for the comparison of results and identification of specific factors influencing the profitability of enterprises across different economic sectors.

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Conflict of interests

The authors declare no conflict of interest.

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THE RURAL POPULATION AND THE POVERTY THREAT

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ABSTRACT

In many European countries, there is an increasing possibility of poverty threat. This paper undertakes a comprehensive investigation into the determinants of rural poverty in 27 European countries, utilizing Eurostat data from 2010 to 2020. The research aims to identify factors influencing poverty threats in rural areas with a detailed focus on social protection expenditure. Two regression models are employed to address these objectives. The primary model analyses the impact of social protection expenditure, rural employment, and freight transport on poverty threats. The supplementary model examines the relationship between social protection expenditure, rural households and the older population. The key findings prove that social protection expenditure significantly reduces poverty threats. However, economic activities such as rural employment and freight transport show no statistically confirmed impact on poverty reduction in rural areas.

Introduction

Sustainability, in general, is a global goal that addresses different aspects such as poverty, health, education, gender equality, water and sanitation, climate change and others. 17 Sustainable Development Goals (SDGs) that integrate social, economic, and environmental are included in "The 2030 Agenda". Many of these goals have a direct impact on rural areas, where the conditions for achieving them may be different from those in urban areas, particularly in terms of access to basic services, but also in terms

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of access to opportunities in general. It is, therefore, necessary to address the needs of rural areas in the context of these objectives.

Rural space is globally interconnected and interdependent, and the interaction of local and global actors creates and trans-forms rural places (Woods, 2007). While the concept of “global countryside” has generated much research on rural economic restructuring, food chains, tourism, and migration, studies on poverty and rural inequality have not received adequate attention. Bajusová et al. (2018) emphasize the role of rural entrepreneurship and business entities in enhancing the competitiveness and sustainability of rural regions in Slovakia.A major turning point occurred in 2004 when two major publications on the issue of rural poverty were presented (Lee et al., 2005, Milbourne, 2004). Similarly, Commins (2004) noted little coverage of poverty and exclusion in rural research in its review article on rural poverty and social exclusion. While overall quantitative poverty levels may not be characteristic of rural areas, the authors have shown (Lee et al., 2005) that the risks of poverty have been socially distributed in rural areas somewhat differently from their urban counterparts.

The phenomenon of poverty is associated with the term “social exclusion” due to its multidimensional nature (van Bergen et al., 2019). The European Union’s Poverty Program, which has existed since 1974, ended in 1994 when the Council of Europe rejected the new Poverty Program (Avramov, 2002). Since then, it has been argued that social exclusion rather than poverty is the main goal of the European Union’s social policy. The European Parliament’s decision of 2008 obliges the Member States of the European Union to ensure equal access to resources and services and promote the integration of disadvantaged groups into mainstream society through active integrated approaches (Allen et al., 2012). State intervention is commonly expected in this area, but there is no consensus on the most effective methods and tools and the extent of public spending to reduce poverty (Caminada & Goudswaard, 2012). One of the alternative approaches to poverty assessment, linking microeconomic and macroeconomic approaches, may be the modification of the Human Development Index (Terzi, 2013). Following the study of causal dynamics, (Heger et al., 2020) improved the landscape as the essence of approaches to poverty reduction. This improvement can take various forms and can be linked to employment and entrepreneurship (Besshaposhny et al., 2021; Fields, 2019; Korsgaard et al., 2015). However, this does not mean a simple implementation of approaches and principles to entrepreneurship in poor rural areas, rich countries, and areas (Moradi et al., 2020), although the use of modern technologies is proving essential (Asongu & Odhiambo, 2019). According to Posada Henao & González Calderón (2010), transportation is a key factor in economic development. Employment and stimulus are impossible without adequate infrastructure, especially transport, which is even more urgent for a viable rural economy (Marr, 2015).

Poverty and social isolation remain a problem in rural communities with high levels of fuel poverty, limited access to health, recreation, and education centres, and a small suffering network of rural transport partnerships, according to (McGuire et al., 2022). For tracking progress against poverty, the living wage methodology provides a wide range of options for obtaining a transparent local measure. According to van de Ven et al. (2021), it can be used, for example, to assess development opportunities for rural households and employers in rural areas, including farmers hiring labor. In addition to the prevailing methods of examining poverty, Watmough et al. (2019) highlight a modern approach using remotely sensed satellite data to monitor development in low- and middle-income countries and spatial estimates of welfare and poverty.

As part of the forecast of the potential risk of poverty, socioeconomic research was carried out during the second decade of the 21st century, focusing on the relationship between social expenditure and poverty (Sawulski & Kutwa, 2022). Based on the aforementioned research results, the negative relationship between social spending and poverty is confirmed, at least in the short term (Szymańska, 2023). The rural elderly population is certainly exposed to the potential risk of poverty, especially with the declining share of the population (Labianca & Valverde, 2019). Redistributive processes, the associated social benefits and social incomes, and their impact on poverty reduction in 2011-2015 in 28 EU countries were examined by (Halaskova et al., 2021). The effectiveness of public social spending in 22 OECD countries in 2004-2012 was examined by (Kim & Kim, 2017), and the relationship between social transfers and poverty rate variation based on Eurostat data for the period 2008-2016 was analyzed by (Miežienė & Krutulienė, 2019). However, public budgets are becoming unsustainable, and the path to recovery is focused on both the revenue and expenditure side.

A descriptive study (Bertolini et al., 2008) on rural poverty in Europe demonstrates the diversity of rural-urban disparities across European countries and explains the different drivers of rural poverty. Shucksmith et al., (2009), Weziak-Bialowolska (2016), as well as Meloni et al. (2024), used a transnational comparative data set that shows that increased rural poverty and the gap between rural and urban poverty can be found mainly in poorer, eastern and southern European countries, the conclusion was also confirmed by detailed analysis of Eurostat data in the EU-28 from (Copus et al., 2015).

Materials and methods

The paper employs multiple regression models to reveal relationships between selected socioeconomic factors and rural poverty. The starting point of this paper was two research questions created by the authors, which express the general idea of research:

Q1 Is the poverty threat in rural regions affected mainly by economics or more likely by other factors?

Q2 Does social protection expenditure depend on the ageing population and on the spatial distribution of households by degree of urbanization?

These questions, grounded in existing literature, fill research gaps in understanding rural poverty threat.

Research Question 1 addresses the debate over primary poverty drivers, recognizing mixed findings on economic versus social-economic influences. Some research emphasizes aspects like employment, while others focus on factors such as social protection. Research Question 2 relates demographic changes and urbanization moving in rural areas to social protection policies, expanding on existing literature.

Together, these questions provide a comprehensive examination of rural poverty determinants and policy responses, addressing important uncertainties in European rural poverty research. The main data source used in the paper was Eurostat and national statistical offices in the last decade. Data from 27 European countries (except Malta, added Norway) in the years 2010 and 2020 were analyzed. Malta was excluded because its values were extremely outliers. And even though Norway is not an EU member country, it belongs to Europe there is evident similarity with Scandinavian countries – EU members. The final number of countries which were included in regression models was 27. This time period was chosen because there is no sense in analyzing year-by-year changes in variables used in this paper. In terms of finding answers to the research questions, the ten-year time horizon was a compromise between the availability of consistent data on relevant parameters and the possibility of recording changes in the evolution of the phenomenon under study. Only variables that are considered by the authors to have a direct impact on the phenomenon under study in the context of the SDGs in relation to the rural population are included in the models. Other potential variables were excluded from the study due to the simplicity of the model used and potential collinearity.

Originally, these data in the regional statistics section were included by other typologies or by the degree of urbanization. For the purposes of the paper, values were used to indicate the share of values in predominantly rural regions on the sum of values in predominantly urban regions plus intermediate regions plus predominantly rural regions or as the share of rural regions on the sum of total regions. The only exception that did not consider the degree of urbanization was social protection. Social protection was monitored for the economy as a total.

Descriptive statistics of key variables related to rural poverty and socioeconomic situation in European countries for 2010 and 2020 are presented in Tables 1 and 2. The analyzed variables include Social Protection (SP), Rural Households (RH), Older Population (OP), Poverty Threat (PT), Rural Employment (REM), and Freight Transport (TR). Social Protection measures government expenditure as a percentage of GDP, while Rural Households represent the share of households in rural areas. Older Population refers to the percentage of the rural population aged 65 and older in fair health, and Poverty Threat quantifies those living below 60% of the median income. Rural Employment indicates the fraction of employment in rural areas, and Freight Transport denotes the percentage of road freight from these regions. The statistical measures cover mean, minimum, maximum, and standard deviation, providing insights into data tendencies and variability.

Table 1. Descriptive statistics of variables 2010

Variable	data	Abbr.	Mean	Min.	Max.	Std.Dev.
Social protection	the general government expenditure on social protection as % of GDP	SP10	17,51852	12,10000	24,80000	3,31384
Rural households	households in rural areas as % of total households	RH10	35,10296	2,81000	60,30000	16,41636
Older population	the population in rural areas in fair health status at age 65+ as % of total population in rural areas	OP10	41,42593	24,90000	53,50000	8,04337
Poverty threat	% of the population in rural areas with income below 60% of median equalised income	PT10	7,35556	0,10000	19,50000	4,81818
Rural employment	employment in predominantly rural regions as % of total employment	REM10	25,97862	0,56988	55,47735	15,45844
Freight transport	road freight loaded in predominantly rural regions as % of total loading road freight	TR10	30,31783	0,80000	65,50329	18,58419

Source: Eurostat and authors' calculations

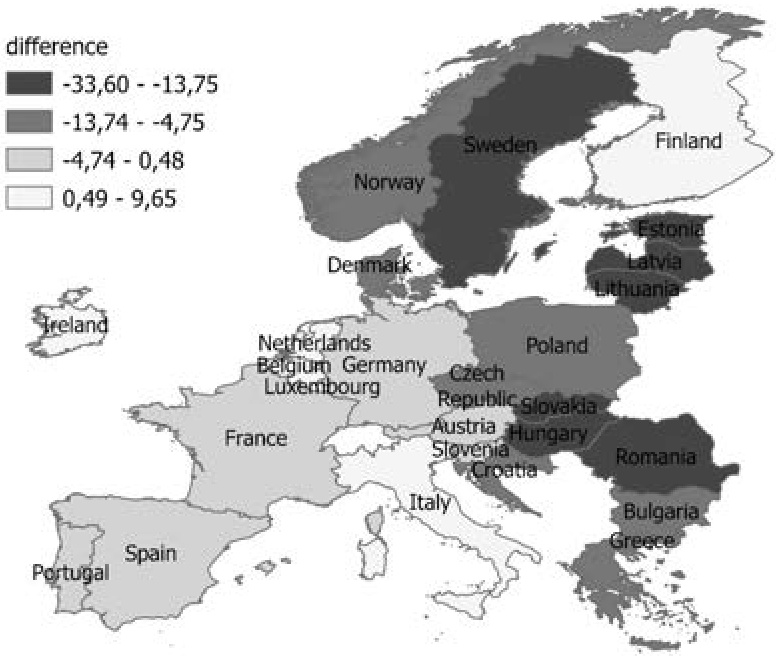
Table 2. Descriptive statistics of variables 2020

Variable	data	Abbr.	Mean	Min	Max	Std.Dev.
Social protection	the general government expenditure on social protection as % of GDP	SP20	18,52593	9,90000	27,20000	4,54182
Rural households	households in rural areas as % of total households	RH20	28,51481	9,61000	44,82000	8,80514
Older population	the population in rural areas in fair health status at age 65+ as % of total population in rural areas	OP20	5,88889	1,20000	16,70000	3,49046
Poverty threat	% of the population in rural areas with income below 60% of median equalised income	PT20	42,00000	21,70000	55,60000	9,42440
Rural employment	employment in predominantly rural regions as % of total employment	REM 20	31,42459	1,03438	59,88293	18,34534
Freight transport	road freight loaded in predominantly rural regions as % of total loading road freight	TR20	23,90269	0,53297	53,20161	14,74072

Source: Eurostat and authors' calculations

The European Union has identified the issue of rural depopulation as one of priorities' areas for policy interventions. However, an evaluation of the effectiveness of these policies during the period under review has not yielded conclusive results, as illustrated in Figure 1 - Rural Households share (change between 2010 – 2020). Negative values represent the decreasing share of rural households; in a simplified way, households move from rural regions to other regions. Over the period under review, there were markedly different trends in the share of rural households, with a one-third to one-fifth decline in the case of Sweden, Romania, and Estonia. This trend in Sweden is consistent with the evolution of the rural population share, as Sweden, Finland, Ireland, and Iceland are among the countries that have shown the most significant decline in the rural population share between 2010 and 2020, more than 20 percentage points. In contrast, Belgium, Luxembourg, Finland and the Netherlands have shown an increase in the share of rural households, albeit of the order of only a few percentage points, which in the case of Belgium and the Netherlands has also been accompanied by a corresponding increase in the share of the rural population.

Figure 1. Rural households share (change between 2010 – 2020)



Source: Eurostat and authors' calculations

For the purpose of answering research questions, the authors used Multiple regression as one of the best methods for explaining economic links. Numeric estimations of the strength of links were calculated using STATISTICA 14 software. Two models were designed, which should explain and answer research questions, so there was the model for question no. 1 and question no. 2. In the first step of the research, the factors that influence the threat of poverty in rural areas were examined. The main model analyses social expenditure, employment and road freight transport were chosen as explanatory variables.

We specified the empirical model as:

$$PT = a + b_1 * SP + b_2 * TR + b_3 * REM$$,

where PT is poverty threat, SP is social protection, TR is freight transport, REM is rural employment, *a* is intercept, and $b_{1},_{2},_{3}$ are coefficients of the independent variables, they indicate change proportion PT with SP, TR or REM change.

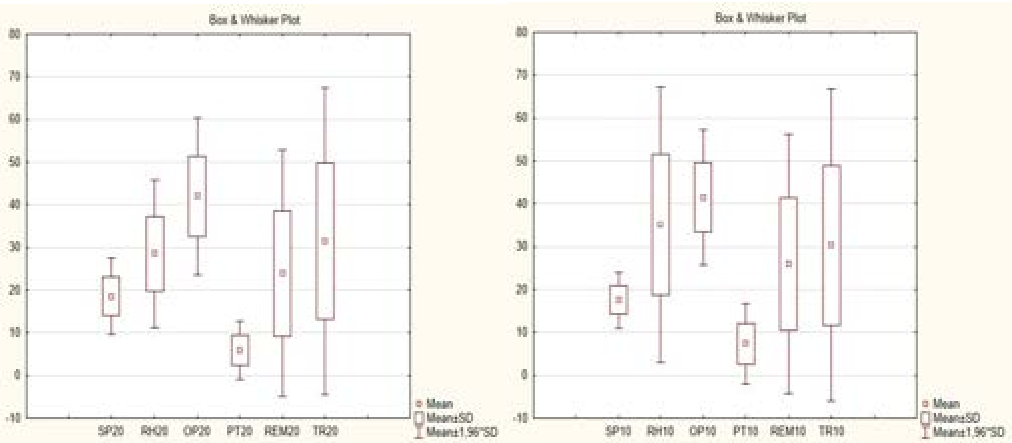
Next, the relationship among social expenditure on one side and rural households and older people on the second side was examined in the two-dimensional space. To understand the relationship among these categories, the following equation was formed as a supplementary model:

$$SP = a + b_1 * RH + b_2 * OP$$

where SP is social protection, RH is rural households, OP is older population, *a* is intercept and $b_{1},_{2}$ are coefficients of the independent variables, they indicate a change proportion SP with RH and OP change.

To demonstrate the variability of variables, the authors used Figure 2. There is clear evidence of the large variability of TR.

Figure 2. Box and Whisker plot of variables in 2010 and in 2020



Source: authors' calculations

To ensure the reliability and validity of the regression analysis, several key assumptions were tested. First, the normality of residuals was assessed using Q-Q plots and histograms, confirming that errors were approximately normally distributed. Second, multicollinearity among predictor variables was examined with Variance Inflation Factors, indicating no significant multicollinearity. Homoscedasticity was evaluated by plotting standardized residuals against predicted values, showing an even spread. The independence of errors was confirmed through the Durbin-Watson test. For the poverty threat variable, slight skewness was corrected with a log transformation to improve model fit. Some heteroscedasticity was detected in the 2020 model, addressed with robust standard errors in analysis. The Durbin-Watson statistics confirmed the absence of autocorrelation. These diagnostic checks enhance the credibility of the regression results and provide insight into the model's limitations. Future research could benefit from larger sample sizes and advanced modelling techniques to further enhance robustness.

A study of rural poverty in European countries using regression analysis has several potential limitations and biases. Bias may arise if relevant variables not subsequently captured in the models are excluded. Similarly, bias may arise already in the measurement of the data. Findings may be affected by endogeneity and simultaneity bias. The assumption of linear relationships between variables may not hold for all aspects of the phenomenon under study, and misspecification of the functional form could lead to biased estimates. While heteroskedasticity and autocorrelation alone may not bias coefficient estimates, they may bias standard errors, which affects the reliability of hypothesis tests and confidence intervals. The high correlation between independent variables such as social protection expenditure and rural employment may lead to unstable coefficient estimates.

Results

Based on statistical analyses by the main model (Table 3), poverty threat is indeed statistically significantly influenced by social protection expenditure. So, if social expenditure decreases, it can cause an increasing poverty threat. These partial results were statistically proven in both observed years. In contrast, the link between poverty threat and rural employment and road freight transport realized in rural areas was not statistically confirmed. The model showed a non-significant influence of rural employment in both observed years, although in 2020, there was a proven negative correlation, which is an expected way to decrease the poverty threat in rural areas. In the case of the economic variable – Freight transport, the expected influence was not proven.

Table 3. The regression results in 2010 and 2020 for the main model

	b*	Standard error of b*	b	Standard error of b	t(24)	p-value
Intercept10			18,34639	4,54944361	4,032668	0,000518692
SP10	-0,541191	0,170965908	-0,78686	0,248576749	-3,165493	0,004320123
TR10	0,3320397	0,255287006	0,086085	0,066186321	1,300652	0,206258893
REM10	0,0227234	0,252399513	0,007082	0,078669441	0,090029	0,929042995
Intercept20			11,45297	2,990736882	3,829482	0,000858343

SP20	-0,507050	0,186446384	-0,389676	0,143287039	-2,719553	0,01222367
TR20	0,5214968	0,403025278	0,099222	0,076681305	1,293955	0,208523899
REM20	-0,258480	0,411393971	-0,061205	0,097414223	-0,628304	0,53599453

Source: authors' calculations

The results of the main statistical model show the following dependencies:

$$PT10 = 18{,}346 - 0{,}787 * SP10 + 0{,}086 * TR10 + 0{,}007 * REM10$$

$$PT20 = 11{,}453 - 0{,}389 * SP20 + 0{,}099 * TR20 - 0{,}061 * REM20$$

The next step involved a more detailed analysis of the variable for which a statistically significant effect was identified in the main model. The multiple regression model proved the relationship between SP, OP, and RH. The evidence is given in Table 4.

Table 4. The regression results in 2010 and 2020 for the supplementary model

	b*	Standard error of b*	b	Standard error of b	t(24)	p-value
Intercept 10			23,98377	4,088984	5,86546	0,000005
RH10	-0,351610	0,199083	-0,07098	0,040187	-1,76615	0,090090
OP10	-0,232828	0,199083	-0,09592	0,082022	-1,16950	0,253686
Intercept 20			29,16192	4,416780	6,602529	7,898E-07
RH20	-0,341384	0,182077	-0,176090	0,093918	-1,874942	0,0730208
OP20	-0,277401	0,182077	-0,133685	0,087746	-1,523537	0,1406936

Source: authors' calculations

The supplementary model for the group of analyzed countries does not prove the relationship among social expenditures and rural older population and households in both observed years. In other words, there was the idea that more aging population and more households in rural areas would require an increase in social expenditures in order to avoid the poverty threat in rural areas. Both years' models proved indirect dependencies. The analysis of social expenditure in relation to population ageing and the degree of urbanization presented only a partial explanation of the poverty threat.

The research clearly shows that social protection expenditure is essential for reducing rural poverty, with a significant negative correlation between social spending and poverty threat in both 2010 and 2020. However, the weakening impact of social protection on poverty - from -0.787 in 2010 to -0.389 in 2020 - raises concerns about the long-term effectiveness of current strategies, suggesting that other factors may be increasingly influencing rural poverty levels or that social protection is not adapting to changing rural dynamics.

The study found no significant influence of rural employment or freight transport on poverty threat, challenging the belief that economic activities inherently reduce rural poverty. Notably, the lack of correlation between freight transport and poverty alleviation indicates that rural logistics' economic benefits may not reach the population directly, prompting a reevaluation of development strategies relying on transportation infrastructure. It is incontestable that support for rural development is closely associated with the implementation of information and communication technologies (Ma et al., 2023, Ignjatović et al., 2024).

An additional model exploring the link between social protection and rural demographics revealed interesting trends. The negative correlation between rural households and social protection expenditure, while not statistically significant, hints at potential disparities in welfare distribution between urban and rural areas. Similarly, the weak negative correlation between the older population and social protection expenditure raises concerns about support for aging rural residents.

Discussions

The key and main purpose of research activities was that the authors used statistical data and tried to verify and generalize the regularities of the relationships. One partial conclusion is that other variables that would perhaps better explain the patterns are not available at either the EU level or national statistical level in the required timeframe and structure. The role of the scientific community, scientific activities, and research is, among other things, to explain and analyze. The final thought of the authors is that we would like data to be able to be analyzed and then confirm or reject the reasoning and then make recommendations to the EU.

The authors´ findings can inspire specific measures to support the development of rural areas. It cannot be ruled out that it might be useful to focus on a few key areas, such as support for rural areas, improvement of infrastructure, support for small businesses and rural entrepreneurship, education and training, and so on. The paper confirms a relationship between social protection expenditure and the ageing rural population, but it does not fully explore how these dynamics interact with other demographic changes, such as migration patterns. More detailed research is needed on how demographic shifts influence social protection needs and poverty risks in rural areas.

If we are concerned with the monitored data in connection with the implementation of the common EU policy in the context of the SDGs, it can be stated that there is a proper justification for choosing the year 2020. Until the end of the mentioned year, EU development aid was implemented through several support programs that were financed from the EU budget and through the European Development Fund that operated between EU member countries. For example, within the multi-year financial period 2014-2020, the development policy was the content of the 4th chapter under the name "Global Europe", for which EUR 59 billion (i.e., 6% of the total budget) was allocated. Funds from the budget were distributed with the help of five thematic instruments, where the Development Cooperation Instrument was focused on the issue of solving issues related to poverty, which was further divided according to geographical areas.

Regional policy within the SDGs is also aimed at reducing potential risks associated with poverty. In order to fulfil these goals within the framework of the development needs of EU regions, 351.8 billion euros were allocated for the program period 2014-2020 (Artelaris & Mavrommatis, 2020). The effectiveness of EU policies aimed at reducing rural poverty and promoting sustainable development remains inconclusive. Existing analyses of the evaluation of the effectiveness of EU policies have yielded inconclusive results. These analyses illustrate that errors and mistakes in economic reasoning, for both economic and non-economic reasons, reflect different linkages and relationships between sub-objectives of economic policy (Brown, 2004; Camaioni et al., 2016; Lipps & Schraff, 2021; Marković et al., 2022).

In a broader context, the performance of the transport sector can be used as an indicator of the performance of the economy. Although the transport sector has a significant impact on rural areas, the performance of rural freight transport, as measured in terms of volume, has not demonstrated a discernible effect on reducing the prevalence of poverty. The most likely explanation for this is that in rural regions, materials resources are handled for the production of products from other areas. Hence, the added value is realized outside rural areas.

Data limitations are mainly in reliance on Eurostat data, which has issues like discontinuities and missing information, highlighting the need for better data collection on rural poverty dynamics. Future research should develop robust methodologies to track rural poverty across Europe.

The limited validity of claims of generally elevated levels of poverty and deprivation in rural areas in Europe has been confirmed in a study by Bernard (2019). Not only do the differences in poverty between rural and urban areas vary in magnitude, but in some countries, these differences are completely skewed in favour of rural areas. This finding has been repeatedly noted. More importantly, there is clear evidence that these differences are far from random. Calculated point elasticities (Wilson et al., 2022) show that despite the apparent trade-off between the two objectives of reducing urban poverty and urban inequality, reducing urban inequality is more effective in reducing urban poverty than promoting growth.

The study relies heavily on Eurostat data, which the authors note has limitations due to discontinuity and missing data from some EU countries. This presents a research gap in terms of data availability and quality. Future studies could benefit from more comprehensive and consistent data collection to better understand rural poverty dynamics across different regions.

Conclusions

The main purpose of the paper is the broader need to analyze one of the aspects of life in rural areas. There is no doubt that without research and scientific contribution, it is not possible.

In the context of the study of the risk of poverty in rural areas, it is possible to confirm the significant connection with social expenditure. Additionally, the influence of rural employment, it is not possible to statistically confirm the connection with the development of freight transport. The mentioned statement lies in the independence of the mentioned business activities in the rural area, as the centres of freight transport and loading places are located outside the area of research – rural areas.

It is evident that a multitude of factors can exert influence on the allocation of financial resources to social protection programs. Furthermore, disparities in wealth and income across nations invariably impact the distribution of resources to social protection programs. The cultural and historical context, along with the associated values and norms in the domains of ageing, family care and social welfare, can also exert a significant influence on government decisions regarding social protection spending, irrespective of the prevailing demographic structure.

These findings highlight the complex nature of rural poverty in Europe and the essential role of social protection policies. The diminishing effect of these policies suggests that other influences or insufficient adaptations to rural changes are at play

The limitation of a more detailed analysis is the scarcity of data, particularly when considering the extent of urbanization. It is important to note that despite the urbanized nature of the European Union (EU), rural regions still encompass over 80% of the EU's land area and are home to approximately 25% of the total population.

The authors, on the basis of the results, recommend that policymakers to take the following steps: integrate social and economic policies for rural development by enhancing employment opportunities, supporting local businesses, and improving access to services; improve data collection and monitoring of rural poverty to understand dynamics and support evidence-based decisions; and foster collaboration among government agencies, local communities, and civil society to create effective strategies for reducing rural poverty and promoting sustainable development.

In summary, while the paper makes significant contributions to understanding rural poverty in Europe, addressing the identified research gaps could enhance its scientific impact and provide more actionable insights for policymakers. Future research could focus on developing models to capture the complexities of rural poverty in an urbanizing context, investigating the long-term effects of social protection measures, exploring the spatial distribution of economic benefits from rural activities.

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Conflict of interests

The authors declare no conflict of interest.

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DECENTRALIZED WASTEWATER TREATMENT: AN INNOVATIVE APPROACH FOR RURAL AREAS

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ABSTRACT

This study provides a comparative analysis of conventional and innovative wastewater treatment technologies for small settlements of up to 2,000 equivalent inhabitants (EH). Conventional systems such as the Sequencing Batch Reactor (SBR), Membrane Bioreactor (MBR), and Moving Bed Bioreactor (MBBR) were evaluated based on treatment efficiency, energy consumption, sludge production, operational complexity, and spatial requirements. Additionally, the potential of phytoremediation, specifically constructed wetlands, as a sustainable and low-cost alternative was explored. The study concludes that phytoremediation systems are a viable option for decentralized wastewater treatment in rural or ecologically sensitive areas due to their low operational costs and minimal energy needs. It recommends wider adoption of these systems, supported by further research and educational programs to optimize their design across different climates.

Introduction

In 2022, the global rural population constituted approximately 43.10% of the total population, equating to 3.43 billion people (UN DESA, 2022). According to World Bank data, the proportion of people living in rural areas has been steadily declining, dropping from 44.81% in 2018 to 43.10% in 2022 (Macrotrends, 2024). This trend is expected to

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continue as urbanization progresses, with projections from the United Nations estimating that the rural population will decline to 3.1 billion by 2050, representing only 22% of the global population (UN DESA, 2022). The highest concentration of rural populations is found in developing countries, particularly in Africa and Asia. For example, in Southeast Europe, rural populations remain significant. In 2022, countries like Moldova (57%), Romania (46%), Serbia (43.13%), Croatia (43%), North Macedonia (42%), and Georgia (41%) had considerably higher rural population percentages than the EU average of 24.53% (OECD, 2022; Trading Economics, 2024). These figures highlight the importance of rural populations in this region, with more than twice as many people residing in rural areas compared to the average in OECD countries.

However, rural populations face significant challenges, particularly regarding access to basic services like sanitation. According to Eurostat (2022), population decline in rural areas is more prevalent than in urban regions, and the lack of access to essential services, such as sanitation, contributes to this trend. A report by UNICEF and the World Health Organization (WHO/UNICEF, 2021) revealed that 4.2 billion people globally, or 46% of the world's population, do not have safely managed sanitation services. In rural areas, access to adequate sanitation is even more limited. In Southeast Europe, for instance, only 43% of rural populations have access to proper sanitation services (OECD, 2022). This situation poses severe health risks and adversely affects the well-being of rural communities. The World Health Organization promotes the Sanitation Safety Plan (SSP) approach to support countries in achieving Sustainable Development Goal (SDG) 6.2, which aims to provide access to adequate and equitable sanitation and hygiene for all by 2030 (WHO, 2024). However, constructing and managing large-scale, centralized wastewater collection and treatment systems is often economically unfeasible for rural areas, particularly in developing regions with declining populations and limited financial resources (Hoffmann, 2020).

As Capodaglio et al. (2017) have noted, centralized wastewater treatment in low-income countries can be prohibitively expensive, often leading to long-term debt burdens. In contrast, decentralized wastewater treatment systems (DWTS) offer a more sustainable, ecologically sound, and cost-effective solution for managing wastewater in rural areas (Muzioreva et al., 2022, Paraušić et al., 2025). DWTS reduce the need for long-distance transport of wastewater, lowering energy consumption and greenhouse gas emissions, and they are particularly suitable for areas with low population densities and dispersed households (Massoud et al., 2009). Additionally, decentralized systems present opportunities for resource recovery, such as the reuse of treated wastewater and byproducts like nutrients, sludge, and energy (Garcia et al., 2022; Đaković et al., 2024; Bernal et al., 2021; Eggimann et al., 2018; Luković et al., 2024). Decentralized systems focus primarily on treatment and disposal, minimizing the collection component, which can account for up to 60% of the total cost of centralized systems (Massoud et al., 2009; Eggimann et al., 2016; Bernal et al., 2021). This cost reduction makes decentralized solutions an attractive option for small settlements.

Furthermore, decentralized systems are flexible and scalable, making them adaptable to local conditions and capable of expanding as populations grow (Bernal et al., 2021; Eggimann et al., 2018; Ignjatijević et al., 2024; Capodaglio, 2017). These systems can be implemented in a variety of settings, from small communities to industrial sites, and can be easily modified to accommodate changing wastewater generation patterns. Their resilience to natural disasters and other disruptions also makes them a more reliable option than large, centralized systems, which are more vulnerable to system-wide failures (Fluence, 2024).

Decentralized wastewater treatment systems can also be designed to align with the social and cultural preferences of local communities, making them more socially acceptable (Massoud et al., 2009). However, despite these advantages, the widespread adoption of decentralized systems faces significant challenges, particularly in terms of regulatory frameworks and institutional support. In many countries, there is a lack of legal and institutional arrangements to incorporate these technologies into formal urban planning processes (Chirisa et al., 2017; Nansubuga et al., 2016; Petković et al., 2024; Muzioreva et al., 2022).

Given these factors, this article aims to present the most frequently used models of decentralized wastewater treatment systems in rural areas with populations of up to 2,000 inhabitants, with a particular focus on both classical technologies and new innovations based on phytoremediation.

Materials and Methods

The methodological approach employed in this study is based on analytical methods, aimed at systematically evaluating and comparing wastewater treatment technologies. The research was conducted in two distinct phases.

The first phase of the study involved a detailed analysis of three widely used conventional wastewater treatment technologies: the Sequencing Batch Reactor (SBR), Membrane Bioreactor (MBR), and Moving Bed Bioreactor (MBBR). The primary objective was to evaluate the performance, operational efficiency, and sustainability of each system. The analysis considered several key parameters, including treatment efficiency, energy consumption, sludge production, and operational complexity. Data for the analysis were drawn from scientific literature, technical reports, and case studies focusing on the use of SBR, MBR, and MBBR technologies in small and medium-sized settlements. Performance metrics from existing wastewater treatment plants employing these systems were reviewed and compared.

In the second phase of the study, an innovative method based on phytoremediation was analyzed. This approach involves the use of constructed wetlands, which mimic the natural processes occurring in wetland ecosystems to treat wastewater. The following aspects were assessed: system design and components, treatment mechanisms, environmental integration, and sustainability. Field data were collected from case studies of operational constructed wetlands, particularly in rural settings. These data were supplemented by information from technical reports and studies focused on the efficiency of phytoremediation for wastewater treatment.

A comparative analysis was conducted to evaluate the relative performance of the conventional technologies (SBR, MBR, MBBR) and the innovative phytoremediation approach. The following criteria were used for the comparison: treatment efficiency, economic viability, sustainability and scalability. The results of the comparative analysis were synthesized to determine the most appropriate wastewater treatment solutions for small settlements, considering both technical performance and ecological sustainability.

For the reasons mentioned above, this article presents the most frequently used models of decentralized water treatment systems in rural areas with populations of up to 2,000 inhabitants, with a special analysis of classical and new technologies based on phytoremediation.

Results and discussion

Several biological wastewater treatment technologies, including the Sequencing Batch Reactor (SBR), Membrane Bioreactor (MBR), and Moving Bed Bioreactor (MBBR), and waste water treatment based on phytoremediation - constructed wetlands (CWs) have been employed effectively over the past decades for the treatment of wastewater (Rashid et al., 2021; Saidulu et al., 2022, as cited in Singh et al., 2022). These technologies have played a crucial role in managing wastewater, particularly in smaller settlements and rural areas.

The Sequencing Batch Reactor (SBR) has been in use since the 1920s and remains one of the most widely adopted wastewater treatment methods, especially in rural regions. The SBR system is a traditional biological treatment technology that employs activated sludge and deep aeration. Unlike conventional wastewater treatment systems, where each stage of treatment occurs in separate reactors, the SBR integrates all stages within a single reactor. This consolidation results in significant cost savings and reduces the spatial footprint required for installation and operation.

In the SBR process, wastewater is treated in cycles using activated sludge, which comprises a complex mixture of microorganisms along with non-degradable organic and inorganic materials from the wastewater. A distinct advantage of the SBR system is its ability to support a diverse range of microorganisms due to the intermittent changes in environmental conditions within the reactor. These dynamic conditions enhance the overall quality of wastewater treatment by fostering the growth of microorganisms capable of efficiently degrading organic pollutants. The treatment cycle within the SBR reactor consists of four distinct phases: filling, aeration, settling, and decanting. After the decanting phase, the treated water is discharged into the receiving environment. These phases are carefully timed and sequenced to allow multiple treatment cycles to be completed in a single day, optimizing the efficiency of the process. By synchronizing these phases with the influent flow, SBR systems are capable of effectively treating wastewater in a compact and economical manner, making them particularly suitable for use in small settlements and rural communities where space and financial resources are limited.

Table 1. Values of treated wastewater using SBR systems (the data is for informational purposes and aims to illustrate the potential)

Parameters	Permitted concentrations for discharge into Class II waters	Values of SBR systems	Minimum Treatment Efficiency Percentage
BPK5 (mg O2/l)	< 25	< 25	70%
HPK (mg O2/l)	< 125	< 125	75%
Suspended matter (mg/l)	< 35	< 35	90%
Total P (mg/l)	< 1	< 1	Secondary treatment
Total N (mg/l)	< 21	< 21	Secondary treatment
Turbidity (NTU)	< 1	< 5	99%
Removal of bacteria (%)		No	-

Source: Authors' calculations

The advantages of these systems include their ability to accommodate significant fluctuations in both flow rate and wastewater composition, making them particularly well-suited for smaller communities where such variability is common. Furthermore, these systems offer automated remote operation, enabling efficient monitoring and control with minimal on-site supervision. They deliver high-quality wastewater treatment, facilitate rapid equipment installation, and require a minimal spatial footprint, which is critical in space-constrained settings.

However, there are notable disadvantages. These systems necessitate the involvement of highly skilled personnel for maintenance and monitoring, due to the complexity of the fully automated processes. Additionally, they have relatively high specific energy consumption, which can increase operational costs. Another limitation is the need for regular sludge disposal, which requires further handling and treatment to ensure environmental compliance.

Membrane Bioreactor (MBR) technology integrates conventional biological treatment processes with membrane filtration, providing an advanced solution for wastewater management. In this system, the biological treatment, which utilizes activated sludge, is coupled with membrane ultrafiltration, resulting in highly efficient wastewater purification. The MBR process is typically carried out in a compact, containerized facility, making it suitable for use in areas where space is limited. The treatment procedure is usually divided into three distinct phases: biological degradation of organic matter, membrane filtration to separate solids from liquids, and the discharge of treated water.

Table 2. Values of Treated Wastewater Using MBR Technology (The data is for informational purposes and aims to illustrate the potential)

Parameters	Permitted concentrations for discharge into Class II waters	Values of MBR systems	Minimum Treatment Efficiency Percentage
BPK5 (mg O2/l)	< 25	< 2	95%
HPK (mg O2/l)	< 125	<50	90%
Suspended matter (mg/l)	< 35	<5	97%
Total P (mg/l)	< 1	<1	95%
Total N (mg/l)	< 21	<15	90%
Turbidity (NTU)	< 1	<5	99.9 %
Removal of bacteria (%)		Yes	99.9%

Source: Authors' calculations

The advantages of Membrane Bioreactor (MBR) systems include their ability to achieve a high level of removal of organic pollutants, nitrogen, bacteria, and viruses, which allows for the discharge of treated water directly into groundwater in the absence of nearby recipients. Moreover, the treated water can be immediately reused for non-potable purposes such as irrigation and toilet flushing, making MBR technology particularly suitable for application in environmentally sensitive areas. These systems occupy a small spatial footprint, feature a high degree of automation, and generate no unpleasant odors or noise, further enhancing their suitability for use in populated or restricted spaces. Maintenance costs for MBR systems are generally lower than those of conventional biological treatment systems, and they produce minimal waste sludge, thereby reducing the costs associated with sludge disposal.

However, there are also notable disadvantages to MBR systems. They require a continuous inflow of wastewater for optimal operation, and in the event of extended downtime, a full system restart is necessary. The maintenance of these systems requires highly qualified personnel, particularly for tasks such as draining and cleaning, which must be carried out by authorized staff. Additionally, MBR systems have relatively high specific energy consumption and require membrane replacement approximately every five years, contributing to ongoing operational costs.

The Moving Bed Bioreactor (MBBR) is a biological wastewater treatment process that uses freely floating carriers to support the growth of biofilm, differentiating it from conventional activated sludge systems. These carriers, made from high-density polyethylene, provide a large specific surface area for microbial colonization, enhancing the efficiency of the treatment process. The carriers typically occupy about half of the reactor's volume, allowing for a substantial increase in the biomass concentration relative to the reactor's total volume.

A key distinction between the MBBR and traditional activated sludge systems lies in the lifecycle of the biomass. In conventional systems, the biomass in the form of activated sludge has a relatively short lifespan due to the regular removal of excess sludge. Conversely, in the MBBR process, microorganisms are immobilized on the biofilm carriers, allowing them to achieve significantly longer lifespans. This results in a more stable and consistent treatment process over time. Additionally, the amount of sludge produced in MBBR systems is notably lower than in conventional systems, largely due to biological efficiencies inherent in the immobilization process.

Table 3. Values of Treated Wastewater from MBBR System (data is for informational purposes and aims to demonstrate the potential)

Parameter	Permissible Concentrations for Discharge into Class II Waters	MBBR System Values	Minimum Treatment Efficiency Percentage
BOD5 (mg O2/l)	< 25	< 25	70%
COD (mg O2/l)	< 125	< 125	75%
Suspended Solids (mg/l)	< 35	< 35	90%
Total P (mg/l)	< 1	< 1	Secondary treatment
Total N (mg/l)	< 21	< 21	Secondary treatment
Turbidity (NTU)	< 1	< 5	99%
Bacteria Removal (%)	-	No	-

Source: Authors' calculations

The advantages of Moving Bed Bioreactor (MBBR) systems include high wastewater treatment efficiency, primarily attributed to the retention of sludge, which facilitates effective nitrification. These systems are capable of automatically adjusting to fluctuations in wastewater load without the need for operator intervention, and they exhibit strong resistance to toxic shocks, making them particularly robust in variable or challenging operating conditions. Additionally, MBBR systems produce minimal sludge, which reduces the costs and complexities associated with sludge management, and they require a relatively small installation footprint, making them ideal for space-constrained settings. However, there are certain disadvantages to these systems. Maintenance of MBBR systems requires a higher level of technical expertise due to the complexity of the process, particularly when managing fully automated operations. This can result in increased staffing requirements and associated costs. The complexity of the system's automation may also present operational challenges that necessitate specialized training for personnel to ensure smooth and efficient functioning.

Wastewater treatment based on phytoremediation

In contrast to conventional technologies typically employed in decentralized wastewater treatment systems for settlements of up to 2,000 equivalent inhabitants (EH), this section explores an alternative approach leveraging the ecosystem services of wetland habitats for wastewater treatment. With growing interest in models that offer high efficiency alongside reduced construction costs, minimal or negligible energy consumption, low maintenance expenses, and easy environmental integration, phytoremediation—

specifically plant-based wastewater treatment systems—presents a promising solution. While this method has been practiced since ancient times, it has only gained significant attention in Western Europe over the last decade. In Eastern Europe, however, these systems are still underutilized.

Phytoremediation systems are multifunctional and can provide additional benefits beyond wastewater treatment, including the production of energy, food, and compost, as well as the reuse of treated water for irrigation, toilet flushing, and other purposes. This multifunctionality makes them economically viable solutions and attractive for investment. These systems mimic natural wetland processes, transforming polluted areas into ecological zones that serve as ecosystem processors. The treatment process begins with mechanical treatment, where solid materials settle in tanks, and the partially clarified water is directed to phytolagoons for further processing. In the biological treatment stage, specific plant species are employed to remove harmful substances from the wastewater, utilizing their natural filtration and absorption abilities. During physical treatment, the wastewater passes through a substrate composed of sand, gravel, and stones, which serves as a filter. Finally, chemical treatment transforms waste materials into harmless substances through processes such as the oxidation and reduction of phosphorus and nitrogen.

The vegetation plays a crucial role in these systems, with plants facilitating oxygen transfer to the root zone, absorbing waste materials, and providing nutrients through decaying organic matter. This supports the development of microorganisms essential for wastewater treatment. Some systems also incorporate energy crops to produce energy, further enhancing their sustainability. Commonly used native plant species include common reed (*Phragmites australis*), bulrush (*Typha latifolia*), yellow flag iris (*Iris pseudacorus*), and sedges (*Carex* spp.), as well as high-energy species like giant reed (*Miscanthus giganteus*) and willow (*Salix viminalis*). Phytoremediation systems offer several advantages, including low construction and maintenance costs, minimal or no energy requirements, and the potential for zero waste generation. They integrate easily into the natural environment without the use of chemicals, and they provide habitats for diverse flora and fauna. Additionally, these systems can rehabilitate degraded land, turning it into ecological zones, and they utilize natural, locally sourced materials for construction. Their flexibility allows for modular designs, making them adaptable for research and educational purposes. However, phytoremediation systems also have disadvantages. They require significantly larger land areas for construction compared to conventional systems and lack standardized design criteria for different climatic conditions, requiring customized designs for each specific case.

In Europe, there is a substantial body of research focusing on wastewater treatment through phytoremediation, with many studies concentrating on municipal wastewater from households. One such facility in Kirnberg, Austria, was analyzed to assess its efficiency. During a study visit in September 2017, in collaboration with representatives from the Faculty of Applied Ecology "Futura," the facility, designed for 300 equivalent inhabitants (EH), was evaluated. The system consists of an aerated receiving shaft, a settling tank, a wave tank operated by a lever mechanism without energy consumption, and four phytoremediation lagoons with vertical water flow, planted with common reed (*Phragmites australis*). A control and inspection shaft is located at the end of the system, ensuring monitoring and maintenance. The Table 4 presents the results of wastewater treatment.

Table 4. Values of Treated Water from the Biological Wastewater Treatment Plant in Kirnberg, Austria

Parameter	Permissible Concentrations for Discharge into Class II Waters	Average Values at the Outlet of the System in Kirnberg	Minimum Treatment Efficiency Percentage
BPK5 (mg O2/l)	< 25	2	80%
HPK (mg O2/l)	< 125	15	80%
Suspended Solids (mg/l)	< 35	1.70	90%
Total P (mg/l)	< 1	0.62	Secondary treatment
Total N (mg/l)	< 21	10.5	Secondary treatment
Turbidity (NTU)	< 1	0.6	99%
Removing bacteria (%)		Partially	No

Source: Authors' calculations

The following tables present a comparative overview of the financial requirements for the wastewater treatment models under consideration. The costs of construction, as well as the maintenance expenses, have been obtained from the company "Borplastika Eko" and are supplemented by personal experience in the design and construction of these systems.

Table 5. Overview and Comparative Analysis of Available Technologies for Wastewater Treatment

Parameter	Minimum Percentage of TreatmentSBR	Minimum Percentage of Treatment MBBR	Minimum Percentage of Treatment MBR	Minimum Percentage of Treatment Fitoremedijacija
BPK5 (mg O2/l)	70%	70%	95%	75 %
HPK (mg O2/l)	75%	75%	90%	75%
Suspended Solids (mg/l)	90%	90%	97%	93%
Total P (mg/l)	Secondary Treatment	Secondary Treatment	95%	Secondary Treatment
Total N (mg/l)	Secondary Treatment	Secondary Treatment	90%	Secondary Treatment
Turbidity (NTU)	99%	99%	99.9%	95%
Bacteria Removal (%)	No	No	99.9%	Partial

Source: Authors' calculations

Table 6. Electricity Requirements for 100, 500, 1000, and 2000 Equivalent Inhabitants (EH)

Electricity Demand for the Entire Facility	SBR Value (kW)	MBR Value (kW)	MBBR Value (kW)	Phytoremediation
100 ES	5.66	19.16	5.66	Negligible Value or None
500 ES	11.66	116.66	15.16	Negligible Value or None
1000 ES	19.66	229.46	23.46	Negligible Value or None
2000 ES	35.46	455.46	43.46	Negligible Value or None

Source: Authors' calculations

Table 7. Comparative Overview of the Financial Aspects for the Considered Wastewater Treatment Models

Parameter	SBR	MBR	MBBR	Phytoremediation
Construction Cost (€/EH) (Excluding Land Area)	210 - 370	350 - 700	330 - 520	130 - 240
Annual Maintenance Costs (€/m^3)	1.70	2.50	1.90	0.10
Required Area (m^2/ES)	0.5 – 0.9	0.5 – 0.9	0.5 – 0.9	2 - 5

Source: Authors' calculations

Despite the diversity of technological processes employed in wastewater treatment plants, the treated effluent must meet the maximum allowable discharge limits to comply with environmental standards. Among the various technologies, Membrane Bioreactor (MBR) systems offer the highest level of wastewater treatment. However, these systems are highly dependent on a continuous inflow of wastewater; any prolonged interruption necessitates a full system restart, which can complicate operations. In terms of operational complexity, MBR systems are the most intricate, requiring highly skilled personnel for both maintenance and operation, whereas phytoremediation-based systems are the simplest and can be managed without specialized training.

Regarding sludge production, MBR systems generate the highest amount of sludge due to their intensive treatment processes. However, they also provide the highest treatment efficiency, making them ideal for meeting stringent wastewater treatment requirements, particularly in sensitive or protected areas. From a financial standpoint, MBR systems are the most expensive to construct, followed by Moving Bed Bioreactor (MBBR) systems, Sequencing Batch Reactors (SBR), and finally, phytoremediation systems, which have the lowest construction costs.

In terms of land requirements, phytoremediation systems demand significantly more space compared to other treatment technologies. While this large spatial requirement may be a disadvantage in urban or densely populated areas, it is less of a concern in rural settings, where degraded or unused land is typically available and can be repurposed for such systems.

Conclusion

Based on the results of this study, it can be concluded that phytoremediation-based wastewater treatment models represent a viable alternative to conventional systems, particularly for small settlements in rural areas. These models have demonstrated the ability to meet the wastewater treatment standards mandated by the European Union and the Republic of Serbia. Their low energy requirements, ease of maintenance, minimal operational costs, and seamless integration into the natural environment make them attractive for rural and ecologically sensitive areas. Additionally, these systems not only treat wastewater but also create habitats for wildlife, transforming treated areas into biotopes that contribute to biodiversity and support broader environmental sustainability.

One of the key advantages of phytoremediation systems is their reliance on natural processes that mimic the functions of wetland ecosystems. This ecological approach promotes sustainable development by utilizing locally available resources, such as native plant species, and minimizing the need for synthetic chemicals or energy-intensive processes. The ability of these systems to produce multifunctional benefits—such as providing treated water for irrigation, energy generation from biomass, and compost production—further enhances their economic viability and attractiveness for investment.

While the disposal of waste sludge remains a concern across all wastewater treatment systems, this issue is less pronounced in phytoremediation systems due to the minimal volume of sludge produced by small-scale plants. However, it is recommended that sludge from these systems be utilized for composting in conjunction with green waste, thereby contributing to a circular economy and achieving zero waste. If composting is not feasible, the sludge should be safely transported to the nearest central wastewater treatment facility equipped with a sludge management line or disposed of at a designated municipal landfill.

In conclusion, there is a strong case for promoting phytoremediation systems as ecologically and economically sustainable solutions for decentralized wastewater treatment in small settlements. It is crucial to encourage designers, planners, and decision-makers to prioritize the adoption of these innovative, environmentally justified approaches. Additionally, efforts should be made to implement educational programs for local residents and users of these systems, fostering greater community engagement and ensuring the long-term success and sustainability of these wastewater treatment models.

Conflict of interests

The authors declare no conflict of interest.

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THE FUTURE OF SERBIAN FRUIT EXPORTS TO EGYPT: OPPORTUNITIES UNDER THE NEW FREE TRADE AGREEMENT

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A B S T R A C T

This study examines the potential impact of the Free Trade Agreement (FTA) between Serbia and Egypt on Serbian fruit exports. It identifies fruit products with strong trade complementarity to Egypt's import needs and projects export growth from tariff reductions. Using Revealed Comparative Advantage (RCA) and the Michaely Trade Complementarity Index (TCI), the analysis highlights Serbia's globally competitive fruit products and their alignment with Egypt's demand. A simulation model, incorporating Egypt's demand elasticity and anticipated price reductions, predicts significant growth for products like fresh apples, plums, and dried apricots, while frozen fruits, despite high RCA, show limited prospects. The findings offer actionable recommendations for expanding production in high-demand sectors, leveraging Serbia's comparative advantages, and diversifying exports to maximize FTA benefits. This study provides a strategic framework for enhancing Serbia's fruit trade with Egypt, supporting informed policymaking and stakeholder decisions in an evolving global trade environment.

Introduction

Free Trade Agreements (FTAs) have proliferated significantly since the turn of the 21st century, with over 354 FTAs currently in force worldwide as of 2024 (WTO, 2024). These agreements play a critical role in reducing both tariff and non-tariff barriers, fostering economic efficiencies through mechanisms like trade creation and trade diversion (Viner, 1950). Beyond tariff reductions, modern FTAs increasingly address non-tariff barriers (NTBs), aligning regulatory standards and streamlining administrative procedures to lower transaction costs and enhance market access (Bhagwati & Panagariya, 1996; Irwin, 2008; Baldwin, 2011). These aspects are especially relevant in developing countries, where average tariffs and NTBs remain significant obstacles to trade (Melchior, 2018). Despite the broader trend of tariff reductions globally, FTAs continue to hold substantial importance for products facing high import duties in specific markets.

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Within this global trend of trade liberalization, Serbia and Egypt have taken a significant step toward strengthening economic ties through their newly signed FTA. The economic ties between Serbia and Egypt have significantly progressed in recent years, marked by a series of agreements aimed at strengthening bilateral cooperation. A pivotal moment occurred in July 2022 when Egyptian President Abdel Fattah el-Sisi visited Serbia, leading to the signing of several agreements, including a Memorandum of Understanding (MoU) on Agriculture. This MoU emphasized the mutual interest in expanding agrarian trade through joint projects, knowledge exchange, and agricultural technology transfers (Ministry of Agriculture of the RS, 2022).

Following this, in December 2022, Egypt expressed a notable interest in importing Serbian fruits and grains, signalling an untapped opportunity for Serbian exporters. While the demand for Serbian grains was expected given North Africa's high import needs (Stanojević, 2022), the interest in Serbian fruits was more surprising, as Egypt has traditionally been a marginal market for these products.

Building on these developments, Serbia and Egypt signed a Free Trade Agreement (FTA) in July 2024, which is currently awaiting ratification. The FTA is set to eliminate or significantly reduce tariffs on Serbian agricultural exports, offering Serbian producers improved market access and price competitiveness in Egypt (Tanjug, 2024).

The significance of this study lies in the mutual benefits the Serbia-Egypt FTA offers to both countries. For Serbia, the agreement presents a valuable opportunity to expand its agricultural exports beyond traditional European markets. While Serbia has a well-established fruit export industry—particularly in frozen berries, apples, and stone fruits—its trade has remained largely concentrated in the EU and neighbouring countries. The FTA, by reducing tariffs and improving market access, enables Serbian producers to tap into Egypt's growing demand for high-quality fruit imports. This, in turn, could open new trade opportunities and support Serbia's efforts to diversify its export markets.

From a broader perspective, this study contributes to the understanding of South-South trade agreements, which have gained increasing relevance in global trade dynamics. Recent research underscores that trade liberalization among developing countries can yield substantial economic benefits, often rivalling those achieved through access to developed markets (Kowalski & Shepherd, 2006; Sanguinetti et al., 2010; Mayda & Steinberg, 2009; Lee & Lee, 2012). In this context, the Serbia-Egypt FTA exemplifies a strategic effort to enhance trade flows between emerging economies.

The primary objective of this study is to assess the potential impact of the newly signed Serbia-Egypt FTA on Serbian fruit exports by identifying high-potential fruit products and estimating the expected growth in trade flows resulting from tariff reductions.

Specifically, the research focuses on:

- Identifying High-Potential Fruit Products: Determining which Serbian fruit products exhibit the strongest trade complementarity with Egypt's import needs under the new FTA framework.

- Estimating Export Growth: Predicting the extent to which Serbia's fruit exports could increase post-FTA, particularly for highly complementary products.

To achieve these objectives, the study employs a combination of trade indices and simulation techniques. The Revealed Comparative Advantage (RCA) index is used to identify Serbia's most globally competitive fruit products, while the Trade Complementarity Index (TCI) measures the alignment between Serbia's export potential and Egypt's import demand. A simulation model then projects the potential growth in Egyptian demand for these products, incorporating key factors such as price elasticity and expected tariff reductions.

This approach provides a predictive analysis of the FTA's impact on Serbia's agricultural trade, offering valuable insights for policymakers and exporters looking to leverage new market opportunities.

Background: Serbian Fruit Exports and Emerging Opportunities in Egypt

Serbia's Fruit Sector

Serbia's strong fruit production is a cornerstone of its agricultural exports, driven by a favourable geographical position and temperate continental climate (Stankov et al., 2023). The country is a global leader in raspberry production and export, with other prominent fruits including apples, plums, cherries, and strawberries (Matkovski et al., 2018).

Fruit exports significantly contribute to Serbia's trade balance, accounting for 3.5–4% of total exports in the past five years—a notable share for low-value, minimally processed products. Frozen fruit, particularly frozen berries, dominates the export structure, consistently representing over 50% of annual fruit export value. In 2021, frozen berries alone generated $682 million, comprising nearly 70% of total fruit exports (Table 1).

Table 1. The structure of fruit export from Serbia (in million USD)

HS	Product	2019	2020	2021	2022	2023
08	Total fruit export	608	736	975	894	789
0811	Frozen fruit	380	476	682	613	516
0808	Apples, pears and quinces	124	133	134	113	106
0813	Dried fruit	18	21	39	58	61
0810	Fresh strawberries, raspberries, blackberries	36	43	58	50	50
0809	Apricots, cherries, peaches, plums	45	59	54	53	44

Source: ITC, 2024b. Trade Map.

Other key categories include apples, pears, and quinces, which maintain stable export values, and dried fruits, which have shown remarkable growth, tripling from $18 million in 2019 to $61 million in 2023. Fresh fruits, such as strawberries, raspberries, and apricots, also play a role but contribute less overall.

Serbia's primary export markets include Germany, Russia, and other European countries, as well as the United States, Saudi Arabia, and the UAE. Frozen products are particularly favoured globally for their shelf life and logistical efficiency, underscoring Serbia's competitive edge in this segment.

The Untapped Egyptian Market and FTA Prospects

Serbia's natural conditions, including its favorable geographical location and suitable climate, make it a competitive fruit producer and exporter (Lukač-Bulatović et al. 2017; Stankov et al., 2023). In contrast, Egypt faces severe agricultural challenges, primarily due to water scarcity. Fruit production, one of the most water-intensive agricultural activities, is increasingly difficult for Egypt as the country struggles with a growing freshwater crisis (Osman et al., 2021). Overuse and climate change have significantly reduced the capacity of the Nile, Egypt's primary source of water and fertile land, further exacerbating these challenges.

Egypt's growing reliance on imports to meet its agricultural needs highlights a significant opportunity for Serbian fruit exports. However, Serbia remains a minor supplier to Egypt, with exports primarily limited to frozen fruits. This underutilization is largely due to systemic barriers, including high tariffs and stringent regulatory requirements. For example, while frozen fruits face a relatively low tariff of 10%, fresh fruit products such as apricots, peaches, and plums are subject to duties as high as 60% (Table 2).

Table 2. Egyptian market access condition for Serbia

Fruit product	HS code	Customs Tariffs
Apples	08081	40%
Pears	08083	40%
Quinces	08084	30%
Apricots	08091	60%
Sour cherries	08092	10%
Peaches, including nectarines	08093	60%
Plums	08094	60%
Strawberries	08101	10%
Frozen berries	0811	10%
Provisionally preserved fruit	0812	10%
Dried apricot	08131	30%
Dried prunes	08132	30%
Dried apples	08133	20%

Source: ITC, Market Access Map, 2024a. https://www.macmap.org/

This tariff disparity has significantly restricted Serbia's ability to penetrate the Egyptian market with fresh and processed fruits, as the high costs erode competitiveness.

Non-tariff measures (NTMs) further complicate access for Serbian exporters. Egypt imposes over 150 regulatory measures on fresh and dried fruits and 161 measures on frozen fruits (ITC, 2024a). Combined with high tariffs, these barriers limit Serbian horticultural products' ability to compete in Egypt's market.

Additionally, Egypt's trade agreements with countries such as the EU, India, the United States, and South Africa provide preferential tariff treatment, giving their exports a significant competitive edge. As a GAFTA member, Egypt also benefits from tariff-free or reduced-tariff imports from other Arab nations. These dynamics have historically marginalized Serbian exports in the Egyptian market. However, it is worth noting that competing nations primarily supply citrus and grapes, which are not Serbia's main export categories, leaving room for other fruits to gain traction.

The FTA between Serbia and Egypt, signed in 2024, signals a shift in trade relations. Building upon cooperative agreements initiated in 2022, the FTA is expected to eliminate customs duties on nearly all Serbian agricultural exports to Egypt, drastically improving market access. Tariffs on key products such as fresh apples (40%) and dried prunes (30%) are slated for removal, with phased reductions for other products ranging from 20% to 60% (Tanjug, 2024).

This tariff elimination is expected to have a profound impact on pricing and demand. Lower import prices for Serbian fruits are likely to make them more competitive and appealing to Egyptian consumers, stimulating demand. For instance, the removal of a 40% tariff on apples is projected to significantly reduce consumer prices, opening opportunities for Serbian producers to expand their presence in the Egyptian market.

While regulatory barriers will still need to be addressed, the FTA offers a unique opportunity to redefine Serbia's role in Egypt's import landscape. By leveraging reduced tariffs, Serbia can diversify its export portfolio and establish a stronger foothold in an untapped yet promising market. The agreement not only aligns with Egypt's need for diversified, cost-effective agricultural imports but also supports Serbia's strategy of expanding trade partnerships beyond traditional markets.

Materials and methods

This research aims to assess the impact of the Serbia-Egypt FTA on Serbian fruit exports by identifying high-potential products and estimating export growth due to tariff reductions.

Research Aims and Questions

The study is guided by two main aims:

1. Identifying Serbian fruit products with the strongest complementarity to Egypt's import needs.
2. Estimating the potential increase in Serbian fruit exports resulting from the FTA's tariff reductions.

The following research questions are addressed:

1. Which Serbian fruit products exhibit the strongest trade complementarity with Egyptian import demand under the 2024 FTA framework?

2. What is the projected increase in Serbian fruit exports to Egypt, particularly for highly complementary products, following tariff reductions?

Methodological Approach

The research applies a two-step methodology:

Step 1: Identifying High-Potential Products

- RCA: Revealed Comparative Advantage, introduced by Balassa (1965), measures Serbia's global export competitiveness for each fruit product using the formula:

$$RCApj = (Xpj/Xj)/(Xpw/Xw) \quad (1)$$

Where:

- X_{pj} = exports of product p from country j
- X_j = total exports of country j;
- X_{pw} = world exports of product p;
- X_w = total world exports

A value greater than 1 indicates comparative advantage. Previous studies, such as Ahmed et al. (2024), Fertő and Hubbard (2003), and Banterle and Carraresi (2007), validate the utility of RCA in agricultural trade analysis.

- TCI: The Michaely Trade Complementarity Index assesses alignment between Serbia's export structure and Egypt's import demand, using the formula:

$$\text{TCI}ab = 1 - \Sigma|\text{Xaj/Xa-Mbj/Mb}|/2 \quad (2)$$

where Xaj is the country a's export of commodity j; Xa is country a's total export; Mbj is the country b's import of commodity j. Mb is country b's total import.

A result near 1 indicates strong complementarity. This approach builds on methodologies discussed by Michaely (1996), Finger and Kreinin (1979), Hoang (2018), and Stanojević (2022).

Step 2: Simulating Export Growth

Simulation models are tools particularly useful for assessing complex systems where multiple variables interact. This research adopts the methodology established by Plummer et al. (2010) to assess the impact of FTAs. It incorporates ITC (2024b) data on tariffs and trade flows.

A simulation model estimates the increase in Egyptian demand for Serbian fruits under the FTA. The model incorporates:

- Demand Elasticity: Measures the percentage change in import quantity relative to price changes, using the formula:

$$E_{QP} = \% \text{ change in } Q \ / \ \% \text{ change in } P \quad (3)$$

Where Q is quantity of demand and P related to prices of imported goods.

- Price Changes: Assumes reductions in tariffs on Serbian fruits, with price changes (p′) modeled to predict import demand.

  The projected demand increase (Y′) is calculated as:

$$Y' = e * p' \quad (4)$$

where e is elasticity and p′ is the price change.

- The net increase in demand is derived as:

$$\Delta Y = Y' - Y \quad (5)$$

Where *Y’* as the projected import quantity is the result of multiplying the elasticity by the change in price:

This approach allows for a quantitative estimate of how much Egyptian demand for Serbian fruits is likely to increase due to the reduced prices following the FTA.

Results

RCA results

The RCA results presented in Table 3 reveal that Serbia holds a significant competitive advantage in several fruit product categories. Frozen fruit (HS 0811) exports represent Serbia’s strongest comparative advantage, with an RCA index exceeding 187.7, indicating a robust position in the global market. This product group also holds a significant share in the country’s total exports, accounting for 2.15% of overall exports and 67% of total fruit exports, valued at approximately $600 million. A 2% share of total exports from a single product group is notably high, especially for agricultural products, which typically have a relatively low unit value. These figures are based on the average export performance from 2019 to 2023.

Table 3. Comparative advantage of Serbian Fruit products

HS cod	Product label	RCA
0811	Frozen fruit	187.77
0813	Dried apricots, prunes, apples, peaches, pears	39.78
0808	Apples, pears and quinces, fresh	26.59
0809	Apricots, cherries, peaches, plums, fresh	13.71
0810	Fresh berries	4.95
0802	Hazelnuts	0.58

Source: Author

Dried fruits and fresh apples and pears also demonstrate strong competitiveness with an RCA of 27 and 40. The other analyzed Serbian fruit products show moderate to low levels of competitiveness. Given its minimal competitive advantage, hazelnuts, with an RCA of 0.58, will be excluded from further analysis, as it suggests limited export potential in this category.

Results of Trade Complementarity Analysis

The Trade Complementarity Index (TCI) between Serbia and Egypt indicates that there is significant potential for Serbian fruit exports across all product groups currently exported. The TCI values for all products are greater than 0.9, demonstrating strong alignment between Serbia's export supply and Egypt's import demand (Table 4).

Interestingly, despite frozen fruits having the highest RCA and the largest share of Serbian fruit exports, other fruit categories exhibit stronger complementarity with Egypt's import structure. Fresh apricots, cherries, and peaches (HS 0809) have the highest TCI at 0.9978, followed closely by fresh berries (HS 0810) and dried fruits (HS 0813), which both demonstrate strong potential for trade expansion with Egypt. This contrast suggests that while frozen fruits dominate Serbia's export profile, other fruit products may offer more favorable opportunities for penetrating the Egyptian market.

Table 4. TCI Results: Complementarity of Serbia's Fruit Exports with Egypt's Imports

HS cod	Product label	TCI
0809	Apricots, cherries, peaches incl. nectarines, fresh	0.9978
0810	Fresh berries	0.9976
0813	Dried apricots, prunes, apples, peaches, pears	0.9975
0808	Apples, pears and quinces, fresh	0.9962
0811	Frozen fruit	0.9709

Source: Author

An inconvenient challenge is that the fruit products with the highest complementarity (HS 0809 and HS 0810) represent a relatively small share of Serbia's total exports. Specifically, Serbian exports of apricots, cherries, peaches, and fresh berries (HS 0809 and HS 0810) averaged only $50-52 million per year between 2019 and 2023, which is ten times lower than the export value of frozen fruits (HS 0811), which averages $600 million annually (see Table 1). This suggests that Serbia currently lacks the production capacity to significantly scale up exports of these high-TCI fruit categories in the medium term. While all fruit groups will be included in the assessment of the effects of tariff reductions, the reality remains that the two product groups with the highest complementarity cannot substantially increase export revenues without significant investment in expanding plantings and production capabilities.

On the other hand, exports of apples, pears, and quinces (HS 0808) are notably higher, averaging $100 million per year (Table 1). Though the TCI for this group is slightly lower than that of the other fruits, it remains very high, and apples—one of Serbia's flagship export products—should continue to be a focus for Serbian producers.

A potentially critical product group is dried fruits (HS 0813), particularly prunes and apricots. This category exhibits a high TCI and has shown rapid growth in production and export volume in recent years. While the average export value remains modest, this group stands out due to its significant export growth. For instance, exports of dried fruit grew from $18 million in 2019 to $39 million in 2021, and nearly doubled again to $61 million by 2023 (Table 1).

Supporting this shift in production is the fact that Serbia's primary export markets for dried fruits—such as the United States, Germany, Russia, and the United Kingdom—are all geographically distant. While some of these markets are closer than Egypt, the difference in transportation costs is not substantial enough to affect competitiveness, making Egypt a similarly viable and cost-effective export destination for Serbian dried fruits.

Simulation Results for FTA Impact

This analysis includes all product groups that demonstrated both a significant RCA and a high TCI. As outlined in the methodology section, the first step involves calculating the elasticity of the Egyptian market for importing these products. Elasticity was estimated for individual products at the 6-digit HS level, as shown in Table 2, which relates to customs tariffs.

Certain products were excluded from the analysis due to limited relevance. Fresh quinces, fresh strawberries, and dried apples were omitted as Egypt rarely imports these products from any source. Additionally, elasticity values for cherries were not calculated due to insufficient import data for 4 out of the 5 analyzed years. As such, estimating the impact of tariff reductions for these products would have limited practical significance.

The data used in the analysis spans the 5-year period from 2019 to 2023. To estimate changes in demand, average elasticity values and average prices for each product were applied. The table below presents the simulation results, highlighting key variables: average elasticity, the percentage change in price due to tariff reductions (p') as indicated in Table 2, the projected percentage change in quantity demanded (YQ'), the projected total import value (Y'), and the projected increase in demand for each product (Y' - Y). It's important to note that these projections refer to Egypt's total imports from the global market, not specifically from Serbia.

Table 5. Result of simulation model: Projected demand

Fruit product	Elasticity (average)	p'	YQ'	Projected import Y' (million $)	Projected demand (million $)
Apples, fresh	-2,3728	-0,4	95%	691,92	336,93
Pears, fresh	-8,1623	-0,4	326%	9,51	7,28
Apricots, fresh	0,2761	-0,6	-17%	2,62	-0,52
Cherries, fresh	-17,8367	-0,1	178%	9,40	6,03
Peaches, fresh	-1,0039	-0,6	60%	24,16	9,08
Plums, fresh	-25,6775	-0,6	1541%	365,11	342,85

Fruit product	Elasticity (average)	p’	YQ’	Projected import Y’ (million $)	Projected demand (million $)
Frozen fruit excl. berries	3,3600	-0,1	-34%	1,22	-0,62
Frozen berries excl. strawberries	-0,9149	-0,1	9%	0,62	0,05
Frozen strawberries	-2,2386	0,1	-22%	0,39	-0,11
Cherries, provisionally preserved	-1,2368	-0,1	12%	1,35	0,15
Dried prunes	11,4334	-0,3	33%	6,41	1,57
Dried apricot	-5,3001	-0,3	159%	14,69	9,02

Source: Author

The projections in Table 5 provide insights into potential export opportunities for Serbia. Products such as fresh apples and fresh plums show the most significant potential, with projected increases of $336.93 million and $342.85 million, respectively. These figures highlight strong opportunities for Serbia to expand exports in these categories, provided production capacity and quality standards are addressed.

Products like fresh pears, cherries, peaches, and dried apricots are expected to see moderate demand growth. While not as significant as apples or plums, these products still offer Serbia a promising chance to enhance its market position in Egypt.

Frozen fruits, including frozen strawberries, and fresh apricots are projected to experience stagnant or declining demand. These products may not represent priority categories for short-term export growth.

Discussion

The analysis of Serbia’s fruit export potential to Egypt under the Free Trade Agreement (FTA) provides critical insights into the opportunities and challenges associated with market expansion. By integrating the findings from Revealed Comparative Advantage (RCA), Trade Complementarity Index (TCI), and demand simulations, this study identifies key products with the highest potential and the structural constraints that may hinder Serbia’s export growth.

Key Findings from RCA and TCI Analysis

Serbia’s global competitiveness in fruit exports is well established, particularly in the frozen fruit sector, where its RCA is exceptionally high (187.7). However, RCA alone does not fully capture the potential of Serbian fruit exports to Egypt. The TCI analysis reveals that Egypt’s import demand aligns more closely with fresh and dried fruits—specifically fresh apricots, cherries, peaches, berries, and dried apricots—rather than frozen fruits.

A key challenge arises from Serbia’s limited production capacity for these high-TCI products. While the total export value of Serbia’s fresh fruit sector remains modest at approximately $50–52 million annually, frozen fruit exports alone exceed $600 million. This disparity highlights the need for strategic investment in expanding the production of high-TCI products to fully capitalize on the FTA.

Dried fruits, particularly prunes and apricots, emerge as a sector with strong potential due to their rapid export growth and high complementarity with Egypt's demand. This segment offers a realistic and scalable avenue for increasing Serbian fruit exports under the FTA.

Simulation Results: Demand Projection

Demand simulations reinforce these findings by estimating the expected growth in Egyptian imports post-FTA. The most significant projected increases are observed in fresh apples and plums, with estimated additional demand of $336.93 million and $342.85 million, respectively. These figures suggest that Serbia's existing export strengths can be leveraged effectively in the Egyptian market.

Conversely, while fresh pears, cherries, peaches, and dried apricots show moderate demand growth, frozen fruits exhibit limited expansion potential. Despite Serbia's dominant position in frozen fruit exports, the stagnant or declining demand projections in Egypt indicate that Serbia must recalibrate its export focus toward fresh and dried fruit categories.

Strategic Recommendations

To fully capitalize on the trade liberalization benefits of the Serbia-Egypt FTA, Serbia should pursue a multifaceted strategy:

- Expand production of high-TCI fruits: Investments in fresh apricots, cherries, peaches, and berries are necessary to align supply with Egypt's import demand and increase export volumes.
- Strengthen the dried fruit sector: Given its strong growth trajectory, Serbia should enhance processing capacity and branding efforts for dried fruits, particularly prunes and apricots, to secure a competitive position in Egypt.
- Leverage existing strengths in apples and plums: These products, which exhibit both high RCA and strong projected demand, should remain a priority for Serbian exporters.
- Diversify through value addition: Expanding processing, packaging, and branding initiatives can enhance Serbia's competitiveness and create differentiation in the Egyptian market.

Conclusion

The Serbia-Egypt FTA presents a strategic opportunity for Serbia to diversify its agricultural exports, with particular emphasis on the fruit sector. While frozen fruits currently dominate Serbia's export portfolio, the analysis highlights that fresh and dried fruits—specifically apricots, cherries, peaches, and prunes—hold the greatest untapped potential in Egypt. However, realizing this potential requires overcoming production constraints and aligning Serbia's supply capabilities with market demand.

The demand simulation results further underscore the importance of targeting high-demand products such as apples and plums while acknowledging the limited prospects for frozen fruits in the Egyptian market. This shift in focus is essential for maximizing the benefits of trade liberalization under the FTA.

By implementing targeted investments in production, processing, and market development, Serbia can strengthen its position in the Egyptian market and expand its footprint in the broader Middle Eastern and North African (MENA) region. More broadly, the Serbia-Egypt FTA serves as a case study on the potential of South-South trade agreements in fostering economic integration and trade expansion between emerging economies.

Future research should explore additional factors such as non-tariff barriers, logistical constraints, and the role of investment in further enhancing Serbia's agricultural trade competitiveness under the FTA.

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Conflict of interests

The author declares no conflict of interest.

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COMPETITIVENESS OF THE AGRI-FOOD SECTOR OF SERBIA THROUGH THE PERSPECTIVE OF UNIT VALUES OF EXPORTS AND IMPORTS

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A B S T R A C T

The paper aims to investigate the export competitiveness of the Serbian agricultural and food (agri-food) sector at the divisional level. The core of the methodological approach is the calculation of export unit values (EUV) and import unit values (IUV) using data from the Statistical Office of the Republic of Serbia (SORS). The paper looks at export values, unit values, net exports, and competitiveness factors of the agri-food divisions for 2023. The obtained values indicate that Vegetables and Fruits is the division that has the largest share in agri-food exports, shows excellent terms of trade, and belongs to the group (category) of rare divisions that achieve competitiveness with quality. The Tobacco division is another important chapter of the agri-food sector, which also achieves non-price competitiveness, has a positive terms of trade and significant net exports, which are very good circumstances in conditions of the necessary structural changes and sustainable export growth of the overall sector. These highly propulsive divisions show the greatest potential for development and increase in the degree of processing, so in the future they should be further supported by the measures of the agricultural policy of Serbia.

Introduction

The agricultural and food (agri-food) sector is the key to ensuring the food security of any nation. In addition, countries have (more or less) economic benefits, considering the continuous increase in the prices of these products on the global level. In developing countries, these benefits improve the trade balance. Furthermore, if we consider the two-way link between agriculture and ecology (environment), it can

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be pointed out that the agri-food sector has significant implications for sustainable socio-economic development.

The Republic of Serbia has very exceptional initial conditions and good production opportunities (including processing capacities) for the development of agriculture, so that with the interaction of other (additional) factors, this sector can achieve a long-term competitive advantage in the world market. When it comes to the necessity of reducing the balance of payments deficit, Serbia relies heavily on the agri-food exports. Therefore, it is essential to study the export competitiveness, export structure and terms of trade of this sector. The period from 2020 to 2023 was marked by many global upheavals, such as the health crisis, the economic and monetary crisis, and the conflict between Russia and Ukraine. All of these events have had an impact on the world economy and international trade (Pantović et al., 2023; Milenković et al., 2023). In such circumstances, there has been disruption in supply chains, a change in the way businesses operate, and a change in global demand. Hence, there is a justification and value of this research.

This research aims to identify the most important divisions in agri-food exports and determine their position from the point of view of achieved unit values, bearing in mind both the world trade and the largest foreign trade partners: the European Union and the members of the CEFTA agreement. According to the latest available data for 2023 (SORS, 2024), Serbia exports 46.79% of its agri-food products to the European Union, while it sells slightly less than 30% (29.13%) to CEFTA members. Competitiveness research is important both for the national economy and the agri-food sector itself, as well as for businesses (micro level) to identify opportunities for the placement of their products and, at the same time, increase their participation and influence in the international market (Lădaru et al., 2024).

Sharples and Milham (1990) define export competitiveness as the ability of a country to produce and sell products and services in a particular market at competitive prices compared to other countries (Paul & Dhiman, 2021). The competitiveness of exports depends on a wide range of factors that affect the economic position of a country: the level of domestic production, the level of domestic demand, production costs, labour productivity, product quality, exchange rate, economic and trade policy of the country, the built brand of the country and certain products, the level of innovation, international standards and certificates, etc. (Sharma, 1992). It relies mostly on productivity (which is determined by production costs), but also on non-price factors of competitiveness, among which stand out: the image and reputation of the country or company, the range and quality of products, and other factors that allow the country to compete in the international market regardless of price (Pantović et al., 2022; Verma, 2002).

To understand external competitiveness, products that belong to the tradable sector are particularly important, because they are placed abroad. Agri-food products are the typical tradable products of every country. Mizik (2021) highlights the following factors that most affect the competitiveness of the agri-food sector: the country's trade policy, production efficiency, and the degree of sophistication of the product. A much broader definition points out that competitiveness in international trade is a measure of a country's advantage or disadvantage in selling its products on the international market (OECD, 2008, p. 87). As a result, the measurement of export competitiveness is a complex issue (Durand et al., 1992). That is why in the scientific community, export competitiveness is one of the leading issues that is approached in different ways. One of the perspectives is an analysis of the export unit values (EUV) and import unit values (IUV). This research addresses this and aims to remedy the scarcity of literature regarding this aspect of the study of competitiveness.

Analysis of export competitiveness through the perspective of IUV and EUV involves consideration of the relationship between price and quality (Aiginger, 1997). The authors will look at four categories of competitiveness, bearing in mind the two-way trade of agri-food products between the Republic of Serbia and the entire world, as well as the most important groups of countries to which it is exported. Simplified, the analysis is based on the foreign trade balance and import-export prices (Juhász & Wagner, 2013). An increase in unit values of products from a particular section may mean either an increase in prices at the level of the section or an increase in exports of more expensive products within the analysed section (Deaton, 1988; McKelvey, 2011), so that unit values cannot be fully used in analyses as a proxy for price. On the other hand, unit values can be a reflection of the quality of a product only if: (i) the EUV is higher than the IUV, and the quantity of exports is higher than the quantity of imports, or (ii) the EUV is lower than the IUV, and the quantity of exports is lower than the quantity of imports (Fischer, 2010). This indicates that there are non-price factors of the competitiveness that a particular sector or group of products has in the world market. Otherwise, the unit values may reflect high production costs.

The research is organized in the following way. The first section discusses the material used in the research, as well as the applied methodology. Then, the results of the research are presented in the form of tables, followed by a discussion related to the most important contribution of this study. The last section deals with the justification of the research and provides the most important conclusions of the paper.

Materials and methods

The calculation is based on SORS data for 2023, so the paper identifies the state of competitiveness of exports of agri-food divisions for the latest available period.

The basis for the empirical analysis consists of export data relating to the following sections (18) of the agri-food sector (Standard International Trade Classification/ SITC – Rev. 4 (United Nations, 2006):

00 - Live animals other than animals of division 03 (abbreviated division title in the text: Live animals),

01 - Meat and meat preparations (Meat),

02 - Dairy products and birds' eggs (Dairy products),

03 - Fish (not marine mammals), crustaceans, molluscs, and aquatic invertebrates (Fish),

04 - Cereals and cereal preparations (Cereals),

05 - Vegetables and fruit (Vegetables and fruit),

06 - Sugar, sugar preparations and honey (Sugar),

07 - Coffee, tea, cocoa, spices, and manufactures thereof (Coffee, tea, and cocoa),

08 - Feeding stuff for animals (not including unmilled cereals) (Feeding stuff for animals),

09 - Miscellaneous edible products and preparations,

11 - Beverages,

12 - Tobacco and tobacco manufactures (Tobacco),

21 - Hides, skins and furskins, raw (Hides),

22 - Oilseeds and oleaginous fruits,

29 - Crude animal and vegetable materials, not elsewhere specified (Crude materials),

41 - Animal oils and fats,

42 - Fixed vegetable fats and oils, crude, refined or fractionated (Fixed vegetable fats and oils),

43 - Animal or vegetable fats and oils, processed; waxes of animal or vegetable origin (Animal or vegetable fats and oils).

These are segments that are common, i.e. accepted as standard parts of the agricultural and food products of Serbia, based on previous literature dealing with agri-food trade and competitiveness (Matkovski et al., 2017; Marković et al., 2022; Matkovski et al., 2019). Bearing in mind the minor participation of Division 26, as well as the fact that it does not include only agri-food products, certain commodity groups from this division were excluded from the analysis due to the simplification of the tabular presentations (Verter et al., 2020). They are five commodity groups: Silk; Cotton; Jute and other textile bast fibres; Vegetable textile fibres; and Wool and other animal hair.

One of the main measures of the quality of agri-food products are the EUV and IUV (Dimitrijević et al., 2023). In addition to a measure of quality, unit values can indicate the degree of productivity and competitiveness (Aiginger, 1997). EUV are obtained by dividing export value by export volume (this can be at the level of sectors, divisions, commodity groups and products). On the other hand, the IUV are calculated by comparing the sum of the import values to the physical volume of imports (at the level of sectors, divisions, commodity groups or products, too).

Whether a particular division of the sector of agri-food products achieves export competitiveness and of what type, it can be determined by analysing the EUV and IUV (together with the observation of the quantities of exports and imports). This analysis is often used as an indicator of the reached price competitiveness, but also the existence of non-price aspects of competitiveness, which is determined based on the following relations (Marković et al., 2019; Mrdalj et al., 2022, Nikolić et al., 2023):

i) Pxij > Pmij Ù Qxij > Qmij Þ non-price competitiveness (competitiveness with quality),

ii) Pxij < Pmij Ù Qxij > Qmij Þ price competitiveness,

iii) Pxij > Pmij Ù Qxij < Qmij Þ price non-competitiveness, and

iv) Pxij < Pmij Ù Qxij < Qmij Þ non-price non-competitiveness (non-competitiveness in quality).

The first group consists of those divisions whose export quantity (Qxij) exceeds the volume of imports (Qmij) and whose EUV (Pxij) is higher than the IUV (Pmij). This category achieves competitiveness with quality. Products from this group, although more expensive than imported equivalents, achieve a higher volume of exports than imports, which shows the existence of certain non-price factors of competitiveness.

The second group of products also has a positive foreign trade balance (in quantities), which means that they are competitive on the global scene. However, the lower EUV than the IUV for the same division implies that these segments achieve price competitiveness.

The third segment is related to price non-competitiveness. A country (in exports of this category) achieves a lower volume of exports than imports, and as the EUV are higher, such divisions are not price competitive in a global or specific market.

The last category consists of divisions with a negative trade balance (bearing in mind the quantities) despite the lower EUV compared to the IUV. Judging by the previous mathematical relation, as expected, this segment includes divisions (products) that do not have satisfactory quality on average, so they are a mirror of non-competitiveness in quality.

Results

Table 1 offers a view of the export value of agricultural and food divisions in 2023, and their share in total exports of agriculture and food industry of Serbia. The data show that the Vegetables and Fruits are the most represented (22.25%), while Cereals are in second place in total exports (16.43%). Exports from these two divisions generate nearly USD 2 billion. According to data for 2023, exports from the agri-food sector of Serbia amounted to over USD 5 billion.

Table 1. Export values of agri-food divisions and their importance in exports of the analysed sector (2023)

Divisions	Export value (in thousands of dollars)	Participation in sectoral exports (in percentages)
00 Live animals	52,056	1.04%
01 Meat	109,585	2.19%
02 Dairy products	195,353	3.90%
03 Fish	15,710	0.31%
04 Cereals	823,461	16.43%
05 Vegetables and fruit	1,115,575	22.25%
06 Sugar	86,251	1.72%
07 Coffee, tea, and cocoa	214,044	4.27%
08 Feeding stuff for animals	429,489	8.57%
09 Miscellaneous edible products and preparations	357,623	7.13%
11 Beverages	506,711	10.11%
12 Tobacco	593,369	11.84%
21 Hides	12,248	0.24%
22 Oilseeds and oleaginous fruits	146,471	2.92%
29 Crude animal and vegetable materials	63,022	1.26%
41 Animal oils and fats	5,100	0.10%
42 Fixed vegetable fats and oils	278,122	5.55%
43 Animal or vegetable fats and oils	8,626	0.17%
Total agri-food export	**5,012,816**	**100%**

Source: Calculation of authors using the data of the SORS, 2024.

Table 2 provides an overview of the EUV and IUV of 18 divisions in the examined period. EUV are determined as the quotient of the export value to the quantity of exports, while the IUV represent the ratio of the value of imports to the import quantity. The highest EUV are of Fish (10.21) and Tobacco (9.95), while the highest IUV are noticed from the divisions of Tobacco (7.63), Live animals (5.08), and products from division 07 (tea, coffee, cocoa, etc.) (4.73). Cereals have the lowest EUV (0.38), while the lowest IUV for 2023 is recorded by the Oilseeds and oleaginous fruits division (0.89).

Table 2. EUV and IUV of the agri-food sector at the level of divisions (USD per tonne)

Divisions	EUV	IUV
00 Live animals	3.02	5.08
01 Meat	4.09	3.69
02 Dairy products	2.35	2.95
03 Fish	10.21	3.87
04 Cereals	0.38	2.45
05 Vegetables and fruit	1.86	1.24
06 Sugar	0.94	1.31
07 Coffee, tea, and cocoa	5.01	4.73
08 Feeding stuff for animals	0.73	1.20

Divisions	EUV	IUV
09 Miscellaneous edible products and preparations	2.94	3.38
11 Beverages	0.69	1.05
12 Tobacco	9.95	7.63
21 Hides	1.23	1.30
22 Oilseeds and oleaginous fruits	0.63	0.89
29 Crude animal and vegetable materials	2.05	2.70
41 Animal oils and fats	0.85	1.72
42 Fixed vegetable fats and oils	1.11	1.72
43 Animal or vegetable fats and oils	1.21	1.46

Source: Calculation of authors using the data of the SORS, 2024.

Table 3 aims to show the terms of trade (relative unit values), which in this sense will be calculated as the ratio of the EUV to the IUV of a particular division of the Serbian agri-food sector. Trade ratios are greater than 1 (positive terms of trade) if the EUV are higher than the IUV, and vice versa. The Republic of Serbia has by far the best terms of trade when it comes to the Fish division (2.64), while the worst terms of trade are recorded by the Cereals division (0.16). The improvement of the processing of products from the Cereals division is especially important due to the previous fact, as well as the highest value of net exports that this chapter achieves in relation to all others, which in 2023 amounted to over half a billion USD. Vegetables and fruits are also performing well with net exports of over USD 400 million. The Fish division would have to be further supported by agrarian and economic policy makers, given the excellent terms of trade. Of particular concern may be the large absolute decline in the net exports value of the Meat division, so in fact, the highest net imports in 2023 were present in this division (SORS, 2024).

Table 3. Terms of trade of agri-food sector divisions and the net export values

Divisions	Terms of trade	Net exports
00 Live animals	0.59	26,474
01 Meat	1.11	-207,818
02 Dairy products	0.80	-34,537
03 Fish	2.64	-132,309
04 Cereals	0.16	500,702
05 Vegetables and fruit	1.50	402,502
06 Sugar	0.71	-13,414
07 Coffee, tea, and cocoa	1.06	-200,661
08 Feeding stuff for animals	0.61	267,051
09 Miscellaneous edible products and preparations	0.87	22,638
11 Beverages	0.66	311,849
12 Tobacco	1.30	283,357
21 Hides	0.94	-13,566
22 Oilseeds and oleaginous fruits	0.71	33,374

Divisions	Terms of trade	Net exports
29 Crude animal and vegetable materials	0.76	-24,109
41 Animal oils and fats	0.50	-27,778
42 Fixed vegetable fats and oils	0.64	200,467
43 Animal or vegetable fats and oils	0.83	3,102

Source: Calculation of authors using the data of the SORS, 2024.

Table 4 shows the types of competitiveness/non-competitiveness at the level of agri-food divisions, based on the research method for the observed year. It also provides a detailed insight into the number and the share of the formed categories, i.e. groups of divisions in the entire sectoral exports. The data shows that the highest number of divisions belong to those that achieve price competitiveness (12). In addition, the greatest percentage of sectoral exports value are products (divisions) with price competitiveness (91.63%). In general, the situation is favourable because the categories of non-competitive products bring together only six divisions, with a share of only 8.37%.

Table 4. Number, codes and share in exports of agri-food divisions by category to which they belong

Grouping of divisions		2023
Competitiveness with quality	Number of divisions	2
	Division codes	05, 12
	Share in the agri-food export	34.09%
Price competitiveness	Number of divisions	10
	Division codes	00, 02, 04, 06, 08, 09, 11, 22, 42, 43
	Share in the agri-food export	57.54%
Price non-competitiveness	Number of divisions	3
	Division codes	01, 03, 07
	Share in the agri-food export	6.77%
Non-competitiveness in quality	Number of divisions	3
	Division codes	21, 29, 41
	Share in the agri-food export	1.60%

Source: Authors' elaboration and calculation on the basis of the SORS, 2024.

The data presented in Table 5 deal with the evaluation of EUV for the analysed years by the most significant export markets of Serbia, to present a comprehensive picture of the export competitiveness of this sector, bearing in mind the geographical distribution of exports. There are two markets: one brings together the European Union countries, and the other, the CEFTA markets.

Table 5. Unit values of divisional exports on the European Union and CEFTA markets

Divisions	EUV	
	EU	CEFTA
00 Live animals	3.85	3.01
01 Meat	5.13	4.03
02 Dairy products	2.65	1.80
03 Fish	16.64	6.14
04 Cereals	0.35	0.41
05 Vegetables and fruit	2.14	1.12
06 Sugar	0.86	0.97
07 Coffee, tea, and cocoa	4.77	5.00
08 Feeding stuff for animals	0.69	0.39
09 Miscellaneous edible products and preparations	2.31	3.46
11 Beverages	0.79	0.57
12 Tobacco	6.75	11.97
21 Hides	1.24	1.27
22 Oilseeds and oleaginous fruits	0.61	0.51
29 Crude animal and vegetable materials	2.63	0.68
41 Animal oils and fats	0.75	6.43
42 Fixed vegetable fats and oils	1.08	1.28
43 Animal or vegetable fats and oils	1.06	2.40

Source: Calculation of authors using the data of the SORS, 2024.

Vegetables and fruits, as the largest part of the Serbian agricultural and food sector, have a significantly higher price on the EU market. On the CEFTA market, the unit values of tobacco exports are higher, as a very propulsive division (based on the previous discussion).

Discussion

Determining the external competitiveness is extremely important, bearing in mind that the analysed sector is leading in reducing the trade deficit and external imbalance of the national economy of Serbia. Although it entails products with lower added value in comparation to other sectors, in the previous period of crises of various nature (COVID-19, disruptions in supply chains, Russian-Ukrainian conflict), we have seen the importance of this sector in ensuring the national food security, but also increased exports, which has reduced the negative consequences for the country’s economic growth. In other words, the agri-food sector is important for the economy of Serbia in the context of economic and social stability (Matkovski et al., 2022). That is why increasing competitiveness is an imperative of Serbia’s national agrarian policy. This implies an increase in exports, an improvement in the structure of exports and an increase in EUV, as well as adequate measures and programs of agrarian policy.

According to the value of exports, the largest share is achieved by fruits, vegetables, and cereals (together close to USD 2 billion). The authors estimate that cereals on the international market have the lowest EUV in 2023. Therefore, strengthening processing capacities to produce high-end cereal products must be imperative in the coming period. The division that includes tobacco products achieves extremely high EUV. It can be the key to positive structural adjustments. In addition, the results show that in 2023 (post-crisis period), Tobacco division together with the Vegetables and Fruits division, it achieved non-price competitiveness in international trade. Bearing in mind the assessment of EUV in the markets of the European Union and CEFTA, it is noted that in the European Union member states, more expensive products from the Fruit and Vegetables Division are exported, while highly processed tobacco products are exported on the CEFTA market.

The sector of agricultural and food products of Serbia has a dominant price competitiveness, both in conditions of the quantity of divisions and the participation of these type of products in the agri-food export. The makers of economic policy in the field of agriculture must be especially concerned about the Vegetables and Fruits; although it records a positive terms of trade, this chapter has a decline in net exports. Vegetables and fruits division is the most important export segment of the agri-food sector (Marković & Marjanović, 2021), so it is especially in the focus of scientists and practitioners who research competitiveness in the international market. Fruit and vegetable production can be significant for increasing exports of organic products, so state subsidies should go to this end. The Meat division may be ideal for increasing the level of finalization of products, but its drastic net imports is a particular trouble for agrarian policy makers. It must be noted that without developed livestock production, there is no developed agriculture in any country. Furthermore, the goal is to have as many divisions as possible in the future that will move to those that achieve competitiveness, with the aim of having as many of them as possible within the category that includes divisions with a qualitative dimension of competitiveness. When looking at the terms of trade (the ratio of EUV to IUV), we point out that the best ratios are in the Fish division, while the division that includes Cereals has the worst relative unit values.

Conclusions

Competitiveness at the macro level is conditioned by comparative advantages (climate and other natural factors), but also by other factors that build on this advantage, such as the technological level of development, quality and education of the workforce, labour productivity, etc. The level of competitiveness of exports can be compared and measured in different ways due to a wide range of factors such as: product quality, export demand, production costs, state subsidies, tariff and non-tariff barriers, crises in the global and internal markets, consumer habits. This is a phenomenon that is difficult to measure, especially when it comes to non-price competitive factors. One of the methods of looking at the factors of export competitiveness is the measurement of EUV and IUV, which was applied in this research. In this way, it is possible to gain knowledge about price competitiveness, but also about the qualitative dimension of competitiveness that certain segments of agricultural and food products achieve abroad.

In conditions where the quantity of exports of a product reaches its maximum, the only chance for a further increase in the value of exports is a rise of the unit values of exported products, which can be ensured by higher product competitiveness. Improving the quality of products is considered one of the best solutions to increase the EUV and enhance the terms of trade (Dimitrijević et al., 2023), especially when it comes to placement on the markets of developed countries. A special place is occupied by organic agricultural production (which most often includes vegetables and fruits) based on modern environmental and safety standards. The second direction for the growth of competitiveness of export is the change of the export structure, which implies an increase in the degree of processing of food products. The possibility of higher finalization of the product is conditioned by the technological equipment and the quality of the workforce. Specialization in the production of cereals is still present, for which Serbian agriculture traditionally has a high comparative advantage. Enhancing the competitiveness of cereals can be accomplished by lower production costs, choice of better seed quality, higher productivity, and further treating within the processing industry. However, in the medium term, priority must be given to other products with a higher chance of value added and with high EUV (vegetables and fruits, tobacco products, fish, meat, animal feed).

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Conflict of interests

The authors declare no conflict of interest.

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THE NET PRESENT VALUE OF INVESTMENTS IN RAISING AND EXPLOITING WALNUT PLANTATIONS

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ABSTRACT

The subject of the research is the application of the net present value and methods based on it for the assessment of the economic justification of raising walnut plantations of Sejnovo variety on 3 and 10 ha, with same cultivation form and planting system. The research was conducted on the basis of data collected during the period 2022-2024. in Western Serbia. For a plantation of 3 ha, indicators of economic effectiveness per unit area are lower than indicators for a plantation of 10 ha, i.e. 53,378 €/ha<8,375 €/ha (net present value) and 69,204 €/ha<73,089 €/ha (capitalised value). Pay-back period for a 10 ha is shorter than a 3 ha i.e. 9.24 years<9.64 years and internal rate of return for a 10 ha is higea than a 3 ha by 0.57%, i.e. 37.92%>37.35%. It is concluded that investing in establishing and exploiting walnut plantations on an area of 10 ha is more economically efficient than an area of 3 ha.

Introduction

The areas under walnut plantations in the world cover 1.1 million hectares, and the production of walnuts in shell in the world is around 3.5 million tons. The world's largest producers are: China, the United States of America and Iran. The area under walnut plantations in Europe occupies 169,000 ha, and the volume of production is about 386,853 tons (FAO, 2024; Nađ et al., 2024). The largest European producers are Ukraine, Greece and Romania. In Serbia, walnuts are grown on 3,307 ha (SORS, 2024). Serbia ranks 25th in the world in terms of the production of in-shell walnuts, accounting for only 0.2% of the total produced quantities. According to the total production of

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walnuts in Europe, Serbia is in ninth place (Dobrescu, 2019). Some of the most famous varieties of walnuts are: Čendler, Tehama, Šampion and Džinovski, while the high quality of the fruits is characteristic of the following walnut varieties: Jupiter, Sava, Šejnovo and Plovdiv walnut (Cerović et al., 2014). Production in perennial plantations, and therefore also in orchards, is highly dependent on natural conditions and is conditioned by numerous risks, such as: founding, cultivation, production, market, financial and other risks (Sredojević, 1998). For walnut production, it is important that it is characterized by modest costs for the care and maintenance of plantations, which, along with small losses in fruit quality after harvest, ranks it among the most successful fruit productions (Inobatov, Ziyadullaev, 2023). The production of walnuts of 2 t/ha in Hungary enables coverage of the total production costs (Apati, 2014). Turk & Rozman (2001) are stating that positive economic results are achieved in the integral production of walnuts. Positive economic effects are achieved in the system of organic walnut production (Očić et al., 2019; Petković et al., 2024; Popa et al., 2023). A comparative analysis of investments in the production of walnuts in the shell and walnut kernels showed that the production of walnuts in the shell is economically unjustified and that for a quick return on investment and profitable production it is necessary to sell shelled and dry walnuts (Apáti et al., 2018). On the farms in Turkey, a profit of over 4,000 €/ha was recorded in the years during the full crop yield (Unakitan, Inan, 2020; Neševski & Bojičić, 2024; Aşkan, 2021). So far, profitability has also been established at different production intensities on farms in Mexico (Fernández-Chávez et al., 2021). Research into the quality of 20 walnut varieties present in the continental part of Montenegro determined intervals of different fruit weights (Jaćimović et al., 2020). Based on the analysis of activities in production technology, supply and demand for walnuts in shell and kernel, different levels of productivity in walnut production have been determined (Bakhshinejad, 2016; Aşkan, 2021; Rakhmonova, 2022).

Economic results in the production of walnuts are to a lesser extent conditioned by agroecological conditions, but they significantly depend on the selected variety, cultivation form and soil quality during the entire period of plantation exploitation. (Janković, Janković, 2014). The success of fruit production is also determined by numerous non-production factors, such as the development of the product market, the availability of professional staff, traffic conditions, the level of economic development and others (Kljajić et al., 2017). The analysis of investments in raising and exploiting walnut plantations in the Republic of Serbia shows more favorable economic effects compared to the results in other countries. This is explained by the fact that the selling price of walnuts is relatively high (Bogdanović, Hadžić, 2019). Research on the movement of the market price of walnut kernels on green markets in the Republic of Serbia indicated that the highest price will be reached at the end of 2023 and the beginning of 2024, in the amount of 9.7 €/kg (Ostojić et al., 2024). The price of walnuts in the shell is lower and is about 1/3 of the price of walnuts in the kernel. The yield per hectare is higher in plantations with a larger number of trees, but the profitability of this system, as a consequence of the increase in investment in raising plantations and the total costs of care, protection and exploitation, is lower compared to the production system with a lower density (Fernández-Chávez et al., 2021). The number of walnut trees per hectare on the farms analyzed in some studies ranged from 120 to 204 (Očić et al., 2019; Milošević & Stankov, 2023; Fernández-Chávez et al., 2021).

The period of raising walnut plantations lasts from five to seven years, when it is expected that the annual value of the production of walnut fruit will exceed the costs of care and protection of the plantations (Unakıtan, İnan, 2019; Inobatov, 2024). Investing in raising and exploiting perennial plantations is a complex and responsible business. Mistakes made during planting cannot be corrected during their exploitation (Sredojević, 1998). Therefore, the subject of research in this paper is the economic analysis of raising and exploiting walnut plantations. The aim of the research is to determine the assessment of economic justification of investing in raising and exploiting walnut plantations of different areas, for the same variety, cultivation form and the number of seedlings per unit area, using the net present value and other methods based on it.

Materials and methods

Investments for the establishment and raising of plantations of walnuts of the Šejnovo variety were determined on the basis of a survey conducted in the three-year period 2022-2024 on selected seven family holdings in Western Serbia, where walnut production is realized. For certain natural inputs, care and protection during planting, as well as work processes and technology of regular walnut production, data from the documentation of internal records on the farms, as well as professional literature, were used. For the analysis of areas and yields of walnut production in the world and in the Republic of Serbia, statistical data bases were used, namely: Food and Agriculture Organization (FAO) and Statistical Office of the Republic of Serbia (SORS). Economic indicators based on the collected data were determined using statistical and calculative methods. Based on the amount of parameters of the economic flow, the net present value of plantations of 3 ha and 10 ha was calculated, and based on it: yield value of plantations; investment pay-back period and internal interest rate. According to the defined criteria for each of the mentioned indicators (Andrić, 1998; Andrić et al., 2005), appropriate ratings were determined, based on which a fairly reliable picture of the efficiency and economic evaluation of the justification of the analyzed walnut plantations as an investment was given.

Investment in raising (growing) plantations (A_0) was determined as:

$$A_0 = (a_0 \times r^m + a_1 \times r^{m-1} + a_2 \times r^{m-2} + \dots + a_{m-1} \times r + a_m) - (b_{h-1} \times r + b_h) \quad [1]$$

$a_{1,}\, a_{2,}\, a_{3\,\dots}\, a_{m-1,}\, a_m$ - financial payments per m years of planting;

i – rate of interest;

r – interest factor (r = 1+i);

m – period of raising (growing) plantations (years);

h – period (years) of receiving financial income during the raising of plantations

The economic benefit per year of exploitation of walnut plantations was determined as the difference between the amount of annual cash receipts from the exploitation of plantations and the amount of annual monetary payments for the maintenance and exploitation of plantations. The final value of plantations is determined as the difference between the estimated value of the wood mass at the end of the period of exploitation (receipt) and the costs of clearing plantations, which was determined by the discounting procedure at the beginning of the period of exploitation of plantations (Sredojević, 1998). The net present (or capital) value of plantations (NPV_0) is obtained when the initial investment is subtracted from the sum of the discounted net annual benefits from the exploitation of walnut plantations and the final value of the wood mass, and it is calculated from the form:

$$NPV_0 = \left[\sum_{i=1}^{n} \left(\frac{b_i - a_i}{r^i} \right) + \frac{B_n}{r^n} \right] - A_0 \qquad [2]$$

a_i - financial payments for the maintenance and use of plantations (i = 1, 2, 3, ... n);

b_i - financial income from walnut plantations in certain years (i = 1, 2, 3, … n);

B_n – financial income from wood pulp at the end of the nth year;

n – period of walnut plantations exploitation (years)

If the net present (capital) value is positive, i.e. $NPV_0 > 0$, the investment is economically justified, and vice versa. The largest amount of money that can be invested in raising walnut plantations so that it is economically justified at a given interest rate and in the planned period is determined by calculating the capitalized value of the plantations (CV_0) according to the form:

$$CV_0 = \sum_{i=1}^{n} \frac{b_i - a_i}{r^i} + \frac{B_n}{r^n} \qquad [3]$$

If the capitalized value is currently higher than the amount of investments in its construction, i.e. $CV_0 > A_0$, investment is economically justified, and vice versa. For the return period of invested capital (t) are also used the terms pay-off, pay-back or pay-out method. It is the moment when the capital value is equal to zero (NPV_0=0), and is calculated as follows:

$$t = t_1 - \frac{NPV_0[t_1]}{NPV_0[t_2] - NPV_0[t_1]} \qquad [4]$$

If the return period is shorter than the planting period, i.e. t < n, investing in raising plantations is economically justified, and vice versa. In order to get an answer to the question: At what level of interest can the capital invested in the investment is returned, that is, repaid, the internal interest rate (i_e) was determined. Essentially, it is the rate at which the net present value equals zero (NPV_0 = 0). Using linear interpolation, the internal interest rate (i_e) was determined from the formula:

$$i_e = i_1 - NPV_{01} \frac{i_2 - i_1}{NPV_{02} - NPV_{01}} \quad [5]$$

If the internal interest rate is higher than the assumed calculative one, i.e., $i_e > i$, investing is economically justified, and vice versa.

Results and discussion

On the basis of the data collected by the survey on the consumption of materials, the labor work and machines during the planting period, as well as the production costs and yield by individual years of exploitation of the plantations, the starting parameters for the economic analysis were determined. The data served as the basis for defining two plantations of walnuts, variety Šejnovo, of the same cultivation system, on two different areas. The data obtained from the internal records of the producers on the surveyed farms served as a basis for the formation of analytical calculations of walnut production, according to which the annual cash receipts and issuances were determined, that is, the net annual benefit for individual years of exploitation.

The starting assumptions for the analysis are:

- plantations are raised at the same time on areas of 3 ha and 10 ha;
- before planting, the land was not used for growing agricultural crops;
- land preparation, i.e. agro-mechanized works are carried out before the beginning of planting, in the so-called "year zero";
- investment dynamics are given in accordance with real investments in practice, whereby investments that are made once do not occur only at the beginning, but in all years of planting;
- the period of raising is five years;
- "small yield" is achieved in the fifth year;
- the exploitation period lasts 30 years;
- at the end of the exploitation period, the final (liquidation) value of the plantation is reached, which represents the difference between the value of the wood mass of the tree and the costs of grubbing;
- calculative rate of interest is 8%;
- the average walnut yield is 3.2 t/ha, the market price of walnuts is 0.3 €/kg, and the price of the wood mass of de-rooted walnut is 300 €/m^3.

Walnut planting is a long-term investment that requires high financial investments at the time of establishment, and compared to other fruit species, it is characterized by a longer cultivation period and a relatively long period of exploitation (Sredojević et al., 2024). On the basis of economic parameters determined by processing data from the field collected by the survey, as well as technical and technological norms, along with previous analytical calculations, the amounts of investment investments were determined.

The calculation procedures of the amount of financial investments according to individual work processes, from the execution of agro-mechanized works, land preparation, planting, procurement of machinery and care for each year of cultivation of crops are calculated, and according to the dynamics of the investment and with the calculated intercalary interest are given in tables 1 and 2.

Table 1. Investments for raising 3 ha of walnut plantations, 120 seedlings/ha

P u r p o s e	**Monetary amounts per m years of plantation cultivation (€)**						**Sum (€)**
	0[1)]	**1**	**2**	**3**	**4**	**5**	
Agro-mechanized operations	1,300	850	700	650	600	650	4,750
Labor cost	300	1,500	980	940	870	1,030	5,620
Material[2)]	200	4,600	930	950	1,050	1,120	8,850
Procurement of machinery	-	3,200	3,200	-	-	-	6,400
Roads in the plantation	-	800	800		-	-	1,600
Irrigation system	-	1,100	1,100	-	-	-	2,200
Installing a fence	-	800	850	-	-	-	1,650
Project, supervision and control	1,100	700	400	400	400	400	3,400
Permanent working capital	-	-	-	1,600	1,600	-	3,200
Investments by year:	2,900	13,550	8,960	4,540	4,520	3,200	37,670
The value of a "small yield"[3)]	-	-	-	-	-	2,050	2,050
Corrected investments	2,900	13,550	8,960	4,540	4,520	1,150	35,620
Correction factor (1,08^{m})	1.4693	1.3605	1.2597	1.1664	1.0800	1.0000	-
Total investments:	**4,261**	**18,435**	**11,287**	**5,295**	**4,882**	**1,150**	**45,310**
Share by age (%)	**9.40**	**40.69**	**24.91**	**11.69**	**10.77**	**2.54**	**100.00**

Source: Authors' calculation

[1)] *Included investments in the preparation of land for planting*

[2)] *Seedlings, mineral fertilizers, means of protection, etc.*

[3)] *The value of the yield during the planting period minus the harvest costs*

Table 2. Investments for raising 10 ha of walnut plantations, 120 seedlings/ha

P u r p o s e	**Monetary amounts per m years of plantation cultivation (€)**						**Sum (€)**
	0 [1)]	**1**	**2**	**3**	**4**	**5**	
Agro-mechanized operations	3,800	2,300	1,900	1,800	1,700	1,900	13,400
Labor cost	1,080	4,200	2,750	2,800	2,580	1,200	14,610
Material[2)]	680	15,480	2,900	3,100	3,400	3,800	29,360
Procurement of machinery	-	10,700	10,700	-	-	-	21,400
Roads in the plantation	-	2,100	2,100	-	-	-	4,200
Irrigation system	-	3,700	3,700	-	-	-	7,400
Installing a fence	-	2,300	2,300	-	-	-	4,600
Project, supervision and control	3,500	2,200	1,350	1,350	1,350	1,350	11,100

Purpose	Monetary amounts per m years of plantation cultivation (€)						Sum (€)
	0 [1)]	1	2	3	4	5	
Permanent working capital	-	-	-	5,100	5,100	-	10,200
Investments by year:	9,060	42,980	27,700	14,150	14,130	8,250	116,270
The value of a "small yield"[3)]	-	-	-	-	-	6,800	6,800
Corrected investments	9,060	42.980	27,700	14,150	14,130	1,450	109,470
Correction factor (1,08^m)	1.4693	1.3605	1.2597	1.1664	1.0800	1.0000	-
Total investments:	**13,312**	**58,474**	**34,894**	**16,504**	**15,260**	**1,450**	**139,894**
Share by age (%)	**9.52**	**41.80**	**24.94**	**11.80**	**10.90**	**1.04**	**100.00**

Source: Authors' calculation

[1)] *Included investments in the preparation of land for planting*

[2)] *Seedlings, mineral fertilizers, means of protection, etc.*

[3)] *The value of the yield during the planting period minus the harvest costs*

Looking at the structure of investments by year of raising (cultivation) of seedlings, the largest share is the costs in the first year 41-42%, precisely because of the costs of the seedlings. The established investment investments for the establishment of 3 ha of walnut plantations amount to 45,310 €, i.e. 15,103 €/ha, and for the establishment of 10 ha of plantations, 139,894 €, i.e. 13,989 €/ha is required, which is 8% less per unit area compared to so far of 3 ha. According to Apáti (2014), investments in raising walnut plantations in Hungary amount to around 7,500 €/ha. To raise plantations in the system of integral production in Slovenia, it is necessary to provide about 10,000 €/ha (Turk, Rozman, 2001). In the total investments in establishing and raising walnuts, one of the items is the procurement of mechanization, which due to wear and tear in certain years of plantation exploitation needs to be replaced. Investments in the replacement of mechanization assets in the 10th and 20th years during the exploitation of walnut plantations, according to current values in the amount of 3,200.00 € (for 3 ha) and 5,300.00 € (for 10 ha), at a discount rate of 8%, at the beginning of the exploitation period, they amount to:

In the 10th year …… 3,200 € x 1.08^{-10} = 1,482 €

In the 20th year …… 3,200 € x 1.08^{-20} = 686 €

Total: 2,168 € (for a 3 ha plantation)

In the 10th year ….. 10,700 € x 1.08^{-10} = 4,956 €

In the 20th year ….. 10,700 € x 1.08^{-20} = 2,295 €

Total: 7,251 € (for a 10 ha plantation)

Based on the established investment investments in raising plantations of 3 ha and 10 ha in tables 1 and 2, as well as the calculation of the current amount of investment in machinery that will be replaced due to wear and tear during the exploitation of the plantations, in table 3 are shown the total investments for both plantations.

Table 3. Total investments in raising plantations and in replacing worn-out mechanization during the period of exploitation of walnut plantations

Type of cost	3 ha		10 ha	
	Amount (€)	Share (%)	Amount (€)	Share (%)
Investments in planting	45,310	95.43	139,894	95.07
Investing in the replacement machinery	2,168	4.57	7,251	4.93
T o t a l:	**47,478**	**100.00**	**147,145**	**100.00**

Source: Authors' calculation

According to the amounts determined in table 3, the total investments in raising plantations and replacing worn-out machinery amount to 47,478 € (for 3 ha), i.e., 15,826 €/ha and 147,145 € (for 10 ha), i.e., 14,715 €/ha. Looking at each 1 ha, the investments for the planting of 10 ha compared to 3 ha are lower by 1,111 € (about 8%). Bogdanović and Hadžić (2019) determined the investments for raising 1 ha of walnut plantations in Serbia of about 12,900 €. However, due to the increase in input prices, this research has shown that in Serbia, larger investments are needed per 1 ha of walnut plantations.

The amounts of annual financial income were obtained by multiplying the yield of walnuts with their market prices. The final value of the plantations is the value of the wood mass of the felled plantations less the costs of felling and grubbing. This value is translated, i.e. discounted using compound interest at the moment of completion of planting. Annual financial expenses are related to the maintenance of roads and buildings in the plantation, filling of empty places, as well as for carrying out production in the plantation, compensation for the labor work and others. They are determined on the basis of the consumption of materials, the labor work and the work of mechanization according to technological maps by years of plantation exploitation. And finally, net annual benefits were calculated, as the difference between annual monetary receipts and annual monetary expenditures. Subsequent calculations of indicators of economic effectiveness, with the application of dynamic methods of investment calculation, were performed on the basis of calculation at the level of variable costs. According to the natural amounts of inputs and outputs and corresponding market prices, table 4 shows cash receipts, cash issues and economic benefit by year for the entire investment period.

Table 4. Financial income, financial payments and cash flow during the period of exploitation of 3 ha and 10 ha walnut plantations, 120 seedlings/ha

Years of exploitation	Financial income (€)		Financial payments (€)		Cash flow by years (€)	
	3 ha	10 ha	3 ha	10 ha	3 ha	10 ha
1	8,640	30,000	3,020	9,600	5,620	20,400
2	16,320	57,600	5,710	18,430	10,610	39,170
3	24,000	73,600	8,400	23,550	15,600	50,050
4	28,800	92,800	11,520	33,400	17,280	59,400
5	30,720	105,600	12,280	38,010	18,440	67,590
6	32,640	112,000	13,050	40,320	19,590	71,680

Years of exploitation	Financial income (€)		Financial payments (€)		Cash flow by years (€)	
	3 ha	10 ha	3 ha	10 ha	3 ha	10 ha
7	34,560	118,400	13,820	42,520	20,740	75,780
8-25	36,480	121,600	14,590	48,640	21,890	72,960
26	29,760	96,000	10,410	30,720	19,350	65,280
27	22,500	76,800	7,870	24,570	14,630	52,230
28	15,360	45,000	6,250	14,400	9,110	30,600
29	11,520	41,600	4,030	13,310	7,490	28,290
30	119,840[1)]	399,000[2)]	3,020	9,210	116,820	389,790

Source: Authors' calculation

[1)] 8,640 €+ 3,200€ (PWC) + 108,000€ (wood mass value) = 119,840€

[2)] 28,800€+ 10,200 € (PWC) + 360,000 € (wood mass value) = 399,000 €

If average annual amounts are used to determine economic indicators, the calculation procedure is simpler, but the reliability of the indicator amounts is reduced due to changes in the ratio of input and output over a number of years (Sredojević et al., 2019; Unakıtan and İnan, 2019; Fernández-Chávez et al., 2021). In Hungary, ten years ago, with a yield of 1 t/ha on holdings and an average price of walnuts of 0.55 €/kg, the annual income from walnut plantations was determined in the amount of 850 €/ha (Apati, 2014). On the farm in Croatia, where the organic production of walnuts is realized, an income of 2,760 €/ha was established (Očić et al., 2019), and the structure is dominated by subsidies from the state (54%). On farms in Slovenia, the value of production was determined to be 4,600 €/ha, at a market price of 1.25 €/kg and a yield of around 3 t/ha. (Turk, Rozman, 2001). In Turkey, due to the significantly higher selling price of walnut kernels (over 6 €/kg), the annual value of production was recorded at around 13,000 €/ha (Unakitan, Inan, 2020; Aşkan, 2021).

Researches in Hungary, Slovenia and Croatia have recorded lower annual production costs from around 1,200 €/ha to 2,700 €/ha depending on the period during plantation exploitation (Rozman, 2001; Apáti, 2018; Turk, Očić et al., 2019). The costs of walnut production on farms in Turkey amount to 8,700 €/ha, primarily due to the different ratio of input and output prices in walnut production compared to the Republic of Serbia (Unakitan, Inan, 2020; Aşkan, 2021). In order to determine the economic justification of investment in raising and exploiting walnut plantations on areas of 3 ha and 10 ha, in table 5, the net present value for individual plantation areas was determined by a calculative procedure. For a plot of 3 ha, the net present value is 160,134 €, or 53,378 €/ha, and for a plot of 10 ha, the net present value is 583,746 €, or 58,375 €/ha. Considering that the net present values are positive, it is concluded that investing in the analyzed plantations under the mentioned conditions is economically justified, but for 4,997 €/ha, a greater economic benefit is achieved than plantations on 10 ha. In a related study, which also considered the effects of investing in raising and exploiting walnut plantations on farms in Serbia, a significantly lower net present value of 30,400 €/ha was determined (Bogdanović and Hadžić, 2019). This is explained by the fact that in the last five years there has been a change in the ratio of input and output prices, as well as an increase in the prices of both.

The net present value of plantations depends on numerous factors, the most important of which are: the amount of total investments in raising plantations; the length of the planting period; amount and schedule of net annual benefits; conditions and method of financing plantations; amount of calculated interest rate; length of plantation exploitation period, etc. In practice, it is often recommended that when assessing the economic feasibility of raising and exploiting perennial plantations, and therefore also walnut plantations, an assessment of possible risk should also be included. One of the ways is the correction of the calculated interest rate by applying the double discounting procedure. In this research, the impact of the calculated interest rate on the net present value of plantations was analyzed. The required minimum interest rate on invested funds in walnuts as an investment is 8%, and the interest rate to cover risk and uncertainty is 25% of 8%, so the corrected calculative rate of interest is increased by 2%, i.e. is 10%. Applying a discount factor at a rate of 2%, the present value of the cash flow for both plantations was again discounted in order to include the risk, and this is given in the last two columns in table 5.

Table 5. Net present value of walnut plantations for areas of 3 ha and 10 ha and its movement depending on interest rate risk

Years of exploitation (n)	Nominal amount of cash flow (€)		$\frac{1}{1.08^n}$	Present value of the cash flow (€)		Discounting to capture uncertainty (risk) 25% of 8% = 2%		
						$\frac{1}{1.02^n}$	Present value cash flow (€)	
	3 ha	10 ha		3 ha	10 ha		3 ha	10 ha
0	-47,478	- 147,145	1.0000	-47,478	-147.145	1.0000	-47,478	-147,145
1	5,620	20,400	0.9259	5,204	18,888	0.9804	5,102	18,518
2	10,610	39,170	0.8573	9,096	33,580	0.9612	8,743	32,277
3	15,600	50,050	0.7938	12,383	39,730	0.9423	11,668	37,437
4	17,280	59,400	0.7350	12,701	43,659	0.9238	11,733	40,332
5	18,440	67,590	0.6806	12,550	46,002	0.9057	11,366	41,664
6	19,590	71,680	0.6302	12,346	45,173	0.8880	10,963	40,114
7	20,740	75,780	0.5834	12,100	44,210	0.8706	10,534	38,489
8	21,890	72,960	0.5403	11,827	39,420	0.8535	10,094	33,645
9	21,890	72,960	0.5002	10,949	36,494	0.8368	9,162	30,538
10	21,890	72,960	0.4632	10,139	33,795	0.8203	8,317	27,722
11	21,890	72,960	0.4289	9,389	31,292	0.8043	7,552	25,168
12	21,890	72,960	0.3971	8,692	28,972	0.7885	6,854	22,844
13	21,890	72,960	0.3677	8,049	26,827	0.7730	6,222	20,737
14	21,890	72,960	0.3405	7,454	24,843	0.7579	5,649	18,828
15	21,890	72,960	0.3152	6,900	22,997	0.7430	5,127	17,087
16	21,890	72,960	0.2919	6,390	21,297	0.7284	4,654	15,513
17	21,890	72,960	0.2703	5,917	19,721	0.7142	4,226	14,085
18	21,890	72,960	0.2502	5,477	18,254	0.7002	3,835	12,781
19	21,890	72,960	0.2317	5,072	16,905	0.6864	3,481	11,604

Years of exploitation (n)	Nominal amount of cash flow (€)		$\frac{1}{1.08^n}$	Present value of the cash flow (€)		Discounting to capture uncertainty (risk) 25% of 8% = 2%		
						$\frac{1}{1.02^n}$	Present value cash flow (€)	
	3 ha	10 ha		3 ha	10 ha		3 ha	10 ha
20	21,890	72,960	0.2145	4,695	15,650	0.6730	3,160	10,532
21	21,890	72,960	0.1986	4,347	14,490	0.6598	2,868	9,560
22	21,890	72,960	0.1839	4,026	13,417	0.6468	2,604	8,678
23	21,890	72,960	0.1703	3,728	12,425	0.6342	2,364	7,880
24	21,890	72,960	0.1577	3,452	11,506	0.6217	2,146	7,153
25	21,890	72,960	0.1460	3,196	10,652	0.6095	1,948	6,492
26	19,350	65,280	0.1352	2,616	8,826	0.5976	1,563	5,274
27	14,630	52,230	0.1252	1,832	6,539	0.5859	1,073	3,831
28	9,110	30,600	0.1159	1,056	3,546	0.5744	606	2,037
29	7,490	28,290	0.1073	804	3,036	0.5631	453	1,710
30	116,820	389,790	0.0994	11,612	38,745	0.5521	6,411	21,391
NPV_0 .... without risk coverage:				**+160,134**	**+583,746**	with risk:	**+105,612**	**+438,776**

Source: Authors' calculation

Including the risk and uncertainty of the calculative interest rate, assuming that it would increase by 25%, there would be a decrease in the net present value for both plantations by 35% for 3 ha, and 25% for 10 ha, which would result in extension of the return period of invested capital. That is why it is necessary, before investing, to examine possible financial risks, in order to possibly avoid them or mitigate them to a sufficient extent, thereby increasing investment security. Given that the net present value represents the basis for determining other indicators of the economic justification of investment, according to the above formula and from the determined amounts in table 5, the capitalized value was determined (Sredojević et al., 2024). For a plantation of 3 ha it amounts to 207,612 € (i.e. 62,204 €/ha), and for a plantation of 10 ha it amounts to 730,891 € (i.e. 73,089 €/ha) and these amounts represent the upper limits for investing in raising and exploiting the analyzed plantations. Given that the stated amounts are significantly above the value of the established investments for both plantings, i.e. 207,612 € > 47,478 € and 730,891 € > 147,145 €, means that it is economically justified and that it is economically more efficient to invest in raising plantations of 10 ha, i.e. 73,089 €/ha > 62,204 €/ha. On the basis of the net present value in table 6, the parameters of the test periods of the return of invested capital are given, and then the length of the period is determined analytically below.

Table 6. Calculating the pay-back period of funds invested in raising and exploiting walnut plantations and replacing worn-out machinery

Years of exploitation (n)	**Nominal amount of cash flow (€)**		**Present value of net income for 3 ha (€)**		**Present value of net income for 10 ha (€)**	
	3 ha	**10 ha**	**4 year**	**5 year**	**4 year**	**5 year**
0	-47,478	- 147,145	-47,478	-47,478	- 147,145	- 147,145
1	5,620	20,400	5,204	5,204	18,888	18,888
2	10,610	39,170	9,096	9,096	33,580	33,580
3	15,600	50,050	12,383	12,383	39,730	39,730
4	17,280	59,400	12,701	12,701	43,659	43,659
5	18,440	67,590	....	12,550	....	46,002
6	19,590	71,680	....	....	....	....
7	20,740	75,780	....	....	....	....
8-25	21,890	72,960	....	....	....	....
26	19,350	65,280	....	....	....	....
27	14,630	52,230	....	....	....	....
28	9,110	30,600	....	....	....	....
29	7,490	28,290	....	....	....	....
30	116,820	389,790	....	....	....	....
		T o t a l:	**-8,094**	**4,456**	**-11,288**	**34,714**

Source: Authors' calculation

According to the amounts determined in table 6, the interpolation procedure determined the shortest period of time for which the investments in raising plantations and replacing worn-out machinery during the exploitation of plantations will be returned, and it amounts to:

$$t = 4\text{ year} - \frac{(-8{,}094\text{ €})}{(+4{,}456\text{ €}) - (-8{,}094\text{ €})}$$ = 4.64 years from the period of exploitation, i.e.9.64 year from the century of planting (for 3 ha)

$$t = 4\text{ year} - \frac{(-11{,}288\text{ €})}{(+34{,}714\text{ €}) - (-11{,}288\text{ €})}$$ = 4.24 years from the period of exploitation, i.e. 9.24 year from the century of planting (for 10 ha)

The calculated pay-back periods of individual plantings are shorter than their life span, i.e. 9.64 years < 35 years and 9.24 years < 35 years, that is, shorter than the longest period for which the funds should be returned so that the investment would be economically justified.

Therefore, investment investments for a plantation of 10 ha will be returned in the first quarter and for 3 ha in the last quarter during the 10th year of the life of the plantation after planting. Therefore, considering that the determined periods are shorter than the planned life spans of the plantations, this indicator leads to the conclusion that investing in raising both analyzed walnut plantations is economically justified. By comparing the established periods, the evaluations obtained based on the previous indicators are confirmed that it is more economically advantageous to invest in raising plantations of 10 ha, because the capital return period is shorter, i.e. 9.24 years < 9.64 years.

Based on the amount of net present value calculated in a tabular manner similar to the pay-back period at trial interest rates of 35% and 40%, by the interpolation process, according to the above-mentioned form, the internal interest rate was determined for both areas of walnut plantations, namely:

$$i_{e(3ha)} = 0.35 - 24 \in \frac{0.40 - 0.35}{-27 \in -24 \in} = 0.3735 = 37.35\%$$

$$i_{e(10ha)} = 0.35 - 18{,}970 \in \frac{0.40 - 0.35}{-13{,}470 \in -18{,}970 \in} = 0.3792 = 37.92\%$$

The calculated internal rate of return of 37.35% and 37.92% are over four times higher than the assumed calculative interest rate (8%), which means that according to this indicator, investing in both plantations is economically justified, but investing in a plantation of 10 ha is more economically advantageous, that is 37.92% > 37.35%.

The parameters of the investment calculation of raising and exploiting the analyzed walnut plantations, on the basis of which the indicators of economic effectiveness were determined, are given in table 7.

Table 7. Parameters of investment calculation of raising and exploitation 3 ha and 10 ha of walnut plantations

Parameters of investment calculation	Amount	
	3 ha	10 ha
m - period of raising (growing) plantations	5 years	5 years
n - period of exploitation of walnut plantations	35 years	35 years
i - rate of interest	8 %	8 %
A_0 - total investments	47,478 €	147,145 €
b_i - financial income by years of exploitation	Table 4	Table 4
a_i - financial payments by years of exploitation	Table 4	Table 4
k_i - cash flow by years of exploitation	Table 4	Table 4
B_n - final (liquidation) value of walnut plantations	111,200 €	370,200 €

Source: Authors' calculation

Looking at the unit area, investments for a 3 ha plantation are higher than investments for a 10 ha plantation by 1,112 €/ha, i.e. 15,826 €/ha > 14,714 €/ha. In order to make a comparative analysis of the economic effectiveness of the analyzed plantations, in Table 8 are shown the amounts of individual indicators and the fulfillment of the criteria for making an assessment.

Table 8. Indicators of the economic justification of raising and exploitation 3 ha and 10 ha of walnut plantations

Indicators of economic justification of walnut plantations	Amount and fulfillment of criteria	
	3 ha	10 ha
NPV_0 - net present value of walnut plantations	160,134 € > 0	583,746 € > 0
CV_0 – capitalised value of walnut plantations	207,612 € > 47,478 €	730,891 € > 147,145 €
t – pay-back period	9.64 years < 35 years	9.24 years < 35 years
i_e - internal rate of return	37.35 % > 8 %	37.92 % > 8 %

Source: Authors' calculation

The calculated indicators of economic justification show that, under the assumed organizational and economic conditions, investing in raising both analyzed walnut plantations would be expedient, that is, economically justified. For a plantation of 3 ha, indicators of economic effectiveness per unit area are lower than indicators for a plantation of 10 ha, i.e. 53,378 €/ha < 58,375 €/ha (net present value) and 69,204 €/ha < 73,089 €/ha (capitalised value). Then, the return period of investment investments for a 10 ha plantation is shorter compared to a 3 ha plantation, i.e. 9.24 years < 9.64 years and the rate of capital return for a 10 ha plantation is more favorable than a 3 ha plantation by 0.57%, i.e. 37.92% > 37.35%. Based on the net present value and other indicators determined on its basis, it can be concluded that investing in raising and exploiting walnut plantations on an area of 10 ha is economically more efficient than investing in raising and exploiting plantations on an area of 3 ha.

In order to be able to compare investments in raising walnut plantations of different areas, a relative indicator was also determined from the ratio of the net present value of plantations and the present value of investments, i.e.: 160,134 € / 47,478 € = 3.37 (for 3 ha) and 583,746 € / 147,145 € = 3.98. For each euro of investments, 3.37 € (for 3 ha) and 3.98 € (for 10 ha) of accumulation are realized, where 3.98 > 3.37, which means that the investment in raising and exploiting a plantation of 10 ha is more profitable compared to the current 3 ha.

Conclusions

By applying the net present value and methods based on it, in this research, the evaluation of the economic justification of raising walnut plantations was determined, as well as the choice between areas of 3 ha and 10 ha, the Šejnovo variety, the same cultivation form and planting system. The total investments in raising plantations and replacing worn-out machinery amount to 47,478 € (for 3 ha), i.e. 15,826 €/ha and 147,145 € (for 10 ha), i.e. 14,715 €/ha. Looking at 1 ha, investments for planting 10 ha are lower compared to 3 ha, by 1,111 € (about 8%).

At a calculated interest rate of 8%, a net present value of 160,134 € (for 3 ha) and 583,746 € (for 10 ha) is achieved. Including the risk and uncertainty of the calculative interest rate, provided that it is increased by 25%, there would be a decrease in the net present value for both plantations, namely by 35% for 3 ha, and 25% for 10 ha, which would extend the return period of the investment capital. According to the yield value, the upper limit of investment investments is 207,612 € (for 3 ha) and 730,891 € (for 10 ha), and considering that this value is higher than the total investment investments of individual plantations, the investment is economically acceptable. The planned investments would be recovered during the 10th year, which is a much shorter period of time than the period of use of plantations, i.e. 9.24 years < 35 years and 9.64 years < 35 years. The calculated internal interest rates of 37.35% and 37.92% are higher than the calculated 8%, which means that investing in raising both plantations is economically expedient.

Looking at the unit area, investments for a 3 ha plantation are higher than investments for a 10 ha plantation by 1,112 €/ha, i.e. 15,826 €/ha >14,714 €/ha. The calculated indicators of economic justification show that, under the assumed organizational and economic conditions, investing in raising both analyzed walnut plantations would be expedient, that is, economically justified. For a plantation of 3 ha, indicators of economic effectiveness per unit area are lower than indicators for a plantation of 10 ha, i.e. 53,378 €/ha < 58,375 €/ha (net present value) and 69,204 €/ha < 73,089 €/ha (capitalised value). Then, the return period of investment investments for a 10 ha plantation is shorter compared to a 3 ha plantation, i.e. 9.24 years < 9.64 years and the rate of capital return for a 10 ha plantation is more favorable than a 3 ha plantation by 0.57%, i.e. 37.92% > 37.35%. For each euro of investments, 3.37 € (for 3 ha) and 3.98 € (for 10 ha) of accumulation are realized, where 3.98 > 3.37, which means that the investment in raising and exploiting a plantation of 10 ha is more profitable compared to the current 3 ha.

Based on the net present value and other indicators determined on its basis, it can be concluded that investing in the raising and exploitation of walnut plantations on an area of 10 ha is more economically efficient and sustainable than plantations on an area of 3 ha.

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Conflict of interests

The authors declare no conflict of interest.

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ANALYSIS OF THE ECONOMIC SIGNIFICANCE OF AGRICULTURE IN THE REPUBLIC OF SERBIA AND THE REPUBLIC OF CROATIA

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A B S T R A C T

The aim of the paper is to analyze the economic significance of agriculture in Serbia and Croatia. Bearing in mind the similarities in the characteristics of agricultural production, as well as the economic characteristics of agricultural entities, the authors of the research start from the hypothesis that agriculture has approximately the same economic significance in the current period in both countries. In order to verify the hypothesis, the paper analyzes the relevant macro-economic indicators. For this purpose, the following methods are used: desk research, descriptive statistics, analysis and synthesis, as well as the comparative method. The authors conclude that in recent years the participation of agriculture in the gross domestic product has recorded a downward trend in both countries, as well as the participation of the number of employees in agriculture in the total number of employees. Based on the conducted research, the authors conclude that agriculture has a decreasing economic significance and in Serbia and in Croatia.

Introduction

Rural areas occupy a dominant part of the territory of both the Republic of Serbia and the Republic of Croatia. More precisely, according to the categorization of the Organization for Economic Cooperation and Development (OECD), 79.5% of the territory of the Republic of Serbia (IPARD III 2021-2027) and 63% of the territory of the Republic of Croatia are considered rural areas (EC-2022). In Croatia, 42.5% of the total population lives in rural areas (EC-2022). According to the results of the

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Population Census in Serbia, which was carried out in 2022, 38% of the total population lives in rural areas (RIS-TPS-2022). These two countries were taken as comparative examples considering that, in addition to the fact that rural areas are represented on the majority of the territory in both countries, the structure of agricultural subjects is similar, as well as the average size of their agricultural holdings *(Table 1)*.

In the structure of agricultural holdings (AH) in both countries, family agricultural holdings (FAH) predominate. In the year 2023, the share of FAH in the total number of AH was 99.6% in Serbia and 74.6% in Croatia. In Croatia, a 23% decline in the share of FAH within AH was recorded in the year 2023 compared to 2018; however, FAH still maintain a dominant position in the structure of agricultural holdings. In Serbia, the share of FAH in the total number of AH decreased by only 0.1% in the year 2023 compared to 2018. The average agricultural holding size remained approximately the same in both countries in 2018 and 2023. Furthermore, both countries experienced an increase in the average agricultural holding size in 2023 relative to 2018, with a 32% growth in Croatia and a 23% growth in Serbia *(Table 1)*.

Table 1. The number of agricultural holdings and the average holding size in Croatia and Serbia

Indicators	Croatia		Serbia	
	2018	2023	2018	2023
Number of agricultural holdings (AH)	167,676	164,629	564,541	508,365
Number of family agricultural holdings (FAH)	162,248	122,879	562,896	506,323
The share of family agricultural holdings in the total number of agricultural holdings	96.8%	74.6%	99.7%	99.6%
The average holding size of agricultural entities	5.3 ha	7 ha	5.2 ha	6.4 ha

Source: MAFF-ARSA-2018, MAFF-ARSA-2023, RIS-SYRS-2023, RIS-RCA-2023

A similar situation is observed in both countries regarding the age and educational structure of family agricultural holding (FAH) owners. In the year 2023, owners aged over 65 years had a dominant share in the age structure of FAH owners in both countries. Specifically, they accounted for 51% of the total number of FAH owners in Croatia and 45% in Serbia (MAFF-ARSA-2023, RIS-EAP-2024). Regarding the educational structure of FAH owners, secondary education was the most prevalent level. In the year 2023, 38.9% of FAH owners in Croatia and 38.1% in Serbia had secondary education. It is important to note that this analysis only considers formal education levels of FAH owners and does not account for any forms of non-formal education (MAFF-ARSA-2023, RIS-CA-2023).

Furthermore, the unfavorable age structure of family agricultural holding (FAH) owners, the small size of holdings, and the increasingly pronounced depopulation of rural areas represent significant constraints on agricultural development as well as rural development in both countries (Prudky et al., 2025; Aničić and Paraušić, 2020; Radosavljević et al., 2023). These socio-economic characteristics also present a limiting factor for the development of agricultural production insurance, which remains underdeveloped in both countries (Radović, 2020a; Radović, 2020b). Considering the growing impacts of climate change and its adverse effects on agricultural production, agricultural insurance in the current conditions can be regarded as an essential agrotechnical measure to ensure profitable production and the development of agriculture (Radović, 2024).

The development of agriculture, as the most important activity within the primary sector of the economy, represents the basis for the development of the secondary as well as the tertiary sector, i.e. it significantly affects the overall economic development of a country (Zelenović et al., 2023). Given that, in both countries, the structure of agricultural entities is dominated by small agricultural holdings, which are unable to achieve the necessary levels of productivity, efficiency, and profitability, it is crucial to promote their consolidation in order to enable the development of agriculture. Jeločnik et al. (2023) argue that one of the economically validated methods of consolidation is the establishment of cooperatives, or the development of cooperative farming. By fostering cooperation among small agricultural holdings, these cooperatives can enhance economies of scale, improve market access, and facilitate the implementation of modern agricultural practices, thereby contributing to the overall advancement of agricultural production and rural development.

Agriculture has a significant impact on the development of the entire economy (Grujić-Vučkovski et al., 2022). However, Dimitrijević et al. (2023) observed that this impact has been declining in recent years in Serbia, particularly when considering the share of agriculture in gross domestic product (GDP) as well as its role in employment. It is well known that the development of agriculture depends on numerous factors, among the most important being the level of financial investment and labor productivity. Additionally, the development of agricultural production directly influences the food security of a country (Kovljenić and Raletić-Jotanović, 2021; Jurjević et al., 2022). The relationship between agricultural development and food security highlights the importance of increasing investment in agriculture, improving productivity, and ensuring a stable and sufficient supply of food for the population. Thus, while agriculture's contribution to the economy may be waning in some areas, its role remains central to ensuring national food security and fostering long-term economic stability. Considering the importance of agricultural production in both countries, the objective of this study is to analyze the current economic significance of agriculture in the Republic of Serbia and the Republic of Croatia.

Materials and methods

Considering the similarities in the characteristics of agricultural production, as well as the economic attributes of agricultural entities in both countries, the authors hypothesize that agriculture holds approximately the same economic importance in the current period in both Serbia and Croatia.

To verify this hypothesis, the study analyzes relevant macroeconomic indicators: (a) the share of agriculture in gross domestic product (GDP); (b) the share of agriculture in foreign trade exchange; and (c) the share of agriculture in total employment.

The data sources include official statistical reports from both countries. The research employs several methods, including desk research, descriptive statistics, analysis and synthesis, as well as comparative and descriptive methods. By examining these indicators, the study aimed to provide a comprehensive overview of agriculture's role in the economies of both countries, highlighting its significance not only in economic terms but also in terms of employment and rural development.

Results and Discussions

In order to analyze the characteristics of agricultural production, the structure of utilized agricultural land and the livestock fund in the Republic of Serbia and the Republic of Croatia for the year 2018 and 2023 are presented in tables 2 and 3. In the structure of utilized agricultural land, arable land and gardens dominate in both countries. Meadows and pastures occupy the second position, followed by orchards and vineyards, which cover significantly smaller areas. Based on the tabular presentation, it can be concluded that the structure of utilized agricultural land is similar in Croatia and Serbia, with only slight changes in this structure observed in 2023 compared to 2018 (*Table 2*).

Table 2. The structure of used agricultural land in Croatia and Serbia

Structure of used agricultural land	Croatia		Serbia	
	2018	2023	2018	2023
Arable land and gardens	54.1%	58.3%	73.98%	77.20 %
Meadows and pastures	40.9%	36.2%	19.47%	16.5%
Orchards	2.2%	2.6%	5.26%	5.7%
Vineyards	1.4%	1.3%	0.59%	0.5%
Olive groves	1.3%	1.4%	-	-
Other lands	0.1%	0.2%	0.02%	0.1%
Total:	100.00%	100.00%	100.00%	100.00%

Source: MAFF-ARSA-2018, MAFF-ARSA-2023, RIS-SSAH-2018, RIS-CA-2023

Furthermore, in the structure of livestock fund in Croatia, significant changes were observed between the year 2018 and 2023 (*Table 3*). The production of pigs, sheep, goats, and poultry all experienced notable declines, with reductions of 19%, 13%, 9%, and 6%, respectively. This trend suggests a decrease in the overall scale of animal husbandry in Croatia, possibly due to factors such as market conditions, changing consumer preferences, or economic pressures on small and medium-sized farms. In contrast, the number of cattle saw a slight increase of 0.3%, indicating a modest stability in this sector, while the most significant growth was recorded in the number of beehives, which rose by 24%. This increase in beekeeping could be attributed to rising demand for honey and other bee-related products, as well as potential shifts towards more sustainable agricultural practices.

Similarly, in Serbia, livestock production trends from 2018 to 2023 show a predominance of decline across various sectors (*Table 3*). The number of cattle decreased by 18%, pigs by 31%, sheep by 5%, goats by 32%, and poultry by 7%. These declines reflect broader challenges faced by the Serbian agricultural sector, including issues related to productivity, market access, and the sustainability of traditional farming methods. The most notable trend, however, was the significant increase in the number of beehives, which grew by 38%, mirroring the situation and in Croatia. This indicates a growing recognition of the economic potential of beekeeping in Serbia, possibly driven by the global rise in demand for honey and other bee-derived products.

These trends in both Croatia and Serbia highlight the challenges faced by traditional livestock sectors, particularly in the context of economic pressures, market dynamics, and changing consumer behavior. Furthermore, the main reason for this decline in Serbia was the decreasing profitability of livestock production, which is further exacerbated by the highly debated current "ecological campaign." A similar situation is present in Croatia. A group of authors (Gantner et al., 2024; Gantner et al., 2022) argues that livestock production has been unfairly accused of being an environmental polluter, as this sector actually has the potential to contribute to mitigating climate change. These authors emphasize the importance of livestock production for human nutrition, particularly in providing protein-rich food sources, and argue that, if managed sustainably, livestock farming can play a significant role in environmental conservation and biodiversity.

On the other hand, Crnčan et al. (2017) concluded that in Croatia, the highest revenues from agricultural production in the year 2015 were generated in livestock production, specifically in pig farming and poultry farming. This highlights the economic importance of livestock sectors in the region, despite the challenges they face. The contrasting perspectives on livestock production reflect ongoing debates about its environmental impact and economic significance. While concerns over sustainability and emissions are valid, the contribution of livestock to the economy and food security cannot be overlooked. These discussions suggest the need for a balanced approach to agricultural policy that supports both sustainable practices and the continued economic viability of livestock farming.

Table 3. The structure of livestock fund in Croatia and Serbia

Structure of livestock population	Croatia		Serbia	
	2018	2023	2018	2023
Cattle	414,125	415,204	881,152	725,408
Pigs	1,049,123	852,523	3,266,102	2,263,705
Sheep	636,294	552,083	1,799,814	1,702,682
Goats	80,064	72,809	218,397	149,558
Poultry	11,413,000	10,744,878	23,184,387	21,604,693
Bee hives	372,002	461,497	914,000	1,261,323

Source: MAFF-ARSA-2018, MAFF-ARSA-2023, RIS-SSAHL-2018, RIS-CA-2023.

Furthermore, the value structure of agricultural production is quite similar in both Croatia and Serbia (*Table 4*). Specifically, in this structure, the largest share in the year 2023 was held by the production of cereals and pigs. This reflects the significant role that these sectors play in the agricultural economy of both countries. The production of cereals, being a staple in both national economies, continues to dominate, followed closely by pig farming, which has historically been a cornerstone of livestock production in both countries.

Other sectors, such as dairy production, fruit cultivation, and vegetable farming, contributed to the overall value of agricultural production, but their share remained relatively small in comparison to cereals and pigs. The minor deviations in the participation of these other sectors highlight some sectoral differences but do not indicate major shifts in the overall structure of agricultural production. These similarities in the value composition suggest that the agricultural economies in both countries are heavily reliant on a few key sectors, primarily cereal crops and livestock, and any policy changes or market fluctuations in these areas could have substantial effects on the agricultural economies.

Table 4. Value structure of agricultural production in 2023 in Croatia and Serbia

Croatia		**Serbia**	
Type of agricultural products:	Share in the total value of agricultural production (%)	Type of agricultural products:	Share in the total value of agricultural production (%)
Cereals	16.50	Cereals	24.31
Pigs	13.10	Pigs	11.53
Cattle	12.10	Cattle	5.16
Vegetables	7.30	Vegetables	5.12
Forage crops	7.00	Forage crops	4.17
Dairy	6.60	Dairy	6.11
Poultry	5.40	Poultry	3.08
Oilseeds	5.20	Oilseeds	10.65
Wine	4.80	Wine	9.98
Other	22.00	Other	19.89
Total	100.00	Total	100.00

Source: MAFF-ARSA-2023, RIS-SYRS-2023

Novaković et al. (2024) stated that one of the potential directions for the development of agricultural production is the shift towards organic farming. Furthermore, Tomaš et al. (2019) highlights that in recent years, ecological production has been intensively developing in Croatia, which, to some extent, can be viewed as a response to the increasingly evident climate changes. According to literature sources, organic farming has developed more rapidly in Croatia than in Serbia in recent years. Šeremešić et al. (2024) report that the area dedicated to organic farming in Croatia increased from 23,351 hectares in 2010 to 121,924 hectares in 2022. In contrast, during the same period, Serbia saw an increase from 8,635 hectares to 23,527 hectares. The greater development of organic farming in Croatia compared to Serbia is also reflected in the data presented in *Table 5*. This expansion in organic farming in Croatia can be attributed to various factors, including stronger policy support, increased consumer demand for organic products, and greater investments in sustainable agricultural practices. In contrast, while organic farming is growing in Serbia, the pace remains slower due to challenges such as limited access to organic markets, lower levels of awareness consumers, and a need for stronger institutional support.

Table 5. Ecological / Organic agriculture in 2023 in Croatia and Serbia

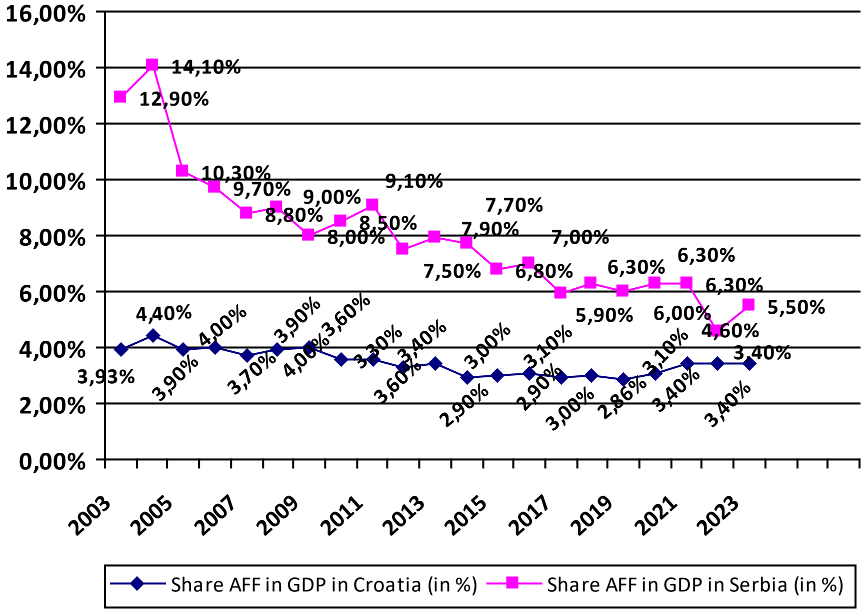
Ecological agriculture (EA) in Croatia		Organic agriculture (OA) in Serbia	
Participation of agricultural holdings (AH) in EA in the total number of AH	4.01%	Participation of agricultural holdings (AH) in OA in the total number of AH	1.29%
Participation of agricultural land areas in EA in the total utilized agricultural land (UAL)	8.10%	Participation of agricultural land areas in OA in the total utilized agricultural land (UAL)	0.90%
Participation of cattle in EA in the total number of cattle	9.20%	Participation of cattle in OA in the total number of cattle	1.20%
Participation of sheep in EA in the total number of sheep	13.20%	Participation of sheep in OA in the total number of sheep	0.90%
Participation of goats in EA in the total number of goats	10.00%	Participation of goats in OA in the total number of goats	0.40%
Participation of pigs in EA in the total number of pigs	0.10%	Participation of pigs in OA in the total number of pigs	0.01%
Participation of poultry in EA in the total number of poultry	0.10%	Participation of poultry in OA in the total number of poultry	0.20%

Source: MAFF-ARSA-2023, RIS-SYRS-2023

The participation of agriculture, forestry, and fisheries (AFF) in Gross Domestic Product (GDP) in Serbia and Croatia over the past two decades (2003-2023) is presented in the graphical representation (Figure 1). A comparative analysis of the data reveals that, throughout the analyzed period, AFF contributed a higher percentage to GDP in Serbia than in Croatia. In the year 2003, at the beginning of the period, the share of AFF in Serbia's GDP was 12.9%, while in Croatia it was 3.93%. This indicates that, in 2003, Serbia's AFF contribution to GDP was nearly three times higher than that of Croatia. However, by the end of the period in 2023, the share of AFF in Serbia's GDP had decreased significantly to just 5.5%, marking a 57% decline compared to 2003, while in Croatia, the share in 2023 was 3.36% (Figure 1). On average, the participation of AFF in GDP between 2003 and 2023 was 8.10% in Serbia and 3.46% in Croatia. This decline in Serbia's AFF contribution reflects broader structural changes in the economy, indicating a shift away from agriculture and rural sectors, while highlighting the relatively stable but smaller role of AFF in Croatia's economic structure.

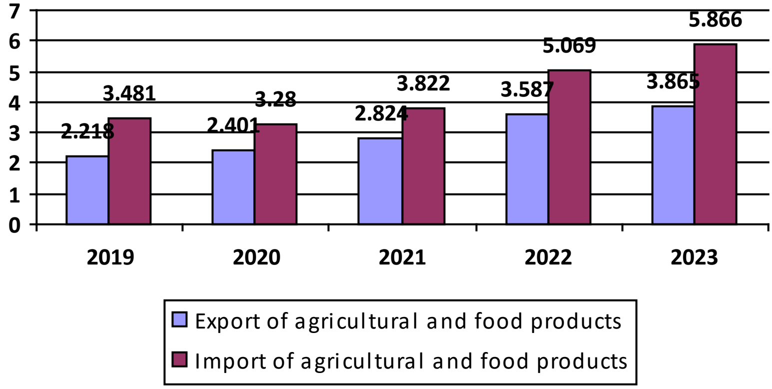
The foreign trade exchange of agricultural and food products in Croatia and Serbia during the period 2019-2023 is graphically represented in Figure 2 and Figure 3. Exports of agricultural and food products from Croatia exhibited a growing trend over the period 2019-2023. Specifically, the value of exports increased by 1,647 million euros, or 74%, between 2019 and 2023. However, a negative aspect is that imports of agricultural and food products also followed an upward trend during the analyzed period. In terms of value, imports increased by 2,385 million euros, or 68%, in 2023 compared to 2019 (*Figure 2*).

Figure 1. Share agriculture, forestry, and fisheries (AFF) in Gross Domestic Product (GDP) in the period 2003 – 2023



Source: SBS-AGDP-2024, RIS-PAFFGDP-2003-2023

Figure 2. Foreign trade exchange of agricultural and food products in Croatia in the period 2019-2023 (in million €)



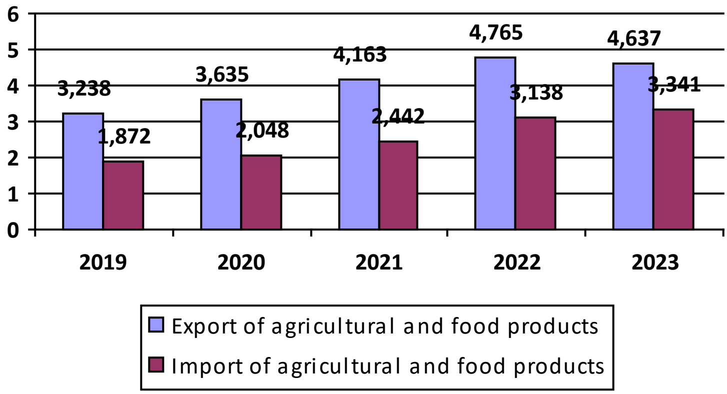
Source: MAFF-ARSA-2023

Exports of agricultural and food products from Serbia demonstrated a rising trend during the 2019-2022 period – in value terms, exports increased by 1,527 million euros, or 47%, in 2022 compared to 2019. However, in 2023, Serbia experienced a slight decline in exports compared to 2022, with a decrease of 128 million euros, or 0.03%.

Similar to Croatia, Serbia also saw an increase in imports of agricultural and food products over the entire analyzed period. The value of imports in Serbia rose by 1,469 million euros, or 78%, in 2023 compared to 2019 (*Figure 3*).

These trends highlight the growing importance of agricultural and food product trade for both countries, but also underscore the need for improving the trade balance by addressing the increasing imports in relation to exports. While both countries experienced growth in exports, the significant rise in imports suggests challenges in achieving self-sufficiency and competitiveness in the agricultural sector.

Figure 3. Foreign trade exchange of agricultural and food products in Serbia in the period 2019-2023 (in million €)



Source: RIS-SYRS-2023

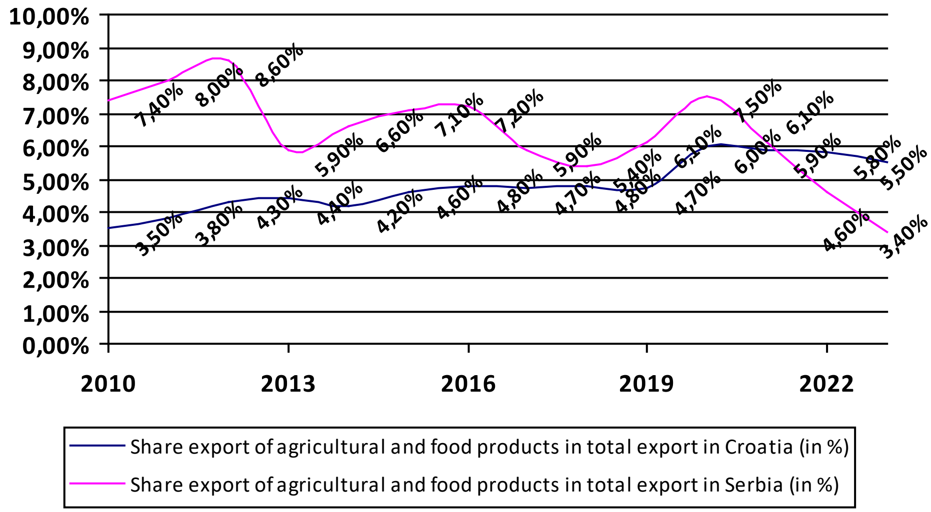
Agricultural products play a crucial role in the export structure of Serbia (Vujičić et al., 2024). Serbia is considered the most significant foreign trade partner among the countries of the Western Balkans (Jalić et al., 2024). Within Serbia's fruit export structure, raspberries hold a dominant share. For instance, between the year 2000 and 2022, the value of frozen raspberry exports increased threefold, while the export value of fresh raspberries grew twentyfold (Kljajić et al., 2023).

The average share of agricultural and food product exports in total exports in both Croatia and Serbia exhibited significant fluctuations during the period from 2010 to 2023 (*Figure 4*). Over this period, the average share of agricultural and food product exports in total exports was 4.8% in Croatia and 6.4% in Serbia. These fluctuations can be attributed to a combination of factors, including changes in global demand, market conditions, and internal policy adjustments in both countries.

The higher share of agricultural exports in Serbia, compared to Croatia, underscores the importance of agriculture in the Serbian economy, particularly in sectors like fruit and vegetable production. However, these numbers also highlight challenges, such as the need to diversify export products and reduce dependency on a few key agricultural products, as well as the impact of external market conditions on the stability of export figures.

In Croatia, while the average share of agricultural exports is lower, it reflects a more diversified export portfolio. The fluctuations observed in both countries suggest that agricultural exports are sensitive to global economic shifts, agricultural production changes, and policy interventions. Future trends will likely depend on these countries' ability to adapt to changing international demands, improve production efficiency, and expand into new export markets.

Figure 4. Share of export of agricultural and food products in total export in Serbia and Croatia in the period 2019-2023 (in %)



Source: SBS-FT-2025, RIS-SYRS-2010-2024

The share of agriculture in total employment in Serbia and Croatia during the period from 2002 to 2022 is presented in Tables 6 and 7. Analyzing the participation of agriculture, forestry, and fishing (AFF) in overall employment, it can be concluded that both countries experienced a declining trend over the analyzed period. This trend highlights significant changes in the structure of employment in these sectors.

Table 6. The share of agriculture in total employment in Serbia in the period 2002 – 2022

Year	**Serbia**		
	The total number of economically active population	The total number of employees in agriculture, forestry, and fishing (AFF)	The share of employees in AFF in the total number of economically active population (in %)
2002	2,642,987	580,339	21.96
2011	2,304,628	340,186	14.76
2022	2,401,690	106,021	4.41

Source: RIS-EAP-2024

Specifically, the percentage of employees in agriculture, forestry and fishing relative to total employment declined notably by 2022 compared to the first year of the analyzed period. In Croatia, the share of employees in agriculture decreased by 49%, while in Serbia, it showed a much sharper decline of 80%.

Table 7. The share of agriculture in total employment in Croatia in the period 2002 – 2022

Year	Serbia		
	The total number of employees	The total number of employees in agriculture (insured agricultural workers)	The share of employees in agriculture in the total number of employees (%)
2002	1,432,454	32,339	2.26
2011	1,642,474	21,204	1.29
2022	1,619,969	18,657	1.15

Source: RIS-EAP-2024

These results suggest a substantial transformation in the labor market dynamics of both countries, reflecting broader structural changes in their economies. In Croatia, the decrease in agriculture employment could be attributed to ongoing industrialization, urbanization, and the growth of other sectors such as services and manufacturing. Similarly, Serbia has seen a shift away from agriculture towards more diversified economic activities, with significant advancements in urban development and the services sector.

Furthermore, this reduction in AFF employment may also be influenced by changes in agricultural productivity, technological advancements, and the overall modernization of the agricultural sector, which reduces the need for manual labor. Furthermore, the outflow of rural populations to urban areas in search of better opportunities has likely contributed to this trend. Finally, these shifts highlight the evolving nature of the economies in both countries and the need for policies that support rural development, provide alternative employment opportunities in agriculture, and invest in modernizing the sector to improve its competitiveness.

Conclusion

The Both the Republic of Serbia and the Republic of Croatia have rural areas that make up the majority of their territories. Family agricultural farms play a dominant role in the agricultural sector in both countries, and the average size of agricultural holdings is relatively similar. The age and educational structure of family farm owners is also comparable, with the majority being older than 65 years and having a middle level of education. Depopulation of rural areas represents a significant constraint for the development of agriculture and rural development in both countries.

In terms of land use, arable land and gardens dominate in both countries, followed by meadows and pastures, while orchards and vineyards occupy much smaller areas. The livestock fund has shown a decline in the number of animals between 2018 and 2023, with the only increase being in the number of beehives in both Serbia and Croatia. Similarly, the structure of agricultural production in both countries is dominated by the production of cereals and pig farming. When analyzing the development of organic agriculture, Croatia exhibited a higher level of development in 2023, both in crop and livestock production.

Given these similarities, the authors hypothesized that agriculture in both countries holds approximately the same economic significance in the current period. Based on the conducted research, this hypothesis has been confirmed.

Agriculture has a declining economic significance in both countries, despite the growing trend of exports of agricultural and food products in recent years. This conclusion is derived from the following indicators:

- The share of agriculture, forestry, and fishing in gross domestic product (GDP) has shown a declining trend between 2003 and 2023 in both Serbia and Croatia. The percentage of agriculture, forestry, and fishing in GDP fell in 2023 compared to 2003: (a) in Serbia by 57%; (b) in Croatia by 14%.

- Both in Serbia and Croatia, the percentage of employed individuals in agriculture, forestry, and fishing has significantly declined in recent decades. The share of employees in these sectors in total employment decreased in 2022: (a) in Croatia by 49% compared to 2011; (b) in Serbia by 80% compared to 2002.

This evidence points to the fact that, while agriculture remains an important part of the rural economy, its overall economic role has diminished over time in both Serbia and Croatia. Despite this decline, agriculture's role in the rural workforce and the export sector remains a key focus for the future development of rural areas.

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Conflict of interests

The authors declare no conflict of interest.

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A PRODUCTION AND ECONOMIC ANALYSIS OF RASPBERRY AND ITS IMPACT ON THE SUSTAINABLE DEVELOPMENT OF RURAL AREAS: A SPECIAL FOCUS ON THE SITUATION IN THE SERBIA AND POLAND

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ABSTRACT

Raspberry is Serbia's most significant agro-industrial export, giving the country a competitive edge globally despite its smaller size and lower technological development. Over the past decade (2013–2022), raspberry production has faced challenges, including disputes over purchase prices between producers and cold store owners. The paper analyses global, European, and Serbian raspberry production, including yields, export/import data, and prices, with a comparison to Poland—another leading producer. Both countries have ideal conditions for high-yield raspberry farming, though production remains extensive in some areas. Serbia holds a top global position in frozen raspberry exports, and there is strong potential for growth, especially in fresh and organic raspberries. This requires government support, subsidies, and better use of natural and local resources to boost competitiveness and rural development.

Introduction

The Republic of Serbia has 3,239,374 ha of agricultural land, out of which orchards account for 6.05%, covering an area of 196,129 ha. Fruit production is diverse and highly significant for the economy and economic development of the Republic of Serbia. According to the land they cover, plums are the most prevalent fruit. In 2023,

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plums were grown on the area of 74,418 ha, producing 362,713 tonnes with the yield of 4.9 t/h. Apples, grown on the area of 27,412 ha, reached the production of 379,690 tonnes and the yield of 13.9 t/ha. Following apples and plums, sour cherries were cultivated on the area of 19,614 ha, producing 144,849 tonnes with the yield of 7.4 t/ha (Statistical Office of the Republic of Serbia, 2023).

When it comes to the production of berries, including strawberries, raspberries, blackberries, blueberries, and alike, raspberry is the most significant for the economy of Serbia. It is the leading fruit species in terms of the export value and its percentage share in the total fruit export from Serbia (Cvijanović et al, 2017). This is supported by the fact that in 2022, Serbia exported the total of 1,386.8 tonnes of fresh raspberries valued at USD 6,317.6 thousand. The greatest portion of this was exported to the countries of the European Union. In addition, in 2022, Serbia exported 67,364.5 tonnes of frozen raspberries (without sugar) valued at USD 372,850.7 thousand to global markets. However, the majority of the frozen raspberries, approximately 77% of the total export, are exported to the EU countries, amounting to 52,802.0 tonnes valued at USD 286,897.8 thousand (https://data.stat.gov.rs/Home/Result/170304?languageCode=sr-Cyrl&displayMode=table&guid=b0462e45-3394-4be4-992c-162751e0a6ea).

Apart from the large financial gain, raspberry production also ensures the employment of a large number of workers, which is very significant from the socio-economic point of view (Kljajić et al, 2017b). Throughout a year, approximately 200,000 people from different age groups are involved in raspberry production, including the processes of production, harvesting, purchase, sale and procession. Therefore, raspberry farming is of great importance for the survival of villages and overall rural development. Moreover, the above mentioned can help reduce the unemployment in certain rural areas in Serbia. Josipović, 2019, states that rural areas can become a good place to live if people are offered sufficient business opportunities, which can be achieved through the development of raspberry farming. For this reason, Dimitrijević and Ceranić, 2011, define raspberry as *a labour-intensive crop*, since there is a high need for labour at almost all stages of its production cycle, particularly during the harvesting period. Additionally, workers from other industries, such as the machinery and chemical sectors, are also indirectly employed. The machinery industry is important due to the use of driving and attaching devices, as well as cold storage and processing capacities, while the chemical industry is significant for treating raspberries against diseases and pests.

Raspberries are grown on small areas and their production is a secondary economic activity on many farms and for a large number of producers, making it not their main source of income. Consequently, there should be greater commitment to its production, which involves modern agronomy practices, mandatory irrigation of crops, hail protection, crop insurance, energy savings through innovative technologies, etc. This can increase raspberry production from the average 7 t/ha to around 13 t/ha, as well as the quantity of first-class raspberry produced, which achieves the best prices on the market (Radosavljević, 2016; Jakšić i sar., 2023). In addition, according to Kolarić et al. (2023), the dominant *Willamette* variety, as well as the *Meeker* variety, should be retained in the future production, as these are the raspberry varieties most demanded by global buyers.

The aim of the paper is to examine the actual state of raspberry production and export from the Republic of Serbia. By observing the raspberry production and turnover during the previous ten years and comparing these indicators with international experiences, an overview of the raspberry farming situation on the Serbian market is obtained, along with its advantages and disadvantages. Based on the analysis of the situation, the authors provided suggestions for the improvement of raspberry production and, consequently, its export.

Materials and methods

The research period in the paper covers the period from 2013 to 2022. For the territory of Serbia and Poland. For the analysis of the situation on the territory of Serbia, data from the database was used of the Statistical Office of the Republic of Serbia and the Food and Agriculture Organization of the United Nations (FAO). The research in the paper is based on secondary data, and it represents the procession of available data by applying standard statistical and mathematical methods. Standard indicators of descriptive statistics were used (arithmetic mean, standard deviation and coefficient of variation). The standard deviation was used for the average deviation from the arithmetic mean. The stability of the occurrences was calculated using the coefficient of variation (CV). For the territory of Poland the main data for analysing were obtained from the databases of The National Support Centre for Agriculture – KOWR, Statistics Poland and Ministry of Agriculture and Rural Development – MRiRW.

In addition, the results obtained in previous studies on the same or similar topics were used by referencing scientific and professional papers, and the data were interpreted using tables and graphs.

Results

Raspberry production in the world

Red raspberry (Rubus idaeus L.) belongs to the family Roasaceae Juss, Rubus genus, which encompasses 12 subgenera with more than 439 species. It is a specific fruit with distinct characteristics compared to other fruits. It contains ellagic acid, quercetin, anthocyanins, salicylic acid, catechins, vitamin C and phytoestrogen, which results in its high ORAC (Oxygen Radical Absorbance Capacity). This helps to fight cancer, lowers cholesterol levels in blood, reduces risks of heart and blood vessel diseases and slows down ageing. In addition, raspberries have a strong aroma, relatively high dry matter content and a good acid and sugar ratio. In addition to treating numerous diseases, raspberries are used for prevention, and both the fruit and leaf have medicinal properties. All these facts indicate that raspberry is an exceptionally high-quality fruit, in high demand both on the domestic and global market, where it has a high price

(Graham et al, 2007; Kljajić 2017a; Milić et al, 2011; Kljajić and Subić, 2022a; Ispiryan et al, 2023; Kljajić et al, 2023; Roxana et al, 2024; Ispiryan et al, 2024; Nedeljković et al, 2024; Zdravković i sar., 2024)

According to the FAO statistical data, Europe was the leading continent in the raspberry production during the ten-year period observed in this study. Raspberry plantations cover an area of 87,555,000 ha on the European continent, which accounts for 77.56% of the total global area where raspberries are cultivated. America ranks second with 19,194,000 ha or 17.00%, followed by Asia with 3,271,000 ha (2.90%), Africa with 2,528,000 ha or 2.24% and Oceania with 338,000 ha or 0.30% of the global raspberry cultivating area (Table 1).

Table 1. Distribution of raspberry harvested areas worldwide by continent in the 2013-2022 period (units in 000 ha)

	Africa	**America**	**Asia**	**Europe**	**Oceania**	**World (total)**
Average during the 2013-2022 period	2,528	19,194	3,271	87,555	338	112,886
Structure (world=100%)	2.24	17.00	2.90	77.56	0.30	100.00

Source: Authors' calculations based on the FAO database, 2023

The analysis of the average annual raspberry production for the 2013-2022 period shows that the dominant areas under raspberry plantations are proportional to the realized production. Thus, the realized raspberry production in this period in Europe was 540,968.92 tonnes, which accounts for 66.25% of the total global production. In terms of production, Europe is followed by America, with the production of 234,609.50 tonnes or 28.73%; Africa, with the production of od 25,306.83 tonnes or 3.10%; Asia, with the production of 15,037.24 tonnes or 1.84%; and finally Oceania with the production of 693.76 tonnes of the total global raspberry production. The areas under raspberry plantations and the actual production are in disproportion in Asia and America (Table 2).

Table 2. Average raspberry production worldwide by continent in the 2013-2022 period (units in 000 tonnes)

	Africa	**America**	**Asia**	**Europe**	**Oceania**	**World (total)**
Average during the 2013-2022 period	25,306.83	234,609.50	15,037.24	540,968.92	693.76	816,616.20
Structure (world=100%)	3.10	28.73	1.84	66.25	0.08	100.00

Source: Authors' calculations based on the FAO database, 2023

Observing the average yield per unit of area in the studied ten-year period, it can be seen that the average raspberry yield at the global level was 7.2 t/ha. The largest yields per unit of area were realized in America (12.11 t/ha) and Africa (9.87 t/ha). The average yield per unit of area was 6.18 t/ha in Europe, 4.60 t/ha in Asia and only 2.05 t/ha in Oceania (Table 3). Considering the cultivation area and production of raspberry in Europe, based on the data on average yields, it can be concluded that raspberry production on the European continent is extensive and should be improved.

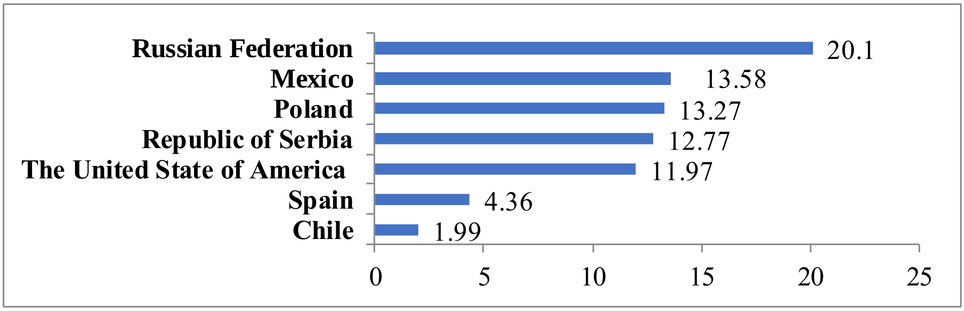
Table 3. Average raspberry yields worldwide by continent in the 2013–2022 period (units in tonnes/hectare)

	Africa	America	Asia	Europe	Oceania	World (total)
Average during the 2013-2022 period	9.87	12.11	4.60	6.18	2.05	7.20

Source: Authors' calculations based on the FAO database, 2023

Based on the average annual raspberry production in the 2013-2022 period, the Russian Federation is ranked first with the average production of 164,140.00 tonnes, which accounts for 20.10% of the global production. Mexico is ranked second with the share of 13.58%, followed by Poland with the share of 13.27%. The Republic of Serbia is the fourth with the share of 12.77%. Serbia is followed by the United States of America (11.97%), Spain (4.36%) and Chile (1.99%), as shown in Figure 1.

Figure 1. Average annual raspberry production worldwide by country during the 2013-2022 period (units in tonnes)



Source: Authors' calculations based on the FAO database, 2023

In 2022, Serbia placed third according to its raspberry production (Table 4), following Russia and Mexico. Poland is in fourth place, right behind Serbia.

Table 4. International Production: Raspberries (Production in (000) MT) in 2022

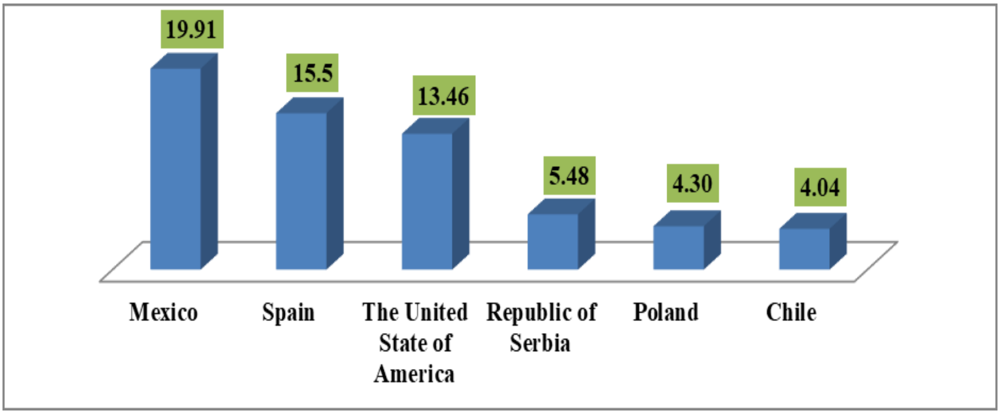
	Country	Production	Share (%)
1	Russia	212.30	22.40
2	Mexico	173.74	18.33
3	**Serbia**	116.09	12.25

	Country	Production	Share (%)
4	**Poland**	104.90	11.07
5	The USA	76.48	8.07
6	Spain	45.42	4.79
7	Morocco	45.04	4.75
8	Ukraine	33.57	3.54
9	Portugal	29.30	3.09
10	The UK	16.34	1.72
	Total	853.18	

Source:https://agriexchange.apeda.gov.in/International_Productions/International_Production.aspx?ProductCode=0547

According to the annual raspberry production per unit of area, Mexico is on the top of the list with the yield of 19.91 t/ha, while Chile is the last on the list with the yield of 4.04 t/ha (Figure 2). These indicators show that the application of higher-quality treatments in raspberry care results in better yield per hectare and improved fruit quality.

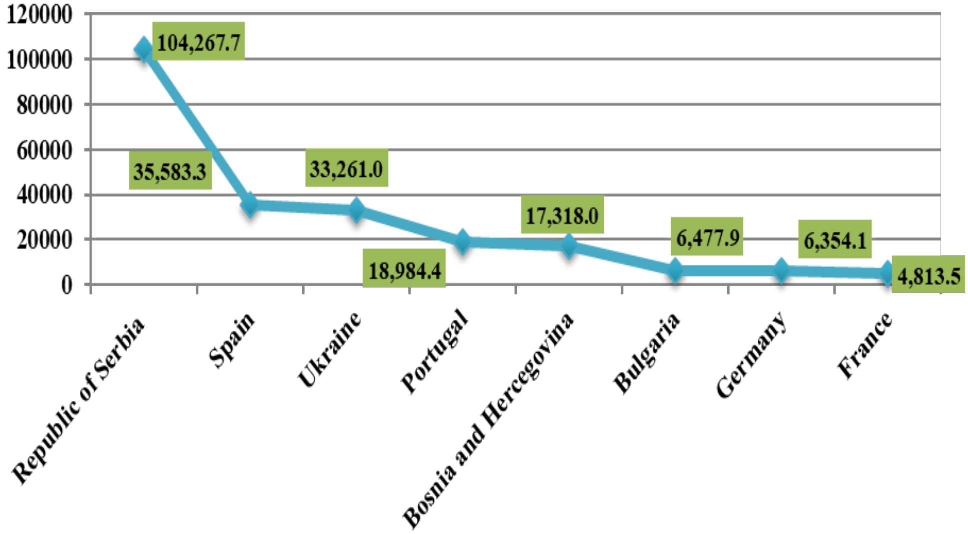
Figure 2. Average annual raspberry yield worldwide by country in the 2013–2022 period (units in tonnes/hectare)



Source: Authors' calculations based on the FAO database, 2023

For the studied ten-year period (2013-2022), the total average raspberry production in Europe amounted to 87,555,000 tonnes, which represents 77.56% of the total global raspberry production. The greatest producers of raspberries are the Russian Federation, Poland, Serbia, Ukraine, Portugal, Bosnia and Herzegovina, Bulgaria, Germany and France (Figure 3). The largest production is realized in the Russian Federation, while the smallest production is in France. The Republic of Serbia is ranked third among raspberry producers in Europe with the average production of 104,267.7 tonnes, which accounts for 17.42% of the total European raspberry production.

Figure 3. Average annual raspberry production worldwide by country in the 2013–2022 period (units in thousands of tonnes)



Source: Authors' calculations based on the FAO database, 2023

Analysis of raspberry production in Serbia

In Serbia, the production of raspberry as a commodity started around 1920 and has continuously increased ever since. In the 1980s, the production reached the level which made Serbia the leading global producer of raspberries with the annual production of 116 thousand tonnes. In the last several years, raspberry production has slightly decreased. However, even with this lowered production of 65 to 100 thousand tonnes, Serbia accounts for 20% of the global raspberry production. Approximately 85-90% of the raspberries produced in Serbia are exported to the global market, while the remaining small percentage is consumed in Serbia (Kljajić et al, 2022; Zdravković i sar., 2024).

The leading raspberry-growing regions in Serbia where raspberries are produced and exported to the global market are:

- Valjevo district - Podgorina and Pocerina;
- Šabac district - Krupanj, Loznica and Bajina Bašta;
- Kosjerić district – the Povlen – Varda area;
- Požega district – the surroundings of Požega;
- Arilje district – the entire surrounding area of Arilje;
- Ivanjica district - Ivanjica, Kaona, Kotraža and Guča;
- Čačak district - Čačak and Kablar with the surroundings;

- Kraljevo district – Kraljevo and Dragačevo with the surroundings;
- Leskovac district – the hilly-mountainous region (Kljajić, 2014).

The production is carried out on small family holdings with an average size of 0.36 ha. The leading raspberry variety is Willamette, which reaches maturity in June and July and has an average yield of around 5.5 t/ha. In the Arilje raspberry growing hills, which is the leading area for raspberry production, the yield is sometimes as high as 30 t/ha.

According to the SORS data (Table 5), the average area dedicated to raspberry cultivation amounted to 19,662 ha in the entire territory of Serbia from 2013 to 2022. The smallest area was recorded in 2013 (13,118 ha), while the largest was in 2020 (24,028 ha). If 2013 is taken as the base year for analysing changes of the areas where raspberry is cultivated, it can be noticed that the areas increased from 2013 until 2020, after which there was a slight decline. The constant production growth indicates improvements in the production process, investment in newer technologies and modern agrotechnical measures used by agricultural producers. The interruption of the production growth tendency was caused by climate changes (drought or hail), which can certainly destroy raspberry yield. In addition, outdated plantations and the arrival of new ones can lead to a temporary gap in production.

Table 5. Annual changes in areas dedicated to raspberry cultivation in the Republic of Serbia by region in the 2013–2022 period (units in ha)

Research year	Serbia-north		Serbia-south		Republic of Serbia (total)	Base Index (2013=100)
	Belgrade	Vojvodina	Šumadija and Western Serbia	Southern and Eastern Serbia		
2013	278	505	11,143	1,192	13,118	100
2014	365	627	11,909	1,891	14,792	113
2015	378	650	13,210	1,973	16,211	124
2016	632	882	16,404	2,276	20,194	154
2017	688	1023	18,175	1,975	21,861	167
2018	711	1248	18,503	2,192	22,654	173
2019	786	1456	18,746	2,261	23,249	177
2020	786	1456	19,268	2,518	24,028	183
2021	703	1192	16,669	2,243	20,807	159
2022	573	905	16,187	2,038	19,703	150
Arithmetic mean	590	994	16,021	2,056	19,662	
Coefficient of variation	57.5	32.5	17.4	16.5	18.0	
Participation structure	3.0	5.1	81.5	10.5	100.0	

Source: Statistical Office of the Republic of Serbia, Statistical yearbooks, 2014–2023

The largest areas under raspberry cultivation in the Republic of Serbia are located in the Šumadija and Western Serbia region (81.5%). This region is known for its traditional raspberry growing. The largest raspberry-growing areas are found in the Zlatibor and Moravica districts of this region. The production centres are Arilje, Ivanjica, Lučani, Čačak, Požega, Užice, Sjenica, followed by Western Serbia – the districts of Mačva and Kolubara (Valjevo, Šabac, Osečina, Ljubovija). The remaining 18.5% is distributed among all other regions: 10.5% in Southern and Eastern Serbia, 5.1% in Vojvodina and 3.0% in the Belgrade region. The coefficient of variation of production areas ranges from 16.5% in the Southeast Serbia region to 57.5% in the Belgrade region.

Along with the production areas, raspberry production had an uneven volume and certain annual fluctuations from 2013 to 2022. At the level of the Republic of Serbia, the average annual production amounted to 106,987 tonnes. The maximum production was realized in 2018 (127,010 tonnes), while the minimum was in 2013 (74,682 tonnes). The coefficient of variation is 18% (Table 6). Certain fluctuations can be noticed when analysing the production trends based on the base index with the base year of 2013. Raspberry production is uneven at an annual level, which makes it unpredictable.

Table 6. Statistical indicators of raspberry production in Serbia by region in the 2013–2022 period (units in t)

Research year	Serbia-north		Serbia-south		Republic of Serbia (total)	Base Index (2013=100)
	Belgrade	Vojvodina	Šumadija and Western Serbia	Southern and Eastern Serbia		
2013	2,061	3,093	63,604	5,924	74,682	100
2014	2,691	3,765	66,857	9,370	82,683	111
2015	2,629	4,595	80,845	9,096	97,165	130
2016	4,499	5,922	93,076	9,675	113,172	152
2017	4,868	6,559	91,273	7,042	109,742	147
2018	5,051	8,680	104,894	8,386	127,010	170
2019	2,828	6,849	102,653	7,728	120,058	161
2020	2,505	5,515	101,824	8,936	118,674	159
2021	2,511	4,900	94,749	8,429	110,589	148
2022	2,335	4,260	101,171	8,327	116,093	155
Arithmetic mean	3,198	5,414	90,095	8,291	106,987	
Coefficient of variation	33.7	29.0	15.7	13.0	15.0	
Participation structure	3.0	5.1	84.2	7.7	100.0	

Source: Statistical Office of the Republic of Serbia, Statistical yearbooks, 2014–2023

Similarly to the production areas, the largest production level is achieved in the Šumadija and Western Serbia region, where the production share is 84.2% of the total raspberry production in Serbia. This is followed by the Southern and Eastern Serbia region (7.7%), the Vojvodina region (5.1%) and the Belgrade region (3.0%). In the analysis of raspberry production in the Republic of Serbia by region, the Vojvodina and Belgrade regions show a positive correlation between their share in the production volume and the total area under raspberries. The Šumadija and Western Serbia region has a slightly higher percentage share in the production volume compared to its share of areas under raspberries. This situation is reversed in the Southern and Eastern Serbia region, which has a slightly lower percentage share in the production volume compared to its percentage share of areas under raspberry plantations. These deviations are not large, amounting to only a few percentage points.

The average yield in the raspberry production at the level of Serbia amounts to 6.3 t/ha. However, there are certain differences per region. The greatest average value is achieved in the Belgrade region (5.8 t/ha), while the smallest is in the Southern and Eastern Serbia region (4.1 t/ha). The coefficient of variation of the yield is the highest in Vojvodina (20.4%), while it is the lowest in the Šumadija and Western Serbia region (6.1%), which can be seen in Table 7.

Table 7. Statistical indicators of raspberry yield in Serbia by region in the 2013–2022 period (units in t/ha)

Research year	Serbia-north		Serbia-south		Republic of Serbia (total)	Base Index (2013=100)
	Belgrade	Vojvodina	Šumadija and Western Serbia	Southern and Eastern Serbia		
2013	7.4	6.1	5.7	5.0	5.7	100
2014	7.4	6.0	5.6	5.0	5.6	98
2015	7.0	7.1	6.1	4.6	6.0	105
2016	7.1	6.7	5.7	4.3	5.6	98
2017	7.1	6.4	5.0	3.6	5.0	88
2018	7.1	7.0	5.7	3.8	5.6	98
2019	3.6	4.7	5.5	3.4	5.2	91
2020	3.2	3.8	5.3	3.5	4.9	86
2021	3.6	4.1	5.7	3.8	5.3	93
2022	4.1	4.7	6.3	4.1	5.9	104
Arithmetic mean	5.8	5.7	5.7	4.1	5.5	
Coefficient of variation	30.3	20.4	6.1	13.8	6.3	

Source: Statistical Office of the Republic of Serbia, Statistical yearbooks, 2014–2023

Despite the trend of increasing planting areas and number of productive stems, the yield generally remains the same or even decreases. This leads to the conclusion that Serbia has a high potential for raspberry farming, but that it is still insufficiently used. The reason can be found in the inadequate application of agrotechnical measures. According to Radosavljević, 2016, the export stagnation can also be caused by insufficient quantities which are produced, and that this is an area that needs improvement. Therefore, an increase in the economic efficiency of raspberry production can be achieved by boosting the primary raspberry production through improving the quality, and by processing raspberries into certain raspberry-based products (Sredojević i sar., 2013).

Analysis of raspberry production in Poland

Raspberries are the third largest berry species grown in Poland in terms of production scale, after strawberries and currants. Poland is gradually strengthening its position, being the largest raspberry producer in Europe and the second largest in the world. In 2012, Poland's share in European and world raspberry production was 28% and 21%, respectively. The area of raspberry cultivation increased from 13.3 thousand ha in 2003 to 28.4 thousand ha in 2012, with a simultaneous increase in production from 42.9 thousand tons to 127.1 thousand tons. (Ciebień et al. 2015).

The total area of raspberry cultivation decreased by and amounted to 19.3 thousand ha in 2024. The decrease mainly concerns raspberry plantations intended for processing, while an increase is observed in the area of dessert raspberries, including those grown under cover (Nosecka 2024).

Poland has very good conditions for growing raspberries, which makes the country one of the largest producers of this fruit in Europe. First of all, a favourable factor is the moderate climate with cool winters and moderately warm summers, which is ideal for growing raspberries. Some raspberry varieties require a period of winter cooling to produce a good harvest. The second factor is the soil. Raspberries grow best in slightly acidic soils (pH 5.5–6.5), permeable and rich in nutrients. In Poland, soils of this type occur in many regions, which allow the development of raspberry plantations. The most dominant raspberry varieties in Poland are: Polana and Polka (https://www.szkolkarstwo.com.pl/najczesciej-uprawiane-odmiany-malin-polka-i-polana; https://wmodr.pl/files/PvKIsiYRS36JXNodLcR3Dqc3GcbIHJKNHQs99SwK.pdf).

Table 8. Areas of Poland with the most favourable conditions for growing raspberries

No.	Voivodship	Raspberry cultivation area in 2023 (ha)	Characteristics
1.	Lubelskie	15.45	The largest raspberry cultivation area in Poland. Loess soils: fertile, well-drained, and slightly acidic. Moderate temperatures and optimal rainfall. Long-raspberry cultivation traditions.
2.	Mazowieckie	2.06	Fairly fertile soils. Warm summers, cool winters and even distribution of precipitation.
3.	Podkarpackie	1.02	Foothill areas with mineral-rich soils. A climate favourable for the natural hardening of plants. An ideal location for organic raspberry cultivation.
4.	Małopolskie	0.40	Areas around Nowy Sącz and Tarnów. Sandy-clay soil with appropriate humidity level. Good farming structure and processing facilities.

No.	Voivodship	Raspberry cultivation area in 2023 (ha)	Characteristics
5.	Dolnośląskie	0.22	Areas of the Kłodzko Valley and the Odra Valley. Light and permeable soils. Early spring and a long vegetation period.
6.	Wielkopolskie	0.20	Kalisz and surrounding areas. Light soils, moderately moist, ideal for intensive cultivation.

Source: Krajowe maliny… (2020), KOWR (2021), GUS (2024)

The best conditions for growing raspberries are in the Lublin region (Lublin Voivodeship), which is known as the “raspberry basin” of Poland. It is there that a significant part of the country’s raspberry production is formed (Table 8).

Poland has a long tradition of raspberry cultivation and a well-developed processing infrastructure. Many farms specialize in producing high-quality organic raspberries. More and more growers are using foil tunnels, which allows for extending the harvest period and protecting plants from adverse weather conditions. This is particularly important in regions that do not have particularly favourable natural conditions for growing raspberries.

Discussions

The position of raspberry in Serbia’s export of agricultural and food products (foreign trade exchange)

Raspberry is one of the main export goods from Serbia and it represents the key of the rural development in the regions known for raspberry production (Arilje, Valjevo, Ivanjica...). Approximately one quarter of the global raspberry production is realized in Serbia. The analysis of production and export indicates a consistent stagnation in production, year after year, accompanied by an increase in prices.

Raspberries are mainly exported in frozen forms, such as rolls, crumble, blocks, puree, and their natural state. In recent years, there has been an increase in the production of processed raspberry products (juice, jam, as well as a high-quality product of lyophilized raspberry). Almost all raspberries produced are sold through official market channels (such as purchases and sales to cold storage facilities).

During the period from 2013 to 2022 Serbia exported 89,905.9 tonnes of frozen raspberries valued at about EUR 236723.7 thousand. Serbia imports significantly smaller quantities of frozen raspberries. During the same period, 6,879.4 tonnes of frozen raspberries valued at about EUR 15,401.2 thousand were imported to Serbia (Table 9).

Table 9. Raspberries, frozen, without sugar/Export and import of raspberries to/from all countries in the world/2013-2022

	Export		Import	
	Quantity (in tonnes)	**Value (in 000 EUR)**	**Quantity (in tonnes)**	**Value (in 000 EUR)**
2013	61,416.9	141,048.9	4,043.2	7,641.2
2014	73,252.6	178,519.9	4,253.7	9,500.4
2015	93,731.6	241,241.4	5,061.9	13,128.4
2016	85,956.9	224,070.0	6,225.1	14,427.9
2017	94,000.2	206,634.0	11,067.1	18,017.2
2018	103,275.8	191,417.3	10,713.2	15,003.6
2019	114,354.2	209,336.7	8,772.6	14,333.3
2020	107,745.2	259,278.7	8,057.5	18,447.4
2021	97,961.5	360,609.4	6,673.1	25,640.4
2022	67,364.5	355,080.6	3,926.8	17,872.1
Average	89,905.9	236,723.7	6,879.4	15,401.2

Update date: 21.03.2024. Source: SORS;

https://webappcenter.nbs.rs/WebApp/ExchangeRate/ExchangeRateAverage?isSearchExecuted=true&Currency=978&Period=2&OrderBy=Date+desc&Pagging.CurrentPage=1&Pagging.PageSize=50

The largest quantities of frozen raspberries without sugar are exported to the EU countries: Germany (28,304.3 t), France (19,080.9 t), Belgium (6,818.4 t), the United Kingdom of Great Britain and Northern Ireland (4,238.7 t), and Austria (3,001.5 t) (mainly due to the growing focus on healthy diets in these countries). Raspberries are imported from Bosnia and Herzegovina (5,117.6 t), Germany (399.3 t), Poland (253.4 t), Bulgaria (117.9 t), Belgium (71.9 t), and Austria (51.5 t) (https://data.stat.gov.rs/Home/Result/170304?languageCode=sr-Cyrl&displayMode=table&guid=966f539d-3ec8-4aca-be32-ba278a7e1662)[4].

During the period from 2013 to 2022, 3476.0 tonnes of fresh raspberries valued at around USD 5903.5 thousand were exported from Serbia. Significantly lower quantities of fresh raspberries are imported to Serbia. During the same period, 98.6 tonnes of fresh raspberries valued at around EUR 302 thousand were imported to Serbia (Table 10).

Table 10. Raspberries, fresh/Export and import of raspberries to/from all countries in the world/2013-2022

	Export		Import	
	Quantity, in tonnes	**Value in thousand EUR**	**Quantity, in tonnes**	**Value in thousand EUR**
2013	597.6	985.0	0.2	4.1
2014	5,056.0	9,009.6	26.3	58.2
2015	6,422.4	11,733.1	2.2	35.0
2016	3,389.2	6,052.3	96.7	230.1

4 *The data refer to the average values during the 2013-2022 period.*

	Export		Import	
	Quantity, in tonnes	Value in thousand EUR	Quantity, in tonnes	Value in thousand EUR
2017	5,663.9	7,027.9	130.4	185.2
2018	3,858.3	3,771.3	74.7	205.5
2019	4,922.4	6,004.1	81.4	197.1
2020	1,563.6	2,678.6	30.8	133.8
2021	1,900.1	5,756.2	42.6	393.7
2022	1,386.8	6,016.5	500.3	1,577.7
Average	3,476.0	5,903.5	98.6	302.0

Update date: 21.03.2024. Source: SORS; https://www.nbs.rs/sr_RS/finansijsko_trziste/medjubankarsko-devizno-trziste/kursna-lista/prosecni-kursevi/index.html

The largest quantities of fresh raspberries are exported to the EU countries, primarily to Austria (1,576.3 t), Germany (1,322.7 t), and Italy (503.1 t) (https://data.stat.gov.rs/Home/Result/170304?languageCode=sr-Cyrl&displayMode=table&guid=eb42bd8b-0cee-430e-a549-d4df387a4bdb).[3]

The position of raspberry in export of agricultural and food products of Poland (foreign trade exchange)

Table 11. shows the value of raspberry exports and imports from/to Poland. The data shows that exports of both fresh and frozen raspberries from Poland are increasing year by year, which confirms intensive production.

Table 11. Raspberry export and import – Poland, 2013-2022

YearS	Raspberry export				Raspberry import			
	(thousand EUR)		(t)		(thousand EUR)		(t)	
	Fresh	Frozen	Fresh	Frozen	Fresh	Frozen	Fresh	Frozen
2013	23,933.50	101,214.90	16,221.40	63,921.40	1,786.90	7,096.90	313.2	2,765.80
2014	26,197.00	118,625.70	18,192.80	60,641.30	3,329.20	11,276.70	902.3	4,694.80
2015	39,339.00	123,308.60	17,880.00	57,530.30	5,416.10	20,802.80	5,259.60	7,685.30
2016	32,362.90	119,589.60	18,899.80	53,378.00	6,092.60	18,832.00	1,824.50	8,289.50
2017	18,436.60	96,682.40	10,808.20	53,500.80	6,433.50	25,644.80	2,187.40	14,408.10
2018	15,968.30	74,824.80	11,354.50	48,763.00	8,000.80	23,552.20	1,832.60	15,552.00
2019	17,492.60	71,871.70	7,698.50	46,948.20	15,605.20	32,136.60	3,194.30	19,127.10
2020	23,766.50	100,099.40	8,487.40	49,087.40	15,339.70	46,065.00	2,678.60	20,904.40
2021	40,663.20	192,388.10	8,792.20	60,112.30	23,424.70	96,524.80	3,757.50	26,538.40
2022	49,882.70	218,719.60	11,140.20	48,774.60	31,363.10	106,181.70	4,843.50	28,997.30

Source: MRiRW (2025)

The price of raspberries is affected by several factors (exchange rates, import duties, weather conditions, as well as the supply and demand), which causes fluctuations over years. The purchase price of raspberries experienced a slight decline from 2013 to 2019, after which the price started to rise (Table 12). During the "COVID" pandemic, there was a growing global demand for raspberries and other berries, which led to an increase in the price. The reason for this is the content of the raspberry fruit, which has medicinal properties serving both as an antioxidant and prevention.

Table 12. Raspberry purchase prices in Republic of Serbia, 2013-2022

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Average price**
Purchase price (EUR/kg)	1.63	1.30	1.60	1.58	1.09	0.81	1.22	1.67	3.21	4.16	1.83

Source: SORS; https://www.nbs.rs/sr_RS/finansijsko_trziste/medjubankarsko-devizno-trziste/kursna-lista/prosecni-kursevi/index.html

Serbia is competitive on the global market due to the lower service costs during the raspberry production process (transport costs, cheap labour and inexpensive land), which allows exporters to offer lower prices while still making a profit. Since the demand for raspberry is growing on the global market, investing in this production is fully justified. Therefore, it can be expected that the export of frozen raspberries will increase in the upcoming period.

Representatives of raspberry growers' associations have proposed an initiative to declare raspberry to be a strategic product, which would establish a uniform price per kilogram in the entire territory of Serbia and ensure government subsidies for each kilogram delivered. It is also necessary to invest in irrigation systems, since high revenues cannot be achieved without them.

In the years 2013-2022, there was a significant fluctuation in the prices paid to producers of fresh raspberries. The starting price (EUR 1.20 in 2013) was close to the price in 2016 (EUR 1.19). The lowest value was recorded in 2018 (EUR 0.56), while the record value was recorded in 2021 (EUR 3.50) and slightly lower in 2022 (EUR 2.96). The average price for 1 kg of raspberries in Poland in the analysed period amounted to EUR 1.62 (Table 13).

Table 13. Prices paid to producers for fresh raspberries in Poland (EUR/kg), 2013-2022

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average price
Purchase price (EUR/kg)	1.20	1.13	1.82	1.19	1.03	0.56	0.97	1.39	3.50	2.96	1.62

**Prices were converted from PLN to EUR at the average exchange rate as of August 31. particular year*

Source: own calculations based on: (GUS 2015; Nosecka 2024)

The purchase prices of raspberries in Serbia are similar to those in Poland. The average purchase price of raspberries for the research period is 1.83 euros, while in Poland it is 1.62 euros. The lowest purchase prices for both countries were in 2018 (0.81 euros in Serbia and 0.56 euros in Poland), which shows a similar situation on the raspberry market in both countries.

Measures for improving raspberry production

Raspberry is one of the most important fruit species in the agricultural economies of many countries, particularly in the regions with favourable climate and soil conditions for cultivation. In addition to being a significant economic resource, raspberry production plays a key role in sustainable development since it connects its economic, ecological, and social aspects. Furthermore, the importance of raspberry for sustainable development is reflected in the combination of economic profitability and a careful approach to the environment and communities, thus contributing to the sector's sustainability. The application of modern technologies and innovative methods in raspberry production can bring long-term benefits to agricultural producers and the broader community, as well as the country as a whole.

Improvement of raspberry production requires an approach which involves modern agronomic techniques, efficient organization, as well as the use of new technologies to improve the quality, quantity and economic sustainability of production, but also the safety and quality of the produced raspberry. According to Popović i sar. (2017), safety and quality have the decisive impact on the competitiveness of the agri-food sector in the domestic and global market, since they establish a good reputation for producers. Some of the measures for intensifying raspberry production would include the following:

- Creating new or modernizing old plantations in the areas with the optimal natural characteristics for raspberry production in order to gain maximum results, or in other words, *zoning of areas for raspberry cultivation.* This is important because in recent years, there have been attempts to grow raspberries on large areas in the parts of Serbia where raspberries were never traditionally cultivated, such as the region of AP Vojvodina, and these attempts have not given favourable results;
- Monitoring soil quality in order to preserve and improve its potential and effective production capacities. In addition to using certified planting material of high-quality raspberry varieties, successful raspberry production must be conducted on the suitable soil type in order to achieve the maximum yield potential. The best soils for cultivating raspberries are permeable, loose, slightly acidic soils with a pH around 6, rich in humus levels (above 3%) (Kljajić, 2014; Bošković Rakočević i sar., 2021);
- Selecting the appropriate raspberry variety while also introducing new varieties (*Meeker, Polka, Polana, etc.)* which are adaptable to the changing climate conditions observed lately and resistant to a wide range of diseases and pests that have a negative effect on raspberry cultivation. Intensifying raspberry production would increase the export potential and decrease the need for imports;
- Establishing the systems for monitoring plant growth: 1) implementing systems for monitoring plant growth, such as sensors and mobile phone applications. This enables fast detection of problems (for example, lack of nutrients) and timely reactions; 2) using drones equipped with cameras and sensors to monitor crop conditions and provide a detailed insight into the needs and health status of plants;

- Organizing the processing and marketing of raspberries and raspberry-based products through direct sales and rural tourism. In accordance with this, investments should focus on improving storage facilities and processing capacities such as drying plants, processing machines for juice production, and alike;
- Investing in insufficiently developed infrastructure in hilly-mountainous regions;
- Introducing modern technologies of cultivation with the complete implementation of agrotechnical and pomotechnical measures, including the mandatory irrigation and hail protection, as well as crop insurance;
- Using modern technologies for controlling pests and diseases: 1) application of biological preparations and natural enemies for controlling pests, which can reduce the use of chemical pesticides and contribute to a healthier environment and greater fruit health safety, and 2) precise application of pesticides using drones or systems for precise pesticide application which reduces the quantity of applied chemicals and limits the area where chemicals are used. All of this decreases negative environmental impacts;
- Establishing and strengthening of processing capacities. Due to the lack of processing capacities and a short life of fresh raspberries, the majority of raspberries are exported frozen. The dominant variety in raspberry production in Serbia, Willamette, must be frozen within an hour or two after harvesting;
- Improving the logistics and distribution of raspberries which implies developing a logistic system that will ensure faster raspberry distribution with the minimum quality loss. This is essential due to the sensitivity of the raspberry fruit, which requires cooling and transportation under appropriate conditions;
- Associating of producers in order to improve the marketing approach and a response to the growing demands of the modern market. Both large and small holdings must adapt to the market by building economic ties between themselves in order to increase their productivity and production efficiency (Radosavljević, 2014, 2016);
- Collaborating with professionals and agricultural institutions by organizing adequate and continuous education of agricultural producers provided by experts in all production segments. The cooperation with agricultural extension services, research institutes and agricultural experts can inform producers about new methods, technologies and market opportunities. In addition, the relevant Ministry and similar institutions should be involved in supporting agricultural producers by means of subsidies and loans. Apart from the government support, the EU subsidies and grants are very important since they can significantly lower the initial costs for implementing new technologies and methods in the raspberry production process. According to Užar and Radojević, 2017, there are three categories of support measures for berry producers, including raspberry producers: a) ***structural support measures,*** which include improvement of planting, b) ***market support measures,*** which involve measures which stimulate fruit export, and c) ***investment support measures,*** involving financial support for various storage and procession capacities;

- Selling raspberries directly to consumers through established direct sale channels (shops or online sales), which can increase the profit and ensure better control over product quality;
- Producing organic raspberries, as an increasing number of consumers prefer products that are ecologically acceptable. The organic product market can be used in this case;
- Increasing the export of fresh raspberries since their price is two to three times higher than the price of frozen raspberries;
- Producing premium-processed raspberry products;
- Investing in greenhouse raspberry production in order to extend the raspberry ripening period to six months. This would enable the export of fresh raspberries and, consequently, result in a higher price per unit of yield and off-season sales.

In the context of raspberry farming, sustainable development implies the improvement of production and economic results while protecting the environment and enhancing the quality of life of local communities.

Conclusions

From the aspect of export economy, raspberry is one of the most important agricultural crops in the Republic of Serbia since it ensures a large influx of foreign currency and potentially secures the country's leading position on the list of global raspberry producers and exporters. Here success lies in the good international marketing strategy. However, despite the great efforts made by export companies in the field of marketing, the export price of raspberry continues to fluctuate and is influenced by general (global) economic conditions.

The following can be concluded for the observed ten-year period covered in this paper: –The total area where raspberries are cultivated in the world amounts to 112,886,000 ha. The largest areas under raspberries are in Europe (87,555,000 ha or 77.56%); –The greatest global producers of raspberries are the Russian Federation, Mexico and Poland, while Serbia is ranked fourth; –In the Republic of Serbia, raspberries are grown on 19,662 ha. The most dominant raspberry varieties is „Willamette". The largest areas under raspberries are located in the Šumadija and Western Serbia region (16,021 ha or 81.5%). The greatest raspberry producer is the Zlatibor district; –The average yield of raspberries in Serbia amounts to about 5.5 tonnes per hectare; –In Serbia, raspberry production amounts to an average of 106,987 tonnes in the ten-year period (2013-2022); –The largest part of export is directed towards the European Union; –The greatest importers of frozen raspberries from Serbia are Germany, France and Belgium; –The largest quantities of fresh raspberries are exported to Austria, Germany and Italy; –Seasonal raspberry production involves more than 200,000 residents of Serbia, including seasonal workers; –The price of raspberries fluctuates over the years and depends on the exchange rate, import duties, weather conditions, as well as the supply and demand.

In Poland, raspberry production has increased significantly in recent years. The area of raspberry cultivation increased from 13.3 thousand ha in 2003 to 28.4 thousand ha in 2012, with a simultaneous increase in production from 42.9 thousand tons to 127.1 thousand tons, after which production increased steadily. The reason for this is the introduction of the "polana" variety, which produces fruit already in a few months. Also, the European Union subsidies for milk and fruit growing that Poland received in 2007 significantly contributed to the increase in the area under raspberries and the increase in production. But, the total area of raspberry cultivation decreased by and amounted to 19.3 thousand ha in 2024. The decrease mainly concerns raspberry plantations intended for processing, while an increase is observed in the area of dessert raspberries, including those grown under cover.

The best conditions for growing raspberries are in the Lublin region (Lublin Voivodeship), and in addition to Polana, the dominant variety is Polka. Raspberries are mainly exported from Poland to the markets of Germany, Great Britain, Belgium, and France, making it a major competitor of Serbia in exports.

Improvement of raspberry production requires a comprehensive approach that combines modern technologies, environmentally friendly methods and market strategies. Focusing attention on quality, production process efficiency, and product diversification can significantly improve the competitiveness and sustainability of production. By means of education and investment in technology, raspberry farming can become a more profitable and more environmentally responsible sector. Therefore, the goal is to produce sufficient quantities of high-quality raspberries, which would improve the position of both countries in the global market, compared to the current situation.

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Conflict of interests

The authors declare that they have no conflict of interest.

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TYPE OF ACCOMODATION IN RURAL AREAS IN SERBIA AND CHALLENGES IN FUTHER RURAL TOURISM DEVELOPMET

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A B S T R A C T

This study explores tourists' accommodation preferences in rural areas of Serbia, aiming to identify the most frequently used types of lodging, key decision-making factors, and potential differences across demographic groups. The research is based on a survey of 250 respondents conducted in March 2024, with data analyzed using descriptive statistics, t-tests, and ANOVA. Results show that tourists most often choose household-based accommodation and hotels, with location, equipment, and accessibility being the most influential factors. No statistically significant differences were found across gender, age, or education level. The study highlights the dominance of short domestic stays, limited influence of digital platforms, and a high share of informal accommodation practices. Findings suggest the need for investment in infrastructure and support for formalizing rural tourism services. The research contributes to understanding rural tourist behavior and offers practical insights for improving rural hospitality offerings in Serbia.

Introduction

Rural areas, as distinct territorial units, are typically defined by low population density, specific land use patterns, and a strong sense of community identity (Cvijanović & Ružić, 2024). Within these spaces, rural tourism emerges as a multifaceted concept that encapsulates various forms of tourism including agritourism, village tourism, and ecotourism. Although these terms are often used interchangeably, rural tourism remains the most comprehensive, encompassing all tourism activities that occur in

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rural settings and utilize the area's natural, cultural, and economic resources (Janković, 2022). According to the Council of Europe (1986), rural tourism is not restricted to farming activities but broadly includes all services and experiences hosted in rural areas, often provided by local populations through accommodation facilities such as guesthouses, lodges, and agritourism units. The OECD further elaborates this definition by emphasizing the functional, spatial, and cultural dimensions of rural tourism, highlighting its embeddedness in traditional lifestyles and sustainability principles.

Despite its recognized potential, rural tourism in Serbia remains underdeveloped and highly fragmented. While more than 90% of Serbia's land area is classified as rural, and a significant proportion of the population resides outside urban centers, the sector has not reached its anticipated economic and developmental impact (Gajić & Cvijanović, 2022; Vidić, 2018). Structural constraints such as inadequate infrastructure, weak institutional support, and limited entrepreneurial capacity continue to hinder sustainable growth (Bejatović & Ristić, 2016). Although rural tourism is frequently positioned as a strategic tool for revitalizing marginalized areas, enhancing rural livelihoods, and diversifying local economies (Vukolić et al., 2024), empirical research on visitor behavior, preferences, and satisfaction in rural contexts, particularly regarding accommodation, remains insufficient.

The quality and type of accommodation play a crucial role in shaping the rural tourism experience. Accommodation not only serves as a necessary logistical component but also constitutes an experiential and symbolic element that reflects local identity, cultural authenticity, and hospitality standards (Vidić, 2018). Investments in rural accommodation are increasingly recognized as a prerequisite for elevating the competitiveness of rural destinations and addressing visitor expectations. Nevertheless, there is a lack of systematic evidence on how tourists perceive various forms of rural accommodation and what factors influence their decision-making processes, especially in the context of Serbia's post-pandemic tourism recovery.

This paper seeks to address these research gaps by exploring the accommodation preferences of tourists who visit rural areas in Serbia. Drawing on recent empirical data collected in 2024, the study investigates which types of accommodation are most commonly used, which attributes are deemed most important when choosing accommodation, and whether these preferences vary across demographic groups. By focusing on the intersection of consumer behavior and rural development, the study contributes to a deeper understanding of how accommodation-related decisions can inform targeted investment, planning, and policy-making. In order to address the identified research gaps and contribute to evidence-based planning of rural tourism development, this study aims to answer the following research questions:

RQ1: What types of accommodation are most frequently used by tourists in rural areas of Serbia?

RQ2: What factors influence tourists' decision-making when selecting rural accommodation?

RQ3: Are there significant differences in accommodation preferences based on demographic characteristics such as gender, age, and education level?

The findings aim to support the formulation of evidence-based strategies for rural tourism development, with a particular emphasis on aligning the expectations of contemporary tourists with the socio-economic realities of rural communities. Through this approach, the study underscores the strategic importance of accommodation in the broader framework of rural tourism, positioning it as both a driver and a reflection of sustainable rural transformation.

Theoretical background

In contemporary academic discourse, rural accommodation is no longer a homogeneous category. As noted by Cors-Iglesias et al. (2020), the diversity of rural areas in Catalonia leads to the differentiation of peer-to-peer (P2P) accommodation typologies, highlighting the need for localized approaches in planning and evaluating rural tourism supply. Their analysis emphasizes that universal solutions often overlook the specific characteristics of local territories, infrastructure, and social relations. Conversely, Pulido-Fernández et al. (2024) demonstrate that the choice of accommodation (rural vs. hotel) significantly shapes tourist behavior, including length of stay, spending patterns, and activity preferences. The functional aspects of the growth of small accommodation businesses in rural areas are further problematized in the study by Ye et al. (2019), which points out that the expansion of supply may positively impact guest experience and financial performance, but only when accompanied by strategic management and high-quality service. In contrast, Wojciechowska-Solis et al. (2022) identify substantial "quality gaps" in rural accommodation facilities in the Lublin region, which compromise guest satisfaction and the competitiveness of the destination. From a critical perspective, this discrepancy indicates that quantitative growth in supply must be followed by standardization and consistent quality monitoring.

Accessibility introduces an additional layer of complexity, particularly for vulnerable groups. McDaniels et al. (2017) warn that rural communities are often underserved in terms of infrastructure, making it difficult for tourists with special needs to access these destinations. Although tourism is often viewed as a vehicle for inclusion, without adequate accommodation and transport solutions, it may contribute to further marginalization. This issue remains underexplored in the existing literature on rural tourism. When it comes to accommodation selection motivations, Choo et al. (2017) propose a set of criteria that encompass both emotional and functional factors, with authenticity, local interaction, and sustainability emerging as key components. However, as Pina and Delfa (2005) argue, the choice of accommodation type still predominantly depends on tourists' demographic and economic characteristics, suggesting that economic considerations continue to play a primary role despite rising awareness of sustainability. Short-term rentals in rural areas, according to Torkington et al. (2025), offer potential for diversifying accommodation supply and attracting younger visitors. Nonetheless, if not properly regulated, they may generate tensions within local communities. O'Halloran (2025), in a recent entry in the Encyclopedia of Tourism, points out that the phenomenon of rural accommodation remains conceptually unsettled, which complicates comparative research and the formulation of coherent policy frameworks.

Given the growing need for ecological solutions, Domljan et al. (2025) propose the integration of sustainable design, inspired by local heritage, into the interiors of rural accommodation units, an approach that could enhance the distinctiveness of the offer and strengthen local identity. A similar line of argument is developed by Cammarota et al. (2025), who explore local residents' perceptions of the concept of "sustainable hospitality" and highlight that the main challenge lies in bridging the gap between theoretical sustainability norms and practical implementation on the ground. Rural tourism is fundamental for both economic growth and the preservation of culture. Lazović et al. (2024).

Given the identified gaps in service quality, regulatory frameworks, and alignment between sustainability discourse and practice, this study aims to provide a comprehensive understanding of how different types of rural accommodation influence tourist experiences, community perceptions, and sustainable development outcomes, ultimately contributing to more informed planning and management strategies in rural tourism.

Materials and methods

1.1. Sample and procedure

The research was conducted in March 2024 across selected rural and peri-urban areas in the Republic of Serbia, targeting individuals who had actively participated in rural tourism within the past two years. The selection of participants was based on purposive sampling, where inclusion was limited to respondents who had paid for accommodation or other tourist services in rural areas, thus excluding those who visited family or owned private houses in villages.

Data were collected using face-to-face survey interviews, administered by trained research assistants over a period of 18 days (March 4–22, 2024). A total of 250 valid responses were collected. The sample included 116 males (46.4%) and 134 females (53.6%). The largest age group was 18 to 25 years (34.4%), while the smallest group was 51 to 59 years (8.4%). The majority of respondents lived in cities with over 200,000 inhabitants (43.6%), and only 9.6% resided in rural settlements. Regarding education, 40.0% had completed high school, 36.4% held a university degree, and 9.2% had a master's or higher academic qualification. Most respondents were employed (78.4%), predominantly in administrative (20.8%) and professional occupations (18%) (Table 1).

Table 1. Sociodemographic characteristics of respondents

	f	[%]
Gender		
Male	116	46.4
Female	134	53.6
Age		
18 to 25	86	34.4
Od 26 do 30	56	22.4
Od 31 do 40	56	22.4
Od 41 do 50	31	12.4
Od 51 do 59	21	8.4
Place of birth		
City over 200.000 inhabitants	109	43.6
Town from100.000 to 199.999 inhabitants	47	18.8
Town from 50.000 to 99.999 inhabitants	26	10.4
Town up to 50.000 inhabitants	44	17.6
Village	24	9.6
Degree		
Finished high school	100	40.0
College	36	14.4
University degree	91	36.4
Master or higher degree	23	9.2
Job		
Student (without a job)	37	14.8
Student (with job)	17	6.8
Employed	196	78.4

Source: Authors' research

This study adhered strictly to ethical standards for research involving human participants. Participation was anonymous and voluntary, and respondents were informed about the objectives of the study, the confidentiality of their data, and their right to withdraw at any time without consequences. All participants provided verbal informed consent prior to the interview. The study involved no physical or psychological risks and no collection of sensitive personal data, thus formal approval from an ethics committee was not required, in accordance with the ethical guidelines of the Republic of Serbia and the Declaration of Helsinki (2013).

3.2.Instruments and pilot study

The survey instrument was developed following an extensive review of relevant academic literature and was carefully adapted to the specific socio-cultural and infrastructural context of rural tourism in Serbia. It was structured into four thematic sections: (1) sociodemographic characteristics, (2) vacation behavior (frequency, destination, and duration), (3) types of accommodation most frequently used in rural areas, and (4) key factors influencing accommodation selection. The final section comprised 15 items designed to measure the importance of various decision-making elements using a five-point Likert scale (1 = not important at all; 5 = extremely important). These items covered a range of attributes including price, location, accommodation facilities, online reviews (e.g., Facebook, Instagram, Booking), booking procedures, road infrastructure, internet connectivity, and proximity to recreational services.

To ensure the instrument's clarity, cultural relevance, and technical adequacy, a pilot study was conducted with 30 respondents who matched the target profile of rural tourism consumers. The pilot participants were recruited from different age and education groups to verify general comprehensibility across demographic segments. Respondents were asked to complete the full version of the questionnaire and then provide qualitative feedback on the clarity, terminology, item structure, and overall flow of the instrument.

In parallel, the draft version of the questionnaire was reviewed by an expert panel comprising two university professors specializing in rural tourism and one expert in quantitative research methodology. These professionals assessed the content validity of the instrument, offering targeted feedback on the alignment of the items with theoretical constructs and practical applicability in rural tourism research. Their input led to minor but meaningful revisions in phrasing, the inclusion of more context-specific examples, and the reordering of some items to improve logical flow. Following these adjustments, the final version of the instrument was confirmed to be comprehensible and appropriate for full-scale administration. The average completion time during the pilot phase was approximately 10 to 12 minutes, indicating high feasibility for implementation in face-to-face interviews without respondent fatigue.

1.2. Data processing and statistical analysis

Data entry, cleaning, and analysis were performed using IBM SPSS Statistics 27.0 and Jamovi 2.4.8. Descriptive statistics (means, standard deviations, frequencies, percentages) were used to describe the sample and key vacation behaviors (Taherdoost, 2016). To test for differences in preferences across demographic groups, independent samples t-tests (for gender) and one-way ANOVA (for age and education level) were employed (Tavakol & Dennick, 2011). Where applicable, Tukey's HSD post-hoc tests were used to determine the location of significant differences (World Medical Association, 2013). Before performing parametric tests, assumptions of normality and homogeneity of variances were verified using the Shapiro–Wilk and Levene's tests, respectively. All variables met these assumptions. Additionally, effect sizes were calculated using Cohen's d (t-test) and eta-squared η^2 (ANOVA), interpreted as small (0.01), medium (0.06), and large (0.14), where necessary (Taherdoost, 2016).

To evaluate the internal consistency of the instrument, Cronbach's alpha coefficient was calculated for the 15-item scale measuring accommodation decision factors (World Medical Association, 2013). The result of $\alpha = 0.740$ confirmed satisfactory reliability. Internal consistency of subscales grouped by thematic content (e.g., digital accessibility, service quality, infrastructure) ranged from $\alpha = 0.68$ to $\alpha = 0.79$, supporting their application in further analyses. Construct validity was assessed via Exploratory Factor Analysis (EFA) using Principal Component Analysis (PCA) with Varimax rotation, which confirmed a three-factor structure aligned with conceptual groupings: (1) Functional features, (2) Booking and online presence, and (3) Surrounding infrastructure and entertainment. All factor loadings exceeded 0.60, and the Kaiser-Meyer-Olkin (KMO) measure was 0.823, indicating sampling adequacy. Bartlett's Test of Sphericity was significant ($\chi^2 = 893.27$, $p < 0.001$), confirming suitability for factor analysis. Content validity was supported by expert judgment from two professors in rural tourism and one methodological expert, who evaluated item relevance and theoretical alignment (Taherdoost, 2016).

Results

The results indicate that the majority of respondents prefer to diversify their vacation destinations, with more than half (58.4%) spending their holidays both within Serbia and abroad. A smaller segment (21.2%) travels within Serbia and neighboring countries, while a minority of respondents chooses to vacation exclusively either in Serbia (14.4%) or exclusively abroad (6.0%). This suggests that rural tourism in Serbia is predominantly experienced by individuals who also engage in international or regional travel, indicating a mobile and travel-savvy tourist profile. When traveling abroad, most respondents tend to stay for a full week or longer, with 54.0% typically spending 7 to 10 days, and another 27.6% extending their trips to 11 to 14 days. Only a small fraction travels for shorter periods, indicating that international vacations are perceived as more extended and comprehensive experiences. In contrast, vacations within Serbia tend to be significantly shorter in duration. The most common domestic vacation length is 1 to 3 days (38.0%), followed by 4 to 6 days (34.4%), with only 17.2% staying 7 days or more. This pattern reflects a tendency to engage in rural tourism within Serbia through shorter, often weekend-based trips, likely due to factors such as geographic proximity, work obligations, or spontaneous planning. These insights reinforce the role of rural tourism in Serbia as a form of short-term escape rather than a substitute for longer, traditional holidays (Table 2).

Table 2. Where and how much time you spend on vacations

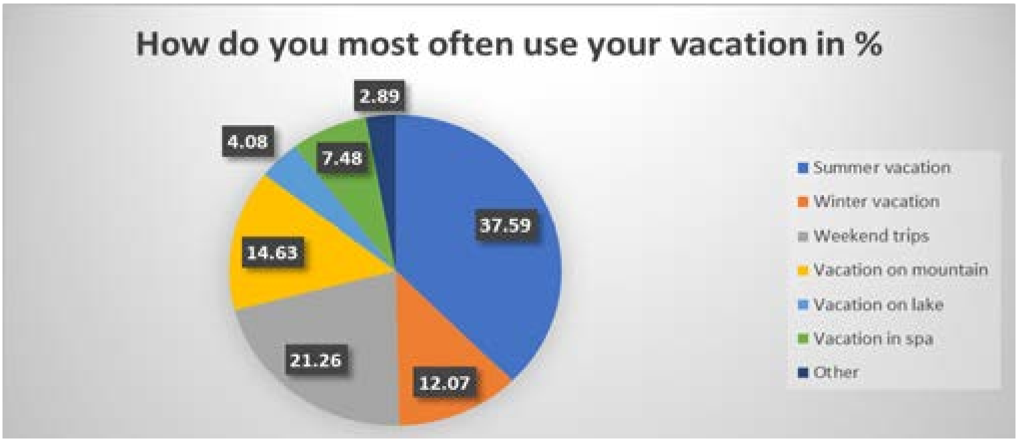
	f	[%]
Where do you usually spend your vacation?		
In Serbia	36	14.4
In Serbia and in surrounding countries	53	21.2
In Serbia and abroad	146	58.4
Exclusively out of Serbia	15	6.0
How long does your vacation usually last when you travel abroad?		
More than 2 weeks	14	5.6
From 11 to 14 days	69	27.6
From 7 to 10 days	135	54.0

	f	[%]
From 4 to 6 days	19	7.6
From 1 to 3 days	13	5.2
How long does your vacation in Serbia usually last?		
7 days and longer	43	17.2
From 4 to 6 days	86	34.4
From 1 to 3 days	95	38.0
One day trip	26	10.4

Source: Authors' research

Figure 1 provides a graphical representation of the dominant patterns in how respondents typically utilize their vacation time, offering insight into the purpose and type of trips they most frequently undertake. The visual data indicate that summer vacations are the most prevalent form of travel among respondents, suggesting that extended leisure trips during the warmer months remain a preferred choice. This is followed by weekend trips, which represent a significant portion of vacation usage, reflecting a trend toward short, frequent escapes likely motivated by proximity, affordability, and time constraints. Other common forms of vacation use depicted in the figure include winter vacations, mountain holidays, spa visits, and lake tourism. These categories point to the popularity of nature-based and health-oriented tourism, especially within domestic or nearby destinations. The inclusion of "other" categories further suggests diversity in travel motivations, potentially encompassing cultural, rural, or family-related travel. Taken together, the figure emphasizes that vacation behavior among respondents is characterized by both seasonal concentration (summer and winter) and purpose-driven segmentation, such as relaxation (spa), adventure (mountain), or convenience (weekend trips). This diversity in vacation usage patterns highlights the importance of offering flexible, tailored rural tourism products that cater to different timeframes, interests, and tourist profiles.

Figure 1. How do you most often use your vacation?

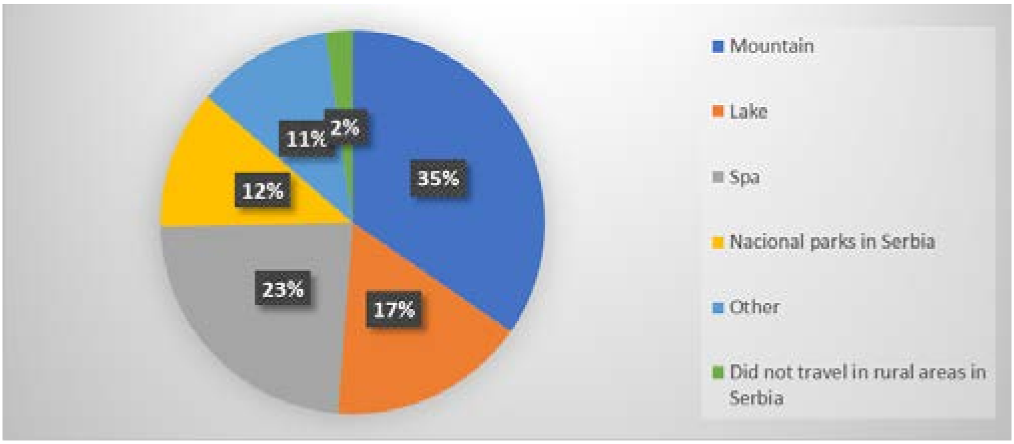


Source: Authors' research

Figure 2 reveals distinct patterns in how tourists engage with rural destinations in Serbia, emphasizing the dominant types of rural environments they prefer when vacationing. The data clearly show that mountain areas are the most visited, with 35% of respondents indicating that their most recent rural vacation took place in a mountainous region. This preference reflects the strong appeal of nature-based tourism, clean air, outdoor recreation, and panoramic landscapes that mountains typically offer, making them a central component of Serbia's rural tourism portfolio. Spa destinations are the second most visited type of rural location, selected by 23% of respondents. This highlights the importance of health and wellness tourism in rural settings, where visitors seek not only rest but also therapeutic and preventive treatments. The popularity of spas points to the multifunctionality of rural tourism, combining leisure with physical well-being. Visits to lakes account for 17%, suggesting that aquatic and recreational amenities also play a significant role in shaping rural travel preferences. Lakes provide opportunities for swimming, fishing, and passive relaxation, especially during warmer months, and are likely visited in short, seasonal stays.

National parks were selected by 12% of participants, indicating interest in protected areas and ecotourism. This reflects a segment of tourists motivated by environmental values, biodiversity, and educational or interpretive experiences related to nature. An additional 11% of respondents categorized their rural vacation as "other," which may include cultural, religious, or agritourism-related visits that fall outside the main geographic typologies. These visits reflect the diversity of motivations for rural travel and suggest opportunities for product diversification. Only 2% of respondents reported that they had not traveled to rural areas, confirming that rural tourism has broad reach and relevance, at least among the surveyed population.

Figure 2. The most common way of using vacation in rural areas



Source: Authors' research

The data presented in Table 3 provide a comprehensive insight into respondents' travel patterns related to rural tourism, focusing on travel destinations, types of rural environments visited, and the categorization and formalization of accommodation used. More than half of the respondents (55.2%) report that they visit rural areas exclusively in Serbia, suggesting that domestic rural tourism remains the dominant form of rural engagement. An additional 24.4% travel to rural areas both in Serbia and neighboring countries, while 18.4% have experience with rural destinations both in Serbia and more distant foreign countries. Only 2.0% of respondents engage in rural tourism exclusively abroad, confirming that Serbia remains the primary rural destination for most domestic tourists. When asked about the last rural destination they visited in Serbia, the majority (45.2%) indicated mountain areas, affirming the continued popularity of mountainous regions as central hubs for rural tourism in Serbia. These areas likely offer appealing landscapes, clean air, outdoor activities, and seasonal tourism infrastructure. Spa towns were the second most visited category (16.4%), reflecting the importance of health and wellness as motives for rural travel. Visits to national parks accounted for 10%, indicating an interest in ecotourism and protected natural areas. Only 9.6% visited lakes, while 18.8% selected "other", likely encompassing cultural villages, rural events, or agritourism farms, demonstrating the diversity of rural tourist experiences. Concerning accommodation formalization, the responses suggest a relatively fragmented and partially informal rural tourism market. Only 29.4% of respondents stayed in categorized accommodation and received a fiscal receipt, indicating a formal, registered service. However, 25.8% stated they stayed in private houses and paid in cash without receiving a receipt, which points to a high share of informality in rural lodging practices. Another 16.5% did not notice the categorization but did receive a receipt, while 4.8% reported both lack of categorization awareness and lack of any receipt, further supporting the presence of semi-legal or informal operations. Interestingly, 4.4% reported staying in private homes booked through platforms like Booking.com, and receiving electronic receipts, which suggests a gradual integration of digital intermediaries in rural accommodation booking, increasing transparency and standardization.

Table 3. Visits of rural areas

	f	**[%]**
Do you visit rural areas and outside of Serbia?		
No, only in Serbia	138	55.2
In Serbia and in surrounding countries	61	24.4
In Serbia and outside of Serbia	46	18.4
Exclusively abroad	5	2.0
What is the last tourist visit that you had in Serbia?		
Mountains	113	45.2
Lake	24	9.6
Spa	41	16.4
Some of Serbian National parks	25	10.0
Other	47	18.8

	f	[%]
Was the last accommodation you stayed in in a rural area of Serbia categorized?		
Yes, it is categorized and I received a receipt when paying for the accommodation	73	29.4
It is categorized, but we did not receive a receipt for the accommodation	9	3.6
I did not pay attention to whether the accommodation was categorized, but we received a receipt for the paid accommodation	41	16.5
I did not pay attention to whether the accommodation was categorized and I did not receive a receipt when paying for the accommodation	12	4.8
We stayed in a private house where we paid for the accommodation in cash, without receiving a receipt	64	25.8
We stayed in a private house for which we paid for the accommodation, and received a receipt by email (booked/paid through Booking)	11	4.4
Something else	38	15.3

Source: Authors' research

Table 4 provides insight into the preferred types of accommodation among rural tourists in Serbia, revealing important patterns in consumer behavior and structural characteristics of the rural hospitality sector. The most frequently chosen type of accommodation is a room or apartment within a household, selected by 25.52% of respondents. This preference highlights the importance of private, family-run lodging that offers direct interaction with local hosts, home-like comfort, and an authentic rural experience. These forms of accommodation often align with tourists' desire for personalized service and cultural immersion. In second place, hotels are preferred by 18.39% of respondents, indicating that even in rural contexts, a significant portion of visitors values standardized services, higher comfort levels, and professional hospitality infrastructure. Hotels likely attract tourists looking for security, convenience, and predictable quality, especially in more developed rural regions or spa areas. Family houses, selected by 17.70%, represent another major category. These are likely visitors' own weekend homes or properties of relatives, indicating a non-commercial but active form of rural engagement. While such travelers may not contribute directly to the accommodation sector, they often support the rural economy indirectly through local spending. Accommodation in restaurants with lodging accounts for 13.10%, and guest houses for 12.18%, demonstrating the continued relevance of small-scale, locally owned rural tourism enterprises that combine food service and overnight stays. These options typically appeal to visitors seeking local cuisine, intimate atmospheres, and integrated experiences. Less frequently selected are etno villages (5.06%), which offer thematic, heritage-oriented environments, appealing to tourists interested in tradition, authenticity, and cultural tourism. However, their relatively low selection suggests that such niche products still cater to a narrow market or may be under-promoted. The remaining categories, salas-style accommodations (2.07%), bed and breakfast (2.30%), vajats (0.69%), and camping (0.92%), are marginal. Their limited usage could stem from a lack of infrastructure, market visibility, or tourist readiness to accept lower service levels or rustic conditions.

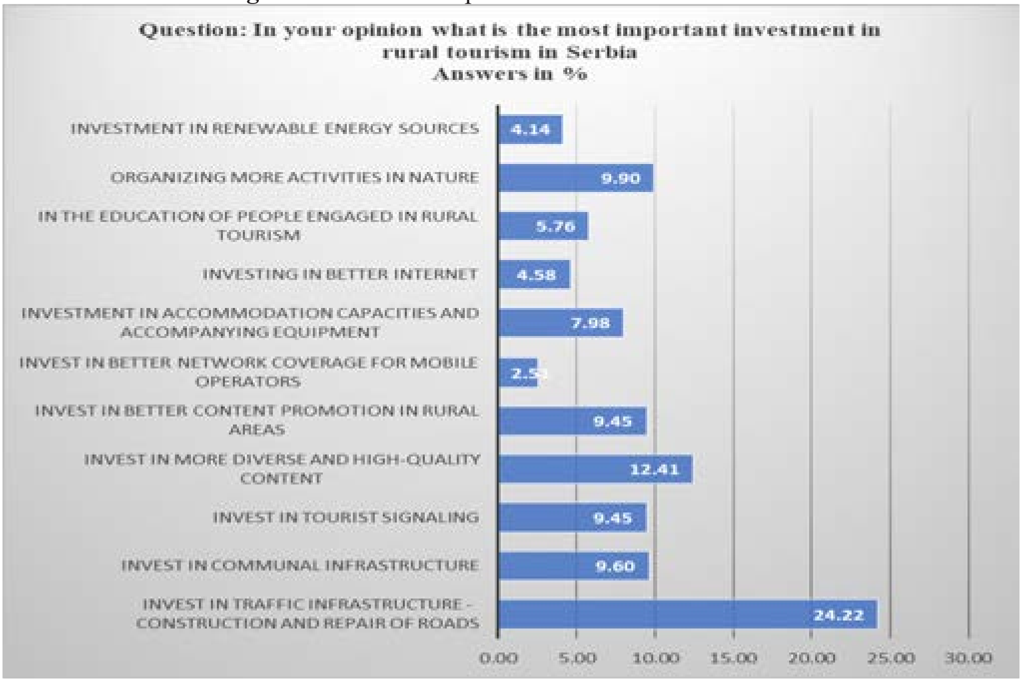
Table 4. What type of accommodation do you most often stay at in a rural area?

What type of accommodation do you most often stay at in a rural area?	Answer in %
Hotel	18.39%
Guest house	12.18%
Restaurant with accommodation	13.10%
Salas	2.07%
Etno village	5.06%
BB (bed and breakfast)	2.30%
Vajat	0.69%
Camp	0.92%
Room/apartment within the household	25.52%
Family house	17.70%
Something else	2.07%
Total	100.00%

Source: Authors' research

Figure 3 illustrates respondents' perceptions of what types of investments are most needed to improve rural tourism in Serbia. The results clearly highlight transport infrastructure as the most urgent priority, selected by 24.22% of participants. This indicates that poor road conditions, limited accessibility, and inadequate transportation networks are perceived as major barriers to the development of rural tourism. Tourists evidently associate ease of access with the attractiveness and feasibility of visiting rural destinations, and improvements in infrastructure are likely to increase visitation rates and enhance overall tourist satisfaction. The second most frequently mentioned investment area is the development of diverse and high-quality tourist content, chosen by 12.41% of respondents. This reflects a growing expectation for experience-rich, well-organized rural offerings that go beyond accommodation, such as outdoor activities, cultural events, gastronomy, and educational programs. Visitors are looking for authentic, engaging experiences that will encourage longer stays and repeat visits. Other investment areas noted in the figure (though specific percentages are not cited here) likely include improvements in digital infrastructure, promotional activities, waste management, and the modernization of accommodation facilities. These components, while perhaps not ranked as the highest priorities, are still essential for building a competitive and sustainable rural tourism offer.

Figure 3. The most important investment in rural area



Source: Authors' research

Based on the results shown in Table 5, it can be concluded that the most important thing for respondents is the location of the accommodation (AS=4.28, SD=0.81) and the equipment of the accommodation (AS=4.28, SD=1.49), while booking via SMS message is the least important thing for them (AS=2.38, SD=1.17).

Table 5. What does mostly influence your choice of accommodation in rural area?

	Min	Max	AS	SD
Accommodation price	1	5	3.86	0.99
Friend recommendation	1	5	4.00	0.96
Pictures and comments on FB	1	5	2.97	1.23
Pictures and comments on IG	1	5	2.90	1.23
Pictures and comments on Booking	1	5	3.23	1.22
Pictures and comments on another online platform	1	5	2.80	1.22
Location of accommodation	1	5	4.28	0.81
Accommodation equipment	1	5	4.28	1.49
Mobile network coverage	1	5	3.71	1.20
Internet signal	1	5	3.76	1.13
Additional entertainment facilities near the accommodation - cafe, restaurant, children's playroom	1	5	3.24	1.32
Additional sports facilities at the accommodation location or in the immediate vicinity of the accommodation	1	5	3.02	1.35

	Min	Max	AS	SD
Quick booking via Booking or another platform and/or other network	1	5	2.95	1.34
Booking via SMS message	1	5	2.38	1.17
Booking without the need to pay by credit card in advance	1	5	3.16	1.27
Good road infrastructure	1	5	3.78	1.12

Source: Authors' research

The reliability of the rural vacation area selection scale was determined based on the Cronbach alpha coefficient. Based on the Cronbach alpha coefficient value, it can be concluded that the correlation is satisfactory (α=0.740). To ensure and improve the quality of services in rural tourism, their standardization is important, and some of the criteria for standardizing accommodation capacities are classified into the following clusters: equipment, environment, intangible aspects, such as attention, privacy or ambiance, and safety and security (Vidić, 2018; 30). Investment in accommodation in rural area that will be part of tourist offer, should take in to consideration the above-mentioned clusters, since it will be easier to find both investment and customers. Rural tourism/agritourism is actually bringing benefits, including the preservation of the natural environment, protection of cultural heritage and traditions and support for agritourism farms (Vukolić, et al., 2024). With adequate investment in accommodation all aspects of rural life and economy could benefit.

The research examined whether there is a significant difference in the factors for choosing a rural vacation area in Serbia in relation to the gender, age and educational level of the respondents. To examine the differences in relation to gender, the independent samples t test was used, while to examine the differences in relation to the age and educational level of the respondents, a one-way analysis of variance (ANOVA) was used.

Based on the t test results shown in Table 6, it can be concluded that there is no significant difference in the factors for choosing a rural place in Serbia in relation to the gender of the respondents.

Table 6. Differences in factors for choosing a rural area for vacation in Serbia according to the gender of the respondents

	Mean Value	t	p
Male (N=116)	3.36 ± 0.61	-1.724	0.086
Female (N=133)	3.50 ± 0.60		

*Statistical significance at the 0.05 level

Based on the results of the ANOVA test shown in Table 7, it can be concluded that there is no significant difference in the factors for choosing a rural place in Serbia in relation to the age of the respondents.

Table 7. Differences in the factors for choosing a rural area for vacation in Serbia in relation to the age of the respondents

	Mean value	F	p
18-25 (N=86)	3.44 ± 0.66	0.702	0.591
26-30 (N=56)	3.52 ± 0.61		
31-40 (N=55)	3.42 ± 0.60		
41-50 (N=31)	3.41 ± 0.52		
51-59 (N=21)	3.26 ± 0.46		

*Statistical significance at the 0.05 level

Based on the results of the ANOVA test shown in Table 8, it can be concluded that there is no significant difference in the factors for choosing a rural place in Serbia in relation to the respondents' educational background.

Table 8. Differences in the factors for choosing a rural area for vacation in Serbia in relation to the respondents' educational background

	Mean Value	F	p
High school (N=99)	3.42 ± 0.67	0.496	0.685
College (N=36)	3.36 ± 0.55		
University (N=91)	3.49 ± 0.53		
Master or higher education	3.40 ± 0.70		

*Statistical significance at the 0.05 level

Discussion

The aim of this study was to examine tourists' preferences for types of accommodation in rural areas of Serbia, to identify the most important factors influencing their choice, and to assess whether these factors differ by gender, age, or education level. The findings provide important insights into both the structure of rural accommodation demand and broader patterns of rural tourism behavior.

Regarding the first research question, what types of accommodation are most commonly used by visitors to rural areas, the data reveal that rooms or apartments within a household (25.52%) and hotels (18.39%) are the most popular options, followed by stays in family houses (17.70%). This structure reflects a duality of demand: one group of tourists is oriented toward personalized, host-centered, and culturally immersive experiences, while another seeks comfort and predictability offered by hotels, even in rural settings. These findings are in line with those of Pina and Delfa (2005), who emphasize the continued relevance of both private and categorized accommodation in rural tourism contexts. The relatively low use of camps, "vajats", and ethno villages suggests that although alternative forms of lodging exist, they remain underutilized, possibly due to limited infrastructure or lack of promotional visibility, similar to what Wojciechowska-Solis et al. (2022) observed in the Lublin region.

In relation to the second research question, what factors influence accommodation choice, the results show that location and equipment of the accommodation (AS = 4.28) are considered most important, followed by friend recommendations and good road infrastructure. Digital influences such as photos and comments on social media (Instagram, Facebook) scored notably lower, which contrasts with findings by Ye et al. (2019), who emphasized the growing impact of digital presence on consumer decisions in rural areas of East Asia. In the Serbian context, however, word-of-mouth and physical accessibility appear to be far more influential. These results also highlight the practical expectations of tourists: they seek functionality, cleanliness, comfort, and easy access, rather than solely aesthetic appeal or online ratings.

As for the third research question, whether demographic factors influence preferences, the results indicate no statistically significant differences in accommodation choice based on gender, age, or education level. This finding suggests a relatively homogenous perception of rural tourism across demographic groups, which may reflect a shared understanding of rural vacationing as short-term, restful, and pragmatic. This outcome is somewhat surprising in light of previous research by Choo et al. (2017), which demonstrated clear generational and gender-based differences in accommodation expectations in South Korea. One possible explanation lies in the specificity of the Serbian context, where the rural tourism market is still emerging and shaped more by availability than segmentation.

The broader implications of these findings suggest that rural tourism in Serbia continues to function within a semi-formal structure, as evidenced by the large proportion of respondents (25.8%) who paid in cash without receiving receipts. Only 29.4% used categorized accommodation and received fiscal proof of payment. This echoes the findings of Pulido-Fernández et al. (2024), who also identified regulatory and formalization challenges in rural hospitality sectors in Southern Europe. The Serbian case reinforces the importance of improving transparency, regulation, and support for formalization in order to foster both trust among tourists and economic sustainability for rural communities.

In terms of investment priorities, respondents most frequently highlighted transport infrastructure (24.22%), followed by the need for diverse and high-quality tourist content (12.41%). This confirms McDaniels et al. (2017), who emphasized accessibility as a fundamental barrier to rural tourism inclusion, particularly in marginalized regions. Without improved infrastructure, even the most authentic or well-equipped accommodations remain underutilized due to logistical limitations.

Finally, the observed preference for mountain areas (35%) and spa destinations (23%) points to a concentration of rural tourism demand in natural and wellness-related environments. This reinforces previous studies (e.g., Vidić, 2018; Gajić & Cvijanović, 2022) that highlight the potential of these segments to lead rural tourism development. However, the low frequency of visits to national parks and alternative forms (such as lakes or cultural villages) suggests thematic underdevelopment and a need to diversify rural tourism products.

This study confirms that accommodation plays a central experiential and economic role in rural tourism. While preferences are clear and relatively unified, challenges related to infrastructure, service formalization, and product diversification remain key constraints. Addressing these gaps through targeted investments, support for small-scale accommodation providers, and clearer regulation could significantly enhance the sustainability and competitiveness of rural tourism in Serbia.

Conclusions

This study examined accommodation preferences and decision-making factors among tourists visiting rural areas in Serbia, with the aim of identifying dominant behavior patterns and informing future development of rural tourism. The findings highlight that the most frequently used types of rural accommodation are rooms or apartments within households and hotels, suggesting a dual trend: a search for authenticity and personal contact with hosts on one hand, and a demand for comfort and standardized services on the other. Respondents emphasized the importance of accommodation location, equipment, and road infrastructure, while digital reviews and social media presence were less influential. No significant differences in preferences were found based on gender, age, or education, indicating a relatively uniform perception of rural vacationing across demographic groups.

6.1.Theoretical implications

The study contributes to the body of literature on rural tourism and consumer behavior by empirically confirming that accommodation preferences are shaped by a mix of functional and experiential factors. It supports earlier claims (Choo et al., 2017; Pulido-Fernández et al., 2024) that accommodation is not merely a logistical necessity, but a core component of the tourist experience. However, the absence of significant demographic differences contrasts with other international studies, suggesting that in developing tourism markets such as Serbia, supply constraints may override segmentation-driven behavior. Additionally, the findings reinforce the theoretical proposition that the structure and formality of rural tourism supply are critical for shaping guest satisfaction and destination sustainability (Ye et al., 2019; Wojciechowska-Solis et al., 2022).

6.2.Practical implications

From a practical standpoint, the study underscores the urgent need for investment in transport infrastructure, which was identified by respondents as the primary barrier to rural tourism growth. Improvements in road quality, signage, and public transport access could directly enhance visitor mobility and experience. Furthermore, the dominance of informal accommodation use (with a high share of cash payments and missing receipts) highlights the need for stronger regulatory mechanisms, fiscal incentives, and support for small-scale providers to enter the formal market. Local tourism organizations should prioritize the development of diversified and experience-based tourism content, particularly around mountains, spas, and agritourism, to encourage longer stays and repeat visitation.

6.3.Limitations and directions for Future research

Despite its contributions, the study is not without limitations. First, the sample size (N = 250) and purposive sampling method, while adequate for exploratory analysis, limit the generalizability of the findings. The research was geographically restricted to Serbia and did not control for regional variation within the country, which may mask local nuances. Additionally, the study relied on self-reported data, which may be subject to recall bias and social desirability effects. Finally, while the study analyzed behavioral and attitudinal variables, it did not incorporate longitudinal tracking or observational methods to validate stated preferences against actual tourist behavior.

Future research should consider expanding the geographic and demographic scope of the study, including a larger and more representative sample from different regions of Serbia and neighboring countries. Comparative studies between rural tourists and urban tourists, as well as between local and foreign visitors, could offer deeper insights into cross-cultural expectations. Moreover, incorporating qualitative methods, such as in-depth interviews or ethnographic observations, would enrich understanding of tourist motivations, emotional connections to rural spaces, and the symbolic value of different types of accommodation. Finally, future work should explore the role of digital transformation, sustainability certifications, and community involvement in shaping rural accommodation strategies, especially in the post-COVID context.

Conflict of interests

The authors declare that they have no conflict of interest.

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ANALYSIS OF RISK AVOIDANCE THROUGH DIVERSIFICATION, WITH REFERENCE TO AGRICULTURAL FARMS

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A B S T R A C T

In this paper, the authors analyze the advantages of business diversification as a concept of a stable investment strategy, by investing capital in several different types of investments with the aim of avoiding or reducing risk. In agriculture, diversification is an agrarian policy embodied in increasing the diversity of economic activities in the rural economy. The social and economic development of rural areas is based on the creation of conditions in which the income of economic entities becomes more stable than in the case when they are engaged exclusively in agriculture, which all contributes to strengthening the social economic position of economic entities in agriculture and slowing down depopulation. The paper, using descriptive and comparative methods, analyzed the successful diversification of agricultural holdings in the territory of Srem. The aim of the research is to look at all the benefits that diversification brings to economic, ecological and social rural development.

Introduction

Investing means investing capital with the aim of satisfying the investor's goal, which is the return of invested funds and the acquisition of profit. The main element that brings uncertainty into the investment process is risk. Risk is actually a measurable possibility of losing invested capital or gaining profit. Risk is different from uncertainty, which is not measurable (Downes, J., et al., 2010; Tešić, R, et al, 2021). Returns on invested

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capital and risks are inseparable. If the level of accepted risk during some investment activity is higher, it is therefore possible to expect a higher level of income. Completely excluding risk from investing is almost impossible. Therefore, in practice, the question is always present - what level of risk in business is acceptable for an investor (Brigham, E. F. 1989). Accordingly, each investor, based on his own risk appetite, will create an optimal portfolio that in the future will bring him the highest possible return for a given level of accepted risk (Fisher, L., et al., 1970).

Diversification represents the concept of a stable investment strategy. It implies the investment of capital in several different types of investments with the aim of avoiding or reducing the investor's risk (Grubel, H. G., 1968). In other words, instead of the investor investing all his capital in one financial venture, diversification implies the distribution of funds over several financial ventures: sectors, financial instruments, assets, investment in several geographical areas, and the like (Brigham, E. F. 1989).

The advantages of diversification are as follows:

- avoiding or reducing risk for the investor - in the event that one investment faces negative trends in the activity, returns from other investments will mitigate that loss,
- higher returns - it is known that some economic activities progress better than others because they adapt better to changes in the market. Through diversification, the investor increases the opportunity to gain profit from investments that achieve positive results (Fisher, L., et al., 1970),
- protection from market volatility - it is the reduction of risk that protects the investor from market volatility. This is especially important if diversification is carried out across several geographical regions, where the weakness of one country's economy is mitigated by the invested funds through the strengthening or stability of another country and/or region. (Divecha, A.B., et al., 1968).

The question is how to diversify your capital? There are several ways to diversify an investment, which can be done in the following ways:

- investing in different types of assets, such as bonds, real estate and raw materials. The advantage of this approach is a significant reduction in risk due to the diversity of investments. However, managing such a portfolio can be very complex precisely because of its diversity and requires regular and proper monitoring and rebalancing (Markowitz, H. M., 1959),
- geographic diversification includes investing in different economic regions or countries. The advantage of geographic diversification is precisely its disadvantage - it largely depends on economies and their political (in)stability, as well as exposure to various currency changes,
- diversification within the same type of asset: this way involves investing in different companies and instruments within the same category, such as investing in stocks or shares within the same sector. The advantage of diversification

within the same class is its simplicity. However, unlike diversification across different classes, the risk is relatively higher because changes within the same sector can affect all of its relevant instruments,

- diversification through passive investment strategies includes investing in index funds and Exchange Trade Fund (ETF). This approach significantly reduces risk because investors are exposed to the entire portfolio that tracks a specific index. In doing so, index funds and ETFs contain a wide range of different companies or property instruments that make up the index (Markowitz, H. M., 1959). Its disadvantage is that the results match the performance of the index itself and therefore cannot outperform the market.

In any case, regardless of the type of diversification, the investor also has obligations:

- to regularly monitor the investment - portfolio performance, to analyze how the investments behave and, based on that, to make an adequate decision on the need for possible changes,
- Also, rebalancing is an important segment of diversification, because every market changes periodically, caused by various factors. Therefore, in order to protect the investment from losses, but also to maximize profits, there is a need for regular rebalancing of the portfolio through the sale and reinvestment of specific parts of the property (Jorion, P., 1985),
- regardless of the above, the investor should always keep in mind the level of his risk tolerance because every investment implies a certain level of risk.

So, it is true that diversification represents the concept of a stable investment policy, but diversification cannot eliminate the total risk. For example, the total risk of investing in securities on the capital market (total risk) consists of:

- systematic risk (market risk, systematic risk, nondiversifiable risk) i
- unsystematic risk (unique risk, firm-specific risk, nonsystematic risk, diversifiable risk).

Systematic (market) risk is related to the functioning of the capital market and affects all types of assets equally. It includes total market risks, i.e. risks affecting all securities: interest rate risk, inflation risk, exchange rate risk, etc. This type of risk cannot be eliminated through diversification.

The part of risk that represents the difference between total and systematic risk is called unsystematic or specific risk. This risk is related to individual securities, i.e. individual companies that issue them. This type of risk can be influenced by diversification, which is why it is called diversifiable. This risk mainly refers to business risk, insolvency risk, non-payment risk, strikes, changes in management, etc. Based on this, it can be concluded that even the portfolio with the largest number of securities in its composition does not reduce the risk below the level of market risk, so diversification can eliminate only part of the risk, but systematic risk, i.e. market risk as a whole remains (Radović, et al, 2012).

Diversification of agricultural activities

Diversification on the agricultural farm is the performance of activities that bring income on the farm and/or outside the farm, that is, any additional activity other than the basic one. It includes all types of activities aimed at increasing farm income. There are many examples of diversification on agricultural farms, for example rural tourism on the farm, then the transition to organic production, handicrafts, drying and packaging of fruits and vegetables, packaging of honey and other agricultural products (Katarina, Đ., et al, 2021).

The diversification of agricultural holdings is influenced by several factors, such as: human potential (years of life, practical knowledge, education, participation of female labor on the farm, etc.), characteristics and structure of the holding (size of the holding, distance, communication, organizational factors and business network), external environment (location of the holding, transport communication, development of the business network).

The essence of diversification is achieving positive results and is reflected in three development dimensions:

- economic sustainability,
- environmental sustainability,
- socio-demographic sustainability.

In the European Union (EU), agriculture is characterized by great internal diversification. It is the result of natural conditions, the level of social and economic development of the countries and the time period when they became EU members. The differences relate to production and economic results, to the agrarian structure, the level of employment in this sector and the importance of agriculture for the country's economy. In the countries that have been members of the community for the longest time, thanks to the implementation of the Common Agricultural Policy, the agricultural sector has achieved significant progress in the field of technology and mechanization, which is a consequence of a large increase in production and labor productivity in agriculture (Chmielewska, B., 2008). In countries that became EU members in 2004 or later, the situation in agriculture and rural areas is completely different than in other EU countries (Kijek et al., 2015), where the level of development and diversification of activities is lower. Research has shown that after each EU enlargement, the regional diversification of basic production and social indicators in the agricultural sector and in rural areas deepens (Chmielewska, B., 2008).

Material and working methods

One of the mechanisms within the rural development policy is research into the possibility of applying diversification in the Republic of Serbia, because the diversification of the rural economy, in addition to economic and social, has a significant environmental component. The importance of the research is further confirmed by the fact that the ownership structure of agricultural farms in Serbia is unfavorable, that small agricultural farms derive their income from primary agricultural production and have an unenviable economic position. The survival and development of agricultural farms could be significantly improved through the diversification of their economic activity.

In accordance with the subject and goal of the research, the method of analysis and synthesis, induction and deduction, historical, descriptive method, as well as the method of comparative analysis were applied in the work.

The data on the realized degree of diversification of agricultural holdings in the Republic of Serbia are based on publications and studies in the Republic of Serbia and case analysis of an agricultural holding that successfully applied diversification methods, the Republic Institute of Statistics, i.e. the 2023 Census of Agriculture. The experiences of EU countries were analyzed based on EU regulations and scientific publications and studies published in international scientific journals.

Research results and discussions

In order to research this topic, the authors analyzed the case of an agricultural farm in the territory of Srem, which over time diversified its activity and achieved the economic and socio-demographic goal of its business.

Table 1. Presentation of the effects of agricultural diversification.

Diversification of agricultural activities				
	Activity	Year of observation/activity	Net profit	Number of employees
1	Agriculture - rearing Sports fishing	2010-2014	Sufficient to cover life's needs and investment in the business	2 family members
2		2014-2020	About 10% profit per year	2 family members
	Diversification introducing the following activities			
3	Organic food production	2020 – 2022	About 10% profit per year	3 family members
4	Eco-tourism	2022 -	About 20% profit per year	3 family members and 1 employee outside the family

Source: Author's research.

The analysis of the agricultural business found that the farm was engaged in vegetable growing and sport fishing. The work was performed with 2 members of the family household. For years, earnings from the activity covered labor costs and necessary living expenses. Then the farm started producing organic food, which made it possible to earn additional income, before the food was placed in larger cities about 50-60 kilometers away, which entailed higher transport costs. From its own products, the farm had fish and all organic products of plant origin for human consumption. In 2022, the farm started to deal with eco-tourism. It used all its products for eco-tourism, reduced transport costs, and sold surplus goods. The number of employees has increased. The net profit made it possible to acquire cash that the farm can use for new potential projects. Poznati ekonomski teoretičar Adam Smit naglašavao je da je bogatstvo naroda rezutat ljudskog rada. Međutim, u ovoj hipotezi izostavljen je jedan veoma značajan činilac, a to su prirodni resursi i njihova uloga u razvoju zemlje i vlasnika prirodnih resursa.

Serbian agriculture is characterized by the great diversification of agricultural holdings and their large fragmentation (average size below 3 ha), insufficient equipment with agricultural machinery, which is still technologically outmoded and outdated, insufficient use of mineral fertilizers and extremely low productivity in all areas of production (average yields are below the EU level). In order to quickly change the current situation in agriculture, it is necessary to provide an adequate agricultural policy, as an integral part of the overall development policy of Serbia, in order to successfully face the increasingly strong competition, to reach a level of productivity that can guarantee decent incomes for the population engaged in agriculture and to achieve competitiveness in the sectors of the economy that rely on agriculture.

Changes in agricultural policy are reflected in the redirection of funds, from direct market support with subsidies to investment support and support for rural development. There are also changes in the orientation of budget funds from large agricultural entities (enterprises, cooperatives and agrocombinates) with different ownership structures, to family commercial farms.

One of the solutions that can influence the elimination and/or mitigation of negative restrictions on the development of agricultural farms is the diversification of the rural economy, which implies the introduction of non-agricultural activities, which contribute to a more rational use of existing capacities on the agricultural farm, and thus acts as a stimulus for the achievement of sustainable development in rural areas (Thomson, K., J., 2019).

Diversification abandons the traditional model of agricultural development. Monofunctional economy gives way to polyfunctional economic activity in which, in addition to food production, the rural population also engages in other activities that are related to agriculture and/or rely on agriculture (Yoshida, et al., 2019). In this way, in addition to more stable incomes, opportunities are created to increase the competitiveness of rural areas.

Diversification can be carried out by performing several additional activities (Patrachanova, 2019): production of organic food, creation of local brands whose competitiveness in the market is based on high quality, improvement of models for the rational use of renewable energy sources/natural resources, production of biological products, work on infrastructure development, establishment of small and medium-sized enterprises in the service sector, development of rural, village and eco-tourism, production of raw materials for industry, etc.

Analyzing the effects of diversification in the rural sector in the countries (EU) in recent decades, several regularities can be observed. Agriculture is still the dominant sector in rural areas, but the importance of non-agricultural activities is growing. In the case of employment in rural areas, there was a decrease in employment in agriculture and an increase in employment in the service sector (Patrachanova, E., 2019).

As an effect of this, there is a tendency to reduce the differences in the economic structure between urban and rural areas. In rural areas that chose to employ the population in the service sector, there was an increase in the number of inhabitants, which represents one of the essential advantages brought by the diversification of the rural economy, but also a confirmation that the return of the population to the countryside does not necessarily have to be linked to the practice of agriculture, but the population of the village can also engage in non-agricultural activities (Mitrović, et al., 2020).

Models of diversification of the rural economy - experiences of the countries of the European Union

Diversification of the rural economy was introduced as one of the measures of the rural development policy in the EU starting in 2000, which was implemented in several stages of the development of alternative jobs, in the secondary and tertiary sectors that provide employment with the aim of slowing down the depopulation process and strengthening the socio-economic position of the rural population, preserving biodiversity and rational use of natural resources (EC, 1999).

The plan for the diversification of the rural economy envisaged: the development of alternative models of agricultural production, the development of rural tourism, the strengthening of activities for the protection of natural resources and the environment, the preservation of cultural heritage and the authentic rural environment, the establishment of small businesses in agribusiness, especially in the field of processing of primary agricultural products (EC, 1999). 10% of the total EU agricultural fund was earmarked for the achievement of these goals. During the implementation of the planned plans, the funds for these purposes increased.

Technological progress and productivity growth in agricultural production have led to a decrease in the need for labor over time. One of the ways to absorb the surplus workforce in rural areas from the primary sector is the diversification of economic activities. Research related to the achieved degree of diversification of the rural economy in EU countries shows certain laws (Thomson, 2019) regarding the achievement of a greater degree of diversification that is present:

- on farms that have larger production capacities,
- on agricultural farms that are oriented towards livestock production in relation to farms dominated by plant production;
- was realized in the so-called peri-urban regions, i.e. rural areas located near cities;
- a greater degree of diversification was achieved in rural regions that have potential for tourism development. A significant model of diversification of the rural economy in EU countries is the development of eco-tourism, which contributes to the protection of nature and the rational use of natural resources, the reduction of unemployment and poverty (Jovanović et al., 2019). One of the good examples is the diversification of farms engaged in livestock production through the development of tourism (Panduru et al., 2021). The construction of hospitality and accommodation facilities, which would enable tourists to stay on the farm or organize summer camps for children and youth, contributes to the economic sustainability of agricultural farms through the marketing of their products. In order to be economically sustainable, tourism must be a function of a sustainable environment, either cultural or natural (Vujović et al., 2020).

  The organization of this type of tourism must be in accordance with ecological principles and environmental protection. The basic preconditions of this model of diversification of the rural economy is the control of resource management, while avoiding physical, chemical and biological pollution.

This is supported by the experiences of agricultural farms in Italy (Giaccio et al., 2018), which in the case of diversification through agritourism are primarily guided by the principles of rational use and preservation of natural resources, as well as the preservation of an authentic rural environment. This is also contributed to by the subsidy system, which conditions the approval of financial support on compliance with the so-called ecological principles.

Diversification has been shown to produce significant positive effects on sustainable rural development:

- ecological, on the rational use of natural resources,
- economic,
- social/societal,
- growth in employment and competitiveness of agricultural farms,
- improving the position of marginalized social groups (youth, women),
- preservation of the rural environment,
- growth in household income stability,
- improving the demographic structure (age and education),

- improving the quality of natural resources,
- more rational use of available production resources,
- reduction of regional differences in the degree of development of rural areas.

In addition to the positive results it achieved in the sphere of ecological sustainability, the diversification of the rural economy had positive implications for the socioeconomic sustainability of agricultural farms (Salvioni et al., 2020). During 2018, a study of 28 EU countries and in 135 regions, based on FADN information, confirmed the existence of a correlation between the degree of diversification of non-agricultural activities and the socio-economic performance of agricultural farms, which is much more pronounced in the central and northern than in the southern and southeastern regions of the EU (Trnkova, 2021).

Diversification of the rural economy in the Republic of Serbia and expected results

The basic direction of the future development of agriculture and the food industry is the optimal use and preservation of available production capacities, increasing the volume of agricultural production, changing the production structure in favor of intensive types of production intended for export, production of high-end and high-quality products.

For the above reasons, the role of rural development policy in the process of improving the economic position of agricultural holdings by diversifying the rural economy is apostrophized. Diversification on agricultural holdings in the Republic of Serbia is applied throughout the territory, with the fact that the type of additional activities differs between regions. The differences are the result of various factors: needs and aspirations of household members, tradition, availability of labor, available agricultural resources, development of social capital.

According to the data of the agricultural census, which was conducted in 2023, of the total number of agricultural farms in our country, 12.4% are farms that, apart from agriculture, obtained income from non-agricultural activities. At the same time, the highest degree of diversification is present in Šumadija and Western Serbia. In this region, farms with other profitable activities make up 18% of the total number of farms, and there are the most young farm owners up to 40 years of age, i.e. 39%. The lowest level of diversification is present in Vojvodina, where only 5.7% of farms earn income outside of agriculture (https://publikacije.stat.gov.rs/G2019/Pdf/G201922002.pdf).

The most common non-agricultural activities in the Republic of Serbia are:

- processing of primary agricultural products, of which the largest number of households, over 50%, is focused on milk processing, followed by a high (about 30%) representation of fruit and vegetable processing, while meat processing is an activity chosen by a smaller number of farms,
- about 20% of farms in the AP Vojvodina provide agricultural mechanization services,

- a significant share of wood processing and other forestry activities is represented,
- in Serbia, rural tourism records a symbolic participation in the structure of other profitable activities on the farm, in contrast to EU countries.

In order to improve the diversification of the rural economy in Serbia, agricultural policy measures are implemented. Regulations on incentives in agriculture and rural development within the framework of incentives for rural development measures also provide support for programs for diversification and improvement of the quality of life in rural areas. Incentives are paid in the form of fees at least in a certain percentage in relation to the total costs, i.e. the value of investments.

Certainly, in the long-term development of agricultural production in Serbia, priority should be given to the production of biologically high-quality food. The demand for these products is constantly increasing on the world market, especially on the markets of developed countries. The organization of production, processing, packaging and marketing create conditions for the full valorization of agricultural resources by exporting biologically highly valuable food to the world market. Serbia should be transformed into an area of traditional conventional agricultural production (Regmi, A., et al, 2009). The largest part of the territory of Serbia is ecologically clean, especially the mountainous area. Agricultural land in Serbia belongs to unpolluted or slightly polluted land in comparison to Europe and is suitable for the production of biologically quality food. This is the comparative advantage of Serbia compared to Europe, where over 95% of agricultural land does not meet the requirements for the production of biologically quality food.

Mountainous and some lowland regions, especially in the territory of central Serbia, fulfill the conditions for the production of biologically quality food. In order for Serbia to take advantage of the advantages in the production of biologically quality food, consistent harmonization of agricultural production standards with the standards of highly developed EU countries is necessary.

For the strategic planning of the development of the production of biologically quality food and the conquest of the market, it is necessary to establish a harmonious relationship between quality and environmental protection, with a clear emphasis on the ecological sign of product quality. Starting from the marketing concept of producing quality food for a well-known customer and the available conditions for that type of production, it is necessary to define the production of biologically valuable food.

Among the products that can be exported immediately are forest fruits: mushrooms, blueberries, snails, medicinal herbs and others. In the case of forest fruits and medicinal plants, it is necessary to define the product in terms of marketing and to solve the problem of purchase, storage and packaging. Certain quality food production programs from Serbia have gained recognition on the world market (in addition to the fact that they are not yet branded and do not carry indications of geographical origin), these are primarily: berry fruits (raspberries, blackberries, strawberries), baby beef and lamb, prunes (with by-products) and other dried fruits, certain wines and fruit brandies, Užice prosciutto, Pirot cheese, Sjenica and Homolj cheese, cream cheese and others (Rajnović, et al, 2023). At the same time, it is necessary to introduce plantation programs for the production of rare, protected species of medicinal plants in the mountains.

In the development program for the production of biologically quality food, it is necessary to define the basis of the current demand, the production program and define the products in accordance with comparative advantages, potential profit, future market development of this branch of products, production diversification, ecological marketing (with quality standards and an ecological sign prominently displayed), in order to satisfy the needs of increasingly discerning eco-food consumers (Rajnović, et al., 2023).

Around 35-40 industrial activities related to agriculture could be located in rural areas, where new jobs would be opened for a greater number of available labor force from the countryside, and cities would cease to be overpopulated with social problems. It is possible to employ a significant number of the able-bodied population in the export-oriented production of high-value food, beef production, plantation production of medicinal plants, vegetable production in greenhouses, then rural tourism, as well as stock market operations in the sale of flowers and vegetables. At the same time, a part of the active population would be engaged in other parts of industry, healthcare, education and the service sector (trade and rural tourism). In this way, the living conditions would be significantly equalized with the living conditions in the city, and the orientation towards the countryside and agriculture would be more attractive for young, educated experts.

Based on the importance of financing current production and investments in agriculture, it is necessary to solve the long-term agricultural financing system in the Republic of Serbia in accordance with the specifics of this activity. It is of particular importance to provide permanent and realistic sources of funds for financing current agricultural production, as well as necessary investments in agricultural machinery and equipment for processing plants, basic herd and long-term plantings and irrigation.

Going through the process of developing diversification during different periods of time, from its very beginning until today, as well as until the implementation of its various models, it can be concluded that its importance in creating an optimal investment investment is immeasurable and that it represents the basis for a portfolio with the minimum possible risk. This was also the basic hypothesis that had to be proved in this work, and which was successfully confirmed on the example of an agricultural farm in the territory of Srem. A great contribution to the understanding of diversification was undoubtedly given by the theory, primarily through a new approach in which the optimal portfolio is not only viewed from the aspect of realizing high returns, but as a relationship between high returns and low risk.

Conclusion

There is fierce competition on the market. By creating an optimal portfolio through diversification that investors will succeed in turning things in the market in their favor. The analysis of the experiences of EU countries shows that diversification in agriculture positively contributes to the achievement of sustainable development of rural areas in all three development dimensions. Economic sustainability represent a kind of upgrading of primary agricultural production. In Serbia, this primarily refers to the processing of primary agricultural products, then the placement of food products in the service sector, rural tourism, can significantly contribute to the stability of the income of agricultural farms and thus to the economically sustainable development of the rural environment. The impact of the diversification of economic activities on the ecological sustainability of rural development and the preservation of natural resources is reflected in the organization of organic production, which is based on the principles of sustainable development and eco-tourism, which in addition to economic, brings a number of ecological benefits to rural areas. The development of the tertiary sector affects the growth of employment and the influx of a young population into rural areas, which contributes to the improvement of the demographic structure and social sustainability.

In the territory of the Republic of Serbia, the highest degree of diversification of economic activities was achieved in the rural areas of Šumadija and Western Serbia, and the most represented non-agricultural activity is milk processing. State support for the diversification of the rural economy in Serbia is realized, based on the model applied by the European Union. The largest part of the funds is aimed at improving the quality of life in rural areas through the development of infrastructure, but also for encouraging non-agricultural activities, which significantly affects the ecological, economic and social sustainability of rural areas of the country.

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Conflict of interests

The authors declare no conflict of interest.

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ACCOUNTING FOR AGRICULTURAL ACTIVITY: HOW TRANSPARENT ARE SERBIAN COMPANIES?

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ABSTRACT

In this study, we analyze compliance with global professional accounting regulation in a sample of Serbian agricultural companies. Focusing on key mandatory disclosures related to biological assets, we calculate the companies' annual and average Disclosure Scores and find significant non-compliance. Despite the adoption of International Financial Reporting Standards (IFRS) as the "gold standard" for high-quality financial reporting, company management fails to provide transparent disclosures in the financial statements, underscoring the importance of country- and company-specific determinants of financial reporting quality. We identify that variations in financial transparency can be explained by differences in the company's reporting framework, type of auditor, and ownership structure, while the effects of company size and legal form remain inconclusive. The findings of our research may be valuable to investors, corporate managers, regulators, and future researchers looking at the quality of financial reporting on agricultural activity.

Introduction

Financial transparency is widely recognized as a cornerstone of modern financial markets and economies, playing a vital role in fostering trust, driving growth, and ensuring long-term financial stability on a global scale. Market failures, crises, and financial scandals throughout history and across the globe consistently highlight the extensive, harmful, and far-reaching consequences of financial opacity and misreporting[3]. The quality of financial information became a critical concern for accounting professionals, regulators, investors, and academics worldwide following

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3 For example, the famous Enron scandal resulted in a 20 billion dollar loss of the company's market value and 98% decrease in market capitalization; see more in Stevanović, Malinić (2009).

a series of dramatic financial and accounting scandals. These events shook financial markets and undermined public trust in financial reporting systems, even in some of the world's most developed economies at the turn of the century. In response to heightened public scrutiny, global efforts were made to strengthen financial market regulations and revise accounting standards. These measures aimed to enhance transparency, improve the quality of financial information, and increase international comparability. Such an environment is believed to facilitate more efficient capital allocation at both local and global levels, enabling market participants to make informed economic decisions i.e. to identify investment opportunities and assess associated risks with more certainty.

However, the actual quality of a company's financial information relies on a number of factors, with the quality of accounting standards oftentimes not being the decisive one. Research show that, under a given set of financial reporting rules, the features of company's disclosed financial information will ultimately be shaped by the reporting choices of the company's management (Watts, 1977, Ball et al., 2003). These "preparer incentives" essentially depend on local market and political forces that set the demand for high-quality financial reporting and define the functions of the financial statements in the economy (Ball et al., 2000, Ball et al. 2003, Goncharov et al., 2009). A large body of research points to numerous determinants of financial reporting quality, both country and company-level. These include the features of the local enforcement systems, capital market, national laws, governance structures, cultural factors, but also the company's listing status, industry, size, the extent of ownership concentration, profitability, indebtedness, type of auditor, etc. (Ball et al., 2003, Leuz et al., 2003, Goncharov et al., 2009, Glaum et al., 2013). Thus it is clear that making informed economic decisions practically hinges on financial statement users' ability to evaluate their quality before drawing any conclusions about a company's performance and future prospects.

These circumstances make the quality of financial reporting a continuous focus of academic research, particularly given the lack of universally accepted definitions and measures of quality, as well as the growing complexities of modern business entities that must be financially recognized. The Serbian reporting environment is especially intriguing due to its proclaimed adherence to global professional accounting regulation of the highest quality (International Financial Reporting Standards – IFRS) alongside the apparent absence of developed capital market that would naturally drive demand for high-quality financial information. As a result, the quality of financial information disclosed by Serbian companies remains an open question.

Our research focuses on agricultural companies for two main reasons: (1) the sector's traditional significance to the Serbian economy and the growing need for enhanced investment efficiency, and (2) the inherent complexities in accounting treatment and financial reporting related to agricultural activity. Beyond typical business risks, the biological nature of agriculture and its vulnerability to climate change significantly heighten the uncertainty surrounding future investment returns for agricultural companies. Monetizing the biological transformation of living animals and plants, accounting for agriculture is designed to help mitigate these informational risks.

However, it is a process abundant with challenges, often requiring agriculture-specific knowledge and valuation skills that surpass an average accountant's expertise. Hence, providing relevant and faithfully presented information on a company's performance related to agriculture could become costly and time-consuming, necessitating close collaboration between accountants and industry experts.

Building on prior research on financial reporting quality, we argue that enhanced transparency in agricultural entities' financial reporting has a potential to promote capital formation within the sector, create more investment opportunities, and lower the cost of capital (Diamond and Verrecchia, 1991, Botosan, 1997, Healy and Palepu, 2001, Botosan and Plumlee, 2002, Francis et al., 2005). However, we anticipate that the overall quality of financial information disclosed by agricultural entities will be influenced by country- and company-specific factors. The varying impact of these determinants makes our research exploratory in nature.

The Characteristics of the Serbian Financial Reporting Environment

Accounting and financial reporting rules vary depending on the type of business entity. "Full" IFRS are mandatory for large legal entities, as well as for parent and public companies, regardless of their size. Other companies also have the option to adopt full IFRS as their reporting framework. Otherwise, they are required to use either the International Financial Reporting Standard for Small and Medium-sized Entities (IFRS for SMEs) or the national rulebook for accounting and financial reporting, depending on their size[4]. The local reporting system is designed to ensure full transparency of business entities' financial information. Serbian Business Registers Agency (SBRA) publishes annual financial statements and audit reports for the most recent three reporting periods on its website.

Country's public commitment to adopting IFRS as a single set of high-quality global accounting standards should ensure the relevance and faithful representation of financial information. However, research show that weaknesses within the national financial reporting system significantly diminish the overall quality of Serbian companies' financial reports (Djukić and Pavlović, 2014, Decker, 2015, Malinić et al., 2016, Vučković Milutinović, 2019, Aničić et al., 2023). These shortcomings can be observed not only in the country's normative and regulatory framework but also in its monitoring and enforcement mechanisms (Vučković Milutinović, 2019). Reporting entities seem to prioritize minimizing the costs of disclosures, without recognizing any additional reporting benefits beyond mere legal and tax compliance (Decker, 2015, Malinić et al., 2016). The perceived quality of disclosed financial information varies somewhat by sector and company size, with financial institutions, large-sized companies, and subsidiaries of international groups often having financial statements of higher quality (Decker, 2015).

4 For more detail see Law on Accounting (Official Gazette of the Republic of Serbia no. 73/2019 and 44/2021 – other law).

The lack of practical use of financial statements' information by the existing and potential investors and creditors in Serbia is generally recognized as one of the key factors hindering improvements in their quality. General purpose financial reporting is designed with an objective to provide financial information about the company that is useful to its capital providers (IASB, 2018, par. 1.2). However, in the absence of capital market demand for high quality financial statements, a company's financial reporting is expected to become susceptible to other influences, predominantly taxation (Nobes, 2006, Goncharov et al., 2009, Djukić and Pavlović, 2014). This is especially true for jurisdictions with strong links between accounting and tax regulations like Serbia.

Capital markets in Serbia remain shallow and underdeveloped, with a limited role in financing the economy (Bango et al., 2019). The financial system is bank-dominated, making banks the primary users of business entities' general purpose financial statements (Bango et al., 2019, Vučković Milutinović, 2019). However, it seems that banks overlook even the most obvious quality issues. Vučković Milutinović (2019) finds that banks in Serbia often ignore modified auditor's opinion in their lending decisions. As a result, companies can expect to face little to no consequences from their capital providers for misreporting financial information. In such circumstances financial statements become perceived as a mere legal requirement i.e. a formality that needs to be met to avoid penalties imposed by national legislation, frequently without sufficient attention to their content (Djukić and Pavlović, 2014, Decker, 2015). Moreover, a significant proportion of companies continue to neglect even this formal obligation. Obradović et al. (2021) report that, as of August 1, 2020, 20% of companies listed on the Belgrade Stock Exchange had not made their 2018 General Purpose Financial Reports publicly available. Furthermore, Mitrović et al. (2024) identify a rising trend in the number of companies failing to disclose financial statements during the 2019–2021 period. Hence, it is not surprising that a substantial portion of companies - 16.75% of all reporting entities in 2023 - failed to prepare and disclose their annual financial statements (APR, 2024, p. 12).

Following Decker (2015) we expect large-sized agriculture companies and subsidiaries of international groups to have better quality disclosures. Larger companies tend to have stronger incentives for compliance, due to their bigger exposure to political pressures and public scrutiny in comparison to smaller companies (Watts and Zimmerman, 1990), as well as the influence of numerous transacting stakeholders (such as suppliers and customers) who act as a powerful market force encouraging voluntary disclosure (Breuer et al., 2020). Furthermore, their accounting departments are also expected to be better equipped, allowing for a higher quality of financial reporting (Glaum et al., 2013). The research by Obradović et al. (2021) corroborates the effect of company size on financial transparency among listed Serbian companies. When a local company is established as a subsidiary of an international group, it is likely to align its accounting and reporting practices with those of its parent company for consolidation purposes. If the group primarily operates in markets with a well-developed financial reporting infrastructure, its local subsidiaries are expected to produce higher-quality disclosures. As Opper (2003) argues, deeper integration into the global economy can create competitive pressure and incentives for companies to enhance their financial transparency.

Information asymmetries and agency problems may encourage the management of companies with widely dispersed ownership to disclose more information compared to closely held or private companies (Glaum et al., 2013). However, we argue that these reporting incentives depend on the strength of local enforcement mechanisms and the actual level of minority investor protection. Therefore, we do not make specific predictions regarding differences in financial reporting quality based on a company's legal and ownership structure.

Dominating the global accounting market, the Big 4 audit firms are widely regarded as pillars of high-quality financial reporting. Their global presence, scale, and reputation are often assumed to result in superior audit quality compared to local auditing firms. While prior studies largely support this expectation, it is important to acknowledge that some of the most significant international financial scandals and frauds have involved companies that received unqualified opinions from Big 4 auditors (Malinić, 2008). This underscores the critical importance of evaluating financial reporting quality for users of general-purpose financial statements. Following Vasilić (2020) and Obradović et al. (2021), we expect Serbian companies audited by a Big 4 firm to demonstrate greater financial transparency.

Recognizing that IFRS for SMEs is essentially a "full" IFRS standard adapted to the needs of SMEs, with modifications based on cost-benefit considerations, we expect agriculture companies applying "full" IFRS to produce higher-quality disclosures.

Challenges in Financial Reporting for Agricultural Activities

One of the key characteristics of agricultural businesses is their reliance on biological assets, such as living animals and plants. These assets undergo continuous transformation through biological development and growth, making their management and valuation uniquely complex. Additional challenges come from their heterogeneities in terms of variety, race, gender, productivity, health status, or stage of the life cycle, as well as their climate and seasonal variability. These factors necessitate specialized expertise from accountants in recognizing, measuring and reporting on biological assets. As a result of these complexities, the agricultural sector is governed by specific accounting regulations, such as International Accounting Standard 41 (IAS 41) Agriculture (IASB, 2020) and a dedicated section (Section 34) of the IFRS for SMEs (IASB, 2025).

IFRS establishes fair value as the primary method for measuring biological assets, both at their initial recognition in company's books and at the end of each reporting period. Specifically, biological assets should be measured at fair value less estimated costs to sell. Any changes in their value during the period are recognized as gains or losses, directly affecting the company's annual financial results. This accounting treatment makes the valuation of biological assets a handy tool for earnings management, potentially introducing significant informational risks for users of financial statements. Furthermore, the fair value model can lead to income volatility, which may obscure a company's true financial performance and complicate predictions of its future returns. This issue is particularly pronounced in the absence of active markets or quoted prices for identical biological assets at the measurement date (which can be reasonably expected for example for crops at the various stages of growth or for combined assets). In such cases, an asset's fair value must be estimated using appropriate valuation techniques, with an emphasis on maximizing the use of relevant observable inputs and minimizing reliance on unobservable inputs (IASB, 2016). However, the use of different valuation techniques and assumptions in estimating the fair value of biological assets directly hinders the comparability and jeopardizes the usefulness of agricultural companies' financial information. Similar issues can be expected in the estimation of an asset's costs to sell.

In the absence of quoted market prices and reliable valuation inputs, companies may opt to abandon the fair value approach and measure biological assets at cost, less any accumulated depreciation and impairment losses. IFRS for SMEs permits this treatment for all biological assets where fair value is not "readily determinable without undue cost or effort" (IFRS for SMEs, par. 34.2). However, IAS 41 allows this treatment only at the initial recognition of an asset, requiring the entity to switch to fair value as soon as it becomes reliably measurable.

The complexities surrounding the accounting treatment of biological assets underscore the need for additional disclosures in the company's notes to the financial statements. This is particularly relevant given the current structure of the Serbian official Balance Sheet form. Biological assets are listed as a single item within the company's fixed assets section, reporting a summarized value that encompasses various categories of assets, with differing valuation basis and expected cash flow streams (including forests, bearer plants, livestock, biological assets under construction, and paid advances for biological assets). In such circumstances, making any inferences about the company's expected future cash flows arising from agricultural activity becomes virtually impossible without additional details. Thereby, the actual usefulness of company's financial information on biological assets for economic decision-making hinges on the managements' commitment to providing transparent disclosures.

Given the prevailing features of Serbian financial reporting environment, we anticipate that the management's incentives for transparent disclosures are likely to be low. The findings of previous studies generally confirm these expectations. Mijić et al. (2011) examined the financial statements of 30 Serbian agriculture companies from 2008 to 2011 and identified significant deficiencies in their compliance with IAS 41 mandatory disclosures. Although the number of compliant companies increased over time, full compliance was observed for the first time in 2010, accounting for only 6.67% of the analyzed cases. The majority of companies failed to disclose both the fair value and physical quantities of their biological assets.

Savić and Obradović (2020) largely confirm these findings in their analysis of 100 Serbian agribusiness entities from 2015 to 2017. They found that only 15% of the examined companies recognized biological assets in their financial statements. While all of these companies stated fair value less costs to sell as the basis for valuation, they failed to provide any further disclosure details.

Using discretionary accruals as a proxy for financial reporting quality, Đorđević et al. (2024) analyzed the 2018-2022 financial statements of 99 large and medium-sized agricultural companies registered in Serbia. They found that more profitable companies tend to have better financial reporting quality, followed by companies audited by Big 4 firms and those with low levels of debt. Their results also indicate that a company's liquidity, board size, and audit tenure have no significant impact on the quality of its financial information.

Tomašević et al. (2024) argue that the complexity of resource management in the food industry can impact a company's financial performance. They document a statistically significant negative relationship between profitability and the materiality of assets, attributing this to food enterprises' inefficiency in utilizing or managing fixed assets. However, these findings may stem from management's failure to provide an accurate valuation of the company's fixed assets, including biological assets.

Materials and methods

Sample construction and data

Our study is based on a sample of Serbian agriculture companies that have officially filed their annual general purpose financial reports (GPFR) for the year 2023 to SBRA. A "company" is any business entity that is legally obliged to file its GPFR, according to the prevailing regulations in the Republic of Serbia. We use *Scoring* database to select companies according to our research criterions. We then use the official publicly available GPFR database of SBRA to collect audited GPFR of selected companies for the period 2021-2023, together with the independent auditor's reports. We also use the websites of SBRA and the Central Securities Depository and Clearing House, to investigate the company ownership.

We focus on companies whose registered activity code belongs to the sector A - Agriculture, forestry and fishing, as defined by the Regulation on the Classification of Activities ("Official Journal of the Republic of Serbia" no 54/2010). Although biological assets can be found in the financial statements of non-agriculture companies as well, we expect these items to be materially insignificant in terms of financial reporting of such companies and therefore omit them from the analysis. This assumption is confirmed by the data from GPFR of Serbian companies for the year ended December 31, 2023 (APR, 2024), as seen in Table 1.

Table 1. Biological assets of Serbian companies in GPFR for the year 2023

Industry sector	Biological Assets	
	Value in RSD 000	Proportion of Total Assets
A - Agriculture, forestry and fishing	176,437,272	17.70%
All other sectors	40,038,251	0.18%

Source: Authors' calculations based on APR (2024)

Creating the sample, we concentrate on medium and large-sized agriculture companies. These companies controlled 60.2% of the total assets, generated 58% of the total revenue and earned 83.6% of the total profit of the entire sector A in the year ending December 31, 2023, as seen in Figure 1 (excluding the negative results of micro-sized companies). Hence, despite not being the most frequent types of companies in the sector (making up for the mere 3.6% of the total number of active agriculture companies, as opposed to 80.8% micro-sized entities), these companies accumulated the dominant part of sector's economic power, which highlights the importance of their financial data quality. The seriousness of this matter is corroborated by the fact that medium and large-sized companies are subject to obligatory annual independent audits, with an aim to increase the credibility of financial information they disclose to the public.

Aspiring to investigate the majority of audit-liable entities, we also include listed agriculture companies, regardless of their size. Being able to accumulate substantial sums of capital, joint-stock companies are generally considered to be "the most significant organizational form of corporate entities" (Malinić, 2007, p. 67). They dominate developed markets and earn the largest amounts of revenue worldwide (Fortune, 2024). Usually having numerous and diversified shareholders, these public companies traditionally use the GPFR and annual business reports as means of communication with their existing and potential capital providers. This makes the quality of their financial data a matter of paramount importance for the efficient capital allocation world-wide.

The sample selection procedure was largely influenced by the availability of data. Hence, our research period is limited to three years, from 2021 to 2023, due to the lack of available financial statements and audit reports for previous years. Our preliminary sample comprised the total of 141 medium, large-sized and listed agricultural companies in the Republic of Serbia. Following the purpose of our study, we investigated Balance Sheets of these companies for 2021, 2022 and 2023, to make sure they had biological assets (AOP 0017 of the Balance Sheet) in the analyzed period. We then excluded the ones that didn't. Accordingly, our final sample was downsized to 47 agriculture companies i.e. 141 firm-years.

Figure 1. Active agriculture companies (sector A) in 2023, registered in the Republic of Serbia, according to company size

**Micro sized companies recorded negative net result overall.*

Source: Authors' calculations

Research design

We analyze the disclosures in the audited GPFR of selected companies, primarily focusing on Balance Sheet, Income Statement and accompanying Notes, aiming to assess the material significance of biological assets and to investigate the compliance of accompanied disclosures with the prevailing regulation requirements.

Investigating the material significance of biological assets in GPFR of analyzed companies, we rely on their financial reporting framework. In terms of IFRS and IFRS for SMEs, materiality of financial information is one of the key aspects of their relevance i.e. usefulness for decision-making. Namely, information is considered to be material if "omitting, misstating or obscuring it could reasonably be expected to influence decisions that the primary users of GPFR make on the basis of those reports" (IASB, 2018, par. 2.11). Being a strictly entity-specific concept based on information's nature, magnitude or both, materiality is not quantitatively pre-defined neither by the accounting standards, nor national regulations. Hence, in the absence of official materiality thresholds, accounting practitioners rely on their professional judgment (Savić, 2019). For the purpose of our research, we label biological assets as materially significant if their value exceeds 1% of the company's total assets.

Analyzing the provided disclosures in Notes, we focus on the following matters:

1. disclosure of company's accounting policy regarding biological assets;
2. description of each group of biological assets;
3. disclosure of gain or loss arising from the change in fair value less costs to sell of biological assets;
4. description of the nature of company's activities involving each group of biological assets;

5. disclosure of non-financial measures or estimates of the physical quantities of each group of company's biological assets at year-end and
6. company's output of agricultural produce during the year;
7. disclosure of information on the estimation of the fair value of biological assets (or the inability to determine it);
8. disclosure of reconciliation of changes in the carrying amount of biological assets between the beginning and the end of the year.

According to the disclosures a company has made in its GPFR (i.e. Notes) for the analyzed period, each company was given an annual Disclosure Score (DS), with higher score meaning better quality disclosures, as shown in Table 2.

Table 2. Disclosure Score

Total number of selected disclosures a company has made in its GPFR (out of the analyzed 8)	**Disclosure Score (DS)**
7, 8	5
5, 6	4
3, 4	3
1, 2	2
0	1

Source: Authors' calculations

Additionally, we examine the independent auditor's reports on the GPFR of analyzed companies and link them to a company's DS for the year, to assess whether auditors consider the possible misreporting practices to be "modification worthy". We also investigate the differences in company's DS according to the type of company's reporting framework (IFRS/IFRS for SMEs), legal form (limited liability company – llc; joint stock company – jsc; public enterprise – pe), size, ownership structure (concentrated/diversified), type of company's dominant owner and type of auditor (Big4/non-Big4).

Results and Discussions

Descriptive statistics

During the period 2021-2023, an average company from our sample controlled assets in the total amount of 8.5 RSD billion, out of which fixed assets amounted to 6.9 RSD billion and biological assets to 3.4 RSD billion (Table 3). At the same time, average equity amounted to 6.8 RSD billion and average net profit to 129.1 RSD million.

The value of biological assets in the GPFR of analyzed companies for the selected period varied from zero (only one firm-year) to the maximum of 111.921,8 RSD billion, making on average 9.86% of company's total assets and 14.02% of fixed assets (Table 4). Biological assets were materially significant (exceeded the amount of 1% of the company's total assets) in 79.29% of the analyzed firm-years.

Table 3. Descriptive statistics for selected financial items (in RSD million)

Item	Mean	Standard deviation	Minimum	Median	Maximum
Total Assets	8,552.5	21,281.9	157.5	2,935.4	138,902.8
Fixed Assets	6,956.8	20,731.8	115.3	1,819.3	136,606.0
Biological Assets	3,424.5	17,011.8	0.0	104.3	111.921,8
Equity	6,840.6	20,152.8	0.0	1,590.1	132,588.6
Net profit	129.1	488.1	-2,219.2	77.9	3,158.7

Source: Authors' calculations

Table 4. Descriptive statistics for biological assets

Item	Mean	Standard deviation	Minimum	Median	Maximum
Biological Assets / Total Assets	9,86%	16,73%	0,00%	5,12%	81,40%
Biological Assets / Fixed Assets	14,02%	19,12%	0,00%	6,95%	84,79%

Source: Authors' calculations

The sample is dominated by medium-sized (74.47%), limited liability (74.47%) companies, with registered activity code 0111 - Growing of cereals (except rice), leguminous crops and oil seeds (51.06%), as shown in Table 5. Concentrated ownership was found in 89.36% of companies, with domestic natural persons as dominant owners in 73.81% of cases. Due to the lack of publicly available data, we were unable to determine the actual owners of identified foreign legal entities. Hence, our results may be biased in this matter. The majority of analyzed companies applied full IFRS, had an unqualified auditor's opinion on their GPFR and a non-Big4 auditor (Table 6).

Table 5. Sample description – status data

Registered activity code		Size		Legal form		Concentrated ownership		Dominant owner	
Type	%	Type	%	Type	%	Type	%	Type	%
0111	51.06%	Medium	74.47%	Llc	74.47%	Yes	89.36%	Domestic natural person	73.81%
0146	14.89%	Large	17.02%	JSc	21.28%	No	10.64%	Foreign legal entity	19.05%
0147	8.51%	Small	6.38%	PE	4.26%			State	7.14%
Other	25.53%	Micro	2.13%						

Source: Authors' calculations

Table 6. Sample description – Financial Reporting Framework and Audit

Financial Reporting Framework		Auditor		Auditor's opinion	
Type	**%**	**Type**	**%**	**Type**	**%**
IFRS	80.85%	Big4	15.60%	Unqualified	81.56%
IFRS for SMEs	19.15%	Other	84.40%	Qualified	13.48%
				Disclaimer of opinion	0.71%
				Not publicly available	4.26%

Source: Authors' calculations

Findings and Discussions

Table 7 summarizes the results of the analysis of the disclosure of information that could help the users of GPFR to better understand the significance of biological assets for company's operations; to assess their impact on the amount, timing and uncertainty of company's future net cash inflows and to evaluate how efficiently and effectively has the company's management used these resources during the year.

Table 7. Disclosures on biological assets in GPFR

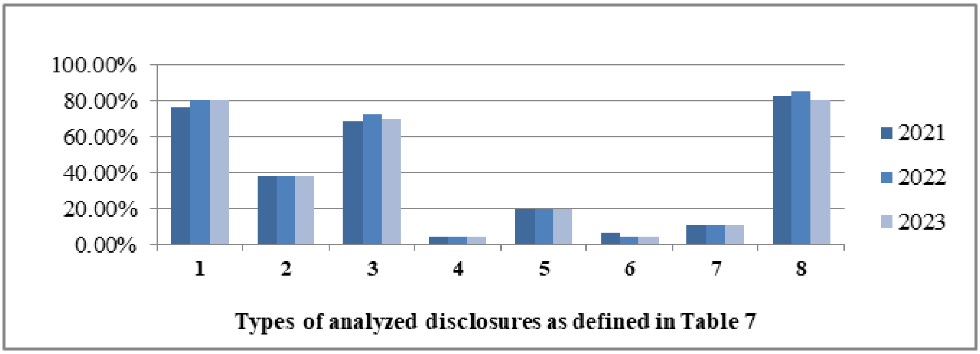
Disclosures in Notes		Disclosed		Not disclosed	
		n	**%**	**n**	**%**
1	Company's accounting policy regarding biological assets	112	79.43%	29	20.57%
2	Description of each group of biological assets	54	38.30%	87	61.70%
3	Gain or loss arising from the change in fair value less costs to sell of biological assets	99	70.21%	42	29.79%
4	Description of the nature of company's activities involving each group of biological assets	6	4.26%	135	95.74%
5	Physical quantities of each group of biological assets at year-end	27	19.15%	114	80.85%
6	Physical quantities of company's output of agricultural produce during the year	7	4.96%	134	95.04%
7	Information on the estimation of the fair value of biological assets	15	10.64%	126	89.36%
8	Reconciliation of changes in the carrying amount of biological assets between the beginning and the end of the year	117	82.98%	24	17.02%

Source: Authors' calculations

The overall impression is that the management of Serbian agriculture companies does not seem to pay sufficient attention to the quality of financial reporting on biological assets. Namely, even the simplest elementary requirement to disclose company's accounting policy regarding the recognition and measurement of biological assets wasn't met in more than 20% of analyzed firm-years. Likewise, in 95.74% of cases a company has failed to provide any disclosures regarding the nature of its activities involving biological assets. The provision of information on physical quantities seems significantly troublesome, as well. The same can be said for disclosures regarding the assessment of fair value of biological assets at year-end, having in mind that in mere 10.64% of analyzed Notes, the management provided some information that could shed light on the valuation process (for example, used prices or assumptions). The most frequently met disclosure requirement refers to the reconciliation of changes in the book value of biological assets between the beginning and the end of the year. However, in all 82.98% of the cases, the requirement was met with a simple table of changes in value, without any additional explanations.

Observing the trend of disclosed information during the analyzed period, we have found that the proportion of companies which have fulfilled individual disclosure requirements varied downwards or stagnated, as seen in Figure 2. This is opposed to Mijić et al. (2011), who determined an increase in compliance with IAS 41 disclosure requirements for the period 2008-2010. Signaling the deterioration of quality in reporting on biological assets, our findings can be interpreted as troublesome, especially considering the fact that we analyzed audited GPFR. Accordingly, auditors have either failed to detect these disclosure shortcomings (and request their corrections during the analyzed period), or have treated these matters as materially insignificant in terms of company's financial reporting as a whole.

Figure 2. Proportion of disclosures on biological assets during the years

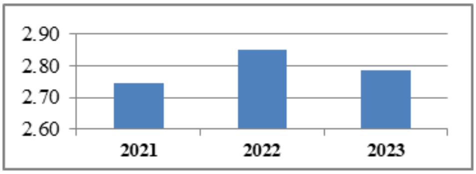


Source: Authors' calculations

Analyzing the total number of disclosures a company has made in its GPFR (out of the selected 8, as seen in Table 7) we have found an average DS (*av*DS) of 2.79. This means that on average, Serbian agricultural companies disclosed between two or three pieces of information regarding their biological assets for the period 2021-2023. Observed annually, *av*DS varied, peaking in 2022 (2.85), as seen in Figure 3. The observed *av*DS for companies with materially significant biological assets was 2.88, compared to 2.55 for others, indicating similar disclosure practices across companies, irrespective of the value of their fixed assets related to agricultural activity.

In 64.54% of analyzed cases, company's annual DS exceeded the average. We have identified only 3 cases (firm-years) in which the disclosure requirements were fully met (Table 8). The most frequent DS (67 firm-years) was 3. In 80.85% of analyzed GPFR (DS 3 and 2), a company has published not more than a half of disclosures required by the prevailing reporting framework. Especially worrying is the fact that all of these GPFR were published as "compliant to IFRS/IFRS for SMEs", while apparently failing to comply with all of IFRS/IFRS for SMEs requirements. The danger lies in the potential for such GPFR to mislead users, which could lead to failed investments and ultimately hinder the efficient capital allocation in the economy. The findings of Goncalves et al. (2017) emphasize this issue, revealing that biological assets are value-relevant when measured at fair value, with their relevance increasing as the transparency of financial statements improves.

Figure 3. Average Disclosure Score (*av*DS) during the years



Source: Authors' calculations

Table 8. Disclosure Scores (DS) of analyzed companies

Disclosure Score (DS)	Firm-years[i]	
	n	%
5	3	2.13%
4	21	14.89%
3	67	47.52%
2	47	33.33%
1	0	0.00%

[i] *Notes to the financial statements were not published for three firm-years.*

Source: Authors' calculations

Our research findings on the effects of company-specific determinants of financial reporting quality are summarized in Table 9.

Table 9. Company-specific determinants of financial reporting quality

Determinant / Average Disclosure Score (*av*DS)			
Framework for financial reporting		***Ownersip***	
IFRS	2.85	Concentrated	2.77
IFRS for SMEs	2.56	Diversified	3.00
Legal form		***Dominant owner***	
Limited liability company	2.78	Domestic natural person	2.51
Joint Stock company	2.80	Foreign legal entity	3.75
Public Enterprise	3.00	The state	2.89
Size		***Auditor***	
Micro	2.00	Big4	3.45
Small	2.00	Other	2.73
Medium	2.90		
Large	2.75		

Source: Authors' calculations

As expected, we have found that agriculture companies applying IFRS achieved higher *av*DS i.e. on average had better quality disclosures on biological assets compared to companies which used IFRS for SMEs as their reporting framework. However, *av*DS of 2.85 seems significantly low in terms of IFRS as the "golden standard" in financial reporting. Similar can be said for companies with Big4 auditors. While they achieved higher *av*DS as predicted, it is clear that an average of 4-5 disclosures on biological assets cannot be considered as full adherence to IFRS disclosure requirements. These findings strongly indicate the deficiencies in application of IFRS in agriculture companies in Serbia. They also confirm the need for effective, country-specific IFRS enforcement mechanisms in securing high quality financial statements.

When it comes to company's size and legal form, our results are inconclusive. While micro and small-sized entities did show lower quality disclosures, companies of medium size unexpectedly scored the highest *av*DS. This outcome is somewhat confusing, considering the additional effects of company's reporting framework (IFRS as an exclusive reporting framework for large-sized entities should provide an additional "boost" to their financial transparency). Hence, a company's size alone does not seem to be a significant determinant of its financial reporting quality.

Considering a company's legal form, we observed the lowest *av*DS in private (limited liability) companies. This aligns with the findings of Gassen and Muhn (2025), who attribute private firms' disclosure choices to informational constraints and processing costs. However, public enterprises, on average, demonstrated better quality disclosures than those listed on the Belgrade Stock Exchange. These findings align with the broader characteristics of the Serbian financial reporting environment. Nevertheless, they raise concerns about the future development of local capital markets and their potential impact on economic growth.

Our findings generally confirm the effect of diversified ownership on financial reporting quality. Still, the highest *av*DS in the analyzed period was detected on a subsample of companies with concentrated ownership and foreign legal entities as dominant owners. This is in line with the findings of Decker (2015). However, lacking the information on the ultimate owners of such companies, we can only assume that they are subsidiaries of a foreign parent i.e. liable to consolidation in other jurisdictions. Hence, it is possible that our results are biased in this matter.

We have found that 81.56% of the analyzed GPFR were certified by the independent auditors as prepared (in all material respects) in accordance with the applicable framework for financial reporting (Table 6). Although such an opinion should generally be considered as a confirmation of company's GPFR quality, our research has shown an *av*DS of 2.82 in the subsample of GPFR with an unqualified auditor's opinion. We believe these findings to be contradictory. It is possible that biological assets of subject companies were not materially significant in terms of audit. Nevertheless, we have determined that in 80% of the GPFR with an unqualified auditor's opinion, the value of biological assets exceeded the amount of 1% of company's total assets for the year. Still, our research has shown that the majority of these GPFR (64.13%) had not more than 3 disclosures pertaining to biological assets, while the highest DS (5) was detected in only 3 observations (firm-years). Interestingly enough, a company with the highest DS had a qualified auditor's opinion in the entire analyzed period (although the qualification was not related to biological assets). When it comes to the subsample of GPFR with a qualified auditor's opinion, we have detected an *av*DS of 3, and only 2 firm-years where the qualification was related to the company's biological assets. Accordingly, our findings suggest that the auditor's opinion should not be regarded as a "bulletproof" guarantee of GPFR quality on Serbian market, at least when it comes to reporting on biological assets. However, it is possible that agricultural activity represents a materially insignificant aspect of analyzed companies' operations i.e. that on overall, biological assets were not considered by the auditors as important information for GPFR users. Hence, these findings should be interpreted with caution.

Conclusions

Our study examines compliance among Serbian agricultural companies that are mandatorily applying IFRS ("full" IFRS or IFRS for SMEs). We focus on disclosures essential for understanding the financial effects of agricultural activities, particularly the assessment of amounts, timing, and uncertainties related to future cash flows from biological assets. Each company was assigned an annual Disclosure Score (DS) based on the number of mandatory disclosures provided for the year. To explore differences in financial transparency, we calculated average Disclosure Scores (*av*DS) and analyzed them in relation to various company-specific factors identified in previous research as potential determinants of financial reporting quality.

Under a given accounting regulation, we argue that the actual characteristics of a company's disclosed financial information are influenced by the local reporting environment and company-specific factors. Despite the adoption of IFRS as the "gold standard" for high-quality financial reporting, Serbia continues to face challenges in the realm of financial reporting, due to weak regulatory mechanisms and limited capital market activity. In the absence of strong market and regulatory pressures, financial reporting quality is expected to decline.

Our findings confirm the generally low quality of financial reporting in the agricultural sector during the analyzed period (2021–2023). Analyzing the total number of disclosures on agricultural activity, we found an *av*DS of 2.79. This indicates that, on average, Serbian agricultural companies disclosed only two to three pieces of information (out of the eight analyzed mandatory disclosures) related to biological assets. Although these financial statements are presented as "compiled in accordance with IFRS" they clearly fail to fulfill their primary objective—providing users with relevant and faithfully represented information for decision-making.

These findings suggest a general lack of commitment to transparent financial reporting by company management. However, given the characteristics of the local financial reporting environment, this outcome is not surprising. Like any other "good", the quality of financial information is expected to ultimately be shaped by the forces of supply and demand. When companies do not perceive tangible benefits from increased financial transparency (such as a lower cost of capital or the success of an IPO) their disclosure policies are likely influenced by other considerations, such as cost-cutting or tax management. This is especially true in a setting where the preferences of financial statements users are uncertain, where the management frequently stays silent, safely hiding in the "shadows of opacity" (Bond and Zeng, 2022, Wang and Zhang, 2025).

Building on previous studies on company-level determinants of financial reporting quality, we find that transparency in disclosures is higher among companies applying IFRS, those audited by a Big 4 firm, companies with diversified ownership, and subsidiaries of foreign parent companies. However, our findings regarding the impact of company size and legal form on financial reporting quality remain inconclusive. Similarly, we do not find a clear relationship between a company's level of transparency (or lack thereof) and the type of auditor's opinion on its financial statements. This suggests that auditors may fail to recognize or address compliance shortcomings. However, it is also possible that the biological assets of the analyzed companies were not materially significant from an audit perspective.

We believe our study provides valuable insights for various capital market participants by highlighting the importance of transparency in financial reporting. Existing and potential capital providers (as the primary users of financial statements) may be reminded of the need to assess the quality of financial reports before making investment decisions. Additionally, company management could be encouraged to improve compliance and financial transparency to secure new financial resources on favorable terms. Regulatory authorities may recognize the necessity of developing effective enforcement mechanisms to ensure that IFRS standards are properly reflected in financial statements, delivering high-quality information to their intended users. Finally, we aim to raise awareness among accounting academics and practitioners about the importance of enhanced education in agricultural accounting.

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Conflict of interests

The authors declare no conflict of interest.

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AGRICULTURE 5.0 POTENTIAL AND THE APPLICATION OF ADVANCED TECHNOLOGIES IN SERBIA

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A B S T R A C T

This study explores key factors influencing Agriculture 5.0 adoption in Serbia, focusing on investment trends, government R&D funding, IoT adoption, and rural internet penetration. Data and literature analysis reveals that domestic investment and R&D spending drive digital transformation, and foreign investment remains volatile. IoT and internet expansion support smart farming but require further investment. Policy recommendations include strengthening digital infrastructure and increasing support for agricultural innovation. Future research should examine long-term investment impacts and sustainability benefits to improve Serbia's transition to digital agriculture.

Introduction

Agriculture has experienced significant transformations over the centuries, evolving from manual labor-intensive practices to the integration of advanced technologies. Agriculture 5.0 signifies a paradigm shift towards the adoption of advanced tools such

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as artificial intelligence (AI), the Internet of Things (IoT), and robotics (Morchid et al., 2024; Munir & Elahi, 2023). This evolution aims to improve productivity, sustainability, and resilience in the agricultural sector. The progression to Agriculture 5.0 builds on previous agricultural revolutions. The initial phase involved the mechanization of agriculture, introducing machinery that reduced the reliance on human and animal labor. Previous phases saw the introduction of chemical fertilizers and pesticides, followed by the Green Revolution, which brought high-yield crop varieties and advanced irrigation techniques (Widianto & Juarto, 2023). Agriculture 4.0 introduced digital technologies, including precision farming and data analytics, enabling farmers to make informed decisions based on real-time data. Agriculture 5.0 extends this digital transformation by integrating AI, IoT, and robotics to create intelligent farming systems that can autonomously monitor, analyze, and manage agricultural processes (Bissadu et al., 2024; Fountas et al., 2024).

Artificial intelligence plays an important role in modern farming by enabling the analysis of vast datasets to inform decision-making. Machine learning algorithms can predict weather patterns, identify pest infestations, and recommend optimal planting times, thereby reducing uncertainties associated with farming (Juwono et al., 2023; Mesías-Ruiz et al., 2023). AI-driven models can analyze soil health and suggest precise fertilizer applications, enhancing crop yields but minimizing environmental impact. Additionally, AI supports the development of autonomous machinery capable of performing tasks such as planting, weeding, and harvesting with high precision, reducing labor costs and increasing efficiency (Holzinger et al., 2024). The Internet of Things further improves agricultural productivity by connecting various devices and sensors throughout the farm. IoT devices monitor soil moisture levels, temperature, humidity, and crop health in real-time, transmitting data to centralized systems for analysis. This connectivity allows for the implementation of precision agriculture techniques, where inputs like water and fertilizers are applied variably across a field based on specific needs, optimizing resource use and minimizing waste (Martos et al., 2021; Victor et al., 2024). For example, soil moisture sensors can trigger automated irrigation systems only when necessary, conserving water and promoting sustainable practices.

Robotics complements AI and IoT by automating labor-intensive tasks, addressing challenges such as labor shortages and the need for increased efficiency. Agricultural robots, or agribots, are designed to perform a variety of functions, including planting seeds, applying pesticides, and harvesting crops (Demircioglu et al., 2023). These robots operate with high accuracy, reducing damage to plants and ensuring uniformity in operations. The use of robotics not only improves productivity but also allows farmers to focus on more strategic aspects of farm management. The integration of these advanced technologies contributes significantly to the sustainability and circularity of agricultural practices. Through utilizing AI, IoT, and robotics, farmers can optimize input usage, reducing the over-application of fertilizers and pesticides, which in turn minimizes runoff and environmental pollution (de la Parte et al., 2024). Precision agriculture techniques ensure that resources are used efficiently, promoting soil health and biodiversity. The data collected through these technologies enable continuous monitoring and improvement of farming practices, supporting a culture of sustainability and resilience against climate change (Imade et al., 2024). The noted technologies are important for improving competitiveness (Bakator et al., 2019). This can further manifest in the development of agro-tourism (Cvijanović, 2020; Đoković et al., 2017). The implementation and application of these technologies often require standards and certification programs that support the changes in the industry (Ćoćkalo et al., 2019). Futhermore, this can lead to increased export of agricultural foods and products which contributes to economic growth (Đurić et al., 2017).

The paper consists of the following sections: Introduction section, and then the theoretical background is provided. Next, the methodology is presented. Afterwards, the results are noted. Then the Discussion section addresses recommendations to improve Agriculture 5.0 potential in Serbia. Finally, Conclusions are drawn and ideas and guidelines for future research are noted.

Theoretical background on Agriculture 5.0 and advanced technologies

In 2016, agriculture has undergone significant transformations, evolving from traditional practices to the integration of advanced technologies, culminating in what is now referred to as Agriculture 5.0 (Aggarwal et al., 2024; Mishra et al., 2024). This latest phase emphasizes the use of artificial intelligence (AI), the Internet of Things (IoT), and robotics to improve efficiency, sustainability, and productivity in farming. Agriculture 5.0 reflects a series of technological advancements. Initially, agriculture relied heavily on manual labor and rudimentary tools. The advent of the Industrial Revolution introduced mechanization, with machinery such as tractors reducing the dependence on human and animal labor. This mechanization marked the first significant shift, enabling farmers to cultivate larger areas with increased efficiency (Haloui et al., 2024).

Agriculture 5.0 integrates digital technologies to create intelligent farming systems. AI plays a central role in this transformation, enabling the analysis of vast datasets to inform decision-making processes. Machine learning algorithms can predict weather patterns, assess soil health, and identify pest infestations, allowing for timely interventions (Polymeni et al., 2023; Tiwari et al., 2021). AI-driven models can analyze satellite imagery to monitor crop health, providing farmers with actionable insights to improve yields and reduce resource wastage (Siddharth et al., 2021). The IoT further amplifies the capabilities of modern agriculture by connecting various devices and sensors across the farm. These IoT-enabled devices collect real-time data on soil moisture, temperature, humidity, and crop growth (Singh & Sobti, 2022). This continuous stream of information allows for precise monitoring and management of agricultural processes. Soil moisture sensors can trigger automated irrigation systems, ensuring that crops receive optimal water levels, thereby conserving water resources and promoting sustainable practices (Das et al., 2024; Sharma et al., 2024).

Robotics complements AI and IoT by automating labor-intensive tasks, addressing challenges such as labor shortages and the need for increased efficiency (Ragazou et al., 2022; Razak et al., 2024). Modern agricultural robots, or agribots, are designed to perform a variety of functions, including planting, weeding, and harvesting. Equipped with advanced sensors and AI capabilities, these robots can navigate fields autonomously, identifying and tending to individual plants as needed (Ayranci & Erkmen, 2024). Autonomous weeding robots can distinguish between crops and weeds, removing unwanted plants without the need for chemical herbicides, thus promoting environmental sustainability. IoT amplifies the capabilities of modern agriculture by connecting various devices and sensors across the farm (Kalpana et al., 2024; Pandrea et al., 2023). These IoT-enabled devices collect real-time data on soil moisture, temperature, humidity, and crop growth. This continuous stream of information allows for precise monitoring and management of agricultural processes. For instance, soil moisture sensors can trigger automated irrigation systems, ensuring that crops receive optimal water levels, thereby conserving water resources and promoting sustainable practices.

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The integration of these technologies not only improves productivity but also contributes to environmental conservation. Precision farming techniques enabled by AI and IoT reduce the over-application of fertilizers and pesticides, minimizing runoff into water bodies and preserving soil health (Mohan et al., 2023). The data collected through these technologies facilitate traceability in the food supply chain, ensuring food safety and quality. Consumers can access information about the origin and cultivation practices of their food, supporting transparency and trust in the agricultural system.

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However, the adoption of Agriculture 5.0 technologies is not without challenges. Smallholder farmers may face barriers due to the high initial investment costs and the need for technical expertise to operate advanced machinery and interpret data. Additionally, concerns about data privacy and the digital divide between technologically advanced and developing regions pose significant hurdles. Addressing these challenges requires collaborative efforts from governments, technology providers, and the agricultural community to develop affordable solutions and provide training to farmers.

Materials and methods

The research framework for this study follows four main phases. The first phase involved collecting relevant literature and data sources necessary to establish a theoretical background. Literature sources were obtained through international databases, institutional repositories, and publicly available reports (FAO, 2024; RZSS, 2024). The theoretical foundation was built on existing studies in the fields of Agriculture 5.0, digital transformation in agribusiness, sustainable farming practices, and technological innovations in precision agriculture.

The second phase focused on analyzing key economic, technological, and policy-driven indicators that influence the adoption of digital farming solutions. The study examined the impact of foreign direct investment (FDI), domestic capital investment, government R&D spending in agriculture, internet penetration in rural areas, and the adoption of IoT technologies in smart farming.

The third phase comprised the statistical analysis of investment trends and economic indicators affecting Agriculture 5.0. A linear regression model was developed to quantify the impact of various investment factors on the Agriculture 5.0 potential index (Agri5_Index). The model incorporated FDI, gross fixed capital formation (GFCF), government R&D expenditure, IoT adoption rate, and rural internet penetration as independent variables.

The fourth phase involved deriving policy recommendations and guidelines for enhancing Agriculture 5.0 adoption in Serbia. Based on the regression findings and literature review, recommendations were formulated to support smart farming innovations, strengthen digital infrastructure, and improve agricultural sustainability through precision technologies.

The study utilized data from multiple sources, including the Food and Agriculture Organization (FAO), the Statistical Office of the Republic of Serbia (SORS), and external reports on agribusiness investment trends. The dataset covered the period from 2019 to 2022, providing insights into the evolution of agricultural investments and technology adoption in Serbia. Key economic and technological indicators analyzed included:

- Foreign direct investment in agriculture (FDI_Agri)
- Gross fixed capital formation in agriculture (GFCF_Agri)

- Government R&D expenditure on agriculture (R&D_Agri_Exp)
- Rural internet penetration rate (Rural_Internet_Penetration)

These indicators were selected based on their relevance in assessing the digital transformation of Serbia's agricultural sector. Data were extracted and processed using spreadsheet software to facilitate statistical analysis. The model was calibrated using empirical data from 2020 to 2022. The regression findings provided insights into how different investment strategies contribute to Agriculture 5.0 readiness in Serbia. Based on the research objectives and methodology, the following hypotheses were formulated:

- H1: Higher levels of foreign and domestic investment positively impact the digital transformation of agriculture.
- H2: Increased government R&D spending in agriculture accelerates the adoption of smart farming technologies.
- H3: Higher IoT adoption rates significantly contribute to the development of precision agriculture.

Results

The results of the assessment of Serbia's Agriculture 5.0 development potential was based on various economic, investment, and technological indicators. The assessment focused on six key factors affecting Agriculture 5.0 potential:

- Foreign direct investment in agriculture (FDI_Agri) – measures the external capital flow into the agricultural sector.
- Gross fixed capital formation in agriculture (GFCF_Agri) – represents domestic investment in agricultural assets, modernization, and mechanization.
- Government R&D spending in agriculture (R&D_Agri_Exp) – an important determinant of innovation, smart farming technologies, and digital transformation.
- Internet penetration in rural areas (Rural_Internet_Penetration) – serves as a prerequisite for IoT adoption and digital farming.

The dataset was compiled from multiple sources, including FAO databases, national statistical reports, and external research findings. The extracted dataset includes investment trends (both foreign and domestic), agriculture's share in the economy, and government spending. The dataset covers the period 2019-2022 (this is the latest data), with emphasis on available investment-related indicators. Key findings are (FAO, 2024; RZSS, 2024):

- FDI in Agriculture (FDI_Agri) fluctuated significantly: peaking at 216 million EUR in 2020, dropping to 167 million EUR in 2021, and further declining to 21 million EUR in 2022.

- Domestic investment (GFCF_Agri) steadily increased, reaching 1,301 million EUR in 2022, suggesting a stronger reliance on local capital for modernization.
- Internet penetration (Rural_Internet_Penetration) in rural areas reached 83% in 2023, showing a solid foundation for smart farming expansion.
- Government R&D (R&D_Agri_Exp) spending on agriculture remains unclear, though total R&D expenditure reached 77 billion RSD (0.95% of GDP).

The main limitation in data preparation was the lack of direct agricultural technology indicators, requiring indirect measures.

The analysis reveals two contrasting trends:

1. Foreign investment (FDI_Agri) is volatile and declining, indicating a reduced external interest in Serbia's agriculture.
2. Domestic investment (GFCF_Agri) is steadily growing, showing a government-driven push for modernization.

The correlation analysis found a strong negative relationship (-0.757) between FDI and GFCF, suggesting that when foreign investment declines, domestic investment increases to compensate. This indicates a substitution effect rather than a complementary relationship. Additionally, rural internet penetration has grown to 83%, which supports future digital agriculture expansion. However, the IoT adoption rate is still unclear, limiting direct insights into smart farming progress.

A linear regression model was constructed to quantify the impact of investment factors on Agriculture 5.0 potential. Since a direct Agriculture 5.0 index does not exist, a synthetic dependent variable (Agri5_Index) was generated based on a weighted combination of FDI, GFCF, and other known factors.

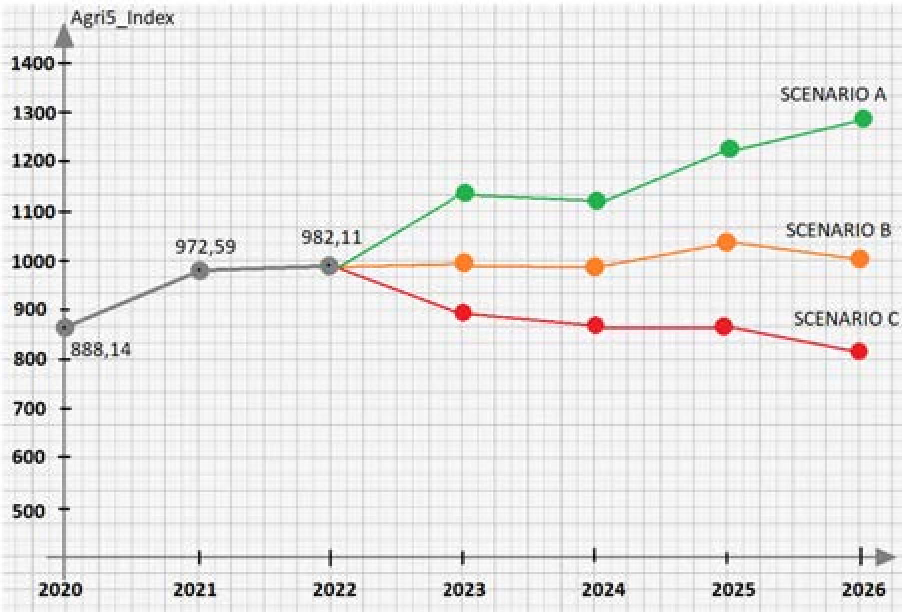
- $\beta 0$ = 326.06 (intercept of the regression model)
- $\beta 1$= 0.0942 (intercept FDI)
- $\beta 2$= 0.3794 (intercept for GFCF)
- $\beta 3$ =2.5 estimated (R&D in agriculture has a high impact on digital farming innovation)
- $\beta 4$=3.0 estimated (IoT adoption rate has an even greater effect on smart agriculture development).
- $\beta 5$=1.5 estimated (Rural internet penetration has a moderate impact on the Agriculture 5.0 index).

The linear equation is: $Agri5\_Index\_t = \beta_0 + \beta_1 * FDI\_Agri\_t + \beta_2 * GFCF\_Agri\_t + \beta_3 * R\&D\_Agri\_Exp\_t + \beta_4 * IoT\_Adoption\_Rate\_t + \beta_5 * Rural\_Internet\_Penetration\_t + \varepsilon\_t$

Based on the regression model, the Agri5_Index2020 is 888.14. The Agri5_Index2021 is 972.59, and the Agri5_Index2022 is 982.11. The regression model suggests that Agricultural 5.0 potential is growing steadily from 888.14 in 2020 to 982.10 in 2022. Additionally, domestic investment (GFCF_Agri) has the strongest impact on Agriculture 5.0 readiness. IoT adoption and rural internet expansion are key accelerators, adding significant predictive power to the index. Declining FDI (from 216M EUR in 2020 to 21M EUR in 2022) weakens growth, but domestic investment compensates. On Figure 1., the potential scenarios of further development of Agriculture 5.0 potential are presented.

Figure1. Agriculture 5.0 potential future outcomes (scenarios)

Scenario A: In this scenario, Serbia undergoes a rapid transformation towards



Source: Authors

Agriculture 5.0, driven by a combination of strong government policies, increased investment, digital infrastructure expansion, and high technology adoption rates. The key influencing factors include a significant increase in government funding for agricultural research and development plays an important role. Serbia allocates more than 1.5% of GDP to R&D, with a specific focus on agricultural digitalization, AI-driven farming solutions, and IoT-based smart monitoring systems. These investments stimulate innovation, enabling the deployment of automated irrigation, drone-based monitoring, and AI-powered predictive analytics for crop management. Government grants and subsidies encourage farmers to adopt precision farming technologies, reducing costs and improving productivity. Investor confidence in Serbia's agriculture sector recovers and strengthens, with annual FDI inflows exceeding 250 million EUR. International agritech companies establish partnerships with local farms, facilitating the transfer of modern machinery, AI-powered robotic harvesters, and big-data-driven farm management software. Increased FDI also supports the creation of agritech incubators, where startups develop machine-learning algorithms for yield prediction and blockchain-based food traceability solutions. IoT adoption in agriculture accelerates beyond 20% of farms, enabled by affordable smart sensors, government-backed innovation programs, and a digital literacy push in rural areas. Farmers integrate IoT-based soil moisture sensors, automated weather stations, and GPS-guided autonomous machinery, which optimize input usage, reduce waste, and improve overall farm efficiency. Large agribusinesses develop cloud-based farm management platforms, allowing real-time tracking of soil health, pest risks, and crop growth, further enhancing precision agriculture practices. Broadband penetration in rural areas increases to over 95%, supported by government-private sector partnerships and EU-backed rural connectivity projects. High-speed 5G networks are deployed in agricultural regions, ensuring seamless real-time data transmission from IoT devices. With reliable connectivity, farmers have direct access to global commodity markets, digital advisory services, and AI-powered farm management platforms. The increased availability of capital and technological advancement lead to a widespread mechanization wave, including the adoption of autonomous tractors, robotic fruit pickers, and AI-driven greenhouse systems. Serbian farmers, supported by favorable government tax incentives on agricultural robotics, transition to fully automated harvesting and precision fertilization, significantly increasing efficiency and reducing labor costs. Advances in AI-powered irrigation and satellite-monitored crop health assessment contribute to higher water use efficiency. Serbia achieves smart water management by deploying IoT-enabled drip irrigation systems that automatically adjust water levels based on real-time soil moisture and weather data. As a result, the agricultural sector reduces water waste while maintaining optimal crop yields, making it more resilient to climate change.

If this scenario materializes, Serbia emerges as a leader in smart agriculture in Southeast Europe, benefiting from higher yields, lower production costs, greater sustainability, and improved rural prosperity. The country reduces its reliance on traditional farming techniques and transitions into a fully digital agricultural economy.

Scenario B: In this scenario, Serbia experiences gradual but uneven progress toward Agriculture 5.0. Some technological advancements occur, but the pace of transformation remains moderate due to limited government support, inconsistent foreign investment, and slow adoption of digital farming practices. The transition to smart agriculture remains incomplete, with only partial adoption of modern technologies across the sector. Serbia maintains its current level of R&D investment (~0.95% of GDP), the funding is not significantly increased. Agricultural innovation receives some government support, but the allocation is not enough to drive large-scale adoption of AI-driven precision agriculture. The focus remains on traditional mechanization and conventional farm subsidies, but digital transformation efforts remain fragmented. FDI remains low but stable, averaging around 50 million EUR per year. International investors show interest in Serbia's agriculture sector, but lack of aggressive government incentives and policy clarity prevents large-scale investment inflows. Some agritech firms establish pilot projects in precision agriculture, but there is no nationwide adoption of high-tech farming. The adoption of IoT-driven smart agriculture remains concentrated in large agribusinesses, but smaller and mid-sized farms lag behind. Farmers experiment with basic IoT solutions, such as soil sensors, automated weather stations, and remote-controlled irrigation systems, but high costs and lack of digital literacy prevent widespread usage. Broadband access continues to expand, but rural connectivity remains uneven, with some remote agricultural regions still lacking high-speed internet. Major farming regions gain access to 4G and 5G networks, small-scale farmers struggle with connectivity issues, limiting their ability to integrate cloud-based farm management solutions. The use of tractors, harvesters, and automated irrigation systems increases, but fully autonomous farming equipment (robotic fruit pickers, AI-driven harvesters) remains rare. Traditional mechanization expands, but the transition to AI-assisted decision-making in agriculture remains slow. Many farmers continue to rely on experience-based decision-making rather than data-driven insights. Some farmers adopt smart irrigation techniques, but many still use traditional flood irrigation or outdated sprinkler systems. Water scarcity risks persist, especially in regions that lack AI-powered irrigation planning. The transition to fully automated, data-driven water management is delayed, limiting Serbia's ability to optimize water use. Serbia makes some progress in precision breeding and crop genetics, but lack of large-scale R&D funding and international collaborations prevents major breakthroughs. Some heat-resistant and drought-tolerant crop varieties are introduced, but not at a level that ensures long-term climate resilience.

This scenario results in moderate progress, where Serbia adopts Agriculture 5.0 at a slow pace. Some farms integrate smart technologies, but many remain reliant on conventional farming methods. Serbia fails to establish itself as a regional leader in digital agriculture, and productivity improvements are limited compared to leading agricultural economies.

Scenario C: In this scenario, Serbia falls behind in the global transition to Agriculture 5.0, resulting in technological stagnation, low investment, and declining productivity. The failure to adopt digital agriculture leads to reduced competitiveness, lower efficiency, and increased vulnerability to climate change and economic fluctuations. Without strong policy intervention and strategic investment, the agricultural sector remains reliant on outdated farming techniques, limiting growth and sustainability. Government expenditure on agricultural research and development falls below 0.7% of GDP, as priorities shift to other sectors. Without sufficient funding, technological innovation slows down, leaving farmers without access to advanced precision farming tools, AI-driven decision support systems, or genetic advancements in crops. Research institutions struggle to maintain agritech programs, and local agritech startups fail to scale due to lack of support. Foreign investment in agriculture collapses to below 20 million EUR annually, as investors lose confidence in Serbia's ability to modernize its agricultural sector. Without FDI, access to modern machinery, AI-powered automation, and blockchain-based supply chain solutions remains extremely limited. Agribusinesses become dependent on outdated farming practices, reducing export competitiveness. Less than 5% of farms integrate IoT technologies, as high costs, lack of digital skills, and poor infrastructure prevent the adoption of smart sensors, automated monitoring systems, and AI-powered farm analytics. Without IoT-driven precision farming, Serbian agriculture continues to suffer from inefficient water use, uncontrolled pest outbreaks, and suboptimal resource allocation. Rural broadband penetration stagnates below 85%, leaving many remote farming communities without reliable internet access. This prevents farmers from using cloud-based farm management systems, digital marketplaces, and online advisory services. The lack of connectivity exacerbates the technological gap between Serbia and other agricultural economies, further limiting growth. Farm mechanization remains outdated, with many small and medium-sized farms continuing to use manual labor and inefficient machinery. The lack of investment in modern agricultural equipment results in lower productivity and higher operational costs. Advanced automation, such as AI-powered tractors, robotic fruit pickers, and drone-assisted farming, remains inaccessible, reducing Serbia's ability to compete with digitally advanced agricultural nations. Inefficient irrigation practices persist, as AI-driven precision irrigation systems fail to gain traction. Farmers continue to rely on traditional flood irrigation and outdated sprinkler systems, leading to water wastage, soil degradation, and reduced long-term sustainability. As climate change worsens, the agricultural sector becomes increasingly vulnerable to droughts and extreme weather conditions. Serbia fails to develop new high-yield, climate-resilient crop varieties, as biotechnology research remains underfunded and poorly integrated into the agricultural economy. Without precision breeding and advanced genetic engineering, Serbia's crops struggle to withstand changing climate conditions and pest outbreaks, reducing overall yields.

Failing to transition to Agriculture 5.0 could set Serbia back decades, making it heavily dependent on traditional, low-tech farming methods while other nations fully integrate AI, automation, and precision agriculture into their food production systems.

Discussion

Based on the theoretical background and data analysis, the hypotheses are addressed as follows:

H1: Higher levels of foreign and domestic investment positively impact the digital transformation of agriculture. Partially Confirmed. The analysis showed that domestic investment (GFCF_Agri) had a strong positive impact on Agriculture 5.0 potential, as indicated by a significant regression coefficient ($\beta_2 = 0.3794$). However, foreign direct investment (FDI_Agri) exhibited volatility and a negative correlation (-0.757) with domestic investment, suggesting that when FDI declines, domestic investments compensate rather than complement. This indicates that FDI does not consistently contribute to digital transformation.

H2: Increased government R&D spending in agriculture accelerates the adoption of smart farming technologies. Confirmed. The regression model estimated that government R&D expenditure (R&D_Agri_Exp) had a strong positive impact on Agriculture 5.0, with an estimated coefficient ($\beta_3 = 2.5$). This highlights that investment in agricultural research directly supports digital transformation, innovation, and the adoption of smart farming solutions.

H3: Higher IoT adoption rates significantly contribute to the development of precision agriculture. *Confirmed.* The regression model estimated that IoT adoption (IoT_Adoption_Rate) had the highest impact among technology-related factors, with a coefficient of ($\beta_4 = 3.0$). This confirms that IoT-driven smart farming solutions, such as soil sensors and automated irrigation systems, play an important role in enhancing agricultural productivity and efficiency.

Furthermore, to transition toward Scenario A (Accelerated Growth) and avoid stagnation, Serbia needs a comprehensive national strategy for Agriculture 5.0. Below are key policy recommendations, categorized into investment strategies, infrastructure expansion, regulatory reforms, and capacity-building initiatives:

- R&D spending in agriculture should be increased to at least 1.5% of GDP to support the development of AI-driven farming solutions, automated irrigation, and climate-resilient crop varieties.
- Agriculture 5.0 Innovation Fund should be established to provide grants for agritech startups and research institutions working on smart farming technologies.
- University-industry collaborations in agritech should be encouraged, supporting knowledge exchange and commercialization of AI-driven agricultural tools.
- A national AI strategy for agriculture should be developed, incorporating machine learning algorithms for pest control, predictive analytics for yield forecasting, and drone-assisted crop monitoring.
- High-speed internet access is essential for the adoption of IoT-enabled smart farming and digital supply chains.
- Broadband coverage should be expanded to ensure 100% rural internet penetration by investing in fiber-optic networks and 5G deployment in agricultural areas.
- Tax incentives should be provided for telecom companies to extend high-speed internet to remote farms.
- “Smart Farms Connectivity Program” could be introduced subsidizing farmers to install IoT-enabled infrastructure (soil sensors, automated irrigation systems).

- Open-data agricultural platform should be developed where farmers can access real-time weather data, soil health analysis, and AI-driven market price forecasts.
- Traditional mechanization must evolve into AI-driven and autonomous farming systems.
- "Smart Agriculture Subsidy Program" should be launched, providing financial support for farmers purchasing precision tractors, robotic harvesters, and AI-powered irrigation systems.
- Public-private partnerships (PPPs) should be planned with agritech firms, making cutting-edge automation accessible to Serbian farms.
- Low-interest loans should be provided for mechanization upgrades, allowing small and medium-sized farms to afford drone-based monitoring, automated greenhouses, and robotic seeding systems.
- An "IoT for Agriculture Grant Program" should be created for funding smart farming solutions like remote soil sensors, GPS-guided drones, and automated irrigation.
- National IoT Agriculture Strategy could be developed promoting data-driven decision-making in farming operations.
- Training programs for farmers should be provided on how to use IoT dashboards, AI-based yield prediction models, and precision application of fertilizers.
- AI-powered irrigation management systems should be implemented, ensuring optimal water distribution.
- Subsidies for smart irrigation systems should be provided, including IoT-enabled drip irrigation and satellite-controlled water distribution networks.
- Serbia should be promoted as a hub for sustainable agriculture and AI-driven food production, attracting international partnerships.
- Agriculture 5.0 courses could be introduced in universities and vocational schools, training students in agri-data science, AI-powered farm management, and precision farming techniques.
- Digital literacy programs for farmers has to be developed, ensuring they can operate smart farm technology effectively.
- AI-powered climate risk analysis tools could be integrated, predicting droughts and extreme weather impacts.

These recommendations if applied in some capacity can significantly affect the trajectory of Agriculture 5.0 development in Serbia.

Conclusion

This study analysed Agriculture 5.0 potential in Serbia. Based on the available data it was found that the primary influencing factors are domestic investment, government R&D spending, IoT adoption, and rural internet penetration. These factors play an important role in the adoption of digital and precision farming technologies. However, foreign direct investment has shown volatility and does not consistently contribute to Agriculture 5.0 development, indicating that Serbia relies more on local investments for modernization. The findings highlight the need for policy measures that support smart farming initiatives, expand digital infrastructure, and increase funding for agricultural research and development. Strengthening investment in IoT-driven agriculture and AI-powered solutions will improve productivity, efficiency, and sustainability, ensuring Serbia remains competitive in the global agricultural sector.

Future research should focus on developing a comprehensive Agriculture 5.0 readiness index to better assess progress and identify areas for improvement. Comparative studies with other countries could provide benchmarks and best practices for Serbia's agricultural transformation. Additionally, long-term analyses on investment impacts, farmer adoption behavior, and sustainability benefits will help refine strategies for integrating advanced technologies in agriculture. Addressing these areas will contribute to a more data-driven and resilient agricultural sector in Serbia.

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Conflict of interests

The authors declare no conflict of interest.

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ON THE EMPIRICAL DISTRIBUTION OF THE BALASSA AND GRUBEL LLOYD INDEX OF SERBIAN FOOD PRODUCTS

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A B S T R A C T

The research analyzes the comparative advantage of Serbia's agricultural food product exports using the Balassa (RCA) and Grubel-Lloyd (GL) indexes, covering 2005–2024. Results for 2024 show a strong RCA in wheat and a significant advantage in flour, corn, barley, groats, and processed fruit. The greatest RCA growth occurred in barley and spices, while chocolate and dairy products saw the steepest decline. The analysis of trade structure indicates that Serbia maintains a predominantly inter-industry trade pattern across most product groups. However, there is notable growth in intra-industry exchange, as evidenced by an increase in the GL index for tea, live animals, cereal products, and chocolate. The highest GL index growth in inter-industry trade was recorded for processed fish. Overall, the study highlights Serbia's stable export surplus in agri-food trade and evolving trade dynamics, especially the increasing presence of intra-industry trade in selected product categories.

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Introduction

In the modern economy, special attention is given to improving the competitiveness and sustainability of enterprises, and the need for business transformation is no longer questioned but seen as essential. Competitiveness and business success are based on continuous development, which includes adequate financing, efficient use of resources, increasing market share, pricing strategies, research and development, service provision, and above all, quality (Porter, 1990). Competitiveness is also strongly linked to the level of technological advancement, the application of knowledge, and research efforts (Ignjatijević et al., 2020, 2022; Leão & da Silva, 2021). In contrast to this microeconomic understanding of competitiveness, the concept of international competitiveness is often associated with the effects of economic policy and global economic trends. Thus, the aim of this research is to analyze the comparative advantage of Serbia's agricultural food product exports using the Balassa index (RCA) while looking at the level of intra- or inter-industry character of the exchange using the Grubel Lloyd index (GL). An overview of the literature is presented below. The research method is then described, followed by results and discussion. The last section contains concluding remarks.

Literature review

Numerous authors have analyzed the competitiveness of various industrial sectors using the RCA index, with a particular emphasis on the food industry. Bojnec et al. (2005) and Bojnec and Marčeta (2022) examined the reforms in Slovenia's food industry, while Prodanović et al. (2021) determined the competitiveness of Serbian honey and analyzed the influencing factors to create an adequate strategy for maintaining and strengthening its competitive position. Jaklič and Svetličič (2017) highlighted that success in foreign markets largely depends on knowledge and adherence to administrative procedures. A significant obstacle to effective international integration lies in the lack of expertise and experience in marketing and management. Several studies conducted by Majkovič et al. (2006), Mizik (2021), Ignjatijević and Cvijanović (2022), Svatoš and Smutka (2012), De Castro and Hnát (2017), as well as Blažková and Chmeliková (2015) and Blažková (2016), reached similar conclusions, identifying products with a positive comparative export advantage and emphasizing the crucial role of structural changes in achieving this advantage. These authors also underline the importance of small enterprises in food processing, which helps reduce the dominance of foreign companies in domestic markets. However, integration into international trade flows increases foreign trade dependence, and Smutka et al. (2017) concluded that EU accession has led to a higher dependence on EU markets. Countries with lower export competitiveness tend to export a greater share of low-processed and semi-processed products with lower unit values (Đurić et al., 2020). Countries with lower export competitiveness tend to export a greater share of low-processed and semi-processed products with lower unit values. Interest in the organic products as premium organic products in the Serbian market [A1] (Vapa-Tankosić et al., 2018; Vapa-Tankosić et al., 2020

Materials and methods

The subject of this research is the analysis of the level of specialization and the revealed comparative advantage in the export of selected agri-food product groups from Republic of Serbia on the international market. The aim is to identify comparative advantages and propose economic measures to stimulate and accelerate the export of agri-food products The research covers the period from 2005-2024, a period of surplus in foreign trade exchange of agri-food sector. To analyze the competitiveness of Serbia's agri-food industry at the sectoral level, researchers employed the Revealed Comparative Advantage (RCA) index and the Export Specialization Indicator (GL), while dynamic analysis was conducted through comparisons of quantitative indicators based on methodologies developed by Havlik, Landesmann & Stehrer (2001), Ignjatijević et al. (2021), Saboniene et al. (2013), and Czarny & Żmuda (2018). The theory of comparative advantage was developed by Balassa, who based his approach on the relationship between export shares and the ratio of exports to imports. He introduced the concept of export performance, which compares a country's industry-specific exports to the global export level of the same product, thereby assessing its comparative advantage. The original RCA coefficient is defined by a:

$$RCA = \ln\left[\frac{X_i}{M_i}\right] \times \left(\frac{\sum_{i=1}^{n} X_i}{\sum_{i=1}^{n} M_i}\right) \times 100$$

, formula

Where *X* is the export value and *M* is the sign for the import value. Index *i* indicates the processed food sector as a whole or products of that sector. In practice, the most commonly used form is the Balassa index, which reflects the logarithmic value of the relative coverage of imports by exports for individual sectors or products, compared to the coverage ratio at the national level. This index is designed to highlight products that demonstrate comparative advantage by having export volumes exceed import volumes.

To analyze the level of specialization within intra-industry trade—defined as the simultaneous export and import of similar or identical product groups within the same sector—the Grubel-Lloyd index is used. This index is calculated for a specific product group i, where X represents export value and M import value. The index ranges from 0 to 1, with higher values indicating a greater degree of intra-industry trade specialization, while lower values suggest that trade is predominantly inter-industry, meaning countries are exchanging different types of products. Intra-industry trade is typically associated with more developed economies, where product differentiation and market segmentation play a larger role. The Grubel-Lloyd index is calculated using the following formula:

$$GL_i^t = \left(\sum_{i=1}^{n} \left(X_i^t + M_i^t \right) - \sum_{i=1}^{n} \left| X_i^t - M_i^t \right| \right) / \sum_{i=1}^{n} \left(X_i^t + M_i^t \right)$$

where is:

- index of intra-industrial trade of sector i in year t,

- export of commodity group i in year t,

- import of commodity group i in year t i t [2005 - 2024].

Results and discussion

The research results indicate that the agriculture and food industry sector represents an important economic segment. The period that preceded these movements[A1] was a period of transition, when the entire economy, including agriculture, was faced with numerous challenges. International isolation, the disintegration of the country and customs and trade restrictions, which led to the loss of traditional markets and a deficit in foreign trade, should definitely be mentioned here. . Nevertheless, if we take into account the data from 2005 and 2024, we conclude that the situation has changed, and that export growth has been achieved various segments of agricultural and food products, such as cereals, vegetables and fruits, animal feed, and others. This indicates a successful market adjustment and a positive foreign trade balance of this sector. The increase in exports was accompanied by an increase in imports, which is the result of increased propulsivity of the sector, due to the growth of domestic demand, demand for specific products and the increased needs of the processing industry for raw materials that are not produced in sufficient quantities in Serbia.

Table 1. Dynamics of export and import of agricultural and food products of Serbia (thousand $)

Products	EXPORT	IMPORT	EXPORT	IMPORT	EXPORT	IMPORT	Δ2024/2015 EXPORT	Δ2024/2015 IMPORT
	2005	2005	2015	2015	2024	2024		
00 - Live animals	2.444,1	8.341,4	58.622,5	31.391,6	44.108,0	42.147,1	-14.515	10.756
01 - Meat and meat products	32.940	15.230,8	97.136,5	100.635,7	103.150,7	343.772,3	6.014	243.137
02 - Dairy products and birds' eggs	11.670,7	12.389,2	89.474,1	49.256,3	224.142,6	240.531,2	134.669	191.275
03 - Fish, crustaceans, molluscs and products thereof	2.184	53.446,4	5.799,5	78.874,9	16.235,3	160.148,4	10.436	81.274
04 - Cereals and cereal-based products	183.579,8	41.521,8	638.078,3	85.919,5	1.104.202,2	350.884,5	466.124	264.965
05 - Vegetables and fruit	261.928,4	160.561,8	763.642,9	302.653,8	1.162.665,6	786.231,2	399.023	483.577
06 - Sugar, sugar products and honey	175.734,3	40.730,2	114.151,2	33.217,8	91.526,9	99.653,8	-22.624	66.436
07 - Coffee, tea, cocoa, spices and products thereof	44.524,4	120.450,6	83.081,1	210.122,4	276.754,9	546.824,2	193.674	336.702
08 - Animal feed	18.533,4	49.020,6	109.897,3	65.355,9	397.276,1	179.917,2	287.379	114.561
09 - Miscellaneous food products and products thereof	42.584,2	89.113,1	126.113	149.135,3	398.981,0	357.872,9	272.868	208.738

Source: RZS * In 2005, SITC, rev 3.

Exports of agricultural and food products of the Food and Live Animals Section (Sections 0) of SITC in 2024 amounted to $3,819,043.30 thousand, while imports amounted to $3,107,982.80. In the analyzed year, an increase in foreign trade was recorded, with a more significant increase in imports of $2,001,419.60 thousand. The largest exports in 2024 were recorded by the sections: Vegetables and Fruits ($1,162,665.60 thousand) and Cereals and Cereal-Based Products ($1,104,202.20 thousand), while these sections also recorded the largest increase in exports in 2024 compared to 2015: Cereals and Cereal-Based Products (an increase of $466,123.90 thousand); Vegetables and fruits (an increase of $399,022.70 thousand) and Animal feed (an increase of $287,378.80 thousand). In comparison with these years, the export of the Live Animals section in 2005 was at a significantly lower level ($2.4 million) compared to 2015 ($58.6 million) and 2024 ($44.1 million). The Cereals and cereal-based products sections ($183.6 million), Vegetables and fruits ($261.9 million) and Sugar, sugar products and honey ($175.7 million) already achieved an enviable export result. We can also conclude that the total value of agricultural and food exports increased from $776 million in 2005 to $2,085.99 million in 2015 (Table 1).

Table 2. Values of the RCA and GL indices of the Serbian agricultural and food products section in the period 2005-2024

Sections	RCA 2005	RCA 2008	RCA 2015	RCA 2024	GL 2005	GL 2008	GL 2015	GL 2024
00 - Live animals	-0.53	0.64	0.47	0.03	0.45	0.42	0.7	0.98
01 - Meat and meat products	0.33	0.29	-0.03	-0.9	0.63	0.71	0.98	0.46
02 - Dairy products and birds' eggs	-0.03	0.28	0.45	-0.05	0.97	0.72	0.71	0.96
03 - Fish, crustaceans, molluscs and their products	-1.37	-1.29	-1.95	-1.71	0.08	0.13	0.14	0.18
04 - Cereals and cereal products	0.62	0.66	1.5	0.86	0.38	0.4	0.24	0.48
05 - Vegetables and fruit	0.21	0.18	0.69	0.29	0.76	0.82	0.57	0.81
06 - Sugar, sugar products and honey	0.63	0.6	0.92	-0.06	0.38	0.45	0.45	0.96
07 - Coffee, tea, cocoa, spices and their products	-0.43	-0.47	-0.69	-0.51	0.54	0.55	0.57	0.67
08 - Animal feed (except cereals in grain)	-0.42	-0.02	0.39	0.59	0.55	0.98	0.75	0.62
09 - Miscellaneous food products and their products	-0.32	-0.19	-0.13	0.08	0.65	0.81	0.92	0.95
Average values	-0.13	0.07	0.16	-0.14	0.54	0.60	0.60	0.71

*Source: RZS * In 2005, SITC, rev 3.*

Analysis of intra-industry trade (GL) and comparative advantage (RCA) at the sector level shows:

Intra-industry trade (GL)

• Intra-industry trade in sectors (presence of exports and imports): live animals GL^{2024} 0.98, while $GL^{2005, 2008}$ were 0.42 and 0.7; dairy products and eggs GL^{2024} 0.96, while $GL^{2005, 2008}$ were 0.72 and 0.71; sugar and sugar products GL^{2024} 0.96, while $GL^{2005, 2008}$ were 0.45; vegetables and fruit GL^{2024} 0.81, while $GL^{2005, 2008}$ were 0.82 and 0.57; animal feed GL^{2024} 0.62, while $GL^{2005, 2008}$ were 0.98 and 0.75; miscellaneous food products GL^{2024} 0.95, while $GL^{2005, 2008}$ were 0.81 and 0.92; coffee, tea, cocoa, spices GL^{2024} 0.6, while GL^{2005}, ^{2008} were 0.55 and 0.57;

• Inter-industry exchange is in sections (presence of export or import): fish and processed products GL^{2024} 0.18, while $GL^{2005, 2008}$ were 0.13 and 0.14; cereals and products GL^{2024} 0.48, while $GL^{2005, 2008}$ were 0.4 and 0.24; meat and processed meat GL^{2024} 0.46, while $GL^{2005, 2008}$ were 0.71 and 0.98.

Comparative analysis of specialization in intra-industrial trade shows an increase compared to 2005 in the following sections: Live animals; Dairy products and bird eggs; Sugar, sugar products and honey; Coffee, tea, cocoa, spices and products thereof; Animal feed (except grains); Miscellaneous food products and processed meats.

Comparative advantage index (RCA)

• The section with the highest RCA index shows that a surplus is achieved in foreign trade and is present in the section cereals and cereal products RCA^{2024} 0.86; animal feed 0.59 and vegetables and fruit 0.29.

• The SITC sections that show a pronounced negative comparative advantage and realize a deficit are Fish, crustaceans, molluscs and their products RCA^{2024}-1.71.

Five sections have a negative comparative advantage (Meat and meat products; Dairy products and bird eggs; Fish, crustaceans, molluscs and their products; Sugar, sugar products and honey; Coffee, tea, cocoa, spices and their products), which indicates a deficit in foreign trade in these products.

Table 3. Rank of export of agricultural and food products of the first 20 by commodity groups from Serbia in 2005, 2015 and 2024 ($ thousand)

	2005			2015			2024	
Product group	**EXP.**	**IMP.**	**Product group**	**EXP.**	**IMP.**	**Product group**	**EXP.**	**IMP.**
Sugar, molasses and honey	168,9	29	058 - Fruit preparations and products (except juices)	404,975	37,747	058 - Fruit preparations and products (except juices)	566,256	114,158
Fruit and products (except juices)	148,3	9,8	044 - Corn, in grains	389,278	19,534	044 - Corn, in grains	482,130	77,646

	2005			2015			2024	
Product group	EXP.	IMP.	Product group	EXP.	IMP.	Product group	EXP.	IMP.
Corn, in grains	103,3	2,1	057 - Fruit, fresh or dried	203,937	151,788	081 - Animal feed (except cereals in grains)	397,276	179,917
Cereal products, flour	48,8	32,8	098 - Edible products and products, nec	117,701	134,593	098 - Edible products and preparations, nec	384,959	327,592
Edible products and products	37,8	87,6	081 - Animal feed	109,897	65,356	057 - Fruit, fresh or dried	293,545	309,559
Vegetables, fresh, frozen, processed	35,2	31,4	048 - Cereal products, flour, starch	108,272	55,456	048 - Cereal products, flour, starch	275,709	245,205
Chocolate and other food products containing cocoa	34,5	35,4	061 - Sugar, molasses and honey	105,693	21,974	041 - Wheat and groats, in grains	256,071	2,057
Fruit and vegetable juices	32	12,4	041 - Wheat and groats, in grains	85,048	666	073 - Chocolate and other food products with cocoa, nn	201,381	173,840
Vegetables, processed	26	15,2	054 - Vegetables, fresh, frozen or processed	77,114	64,964	022 - Milk and products, except butter or cheese	149,763	107,658
Fruit, fresh or dried	20,3	90,4	001 - Live animals	58,623	31,392	056 - Vegetables, roots and tubers, processed, nn	145,221	123,899
Wheat and groats, in grain	20	0,1	073 - Chocolate and other food products containing cocoa	50,157	52,288	054 - Vegetables, fresh, frozen or processed	108,067	213,259
Meat, canned products	18,7	8,2	022 - Milk and products, except butter or cheese	46,036	30,978	061 - Sugar, molasses and honey	75,879	45,954
Animal feed (except cereals in grain)	18,5	49	017 - Meat and edible offal, preserved	45,955	35,192	017 - Meat and edible offal, canned, nn	63,933	81,103
Other meat and edible offal, fresh, frozen	9,8	0	012 - Other meat and edible offal, fresh, frozen	42,996	53,341	046 - Flour, groats and meal, of wheat	59,241	4,976
Groats, wheat flour	7,9	0,1	056 - Vegetables, roots and tubers, processed	42,642	35,153	024 - Cheese and cottage cheese	51,639	84,036

	2005			2015			2024	
Product group	EXP.	IMP.	Product group	EXP.	IMP.	Product group	EXP.	IMP.
Milk and products except butter	7,5	8,6	046 - Flour, groats and meal, of wheat	39,427	2,427	059 - Fruit and vegetable juices, non-farmed, alcohol-free	49,577	25,357
Cheese and cottage cheese	2,5	2	059 - Fruit and vegetable juices, non-farmed, alcohol-free	34,975	13,003	071 - Coffee and coffee substitutes	45,909	208,711
Live animals	2,4	8,3	024 - Cheese and cottage cheese	34,923	11,314	001 - Live animals, other than animals of section 03	44,108	42,147
Groats, flour from other cereals	2,3	0,1	071 - Coffee and coffee substitutes	17,691	112,295	012 - Other meat and edible meat offal, fresh, frozen	27,767	206,377
			043 - Barley, whole grain	9,658	743	043 - Barley, in grain	17,964	2,908

Source: Authors' calculations and RZS, * In 2005, SITC, rev 3.

Analysis of foreign trade turnover in 2024 shows an increase compared to 2005. The largest increase is present in the following commodity groups: Prepared fruit and products (except juices), where an increase in exports of $417.956 million and an increase in imports of $104.358 million was achieved; Corn, in grain, where an increase in exports of $378.830 million and an increase in imports of $75.546 million was achieved; Animal feed (except grain cereals) with an increase in exports of $378.776 million and Edible products and processed foods, with an increase in exports of $347.159 million compared to 2005.

Comparative advantages and the index of intraindustrial exchange of agricultural-food products

The analysis of comparative advantages in foreign trade exchange is devoted to dynamic analysis (RCA index) at the level of commodity groups (aggregation level 3 digits SITC, rev.4). This gives an assessment of the export potential of products of agricultural origin.

Commodity groups can be classified according to the level of comparative advantage indicators (RCA, Balassa index), by classifying products with:

• product groups with an RCA index value of 0 to 1.00 are classified as satisfactory advantages,

• product groups with an RCA index value of 1.00 to 2.00 are classified as having significant advantages and

• commodity groups with an RCA index over 2.00 are classified as having exceptional comparative advantages.

Table 4. Ranking of commodity groups of agricultural and food products of Serbia according to the RCA index of comparative advantage in 2024

Commodity groups	2005*	2008	2015	2024
Exceptional comparative advantag				
041 - Wheat and groats, in grain	0.55	1.62	3.63	3.61
Significant comparative advantages				
046 - Flour, groats and meal, of wheat	1.82	1.77	2.09	1.85
047 - Groats and meal of other cereals	-1.12	2.50	2.56	1.44
044 - Maize, in grain	2.66	1.50	2.24	1.37
043 - Barley, in grain	-0.39	-0.68	1.92	1.36
058 - Fruit preparations and products (except juices)	1.07	1.09	1.78	1.20
Satisfactory comparative advantages				
081 - Animal feed (except cereals in grain)	1.06	0.07	0.39	0.59
059 - Fruit and vegetable juices, non-farmed, alcohol-free	0.04	0.44	0.74	0.50
061 - Sugar, molasses and honey	1.14	0.86	1.18	0.37
075 - Spices	-0.87	0.51	0.35	0.37
022 - Milk and products, except butter or cheese	1.20	0.43	0.30	0.25
098 - Edible products and preparations, nec	-0.54	-0.01	-0.10	0.12
056 - Vegetables, roots and tubers, processed, nec	-0.53	0.17	0.14	0.12
073 - Chocolate and other food products containing cocoa, nec	1.76	0.39	-0.03	0.11
048 - Cereal products, flour, starch	0.19	0.44	0.50	0.09
001 - Live animals, except animals of division 03	-	0.87	0.47	0.03

Source: Authors' calculations and RZS

* In 2005, SITC, rev 3.

The analysis of the comparative advantage of exports of commodity groups showed the following results:

The following commodity groups have an exceptional comparative advantage (the highest coefficient): wheat and oat bran, in grain (RCA^{2024} =3.61);

The following commodity groups have significant comparative advantages: Flour, groats and semolina, from wheat (RCA^{2024}=1.85), Groats and flour from other cereals (RCA^{2024}=1.44), Corn, in grain (RCA^{2024}=1.37), Barley, in grain (RCA^{2024}=1.36), Prepared fruit and products (except juices) (RCA^{2024}=1.20).

The following commodity groups have satisfactory comparative advantages: Animal feed (except cereals) (RCA^{2024}=0.59), Fruit and vegetable juices, non-farmed, alcohol-free (RCA^{2024}=0.50), Sugar, molasses and honey (RCA^{2024}=0.37), Spices (RCA^{2024}=0.37), Milk and products, except butter or cheese (RCA^{2024}=0.25), Edible products and processed foods, n.a. (RCA^{2024}=0.12), Vegetables, roots and tubers, processed, n.a. (RCA^{2024}=0.12), Chocolate and other food products. with cocoa,nn (RCA^{2024}=0.11), Cereal products, flour, starch (RCA^{2024}=0.09), Live animals, except animals from section 03 (RCA^{2024}=0.03).

The research found the largest increase in the RCA index in the following commodity groups: Barley, in grain: From RCA^{2005} from -0.39 in 2005 to RCA^{2024} 1.36, which represents an increase of +1.75; Edible products and processed products RCA^{2005} -0.54 to RCA^{2024}0.12 in 2024, which is an increase of 0.66 index points; Spices: RCA^{2005} from -0.87 to RCA^{2024} 0.37, which is an increase of 1.24 points.

The biggest reduction is present in the product groups: Chocolate and other food products with cocoa, not mentioned): With RCA^{2005} of 1.76, the value of the index was reduced to 0.11 in 2024; for Milk and products, except butter or cheese, the index value was reduced from RCA^{2005} 1.20 to 0.25 in 2024, which is a decrease of 0.95 index points. In the commodity group Sugar, molasses and honey, there is a decrease from With RCA^{2005} 1.14 to 0.37 in 2024, which is a decrease of 0.77. In the commodity group Maize, in grains we have a significant decrease in the value of the index from With RCA^{2005} 2.66 to 1.37 in 2024 (a decrease of 1.29).

Table 5. Values of the intra-industrial trade coefficient (GL) of commodity groups of the SITC Rev.3.

Inter or intra -industry trade	**2005**	**2008**	**2015**	**2024**
Inter-industry trade				
062 - Sugar products	0.13	0.79	0.86	0.45
071 - Coffee and coffee substitutes	0.19	0.06	0.27	0.36
058 - Fruit preparations and products (except juices)	0.65	0.17	0.17	0.34
043 - Barley, in grains	0.00	0.37	0.14	0.28
044 - Maize, in grains	0.57	0.07	0.10	0.28
034 - Fish, fresh, chilled or frozen	0.04	0.04	0.13	0.26
035 - Fish, dried, salted, in brine, smoked	0.04	0.04	0.87	0.26
047 - Groats and meal of other cereals	0.03	0.01	0.06	0.26
012 - Other meat and edible offal, fresh, frozen	0.75	0.91	0.89	0.24
046 - Flour, groats and meal, of wheat	0.27	0.04	0.12	0.15
072 - Cocoa	0.05	0.05	0.25	0.14
042 - Rice	0.43	0.07	0.11	0.12
016 - Meat and edible offal, salted, dried	0.57	0.60	0.54	0.10
037 - Fish, crustaceans, molluscs, etc., preserved	0.01	0.36	0.14	0.09
036 - Crustaceans and invertebrates	0.00	0.00	0.08	0.03
041 - Wheat and groats, in grain	0.07	0.06	0.02	0.02

Inter or intra -industry trade	2005	2008	2015	2024
Inter and intra-industrial trade				
025 - Birds' eggs and egg yolks, fresh, dried (whites)	0.70	0.80	0.86	0.57
045 - Cereals, in grain, other	0.00	0.91	0.86	0.50
Intra-industrial trade				
001 - Live animals, except animals of section 03	0.45	0.26	0.70	0.98
074 - Tea and mate	0.03	0.86	0.77	0.98
057 - Fruit, fresh or dried	0.45	0.70	0.85	0.97
048 - Cereal preparations, flour, starch	0.14	0.55	0.68	0.94
073 - Chocolate and other food products with cocoa, nn	0.03	0.60	0.98	0.93
056 - Vegetables, roots and tubers, processed, nn	0.64	0.82	0.90	0.92
098 - Edible products and preparations, nn	0.10	0.99	0.93	0.92
017 - Meat and edible offal, canned, nn	0.32	0.62	0.87	0.88
022 - Milk and products, except butter or cheese	0.63	0.56	0.80	0.84
024 - Cheese and cottage cheese	0.70	0.51	0.49	0.76
075 - Spices	0.23	0.49	0.77	0.76
061 - Sugar, molasses and honey	0.95	0.26	0.34	0.75
023 - Butter and other milk fats (milk spreads)	0.11	0.79	0.73	0.69
059 - Fruit and vegetable juices, non-farmed, alcohol-free	0.15	0.55	0.54	0.68
054 - Vegetables, fresh, frozen or processed	0.78	0.86	0.91	0.67
011 - Beef, fresh, chilled or frozen	0.00	0.02	0.96	0.65
091 - Margarine and other edible fats	0.15	0.87	0.73	0.63
081 - Animal feed (except cereals in grain)	0.23	0.93	0.75	0.62

Source: Authors' calculations and RZS

In the commodity groups that have an inter-industry character of exchange, in the analyzed period the greatest increase in the Grubel-Lloyd (GL) index was recorded for: Fish, dried, salted, in brine, smoked. The value of the GL index increased from 0.04 in 2005 to 0.26 in 2024, although in 2015 it had a distinctly intra-industry character. In other commodity groups, such as: Coffee and coffee substitutes (increase from 0.19 to 0.36); Barley, in grain (increase from 0.00 to 0.28); Flour and flour from other cereals (increase from 0.03 to 0.26) led to an increase in the GL index. In essence, most commodity groups have fluctuations in the value of the GL index, but the inter-industry character of the exchange remains present throughout the analyzed period, and there is no significant transition to the intra-industry character of the exchange.

In the commodity groups of intra-industrial nature of exchange, the largest increase in the GL index is present in: Tea and mate; Live animals, except animals from section 03; Cereal products, flour, starch; Chocolate and other food products with cocoa,nn; Edible products and processed products,nn and Fruit, fresh or dried. The largest decrease in the GL index is present in: Sugar, molasses and honey; Vegetables, fresh, frozen or processed; Butter and other milk fats (dairy spreads); Margarine and other edible fats. It is important to emphasize that most other commodity groups have achieved a noticeable increase in the GL index. In some groups, we have a moderate increase in the GL index (e.g. cheese and cottage cheese, milk and products other than butter and cheese, canned meat).

Conclusion

In the view of the findings, the 2024 research into the comparative advantage of Serbia's exported commodity groups paints a picture of its international trade position. The data emphatically highlights an exceptional Revealed Comparative Advantage (RCA) in wheat, underscoring Serbia's strong competitive edge in this primary agricultural product. Furthermore, the research identifies a significant RCA in several other key agricultural outputs, including flour, groats, corn, barley, and processed fruit, suggesting a broader strength in the agricultural and food processing sectors.

Interestingly, the dynamics of comparative advantage are not static. The study reveals that barley and spices experienced the largest increase in their comparative advantage during 2024, indicating a growing international competitiveness. Conversely, chocolate and dairy products witnessed the largest decrease in their comparative advantage, suggesting potential challenges or shifts in their global market position.

Delving deeper into the nature of trade, the analysis of inter-industry exchange indicates that for the majority of commodity groups, trade continues to be predominantly characterized by the exchange of goods between different industries. Notably, the Grubel-Lloyd (GL) index showed the greatest increase for fish (dried, salted, smoked), potentially signifying a shift towards more intra-industry trade within this specific sector.

Conversely, the analysis of intra-industry exchange reveals a significant increase in the GL index for tea, live animals, cereal products, and chocolate. This suggests a growing trend of Serbia both importing and exporting similar types of goods within these categories, possibly reflecting product differentiation, specialization within sub-sectors, or the influence of global value chains.

In conclusion, the 2024 research underscores Serbia's strong agricultural export base, particularly in wheat, while also highlighting evolving competitive dynamics and shifts in the nature of its international trade across various commodity groups. The increasing intra-industry trade in certain sectors suggests a more complex and potentially more integrated role for Serbia in the global economy.

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Conflict of interests

The authors declare no conflict of interest.

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SELECTION OF SOCIAL CHANNELS OF COMMUNICATION ON THE EXAMPLE OF AN AGRICULTURAL COMPANY

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A B S T R A C T

The paper selected the most efficient social communication channel in an agricultural enterprise. On this occasion, an innovative expert decision-making method was used, namely its fuzzy variant SiWeC and RAWEC. Ten criteria and six alternatives were set, and the results show that the criteria “Number of users”, “User characteristics” and “Feedback speed” have the greatest importance, while the most important (most favorable) social channel of communication is “facebook.”The successful application of the method used was confirmed, as well as the importance of certain factors in the form of analyzed criteria, the number of which should be increased in future research, and the method itself should be further developed.

Introduction

In modern business processes, continuous correspondence with end consumers is unthinkable without social channels of communication. In addition to the fact that companies promote their products through them, they also establish a partnership with the end users of the services. Therefore, their selection, i.e. evaluation, which is the most favorable at the given moment, is also very important. As concluded by Camacho et al., (2020), social networks have become an indispensable tool for direct communication with consumers in a modern company. Without them, every company today cannot generate sufficient income from the sale of its products. (Maier and Wieringa, 2021). Cheung et al., (2020) believe that social networks (channels) have become a marketing channel recognized for their effectiveness in transmitting information, as a means of

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encouraging consumer and brand engagement, and knowledge of the brand (brand) itself. In this sense, Pour and et al., (2021) believe that marketing on social networks will grow exponentially in the future.

In recent years, we have witnessed a change, i.e. a transformation of the way companies operate on social networks (Appel et al., 2020; Sashi and Brynildsen, 2022). All these changes enable better adaptation and communication between consumers and service providers and vice versa. In addition, the strategic directions of companies' operations are changing, and relations with customers are becoming more and more partner-like, that is, they are getting stronger day by day. It can be said that social networks achieve globalization in the business of companies. Also, the same authors believe that the proper use of social networks can significantly reduce costs when designing marketing campaigns. Given that the target population is the younger generation who grew up on social networks, social networks are becoming the primary medium for marketing new products and services.

In addition to the advantages they offer in modern business, social communication channels also impose certain challenges that are reflected in their complexities, as well as the continuous commitment to their development, i.e. adaptability that is reflected in feedback from consumers. Jiuhardi, et al., (2022) believe that social channels of communication are particularly complex when it comes to the agribusiness sector, i.e. companies that sell agricultural products.

In the earlier period, some researchers tried to determine the relationship between the adopted social channel of communication and the potential benefits for farmers as suppliers/suppliers of products. (Miljković and Alačković, 2015; Mihajlov et al., 2023; Milanović et al., 2020; Kostić & Prdić, 2024; Michelson, 2013; La Torbe, 2001) In addition, many authors have analyzed sales channels and ways of communicating with users, i.e. tried to find the best methods of communication that would facilitate the path to consumers. (Dent, 2011; Milićević et al., 2024; Rosenbloom, 2012; Sigh, 2012; Thakran and Verma, 2013) Therefore, Stević et al., (2023) state that in the prevailing market environment, production is increasingly driven by consumer demand.

In order to successfully choose the appropriate communication channel with the end consumer, we use one of the methods in question. Thus, in some of their earlier research, some authors use these expert methods, showing that they can be used successfully, especially when it comes to agribusiness and agriculture. (Nedeljković et al., 2024; Puška et al., 2023; Nedeljković et al., 2023; Nedeljković et al., 2021; Stevanović-Tošović et al., 2020; Stević et al., 2023; Hatami et al., 2020).

In this sense, the subject of this paper is an agricultural company that markets its products on local and regional search sites, and by choosing the most profitable communication channel, i.e. social networks, it would improve its business and achieve higher profits. The choice of social network is a key factor in the success of the company, which improves its presence on the market and achieves direct communication with consumers.

The aim of the work would be to enable the selection of the most suitable social communication channel in an agribusiness company, which would be based on the use of an innovative expert method. Due to the application of imprecise and unclear information, its fuzzy variant, i.e. logic, would be applied. This would also achieve certain specific goals in the work, such as: development of a multi-criteria decision-making model based on the selection of a social communication channel, determination of the importance of the given criteria that are necessary in the selection of the channel itself, testing the application of the innovative method of multi-criteria decision-making as well as giving the necessary guidelines and recommendations for the next potential research in this area, and using the obtained results in other similar companies in order to improve the communication strategy with consumers. Certainly, the contribution of this paper stems from all of this.

Methodology

As it was pointed out earlier, the subject of the research is a company from the field of agribusiness, which in terms of its volume of business belongs to a medium-sized company. It is located in the area of the territory of the city of Novi Sad and belongs to a relatively new company considering the year of establishment and start of work. In addition to the basic production (agricultural and vegetable crops), which is organized on several thousand hectares, the company also deals with the processing and sale of the obtained agricultural products. The company has a wide range of food products, and exports several thousand of its products to countries in the region and the world. These are food products of frozen and semi-frozen fruits and vegetables, as well as canned products such as jams, marmalades, compotes, etc. In this sense, the company wants to improve its business and focus special attention on the part that concerns communication with end consumers on the local and regional (wider) market. In the future, the company wants channels of communication with consumers, and it is necessary to make the most favorable choice for them and a model that would improve the company's sales and operations in the coming years.

The stages of the research flow consist of the following steps:

- Setting the main goal of the research,
- Selection of decision makers,
- Selection of important criteria for the selection of communication channels,
- Selection of potential social channels of communication to be chosen,
- Using research methods,
- Research results,
- Giving conclusions and recommendations.

The first phase refers to the setting of the main goal of the research, which in this case has already been pointed out earlier that it is the choice of the most favorable social channel of communication with consumers.

In the next phase, decision-makers were chosen, i.e. experts who evaluated the set criteria and based on them ranked the given alternatives in the form of social communication channels. The decision-makers were from the company in question, that is, six of them who were assigned to the positions of the commercial and management sectors in the company.

After their selection, the next stage was the selection of criteria of importance. In this case, the selected experts chose criteria for research that would be the most relevant influencing factors in the final choice of a social channel of communication with consumers in the field of agricultural products and their food items. After joint deliberations, the following criteria were selected, and we can see them in table 1.

Table 1. Overview of used criteria

ID	Criteria	Description
1	Number of users	The total number of active users who use a particular social network as a communication channel.
2	User characteristicS	Gender, age, education, geographical location of the user.
3	Interactivity	The possibility of simple communication between users.
4	Advertising price	All advertising costs.
5	Advertising security	Ensuring user communication and privacy.
6	Message content	Characteristics of messages and their adaptability to the target audience.
7	Compatibility	Integration with other existing communication channels.
8	Personalization of message content	Customizing messages for each user.
9	Feedback speed	Improvement through user experience and elimination of possible future disturbances.
10	Additional/specific features	Existence of certain, additional communication options (specific supplements for certain product groups).

Source: Authors

The next phase referred to the assignment of alternatives in the form of social channels of communication, the choice of which is made. After the previous research of the most frequent use of certain channels of social communication, eight alternatives were established for the purposes of this research, which are shown in the following table 2. In the given alternatives (communication channels), we can see that it is about some relatively older communication channels, but still no less popular even today. During the selection, it was necessary to take into account the most common ways of communication of specific users (providers and consumers of agricultural products and their processing products).

Table 2. Overview of used alternatives (social communication channels)

ID	Alternative	Description
1	Twitter (mreža x)	A social platform for exchanging short messages, news, quick interactions with users and monitoring trends.
2	YouTube	A social video platform, where video content is created, watched and shared. The product and the brand are advertised by video.
3	Instagram	A social communication channel for sharing photos and videos with generated chat options.
4	TikTok	Social platform for creating and sharing short videos and generated with different visual effects. Especially popular among the younger generation.
5	Facebook	A user network for sharing content and connecting with other users, enriched with a multitude of advertising tools as well as a wide range of interaction with targeted users.
6	Telegram	A social application for exchanging messages between users. It is characterized by speed and safety.
7	LinkedIn	A social network intended for business networking and advertising in the domain of business and professional events.
8	WhatsApp/viber	Popular applications for exchanging messages, pictures and videos. Suitable for personalizing messages, forming communication groups and quick contact with users.

Source: Authors

The next step concerns the application of the research method itself. For research purposes, we used innovative methods of multi-criteria decision-making SiWeC (Simple Weight Calculation) and RAWEC (Ranking Alternatives with Weights of Criterion) and their fuzzy variant. The concept of fuzzy logic was first introduced by Zadeh (1965) for the purpose of modeling uncertainty in natural language. Fuzzy logic is a generalized version of traditional logic and includes all theories that use fuzzy sets. According to traditional set theory, the elements of a set are either members of this set (1) or they are not (0). (Katranci et al., 2025)

The use of fuzzy logic imposes the application of a linguistic scale. It contains corresponding fuzzy numbers for each linguistic item that experts use when assessing the weight of given criteria. Based on the survey questionnaire and the linguistic assessment, the experts evaluated the criteria, which were transformed into fuzzy numbers after the corresponding scale. The following table 3 presents the linguistic scale with the associated fuzzy numbers.

Table 3. Linguistic scale and fuzzy numbers

Values	F-numbers
V. low -V-L	1, 1, 2
Low -L	1, 2, 4
M. low -M-L	2, 4, 6
Medium -M	3, 5, 7
M. good -M-G	5, 7, 9
Good -G	7, 9, 10
V. good -VG	9, 10, 10

Source: Puška et al., 2024

The paper uses the subjective Fuzzy SiWeC method, which was created to determine the weight of existing criteria in a simple way, taking into account the importance of employees' ratings (Puška et al., 2024). The phases in using this method are:

Phase 1. Evaluation of the weight of the criteria.

Phase 2. Transformation into fuzzy numbers:

$$\tilde{x}_{ij} = \left(x_{ij}^{l}, x_{ij}^{m}, x_{ij}^{u}\right)$$

Phase 3. Normalization of fuzzy numbers.

$$\tilde{n}_{ij} = \frac{x_{ij}^{l}}{max\ x_{ij}^{u}}, \frac{x_{ij}^{m}}{max\ x_{ij}^{u}}, \frac{x_{ij}^{u}}{max\ x_{ij}^{u}}$$

Where is $max\ x_{ij}^{u}$ the maximum value of alternatives.

Phase 4. Calculation of the value of the standard deviation for the experts' ratings ($st.dev_j$)

Phase 5. Weighting of normalized fuzzy scores with standard deviation values.

$$\tilde{v}_{ij} = \tilde{n}_{ij} \times st.dev_j$$

Phase 6. Calculating the sum of the weights.

$$\tilde{s}_{ij} = \sum_{j=1}^{n} \tilde{v}_j$$

Phase 7. Final Calculation of fuzzy values of criteria weights.

$$\tilde{w}_{ij} = \frac{s_{ij}^{l}}{\sum_{j=1}^{n} s_{ij}^{u}}, \frac{s_{ij}^{m}}{\sum_{j=1}^{n} s_{ij}^{m}}, \frac{s_{ij}^{u}}{\sum_{j=1}^{n} s_{ij}^{l}}$$

For the final ranking of the alternatives, we use the fuzzy RAWEC method.

The purpose of creating the method is to facilitate decision making and ranking of alternatives (Puška et al., 2024a). This subjective method uses the calculation of the deviation from the criterion weights. In this way, this method is specific compared to other methods. Below are the phases of the method namely:

Phase 1. Evaluation of alternatives through linguistic values.

Phase 2. Transformation of linguistic grades into fuzzy numbers.

Phase 3. Formation of the summary decision matrix.

Phase 4. Normalization of the aggregate decision matrix.

Maximum normalization:

$$n_{ij} = \frac{x_{ij}^l}{\max\ x_j^u}, \frac{x_{ij}^m}{\max\ x_j^u}, \frac{x_{ij}^u}{\max\ x_j^u}\ \mathrm{r_{ij}} = \frac{\mathrm{x_{ij}}}{\mathrm{max_i\, x_{ij}}};$$

Minimum normalization:

$$n'_{ij} = \frac{\min x_j^l}{x_{ij}^u}, \frac{\min x_j^l}{x_{ij}^m}, \frac{\min x_j^l}{x_{ij}^l};$$

Phase 5. Cumulative deviations from the values of the weights. In this step, the deviations are first calculated, and then the cumulative deviation is calculated for individual alternatives.

$$\tilde{v}_{ij} = \sum_{i=1}^{n} \tilde{w}_j \cdot \left(1 - \tilde{n}_{ij}\right)$$

$$\tilde{v}'_{ij} = \sum_{i=1}^{n} \tilde{w}_j \cdot \left(1 - \tilde{n}'_{ij}\right)$$

Phase 6. Defuzzification of cumulative deviation. In this step, fuzzy numbers are converted into ordinary values.

$$v_{ij\,def} = \frac{v_i^l + 4v_i^m + v_i^u}{6}$$

$$v'_{ij\,def} = \frac{v'^l_i + 4v'^m_i + v'^u_i}{6}$$

Phase 7. Calculating the value of the RAWEC method.

$$Q_i = \frac{v'_{ij} - v_{ij}}{v'_{ij} + v_{ij}}$$

Results

After the selection of the criteria used for the research, their expert evaluation by the already mentioned six experts followed. On the basis of the survey questionnaire filled out by the experts, the linguistic values (grades) of certain criteria were given (table 4), which were again converted into fuzzy numbers based on the previous scale from table 3. After that, through the methodological steps of the fuzzy SiWeC method, the weights of the criteria were obtained, which can be seen in the following table 5.

Table 4. Expert assessment

	Cr.1	**Cr.2**	**Cr.3**	**Cr.4**	**Cr.5**	**Cr.6**	**Cr.7**	**Cr.8**	**Cr.9**	**Cr.10**
E1	V-G	V-G	M	G	M-G	M-G	M-G	G	V-G	G
E2	V-G	G	M-G	G	G	M-G	G	G	V-G	G
E3	G	V-G	M-G	M-G	G	M-G	G	M-G	G	M-G
E4	V-G	G	M-G	V-G	G	M-G	M-G	G	V-G	M
E5	G	V-G	M	G	M-G	M-G	M	M-G	V-G	M
E6	VG	G	G	G	G	G	M-G	G	G	M-G

Source: Authors

The results from Table 5 show that criteria 1, criterion 2 and criterion 9, namely “Number of users”, “User characteristics” and “Feedback speed” received the greatest weight. According to the expert evaluation, the criteria “Interactivity” and “Additional/specific features” showed the least significance.

Table 5. Weights

Criteria	**Težina**
Cr.1	0,09; 0,12; 0,16;
Cr.2	0,09; 0,12; 0,16;
Cr.3	0,05; 0,08; 0,13;
Cr.4	0,07; 0,11; 0,15;
Cr.5	0,07; 0,10; 0,15;
Cr.6	0,06; 0,09; 0,14;
Cr.7	0,06; 0,09; 0,14;
Cr.8	0,07; 0,10; 0,15;
Cr.9	0,09; 0,12; 0,16;
Cr.10	0,05; 0,08; 0,13;

Source: Authors

After the assessment of the weight of the criteria, there followed an expert assessment of the offered alternatives in the form of social communication channels that the company in question uses in its business. We can see the linguistic assessment of decision makers in the following table 6.

Table 6. Expert assessment of alternatives

DM 1	**Cr.1**	**Cr.2**	**Cr.3**	**Cr.4**	**Cr.5**	**Cr.6**	**Cr.7**	**Cr.8**	**Cr.9**	**Cr.10**
Al.1	L	V-L	VL	M-L	M-L	M-L	V-L	V-L	V-L	L
Al.2	G	M	M	M	M-G	V-G	M	M-G	M-G	M
Al.3	M	M-L	M	M	M	M-G	M-L	G	G	M
Al.4	L	V-L	M-L	V-L	M-G	M-G	M-L	M-G	M-G	M-L
Al.5	V-G	M-G	V-G	G	G	M-G	M	M	V-G	M-G
Al.6	V-L	M-L	V-L	M-L	M-L	M-G	L	M-G	M-G	M-L
Al.7	L	V-L	M-L	M	M-L	M	L	M-G	G	L
Al.8	G	V-G	G	VG	G	G	M	V-G	V-G	M
DM 2	**Cr.1**	**Cr.2**	**Cr.3**	**Cr.4**	**Cr.5**	**Cr.6**	**Cr.7**	**Cr.8**	**Cr.9**	**Cr.10**
Al.1	L	M-L	M	M-L	M-L	M	V-L	M-L	L	M-L
Al.2	M	G	G	M	M-G	M-G	M	M-G	M-G	M
Al.3	M	M-L	M-G	V-L	M-G	G	M-L	M	G	M
Al.4	L	M-G	M	M	M	M-G	M-L	M-G	M-G	M-L
Al.5	V-G	G	G	V-G	G	G	M-G	M	G	M-G
Al.6	V-L	M	G	V-L	V-L	M-G	L	M-G	M-G	M-L
Al.7	L	M	M	G	L	V-L	L	M-G	G	L
Al.8	V-G	V-G	M-G	G	G	G	M	G	M	M
DM 3	**Cr.1**	**Cr.2**	**Cr.3**	**Cr.4**	**Cr.5**	**Cr.6**	**Cr.7**	**Cr.8**	**Cr.9**	**Cr.10**
Al.1	V-L	V-L	M	M-L	M-L	M-L	V-L	V-L	M	M
Al.2	G	M	G	M-L	V-G	M-G	M-L	M	M-G	M
Al.3	M	M-L	M-G	M-G	M-G	V-G	M-L	M	G	M
Al.4	V-L	M-G	M	V-L	G	M-G	M-L	M-G	M-G	M
Al.5	G	V-G	G	V-G	V-G	M-G	M-G	M	G	G
Al.6	V-L	M	G	M	M-L	M-G	V-L	M-G	M-G	M-L
Al.7	M	M	M	G	V-L	V-L	M	M-G	G	L
Al.8	V-G	M	MG	MG	G	G	M	V-G	M	M
DM 4	**Cr.1**	**Cr.2**	**Cr.3**	**Cr.4**	**Cr.5**	**Cr.6**	**Cr.7**	**Cr.8**	**Cr.9**	**Cr.10**
Al.1	V-L	V-L	M	M-L	V-L	M-L	V-L	L	V-L	M
Al.2	M	M	G	G	M-G	M-G	M-L	M	M-G	M
Al.3	M-L	M-L	M-G	M-G	M-G	V-G	M-L	M	G	M
Al.4	L	M-G	M	M	G	V-G	M-L	M-G	MG-	M
Al.5	G	G	G	V-G	G	M-G	V-G	M	G	M-G
Al.6	V-L	M-L	G	M	V-L	M	V-L	V-G	M-G	M-L
Al.7	L	V-L	M	G	M-L	M-G	M	M-G	G	V-L
Al.8	V-G	V-G	M-G	M-G	V-G	G	V-G	V-G	M	V-L
DM 5	**Cr.1**	**Cr.2**	**Cr.3**	**Cr.4**	**Cr.5**	**Cr.6**	**Cr.7**	**Cr.8**	**Cr.9**	**Cr.10**
Al.1	L	M-L	M	V-L	V-L	M	V-L	L	L	M
Al.2	G	V-G	G	M-G	G	M-G	M-L	M	M-G	M
Al.3	M-L	M-L	M-G	M-G	M-G	V-G	M	M	G	M
Al.4	M-L	V-L	M	M-L	G	V-G	M-L	G	M-G	M
Al.5	V-G	G	G	V-G	G	M-G	G	G	G	M-G
Al.6	M-L	M-L	G	V-L	M-L	V-L	V-L	G	M-G	M-L
Al.7	M-L	V-L	M	G	M	V-L	M	M-G	V-G	L
Al.8	M-L	G	V-G	M-G	V-G	M-G	V-G	G	M-G	M
DM 6	**Cr.1**	**Cr.2**	**Cr.3**	**Cr.4**	**Cr.5**	**Cr.6**	**Cr.7**	**Cr.8**	**Cr.9**	**Cr.10**

Al.1	V-L	V-L	M	M-L	M	M-L	L	M-G	M	V-L
Al.2	M-L	M	G	M-G	G	G	M-G	M	M-G	M-G
Al.3	M-L	V-L	V-G	G	M-G	V-G	L	M	G	M
Al.4	M-L	V-L	M-L	G	G	M	M-L	G	M-G	M
Al.5	V-G	G	G	V-G	V-G	M-G	M	M	G	V-G
Al.6	M-G	M-L	G	V-L	M	M	V-L	G	M-G	V-L
Al.7	V-G	M-L	M	V-L	G	M-L	M	V-G	V-G	M-L
Al.8	V-G	G	V-G	M-G	V-G	M-G	M	M-G	M	V-G

Source: Authors

After the necessary steps in the calculation of the RAWEC method, we get the ranking order of the offered alternatives with the corresponding coefficient of value in the following table 7. Here we observe that the social network "Facebook" is the first choice for communication with consumers, while it is followed by the communication applications "WhatsApp or Viber". This result is also a consequence of the previous use of the social network Facebook, considering that the company managed to advertise and sell a good part of its products through this network. It included the largest group of active users of different ages and locations, and provided the fastest feedback. The worst ranked social network is Twitter (network X), which is not surprising because the company uses it on a very small scale due to the very nature of its activity. The social channel "You Tube" is ranked third. We note that the networks that are the most popular among young people today are rated the worst ("TikTok" and "Instagram"), which indicates that in a way the ultimate consumers of the company's products are the older generation.

Table 7. Ranking

Alternative		Q_i	**Rank**
Al.1	Twitter (X)	-0,171	8
Al.2	You Tube	0,286	3
Al.3	Instagram	0,231	4
Al.4	TikTok	0,136	5
Al.5	Facebook	0,453	1
Al.6	Telegram	0,111	6
Al.7	LinkedIn	0,105	7
Al.8	WhatsApp/Viber	0,443	2

Source: Authors

Conclusion

The modern character of business also requires adequate channels of communication with consumers, which with the development of social networks are slowly suppressing the conventional ones. The choice of a favorable communication channel is particularly complex in agribusiness due to the nature of the product itself. This raises the question of his proper selection. From the above in the paper, and on the example of a medium-sized agricultural company, we can conclude that in the given circumstances it is necessary to apply the modern method of multi-criteria decision-making, and in conditions of uncertainty and incompleteness of information and its fuzzy logic.

On a practical example, the highest rated criterium related to the number of active users, as well as their characteristics, and the speed of feedback. In this sense, the social network “Facebook” is ranked best, while the social applications “WhatsApp and Viber” follow right behind it. The worse ranking of the networks used by the younger generation (Instagram and TikTok) is noticeable, as well as the lower evaluation of the “advertising price” criterion.

The contribution of the work is reflected in the indication of the importance of certain criteria in influencing the choice, a solid basis for using examples in other similar companies, and the justified role of the used method SiWeC-RAWEC.

What is needed in the future period of is the inclusion of more criteria as well as the development of the existing methodology on top of the expansion of the existing market and the popularization of the previously less used social channels of communication with consumers.

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Conflict of interests

The authors declare no conflict of interest.

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GREEN MARKETING AS A FACTOR OF SUSTAINABLE RURAL TOURISM IN THE ĐURĐEVIĆA TARA NATIONAL PARK

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A B S T R A C T

This paper examines the role of green marketing in developing sustainable rural tourism, with Đurđevića Tara National Park as a case study. The aim was to assess how tourism stakeholders apply green marketing principles and how tourists perceive ecological aspects of the destination. The research identified two related but distinct dimensions linking perceptions of green marketing with sustainable rural development. Correlation and regression analyses confirmed statistically significant positive relationships between these variables. Key sustainability factors include cooperation with the local community and the use of renewable energy. A moderating effect of tourists' origin was observed: domestic tourists value education and nature preservation more, while international visitors prioritize economic and social benefits. These insights emphasize the need for an integrated approach to planning and the importance of adapting strategies to different visitor profiles to achieve long-term sustainability.

Introduction

In the context of global climate change, growing ecological awareness, and increasing pressures on natural resources, the need for sustainable development models has become an imperative across all sectors of society, especially in tourism. As one of the fastest-growing sectors globally, tourism has a significant impact on the natural and social

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environment, but it also holds great potential for enhancing local communities through the preservation of natural and cultural heritage. In this light, sustainable tourism represents a balance between meeting the needs of modern tourists and preserving the potential of destinations for future generations.

Rural tourism holds particular importance in this context, as it often develops in areas rich in natural beauty and traditional lifestyles but faces challenges such as depopulation, infrastructural neglect, and limited economic opportunities. It is in such environments that green marketing emerges as a key strategic approach for promoting values that go beyond commercial goals (Pantović et al., 2025). Green marketing does not only imply environmentally friendly products and services but also encompasses a whole system of communication and resource management that reflects social responsibility, authenticity, and integrity.

Green marketing becomes a tool through which tourist destinations can clearly communicate their commitment to sustainability, in order to attract an increasing number of eco-conscious travelers. In this sense, it fits into the broader concept of value marketing and ethical marketing, aiming to establish a long-term relationship with consumers based on shared principles and goals.

Durmitor National Park, established in 1952, covers an area of 39,000 hectares and encompasses the Durmitor mountain range, the Tara River Canyon, as well as numerous glacial lakes and forest complexes. The Tara River Canyon, with a depth of up to 1,300 meters, is the deepest canyon in Europe and the second deepest in the world, after the Grand Canyon in the United States. The village of Đurđevića Tara, located near the famous bridge over the Tara River, has approximately 147 permanent residents (Durmitor National Park, https://nparkovi.me/uploads/2023/08/PU-Durmitor.pdf). The area's tourism offer includes more than 10 accommodation facilities, including motels, apartments, and rural households, as well as restaurants that serve traditional Montenegrin cuisine (Panacomp Wonderland, https://www.panacomp.net/motel-tara-mb-durdevica-tara). However, despite its natural beauty and potential for sustainable tourism development, the area faces challenges such as insufficient promotion of cultural and historical heritage, limited infrastructure for renewable energy sources, and the need to improve waste management systems.

Đurđevića Tara National Park, known for the spectacular Tara River Canyon - the deepest in Europe, pristine nature, rich biodiversity, and traditional rural households, represents a representative example of an area where natural potentials intersect with the challenges of developing sustainable tourism. Due to its ecological significance, the Park is under a special protection regime, but it also faces pressures resulting from the growth in tourist demand and urbanization.

The research presented in this paper aims to examine the role and effectiveness of green marketing in shaping the tourist product of Đurđevića Tara National Park, as well as the perception of tourists regarding the ecological aspects of the offer. The goal of the research is to identify existing marketing practices and strategies of local stakeholders, determine the level of awareness and motivation of tourists concerning sustainable choices, and provide recommendations for improving the integrated approach to green marketing, in support of developing rural tourism that is economically profitable, socially responsible, and ecologically sustainable.

Research Objectives

The research objectives are aimed at examining tourists' attitudes and perceptions regarding the application of green marketing in rural tourism at Đurđevića Tara National Park. Based on this, the study seeks to identify the connections between the components of green marketing and the dimensions of sustainable rural development and use these findings to improve future marketing practices.

The following hypotheses are tested:

- H1: The variables of green marketing and sustainable rural development represent two interrelated but theoretically distinct factors in tourists' perceptions.
- H2: The variables of green marketing have statistically significant relationships with the variables of sustainable rural development.
- H3: The origin of tourists has a moderating effect on the relationship between green marketing variables and sustainable rural development variables.

Literature Review

The green promotion strategy focuses on resource usage, where the local population would be directed towards creating their own products characteristic of the area (Apaza-Panca et al., 2024). The implications of green marketing are crucial for achieving green and sustainable tourism. Green tourism contributes to economic growth and the protection of the environment and culture of a specific tourist area (Nekmahmud & Fekete-Farkas, 2021). Green marketing holds great potential in addressing ecological problems that increasingly dominate society, politics, and the economy. It represents a tool for promoting resources, places, and destinations presented in the market as organizations dedicated to nature (Shi et al., 2022). The concept of green marketing is a contemporary response by companies to environmentally conscious consumers and has become a key condition for their survival in the market (Jevtić et al., 2023). Strategies for reducing the effects of accelerated climate change have led marketers to decide on more sustainable processes, products, and offers (Rust, 2020). By using green marketing, negative impacts on the environment are minimized, especially when it comes to the segment of offering tourist services (García-Capdevilla et al., 2021).

Research results (Chin et al., 2018) show that tools of green marketing, such as eco-branding, eco-labels, and ecological advertising, have a positive and significant statistical connection with green consumer behavior among tourists in rural tourist destinations. Research (Nekmahmud & Fekete-Farkas, 2021) shows that green marketing plays a significant and positive role in the development of sustainable tourism, as it encourages investments, ecological awareness, and economic growth through providing tailored, sustainable tourist services. The research revealed that green marketing has a positive and significant effect on tourists' intention to contribute to the preservation of rural tourism sustainability. Key elements of green marketing that require special attention include physical evidence, products, promotional activities, and pricing policy (Cahyanti & Menanti, 2019). Rural green tourism is considered a promising branch of the tourism industry and a tool for enhancing the potential of rural areas (Gutkevych & Haba, 2020). In order to quickly adapt the tourism business, it is necessary to introduce innovative types of tourism that will attract more people and provide additional income through innovative offers and digital tools (Roman et al., 2024).

Sustainable rural development can be observed at the international, national, and local levels. The reason why sustainable rural development should be studied at the local government level lies in its diversity and the potential to create solutions tailored to local needs and opportunities (Rogelj et al., 2024). New technologies and economic incentives are used to provide social benefits, employment, revenue generation, natural resource management, and environmental protection in rural areas (Shahid et al., 2023). Sustainable rural development aims to create synergies between development factors such as energy, health, education, water, food, and economic growth (Hossain, 2017). Rural areas often lack adequate resources and certain external relationships that could provide rural innovators with access to knowledge and other resources to overcome ecological challenges more easily (Chaudhury et al., 2017; Dima et al., 2022; Franzen et al., 2024).

Green spaces and natural attractions form the basis of green tourism, and their sustainable use through strategic planning and cooperation among all stakeholders enables long-term economic benefits and environmental preservation (Ijatuyi et al., 2025). Community involvement in green initiatives, through active participation of local stakeholders and capacity building, is a key factor for achieving sustainable rural development (Muthalib, 2024). Solar panels and the Eco-Crowdinvesting platform help reduce operational costs, improve financing, and empower tourist facilities, making energy more accessible and stable. In line with national digital and green economy strategies, this program enables the tourism sector to access solar energy and innovative financing models, thus strengthening the economic resilience of tourist facilities, promoting environmentally responsible business practices, and raising ecological awareness among tourists and the local community (Prasetyo et al., 2024). The study showed that sustainable ecotourism brings significant socio-economic benefits to the local population, while the proposed development model with government support ensures the preservation of natural resources without jeopardizing the economic and social sustainability of the community (Baloch et al., 2023). Eco-cultural tourism supports the sustainable development of the local community and biodiversity conservation. Its promotion raises awareness about the importance of eco-cultural heritage and enables the population to generate additional income and improve their quality of life through authentic offerings (Prnjat, 2024). Understanding key barriers and developing strategic responses through integrated planning and cooperation among stakeholders represents the basis for creating sustainable models of rural tourism that contribute to the development of local communities and the preservation of rural heritage (Mohamed Al Matris, 2023). The research established a statistically significant connection between the implementation of green projects and overall user satisfaction, with statistically significant differences between younger and older populations (Khmaaj et al., 2025).

Materials and methods

For the purposes of this study, the authors independently constructed a structured survey instrument, grounded in relevant literature from the fields of green marketing and sustainable tourism, and specifically adapted to the context of Đurđevića Tara National Park. The survey contained two key thematic dimensions: green marketing in rural tourism and sustainable rural tourism development. Each of these dimensions included five variables, operationalized through three statements per variable. Respondents rated their agreement with each statement using a seven-point Likert scale, ranging from 1 (”strongly disagree”) to 7 (”strongly agree”). In addition to the evaluative items, the questionnaire included demographic questions related to gender, age, tourist origin (domestic or international), frequency of visits to rural tourist destinations, and main motivations for visiting Đurđevića Tara.

The reliability of the measurement instrument was assessed using Cronbach’s alpha coefficient for each analyzed variable individually. The validity of the instrument was considered from two aspects. Content validity was ensured by carefully selecting and formulating items based on the theoretical framework and examples of best practices in sustainable and green tourism, with particular emphasis on the characteristics of rural tourism in protected natural areas such as Đurđevića Tara National Park. Construct validity, although preliminarily confirmed by the logical alignment of theoretical constructs and items, was further tested through exploratory factor analysis, enabling a deeper verification of the instrument’s structure and the validity of the theoretical dimensions it measures.

The research model includes a total of ten composite variables - five representing green marketing (eco-friendly products and services, green promotion, waste management, renewable energy sources, and local community cooperation) and five representing sustainable rural development (nature conservation, tourist education, support for the local economy, tourist number limitation, and sustainable infrastructure). Each variable is measured through three Likert-scale items, forming a total of 30 evaluative statements.

The variables of green marketing and sustainable development within this study were operationalized through specific statements reflecting particular aspects of the tourist offer at Đurđevića Tara National Park. The variable ecological products and services measures the extent to which the tourist offer contributes to nature conservation through the use of environmentally friendly materials and technologies, as well as the provision of sustainable activities that do not harm the natural environment. Green promotion refers to the availability of information about ecological practices and sustainable tourism, the use of ecological certifications, and the impact of promotional campaigns on environmentally responsible tourist behavior. Waste management encompasses the presence of recycling infrastructure, encouraging visitors to reduce waste, and the involvement of local institutions in ecological waste management. The renewable energy sources variable assesses the application of sustainable energy solutions, such as solar panels, and awareness of the importance of transitioning to renewable energy sources in tourism. Collaboration with the local community measures the extent to which locals are involved in the development of the tourist offer and how much the local economy benefits from tourism through the use of local products and services.

Within the dimension of sustainable development, the nature conservation variable assesses the effectiveness of measures to protect the natural environment, including rivers, forests, and wildlife, as well as ecological awareness among visitors and the impact of tourism activities on the ecosystem. Tourist education measures the availability of educational content on ecology and sustainability through promotional materials, guides, and organized tours. Support for the local economy refers to tourism's contribution to the income of local entrepreneurs, the presence of traditional products and crafts, and the employment of local residents. The tourist number limitations variable examines the existence of measures to control visitor numbers and regulate access to natural sites to reduce negative impacts on resources. Finally, sustainable infrastructure includes the presence of eco-trails and cycling routes, as well as the application of energy efficiency principles and ecological construction in accommodation and infrastructure facilities, allowing tourists to enjoy nature with minimal ecological footprint.

Data analysis was carried out using IBM SPSS Statistics 25. Four statistical techniques were applied: descriptive statistics to summarize variable characteristics, Principal Component Analysis (PCA) to confirm construct validity and reduce dimensionality, Pearson correlation to assess relationships among variables, and multiple regression analysis to determine the influence of green marketing dimensions on sustainable development, with additional testing of the moderating effect of tourist origin.

Results

The research was conducted from June to October 2024, involving a sample of 267 respondents. The survey was administered via an online questionnaire. The sample included 51,7% (138) male respondents and 41,6% (111) female respondents, while 6,7% (18) of participants chose not to disclose their gender. Regarding age structure, 51,7% (138) of respondents were younger than 40 years, while 48,3% (129) were older than 40. A majority of respondents, 64,1% (171), were international tourists, while 35,9% (96) identified as domestic tourists from Serbia.

An analysis of the frequency of visits to rural tourist destinations shows that most visitors to the Đurđevića Tara National Park exhibit continuity in such travels. Occasional tourists, who visit rural destinations one to two times per year, make up the largest group, 42,7% (114) of respondents. Following this are those who frequently visit rural areas (more than three times per year), comprising 32,6% (87) of the sample. Interestingly, 24,7% (66) of respondents were visiting such a destination for the first time, indicating growing interest and potential for attracting new market segments.

In terms of main motivations for visiting Đurđevića Tara National Park, adventure tourism (rafting, hiking) was the most commonly cited reason, mentioned by 35,2% (94) of respondents. This was followed by relaxation and recreation, identified by 33% (88), indicating a dual nature of the offering - both active and passive tourism. Ecotourism, involving nature, hiking, and cycling, was noted by 14,8% (39) of respondents. Business reasons were cited by 9,1% (24), while the least frequent motivation, at 8%, was cultural-historical tourism, reported by 21 respondents. These results suggest that Đurđevića Tara National Park primarily attracts tourists seeking physical activity and direct contact with nature. At the same time, the significant number of new visitors presents an opportunity to develop personalized and targeted marketing strategies within green marketing. On the other hand, the low representation of cultural-historical tourism indicates a need for improved interpretation and promotion of local cultural heritage within the context of sustainable destination development.

For a more comprehensive understanding of the green marketing phenomenon in the context of sustainable rural development, a descriptive analysis of the key variables covered in the study was conducted. This analysis provides insight into the basic statistical characteristics of the respondents' attitudes and perceptions, including mean values, standard deviations, and the range of results. The presented results offer a foundation for identifying dominant patterns of behavior and attitudes towards green marketing practices and their role in promoting sustainable development in rural communities.

Table 1. Descriptive Statistics of Green Marketing Variables and Sustainable Rural Development Variables

Variable	Mark	N	Min	Max	Mean	Standard Deviation	Cronbach's Alpha
Eco-friendly Products and Services	GM1	267	1	7	5,37	1,262	0,723
Green Promotion	GM2	267	1	7	5,56	1,165	0,675
Waste Management	GM3	267	1	7	5,22	1,310	0,788
Renewable Energy Sources	GM4	267	1	7	4,77	1,343	0,717
Collaboration with Local Community	GM5	267	1	7	5,74	1,175	0,767
Nature Conservation	RSD1	267	1	7	4,87	1,155	0,776
Tourist Education	RSD2	267	1	7	5,21	1,210	0,820
Support for Local Economy	RSD3	267	1	7	5,86	1,219	0,797
Limiting Tourist Numbers	RSD4	267	1	7	5,17	1,059	0,756
Sustainable Infrastructure	RSD5	267	1	7	4,95	1,166	0,747

Source: Author's research

In Table 1, the results of the descriptive statistics for the analyzed variables of green marketing and sustainable development within the Đurđevića Tara National Park are presented. All analyzed variables achieved high average values, indicating a generally positive attitude of the respondents towards the analyzed variables. Among the green marketing variables, the highest scores were given to GM5 - cooperation with the local community and GM2 - green promotion, while the lowest-rated variable was GM4 - renewable energy sources. This suggests a significant presence of information about ecological practices and sustainable tourism in Đurđevića Tara National Park, as well as adequate cooperation with the local community in terms of engaging local residents and including local products and services in the tourism offer. According to the respondents' opinion, more attention should be given to the use of renewable energy sources and other green technologies to reduce pollution in this tourist destination.

Among the highest-rated variables concerning rural sustainable development are RSD3 - support for the local economy, specifically employment of local population and offering traditional products and crafts of the region. The variable RSD2 - tourist education also achieved a high average value, indicating that significant attention is being paid to providing adequate information on sustainable tourism and the ecological values of Đurđevića Tara National Park. The lowest-rated variable, RSD1 - nature protection, suggests that activities related to the preservation of the natural ecosystem in the region, as well as raising awareness among visitors about behavioral rules during their stay in the national park, need to be improved.

The reliability of the measurement instrument was assessed using Cronbach's alpha coefficient for each individual variable. The obtained results indicate a satisfactory to high level of internal consistency, with alpha coefficient values ranging from 0,675 to 0,820. These reliability coefficient values (Cronbach's α) indicate the internal consistency and scalability of the measurement instruments.

Factor analysis was applied to identify the underlying latent dimensions structuring the variables within green marketing and sustainable rural development. This analysis allows the reduction of a large number of individual items to a smaller number of factors, which represent interrelated concepts and facilitate the interpretation of complex relationships among the variables. Through factor analysis, the aim was to determine whether the items group into coherent sets that reflect the key aspects of perception and practice in the context of sustainable rural development through green marketing activities.

The results of the analysis show a high suitability of the data for factor analysis. The KMO index was 0,903, which is considered an excellent value, while the Bartlett's test of sphericity was statistically significant ($\chi^2 = 1748{,}321$; df = 45; $p < 0{,}001$), confirming the presence of sufficient correlation among the items. Based on the latent value criterion (Eigenvalue > 1), two factors were extracted, which jointly explain 69,18% of the total variance. The results are presented in Table 2.

Table 2. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5,881	58,807	58,807	5,881	58,807	58,807	5,373
2	1,037	10,373	69,180	1,037	10,373	69,180	3,963
3	,763	7,632	76,812				
4	,532	5,321	82,133				
5	,463	4,632	86,765				
6	,360	3,596	90,361				
7	,321	3,209	93,569				
8	,258	2,584	96,154				
9	,206	2,056	98,210				
10	,179	1,790	100,000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance

Source: Author's research

The first factor, which includes the items GM1, GM2, GM3, GM5, and partially RSD3, explains 58,81% of the variance and conceptually corresponds to the green marketing dimension. The second factor, which explains an additional 10,37% of the variance, includes the items RSD1, RSD2, RSD4, RSD5, and GM4, and reflects the sustainable development dimension.

The pattern matrix presents the standardized regression coefficients (factor loadings) of each item on the latent factors, where each coefficient reflects the unique relationship between the item and the specific factor, independent of the influence of other factors. The rotation was performed in seven iterations and resulted in a two-component solution. The results of the pattern matrix are provided in Table 3.

Table 3. Pattern Matrix[a]

MARK	Component	
	1	2
GM1	,965	
GM5	,891	
GM2	,856	
RSD3	,786	
RSD2	,579	,348
GM3	,532	,307
GM4		,937
RSD5		,730
RSD4	,442	,499
RSD1	,455	,490
Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser Normalization.		
a. Rotation converged in 7 iterations.		

Source: Author's research

Factor 1, which represents green marketing, includes the following items: GM1, GM2, GM3, GM5, and RSD3, which relate to the promotion of ecological values and sustainable practices in the tourism offering. These items show high saturations, especially GM1 (0,965), GM5 (0,891), and GM2 (0,856), indicating their strong association with this factor. Factor 2 represents sustainable development and encompasses items GM4, RSD1, RSD2, RSD4, and RSD5, which refer to aspects of education, environmental protection, and local community involvement. The highest saturation is observed for GM4 (0,937), indicating that this item most accurately measures this factor. Some items (e.g., RSD2, RSD4, RSD1) exhibit significant saturations on both factors, but a dominant relationship can be identified for each. For example, RSD2 has a higher saturation on Factor 1 (0,579) than on Factor 2 (0,348), which is enough to classify it within the first factor, though some overlap is recorded.

The results of the Pattern and Structure matrices confirm a clear distinction between the factors, with dominant saturations within each factor. Additionally, the factors are moderately positively correlated ($r = 0,532$), which validates the use of oblimin rotation and suggests that they represent related, but conceptually distinct theoretical constructs.

Based on the obtained findings, Hypothesis H1 is confirmed: the dimensions of green marketing and sustainable development constitute two interrelated, yet theoretically distinct factors in the perception of tourists, thus confirming the construct validity and theoretical consistency of the measurement dimensions.

The mutual influences and relationships between the analyzed variables of green marketing and sustainable rural development were determined through correlation analysis, and the results are presented in Table 4.

Table 4. Correlation Between Green Marketing Variables and Sustainable Rural Development Variables

	GM1	GM2	GM3	GM4	GM5
RSD1	,544**	,573**	,548**	,531**	,505**
RSD2	,566**	,584**	,479**	,505**	,607**
RSD3	,598**	,604**	,471**	,389**	,678**
RSD4	,525**	,605**	,535**	,554**	,606**
RSD5	,387**	,461**	,508**	,488**	,413**

**. The correlation is significant at the 0,01 level (2-tailed).

Source: Author’s research

The correlation analysis was conducted using Pearson’s correlation coefficient to examine the relationships between items measuring the perception of green marketing and sustainable development. All correlations were statistically significant at the significance level $p < 0,01$, indicating significant mutual relationships between the analyzed variables.

The highest correlation values and statistically significant mutual relationships were observed for the variable GM5 - collaboration with the local community with the variables RSD3 - support for the local economy, RSD2 - tourist education, and RSD4 - tourist number restrictions. This suggests that within the framework of NP Đurđevića Tara, a good relationship with the local community is being developed, primarily concerning the employment of the local population and the offering of traditional products from the region, contributing to the increased income of local entrepreneurs. Additionally, a positive relationship with the local community is confirmed when it comes to educating tourists about the ecological values of this national park and providing information about sustainable tourism, including measures for limiting the number of visitors during the day and managing their movement.

The variable GM2 - green promotion achieved positive and statistically significant correlation values with the variables RSD4 - tourist number restrictions and RSD2 - support for the local community. This further confirms the importance of promotion and the accessibility of information for the number of tourists and local development, particularly regarding ecological practices and sustainable tourism in NP Đurđevića Tara. A high correlation value was also achieved between the variables GM1 - ecological products and services and RSD3 - support for the local community, suggesting that an adequate offer of accommodation and tourist facilities that support environmentally friendly materials, as well as sustainable tourist activities, promotes the development of the local economy through increased revenue and local employment.

Among the weaker, though still statistically significant, correlation values, relationships were found between the variable GM1 - ecological products and services and RSD5 - sustainable infrastructure, and the variable GM4 - renewable energy sources and RSD3 - support for the local community. These relationships suggest that tourist facilities must support ecological standards and energy efficiency principles. Furthermore, local community support must raise awareness about the importance of transitioning to sustainable energy sources in tourism, the development of eco-trails, and the creation of infrastructure that allows tourists to enjoy nature with minimal environmental impact.

Given that all achieved correlation values were positive and statistically significant, regression analysis was performed to determine the impact of the independent variables of green marketing on the dependent variables of rural sustainable tourism. The results of the regression analysis are presented in Table 5.

Table 5. Regression Model of the Impact of Independent Variable of Green Marketing on the Dependent Variable of Sustainable Rural Development (only variables that achieved statistical significance are shown)

Dependent	Independent	β	t	Sig.	R^2	F	Sig.
RSD1	GM1	,193	2,537	,012	,494	50,994	,000
	GM3	,155	2,550	,011			
	GM4	,333	6,673	,000			
RSD2	GM1	,190	2,563	,011	,521	56,883	,000
	GM4	,319	6,587	,000			
	GM5	,312	5,145	,000			

Dependent	Independent	β	t	Sig.	R^2	F	Sig.
RSD3	GM1	,171	2,334	,020	,534	59,773	,000
	GM4	,166	3,465	,001			
	GM5	,434	7,251	,000			
RSD4	GM2	,188	2,545	,011	,556	65,490	,000
	GM4	,338	7,247	,000			
	GM5	,317	5,422	,000			
RSD5	GM3	,250	3,692	,000	,374	31,236	,000
	GM4	,302	5,452	,000			

Source: Author's research

The results of the multiple regression analysis show a significant relationship between the green marketing variables and the dimensions of sustainable development in the context of rural tourism. All regression models have been established, shedding light on predictive relationships between independent and dependent variables. All regression relationships are statistically significant, as confirmed by the high values of the F-coefficient (ranging from 31,236 to 65,490) with significance at $p < 0,001$, indicating that the effects of the independent variables cannot be attributed to chance.

In the model for RSD1 - Nature Protection, three green marketing variables (GM1, GM3, and GM4) significantly contribute to explaining the variance, with renewable energy sources (GM4) having the highest individual impact ($\beta = 0,333$, $t = 6,673$, $p < 0,001$). The total explained variance is $R^2 = 0,494$, with an F-coefficient of 50,994, indicating a very good model.

For RSD2 - Tourist Education, the strongest individual contributions come again from GM4 ($\beta = 0,319$) and GM5 ($\beta = 0,312$), with a significant contribution from GM1. The total model explains 52,1% of the variance ($R^2 = 0,521$), with an F-coefficient of 56,883, confirming the high reliability of the model.

In the case of RSD3 - Support for the Local Economy, the variable GM5 - Collaboration with the Local Community has the strongest impact in the entire analysis ($\beta = 0,434$, $t = 7,251$, $p < 0,001$). This shows that connecting with the local population significantly contributes to economic sustainability. The model has $R^2 = 0,534$ and $F = 59,773$, making it one of the strongest in the analysis.

The model for RSD4 - Tourist Number Restrictions shows the highest explained variance ($R^2 = 0,556$) and the highest F-coefficient value ($F = 65,490$), meaning this model is the strongest and statistically most reliable. Here, GM4 ($\beta = 0,338$) and GM5 ($\beta = 0,317$) play leading roles, while GM2 - Green Promotion also makes a significant contribution ($\beta = 0,188$).

For the variable RSD5 - Sustainable Infrastructure, two variables are significant: GM3 - Waste Management ($\beta = 0,250$) and GM4 - Renewable Energy Sources ($\beta = 0,302$). Although this model has a slightly lower explained variance ($R^2 = 0,374$) and $F = 31,236$, the results are still statistically significant, indicating the importance of these factors.

In conclusion, the most frequent and strongest influencing variables across all models are GM4 - Renewable Energy Sources and GM5 - Collaboration with the Local Community, with GM5 having the largest individual impact in the overall analysis ($\beta = 0{,}434$ in the RSD3 model). These results confirm the importance of strategic community engagement and the use of renewable resources in achieving sustainable development for rural destinations through green marketing.

The model for SD4 (tourist number restrictions) shows the highest predictive power of all analyzed models ($R^2 = 0{,}548$), indicating that green marketing most contributes to shaping the perception of the need for controlled and sustainable management of tourist flows in the destination.

Table 6. Correlation Values Between Green Marketing and Sustainable Rural Development Variables, from the Perspective of Domestic and Foreign Tourists

		GM1	GM2	GM3	GM4	GM5
Foreign tourists	**RSD1**	,537**	,562**	,616**	,650**	,536**
	RSD2	,600**	,585**	,545**	,604**	,657**
	RSD3	,663**	,676**	,539**	,500**	,698**
	RSD4	,634**	,696**	,606**	,678**	,680**
	RSD5	,512**	,520**	,574**	,583**	,458**
	N	171	171	171	171	171
Domestic tourists	**RSD1**	,577**	,586**	,449**	,191	,538**
	RSD2	,494**	,578**	,334**	,306**	,517**
	RSD3	,460**	,466**	,275**	,211*	,614**
	RSD4	,239*	,359**	,334**	,219*	,418**
	RSD5	,101	,319**	,346**	,274**	,322**
	N	96	96	96	96	96

**. The correlation is significant at the 0,01 level (2-tailed).

*.Correlation is significant at the 0,05 level (2-tailed).

Source: Author's research

The results of the correlation analysis indicate significant differences in the patterns of association between green marketing variables and sustainable rural development variables, observed through the lens of respondents' origin-domestic and foreign tourists (Table 1).

Among foreign tourists, the strongest correlation was recorded between the variable GM5 - cooperation with the local community and the variable RSD3 - support for the local economy ($r = 0{,}698$; $p < 0{,}01$). This result suggests that foreign tourists particularly value tourism offers that include local products, engage the local population, and directly contribute to community development. Furthermore, a strong positive correlation between the variable GM2 - green promotion and RSD4 - limitation of tourist numbers ($r = 0{,}696$; $p < 0{,}01$) indicates that access to information about ecological practices and sustainable visitor limits significantly influences foreign tourists' perceptions of responsible visitor management in the Đurđevića Tara National Park.

On the other hand, weaker correlations were observed between the variable GM5 - cooperation with the local community and RSD5 - sustainable infrastructure ($r = 0,458$; $p < 0,01$), as well as between GM4 - renewable energy sources and RSD3 - support for the local economy ($r = 0,500$; $p < 0,01$). These values suggest that foreign tourists are less likely to associate energy efficiency and the use of renewable sources with economic benefits for the local community, and they do not perceive cooperation with the local population as a key factor in infrastructure development.

Among domestic tourists, the strongest correlation was observed between the variable GM2 - green promotion and RSD1 - nature protection ($r = 0,586$; $p < 0,01$). This high correlation indicates that domestic tourists who recognize the importance of nature conservation also appreciate green promotion, i.e., information about ecological practices and sustainable tourism. Moreover, the strong correlation between the variable GM2 - green promotion and RSD2 - tourist education ($r = 0,578$; $p < 0,01$) suggests that domestic tourists interested in ecological values show a strong interest in education regarding sustainable tourism and environmental practices.

Although statistically significant, weaker correlations were found between GM1 - ecological products and services and RSD5 - sustainable infrastructure ($r = 0,101$; $p < 0,01$), as well as between GM5 - cooperation with the local community and RSD4 - limitation of tourist numbers ($r = 0,191$; $p < 0,05$). These values suggest that domestic tourists do not strongly associate environmentally friendly products and services with sustainable infrastructure, nor do they associate cooperation with the local population with measures for regulating tourist numbers in the Đurđevića Tara National Park.

The correlations highlight significant differences in the perception of ecological and sustainable practices between domestic and foreign tourists. Foreign tourists exhibit stronger associations between cooperation with the local community and community economic support, while domestic tourists place greater value on green promotion and nature protection. These differences indicate divergent attitudes and priority interests between tourist groups, implying that strategies for promoting sustainable tourism in the Đurđevića Tara National Park should be tailored to the specific needs of both domestic and foreign tourists.

Discussions

The results of the factor analysis clearly confirm that the variables related to green marketing and sustainable rural development group into two separate but interrelated latent dimensions. The first factor encompasses variables associated with the promotion of ecological values and practices in the tourism offer (e.g., GM1, GM2, GM3, GM5), while the second factor includes variables reflecting broader aspects of sustainable development, such as education, environmental protection, and local community engagement (e.g., SD1, SD2, SD4, SD5, and GM4). These factors are clearly distinguished in the pattern matrix, with high and conceptually consistent variable loadings within each factor. Although there is a moderate positive correlation between the factors (r = 0,532), indicating a degree of relatedness, the correlation is not strong enough to justify their treatment as a single dimension. This confirms the theoretical validity of considering them as distinct constructs. Based on the results of the factor analysis, the first hypothesis (H1) - that green marketing variables and sustainable rural development variables represent two interrelated but theoretically distinct factors in tourists' perceptions-can be considered confirmed. The two identified factors-green marketing and sustainable development - constitute separate but related dimensions within tourists' perception of sustainable tourism practices in rural areas. This distinction highlights the need for an integrated approach in tourism planning, where marketing strategies focused on ecological values are complemented by broader sustainable development concepts. Green marketing strategies play a crucial role in shaping tourist behavior and promoting sustainable development in rural tourism by integrating ecological practices that address environmental, social, and economic dimensions. (Chin et al., 2018).

The results of the correlation analysis indicate the presence of statistically significant and positive relationships between all variables measuring the perception of green marketing and the dimensions of sustainable rural development. Particularly strong correlations were found between the variable GM5 (cooperation with the local community) and the items related to support for the local economy (RSD3), tourist education (RSD2), and limits on the number of tourists (RSD4). This confirms the centrality of ecotourism principles in shaping sustainable rural destinations. Ecotourism, as the purest form of sustainable tourism, links the return to nature with environmental protection and the preservation of cultural heritage (Stefanica & Vlavian-Gurmeza, 2010). This confirms that cooperation with the local community plays a key role in strengthening the sustainability of the destination, both ecologically and socio-economically. Additional support for Hypothesis H2 is provided by the results of the multiple regression analysis, which show that green marketing variables statistically significantly predict all analyzed dimensions of sustainable rural development. The greatest individual contributions to the models come from the variables GM4 (renewable energy sources) and GM5 (cooperation with the local community), indicating their key role in building a sustainable tourism environment. The model for RSD4 (limits on the number of tourists) demonstrates the highest explained variance ($R^2 = 0,556$) and the strongest statistical reliability, further confirming that green marketing significantly contributes to awareness of the need for controlled management of tourist flows in rural destinations. Based on these findings, Hypothesis H2 can be considered confirmed: Green marketing variables have statistically significant relationships with sustainable rural development variables. This points to the necessity of integrating green marketing activities into rural tourism development strategies in order to achieve ecological balance, support local communities, and preserve the destination's natural heritage.

Based on the presented correlation analysis results, Hypothesis H3 is also confirmed - namely, that tourist origin moderates the relationship between green marketing variables and sustainable rural development variables. The results clearly indicate significant differences in the patterns of association between the observed variables among domestic and foreign tourists. While foreign tourists show a stronger connection between cooperation with the local community and economic benefits for the local population, domestic tourists place greater value on green promotion in the context of nature conservation and education about sustainable practices. This insight echoes findings by (Chan & Chau, 2021), who reported cultural differences in eco-conscious behavior between local and foreign tourists in Southeast Asia. These differences reveal distinct priorities between the two groups: Foreign tourists respond more strongly to economic and infrastructural aspects of green marketing, whereas domestic tourists demonstrate greater sensitivity to information and ecological values. Accordingly, the findings confirm that tourist origin influences the strength and direction of the relationships between the variables, validating the existence of a moderating effect. This insight holds important practical implications for the management of protected areas such as the Đurđevića Tara National Park-sustainable tourism promotion strategies must be differentiated according to tourist profiles. For domestic visitors, the focus should be on education, information, and nature conservation, while for foreign tourists, the priority should be on local integration, economic contribution, and the social responsibility of the destination.

Conclusions

This research provides a significant contribution to the understanding of the role of green marketing within the context of sustainable rural development, by analyzing the perceptions of both domestic and international tourists. By confirming the moderating effect of tourists' origin, the study highlights the need for strategically differentiated approaches to sustainable tourism. The practical implications lie in the ability to create more targeted marketing strategies and development policies that align with the specific interests and value orientations of distinct tourist segments.

Future studies could focus on a qualitative exploration of tourists' attitudes to gain deeper insights into their motivational factors, as well as on expanding the sample to include other national parks and rural tourist destinations. Longitudinal research is also recommended in order to track changes in tourist perceptions and behavior over time, along with the inclusion of additional variables such as age, education level, and environmental awareness.

Based on the findings of this study, the need for integrating green marketing into broader strategies for sustainable destination management becomes evident, with particular attention to demographic and cultural differences among tourists. It is especially important for decision-makers and tourism stakeholders to design flexible, inclusive, and educational campaigns that emphasize the preservation of natural resources and the active involvement of local communities. Such approaches not only stimulate economic development in rural areas but also foster responsible tourist behavior that contributes to the long-term sustainability of destinations.

Moreover, this research sets a foundation for evidence-based policy-making and interdisciplinary collaboration, encouraging tourism planners, environmental experts, and marketing professionals to jointly develop resilient models of rural tourism. In an era of growing ecological challenges, embedding green marketing into the core of tourism strategies is no longer optional but essential for ensuring balanced growth and preserving heritage for future generations.

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Conflict of interests

The authors declare no conflict of interest.

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REFORMING THE COMMON AGRICULTURAL POLICY (2023 – 2027) – GOALS AND NEW SYSTEM SOLUTIONS –

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ABSTRACT

The Common Agricultural Policy (CAP) is crucial for ensuring the future of agriculture and the rural development in the EU. The shortcomings of CAP in the previous period, challenges related to the global economic and geopolitical situation, the increasing need for environmental preservation and the necessity to mitigate climate change have led to CAP reform for 2023-2027. The subject of this study is to analyse the general and specific goals of the new CAP reform, as well as the adopted systemic solutions. The aim is to present the key goals, objectives and elements of the reformed CAP, particularly the most significant innovations – national strategic plans, various forms of direct payments and new environmental solutions within both pillars of CAP. The results show that strategic plans and new system solution provide a good starting point to ensure the fulfilment of the specific needs of EU farmers and rural communities, using CAP measures and instruments set in the strategic framework. The new environmental solutions have caused concern among some EU farmers and are subject to revision.

Introduction

The Common Agricultural Policy (CAP) represents a sophisticated system of legal regulations, budgetary support, and other public interventions related to agriculture and rural areas in the EU (Božić & Papić, 2017). The goals of CAP include: ensuring income for the rural population, stabilizing the market, and increasing the productivity and competitiveness of food production. Later, the sustainable management of natural resources, climate action, and rural development were also incorporated.

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The CAP was established in 1962 as a policy to promote agriculture through product price policies, the abolition of tariffs on mutual trade, and the introduction of a unified foreign policy. In the first decades of its existence, support for farmers was realized through high guaranteed prices for agricultural products and high import protection, i.e. market interventions. Price support, as the core concept of CAP, created a range of positive and negative effects (overproduction, waste, and increased public spending). Therefore, this policy had to be reformed and adapted to changes in the environment.

The MacSharry reform of 1992 marked a significant shift in the CAP. The reform aimed to reduce market distortions and provided direct aid to farmers (tied to production levels like the area farmed or the number of livestock) as compensation for reduced price support for agricultural product. With Agenda 2000, rural development policy was named the "second pillar" of CAP, which combines various measures, while agri-environmental measures (AEM) gain particular importance.

The Fischler reform from 2003 introduced a complete change in the support mechanism, which was decoupled from production. The most significant element was the Single Payment Scheme (SPS), a form of direct payments detached from production, based on previous payments in period 2000 to 2002. Eligibility for SPS direct payments depended on compliance with specific standards such as environmental protection and animal health. The reform continued in 2008 with the Health Check.

The reform for 2014-2020 included further market deregulation, transitioning to a new, more targeted system of direct payments to producers. This system includes mandatory direct payments such as: the Basic Payment Scheme (BPS) per hectare, the Young Farmers Scheme, greening (ecological) payments and several forms of voluntary payments (redistributive payment, natural constraint support, coupling aids and small farmer scheme). The most significant change was the introduction of greening. These required meeting three conditions: the maintenance of permanent grasslands, crop diversification and reservation of at least 5% of arable land for areas of ecological interest, such as hedges, ponds or fallow land (Božić & Papić, 2017).

However, the European Court of Auditors found that greening has not effectively improved the environmental and climate sustainability of agricultural practice. This is mainly due to the lack of measures offered to farmers, allowing them to only marginally modify their agricultural practices to benefit from green payments (Bourget, 2021).

In general, the CAP development has been marked by increased attention to certain ecological principles, food safety, and animal welfare. Farmers are obliged to fulfil these conditions to be eligible for direct payments and agri-environmental measures.

The CAP reform also included changes to market policy, specifically to Common Market Organizations (CMOs). Market interventions are in a process of continuous deregulation and serve as "safety nets" to encourage farmers to better respond to signals from the market. Given the disruptions of global agricultural markets, worsening effects of climate change, and volatility of agricultural prices, the abandonment of CAP market regulation instruments has gone too far (Bourget, 2021).

The shortcomings of CAP in the previous period, EU expansions, diversity of agriculture in member countries, challenges related to the global economic and geopolitical situation, and increasing need for environmental preservation and concern about climate change have led to a CAP reform for 2023-2027.

The purpose of this paper was to reviewed changes in the latest CAP reform and to have insight into the impact of these changes on the future of agriculture in EU. The aim is to analyze the general and specific goals, and to emphasize the most important changes in the new adopted systemic solutions. In order to pursue this aim two research hypotheses are posed. H_1: The decentralization of CAP, which takes place through the adoption of national CAP Strategic Plans, contributes to a greater appreciation of the national specificities of farmers and rural areas. H_2: The CAP reform 2023-2027 continues the greening policy, but new required environmental solutions are too demanding, especially for small farmers, and may be subject to revision.

Materials and Methods

The analysis of the overall and specific objectives, and adopted systemic solutions of the CAP 2023-2027 reform, was conducted using desk research of relevant literature in support with compilation methods and content analysis.

Literature sources include scientific papers and studies as well as legislative acts, reports, strategies, and other official documents of the EU institutions: the European Commission (EC), European Council and European Parliament.

Results and Discussion

Legislative Framework, Strategic Plans and Goals of CAP 2023 - 2027

The first proposal from the EC titled "The Future of Food and Farming" was presented in July 2017 (EC, 2017), while the agreement on the new CAP reform was adopted in December 2021.

The new legislative framework, which took effect on January 1, 2023, sets the foundation for a fairer, greener, and results-oriented CAP. It aims to ensure a sustainable future for European farmers, provide targeted support to smaller farms, and allow greater flexibility for EU member states to adapt measures to the particular circumstances of their territories (EC, 2021).

There are three major ideas in the EC proposal for this reform: *simplification*, *increased subsidiarity* and *heightened environmental ambition*. Subsidiarity is well-established as the EC common framework and must be implemented in each member state through a national strategic plan (Barral & Detang-Dessendre, 2023).

The legislative framework for the CAP Reform 2023-2027 consists of three EU regulations, which have been in effect since January 1, 2023:

1) CAP Strategic Plan Regulation – The future CAP will be implemented through national CAP Strategic Plans, tailored for each Member State, outlining the key parameters for executing all CAP instruments, including direct payments, rural development, and sectoral interventions (EU Regulation 2021/2115)[4];

2) Common Market Organisation Regulation emphasizes the importance of maintaining and enhancing the market orientation of EU agriculture. The EC has not proposed any specific changes to market intervention but instead focuses on key areas where there is potential to boost the sector's competitiveness and/or simplify existing regulations (EU Regulation 2021/2116); and

3) Horizontal Regulation is related to adapting the financing, management and monitoring of CAP rules with an aim to increase subsidiarity and simplification and to give more responsibility to member states (EC, 2020b).

The most significant innovation is that each EU country develops a national CAP Strategic Plan (CSPs). This plan must implement CAP measures and instruments in alignment with the EU strategic structure while also addressing the specific needs of farmers and rural communities (EU Regulation 2021/2117).

The new operational approach simplifies administrative processes so that each country submits a single strategic plan, rather than numerous individual programs, covering all forms of support. However, national variations through strategic plans do not guarantee simplification of measures, moreover the complexity of the policy has significantly increased (Runge et al., 2022)

The CAP strategic plans provide guidelines for the support for farmers and rural population. After the EC approve these plans, countries implement policies, and provide monitoring using a set of common indicators and reporting.

The approved Strategic Plans are designed to include increased environmental ambitions and make a significant contribution to the goals of the European Green Deal, the Farm to Fork Strategy (EC, 2020a), and the Biodiversity Strategy (EC, 2024b), while also taking into greater account specific local conditions and needs of individual member states.

This reform also sets different environmental targets. However, setting ambitious environmental goals is not sufficient; it is equally crucial to provide the necessary resources to achieve them. One of such goals is to establish certain limit for agricultural area under organic farming (25%) and areas under high-diversity landscape features (10%) (Barral & Detang-Dessendre, 2023). However, allocating 25% of land to organic farming could lead to market saturation, as organic goods are typically more expensive than conventional ones (Bourget, 2021).

In addition to the novelties such as creating specific strategic plans for each country and further work on common agricultural market, this new CAP reform is deeply engaged in economic, ecological, and social spheres through three general objectives: (1) to

4 Full titles of the listed regulations are given in the literature at the end of this paper.

ensure food security creating resilient and diversified agriculture, (2) to emphasise the environmental and ecological issues and (3) to further develop rural areas (EU Regulation 2021/2115). These three broad objectives are realized and simplified through ten specific objectives (Figure 1).

It can be concluded that the reformed CAP aims to provide support to smaller farms; enhance the contribution of agriculture to the ecological and climate goals; strengthen the socio-economic development of rural areas; and ensure greater flexibility for member states to adapt measures to local conditions and needs (through national strategic plans).

Figure 1. Ten specific objectives of CAP 2023 - 2027

Source: EC (2024a). Key policy objectives of the CAP 2023-2027

In conclusion, new CAP seeks to support small farms, enhance agriculture's contribution to ecological and climate goals, and strengthen rural areas, while at the same time gives more freedom to each EU country to create supportive measures according to it needs.

Funding of CAP 2023-2027 and Support for Farm Income

In the context of climate and geopolitical uncertainties, rising input costs, and ecological and social challenges, farmers and rural areas in the EU require stable support from the CAP. These include support through direct payments, interventions for specific market sectors, and support for rural development. The CAP retains its previous structure in two pillars:

- Pillar I covers direct payments and the common market organisation, and is completely funded by EU funds, and

- Pillar II includes rural development instruments, which are co-financed by the EU and member states from national funds.

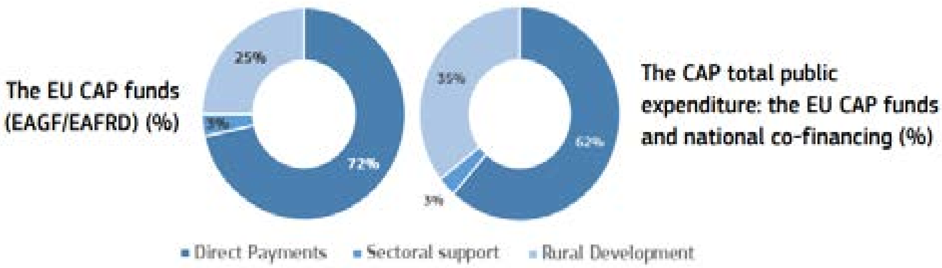
Strategic plans are financed on the basis of the Multiannual Financial Framework (MFF) for the period 2021-2027, which is the long-term budget of the EU, and includes funds for financing the whole CAP (in the total amount of 378.5 billion Euros) (EC, 2023b). Of this amount, the MFF has allocated €264 billion in the 2023-2027, through two funds:

1) *European Agricultural Guarantee Fund* (*EAGF*), which constitutes about 75% of the CAP budget (€198 billion). This fund primarily finances measures under Pillar I (about 72% for direct payments and around 3% for support to stabilize internal agricultural markets); and

2) *European Agricultural Fund for Rural Development* (*EAFRD*), which finances measures under Pillar II (rural development) and makes up 25% of the CAP budget (€66 billion) (EC, 2023b).

Including national co-financing, the CAP mobilizes a total of €307 billion for the period 2023-2027, of which direct payments make up 62% while support for rural development reaches 35% (Ecorys, Metis & Agrosynergy, 2023) (Figure 2).

Figure 2. Distribution of planned expenditures within the CAP, %, 2023-2027



Source: EC (2022). Common agricultural policy for 2023-2027: 28 CAP strategic plans at a glance

In the structure of the total CAP funds, direct payments account for 62%, while the rural development support share (EAFRD) increases to 35% (EC, 2022).

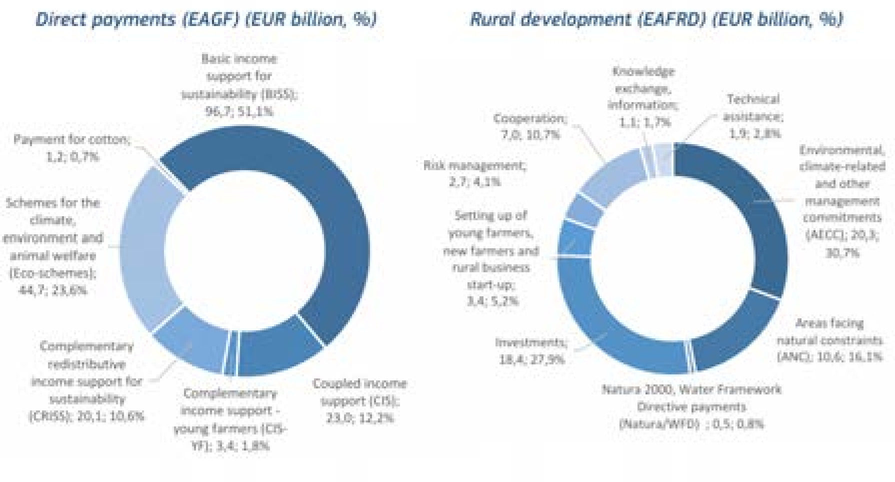
The idea behind sustainable farm income is to support income of EU farmers, while providing food security on the long run and economic sustainability of agriculture. Although farm incomes in the EU are lower than the economy average, the gap is gradually narrowing due to structural changes, primarily the outflow of labour from agriculture. On average, farmers' gross income amounts to 49% of the average EU salary (2021), compared to a third a decade ago (EC, 2022).

The new CAP provides greater flexibility for member states to choose how to allocate subsidies within their national strategic plans, facilitating alignment with specific national needs. The support for sustainable farm income is primarily achieved through direct payments (Figure 3).

Member states define in their CAP plans which farmers qualify as "active farmers" and are eligible for direct payments. The most significant support to farmers is provided through *basic income support per hectare* (about €19 billion annually), with an additional €9.6 billion planned for income support for specific groups and needs of farmers. Direct payment also includes income support for small and medium size farms and eco-shemes for climate, environment and animal welfare.

The second pillar is co-funded by the EAFRD and national sources and includes wide range of rural development support measures. They focus on land (agricultural and forest) suitable for environmental and climate management; animal welfare; and compensations for areas with natural and other handicaps (ANC); investments, and more (Figure 3).

Figure 3. Planned distribution of EU funds for direct payments (EAGF) and rural development (EAFRD), 2023-2027



Source: EC (2022). Common agricultural policy for 2023-2027: 28 CAP strategic plans at a glance

In the previous period the differences in direct payments for farms in different countries was significant. So, one of the aims of the new CAP is also to achieve a more fair distribution of income support. In addition to this, support should be more focus on small and farms of medium size. It also seeks to improve working conditions and future prospects for the new generation of European farmers.

The *mandatory redistribution of support* requires all member states to allocate at least 10% of national envelopes for direct payments to redistributive payments, aiming to enhance support for smaller farms. Approximately €4 billion annually is planned for complementary redistributive payments (compared to €1.7 billion in the previous period under CAP 2014-2020). Thanks to redistributive payments, direct payments per hectare for the smallest farms can increase by 7 to 10% (EC, 2022).

The capping and degressivity mechanism can be used for redistributing support. The idea behind it is to distribute direct payments so that farmers with greater needs have more support.

Capping allows a Member State to limit the amount of basic income support granted to a farmer per calendar year to EUR 100,000, reduced from the previous threshold of EUR 150,000. Every country is free to choose will it apply reduction of payment or capping (or both or neither) to achieve this goal.

Degressivity is based on progressive reduction of payments above a certain level. So, if the total amount of income support received by a single farm is more than €60,000, each country can reduce it up to 85%. Savings from the reduction in direct payments stay in the CAP budgets of that country and can be used for other purposes such as redistributive payments. The voluntary approach to this measure remains unchanged.

The race to increase farm sizes will continue, potentially creating challenges for young farmers starting new farms, despite the increase in the share of direct payments allocated to young farmers from 2% to 3% of national envelope for direct payments (Bourget, 2021).

The new CAP will continue to reduce the disparity in direct payments between and within member states. The differences between levels of direct payment received by countries are huge, where some receive below 90% of the EU average. In the next 5 years the difference between their current level of payment and EU average will be halved. In other words, payments in countries with above-average payments should decrease in favour of countries with below-average payments. This process is called *external convergence*. This measure is complemented by *internal convergence* within member states. Under this system, direct payments per hectare based on historical levels will also be re-evaluated so that more fair system is created by 2026. By then, all basic income support payments within the member state must have a per-hectare value of at least 85% of the average (*internal convergence*) (EC, 2023b).

In November 2023, the EC published a report on the collective efforts of all CAP strategic plans during the first year of implementation (EC, 2023a). As these new measures are still young, their effects are hard to evaluate, but some general ideas are underlined in this document. It was particularly highlighted that CAP is still focused on food security and aim to provide fair distribution of support, especially for 377,000 young farmers.

Increasing Competitiveness and Productivity

Agriculture is facing several important challenges: global demand for agricultural and food products is rising, while resources remain limited and climate conditions continuously deteriorate. In such circumstances, agricultural productivity is of vital importance. Enhancing productivity in European agriculture will contribute to develop market orientation and ensuring greater competitiveness for farmers, thereby strengthening their position in the food supply chain.

Improving the Position of Farmers in the Chain Value

After decades of deregulation, the organization of European markets of agricultural products is getting new foundations. The instability of global agricultural markets causes significant price fluctuations and creates problems for farmers, especially in conditions of overproduction (Bourget, 2021).

New interventions in the CAP are aimed at protecting EU farmers and strengthening their market position. Market interventions primarily have a stabilization function and play a role in ensuring food availability. For market interventions, 3% of the CAP budget for 2023-2027 is allocated (approximately 9 billion Euros) (EC, 2023b). Strengthening the position of farmers in the market chain is also achieved by enhancing the role of producer organizations, encouraging cooperation among farmers, promoting research and innovation, increasing market transparency, and ensuring effective mechanisms against unfair competition (Bourget, 2021).

Improving Environmental Sustainability and Climate Resilience

Agriculture is more sensitive to climate change than most other economic sectors, yet it is also a major contributor to greenhouse gas emissions. Farmers have a key role in environmental protection and biodiversity conservation by efficiently managing natural resources such as water, soil, and air. Furthermore, agriculture plays a crucial role in fulfilling the commitments of the Paris Agreement on climate. It is no surprising that three of ten specific CAP goals are directly related to these issues: mitigating climate change, managing natural resources, and preserving biodiversity.

Under the new CAP, farmers have the opportunity to further contribute to environmental protection and will be rewarded if they exceed the set criteria.

The new green architecture of CAP, as termed by the EC for measures related to the environment and climate, is based on enhanced conditionality; eco-schemes within the pillar I and environmental and climate measures in the second pillar, and must be included in the national strategic plans (EC, 2023a).

The *cross-compliance* is an element of the reform focused on increasing accountability for sustainable farm management. The new conditionality system includes enhanced Statutory Management Requirements (SMR) and standards for Good Agricultural and Environmental Conditions (GAEC) that go beyond SMRs, GAECs and the greening rules applicable within the 2014-2020 CAP (Guyomard et al., 2020; EC, 2023a).

Big farmers in the EU must comply with given measures. One of these measures is the obligation to implement crop rotation to improve soil health. Small holdings (under 10 hectares) and farms with large areas of permanent grassland may be excused. Organic farmers are automatically considered to meet cross-compliance obligations.

Another measure, within the eco-scheme, designed to preserve biodiversity is the conversion of at least 4% of arable land for non-productive purposes. In addition to this, 3% of land should be dedicated to nitrogen-fixing crops, which farmers can further "top up" to 7%. There is also an exemption for holdings under 10 hectares of arable land. The purpose of these measures is to maximise the benefits for climate and the environment so each country has significant flexibility in implementing the conditionality system in a way that suits its specific conditions.

Eco-schemes, along with certain types of payments in the second pillar of the CAP, will support many voluntary actions that go beyond conditionality. Member states must make available eco-schemes in their plans related to at least two areas of action.

These ecological goals of CAP are new and require significant changes in designing agricultural and food production. No analysis has been provided on potential negative economic implications of such changes. Therefore, all adverse consequences must be addressed to develop adequate policies that will ensure acceptable measures and transformations related to agricultural production, food and nutrition, as well as trade and innovation (Barral & Detang-Dessendre, 2023).

These viewpoints were confirmed during the first year of implementing CAP strategic plans, leading to farmers' protests concerning compliance with certain ecological requirements. In response, the European Parliament and Council adopted a targeted revision of the basic CAP regulations in May 2024 (EU Regulation 2024/1468).

Numerous exemptions were provided. These measures can be excluded in case of unfavourable weather conditions. Small farms with less than 10 hectares are also exempt from controls and penalties related to environmental compliance. This applies to 65% of farmers receiving CAP support, who manage only 10% of the land. Since strategic plans should be tailored to the needs of a specific country, each member states can review its strategic plans twice a year, instead of once as previously required.

Strengthening Socio-Economic Development of Rural Areas

One of the important issues related to rural areas is the level of income per capita, which is lower that EU average. In this sense, CAP has an important role in alleviating unemployment and poverty in these regions.

Rural development measures remain similar to those from the previous period (2014-2020). Member states are required to spend at least 35% of their rural development budget on environmental, climate, and animal welfare measures, with half of the payments for areas with natural constraints (ANC) counted towards this amount (Guyomard et al., 2020).

Support for Generational Renewal

The number of young farmers in the EU is constantly declining. Only 11% of farmers in the EU are under 40 years (EC, 2021: 10). Therefore, generational renewal in agriculture is defined as a new CAP goal. Young farmers receive increased support to at least 3% of each Member State's envelope for direct payments. This support is provided through complementary income support, start-up aid for new young farmers, or investment support (EC, 2023a). Budgetary expenditures for income support for young farmers during the previous period (2014-2020) ranged from 1.5% to 6% for most member states (EC, 2021: 10).

Young farmers and generational renewal will be a supported with at least EUR 8.5 billion. New CAP has, for the first time, gender equality as one of the objectives. Gender imbalance is a key concern in the EU, including the gender gap in farming and rural areas (Ecorys, Metis & Agrosynergy, 2023). Some member states dedicate additional resources to promote farm succession, enhance gender equality in rural communities, and empower women in agriculture (EC, 2022).

Social Conditions: Linking Support to Compliance with Farmers' Rights

Novelty in the new CAP reform will be mandatory starting from 2025. They have social dimension which focus primarily on season workers, but also to other workers employed on farms. This includes the implementation of penalties for farm managers who do not comply with directives related to predictability and transparency of employment conditions, as well as the safety and health of agricultural workers (Bourget, 2021).

This is related to social conditionality, meaning that all forms of support are linked to complying with rights of farm workers. Transparent and predictable employment conditions are guaranteed, requiring employers to ensure the safety and health protection of employees, including the proper use of agricultural machinery, equipment, and protective clothing.

Conclusion

The paper examines the evolution of the Common Agricultural Policy from 1962 to 2023-2027 reform, which is analyzed in detail. Changes in the CAP across various phases and preceding reforms have rendered this policy exceptionally complex. The forms of support have evolved from the initial idea of establishing a common market and policy with high guaranteed prices and market intervention for agricultural products, introduction direct aid payment, to the introduction of rural development policy as a "second pillar," followed by agri-environmental measures. Subsequent developments included food safety, greening payments, and income support for areas with natural constraints, culminating in special schemes for vulnerable groups such as small-scale and young farmers.

Keeping this in mind, it is hardly surprising that simplification is one of the three key objectives of the latest CAP reform. In order to achieve this, national CAP Strategic Plans are introduced. In these documents, each EU country has the possibility and freedom to create and adopt measures tailored according to local conditions and specific needs of their farmers. Of course, national plans are created in accordance with the set strategic framework at the EU level.

Although these changes are created aiming to simplify CAP, it seems that it is even more complex than before. However, some progress has been done on sustainable management of natural resources, farm income and economic sustainability. Further attention should be aimed at reinforcing skills, training and advisory capacity, reducing the administrative burden and monitoring their implementation and results including adjusting national Plans where necessary (EC, 2023a).

It could be concluded that the latest reform of the CAP is to minimize the common elements of the EU member states, while more and more freedom in solving various issues in agriculture is given to national bodies. Therefore, the first hypothesis is confirmed.

For a fairer distribution of support, redistributive payments, previously voluntary, become mandatory for all member states. This measure is supported by 10% of the total amounts for direct payments, in order to shift the support from larger to smaller farms. However, the upper limit and gradual reduction of direct payments for large farms is left for individual countries to determine. This means that the possibility of achieving savings for direct payments and redistribution of support in favour of small farms is significantly reduced.

The introduction of agri-environmental measures dates back to 1992, and since then, these measures have remained among the most important. These measures remain highly significant in the latest reform. Farmers must comply with these conditions to qualify for other types of support. This confirms that the second hypothesis is also confirmed, especially considering the limitations and challenges faced by small-scale farmers. On the other side, environmental organizations evaluated these measures as insufficient. Even so, they were extremely demanding to implement in the first year and used great concern to farmers and led to their protest. As a response, there was a revision of the basic legal acts of the new CAP, which gives the possibility of deviations from the adopted rules as well as exemptions from some environmental requirements, especially for small farms.

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Conflict of interests

The authors declare no conflict of interest.

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ANALYSIS OF THE PRODUCTION COST OF A UNIT OF BIODIESEL PRODUCTION IN THE BIODIESEL PLANT

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A R T I C L E I N F O

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A B S T R A C T

Biodiesel is defined as mono-alkyl ester of fatty acids obtained from vegetable oils or animal fats. In this paper, an analysis of the cost of the production of a unit of biodiesel is given. It is shown which parameters affect the cost price of the unit of this product produced in the biodiesel plant. Analyzed biodiesel plant is in Skopje in North Macedonia with a projected capacity of 20,000 tons of biodiesel per year. Also, a comparative analysis of different cases was done: the case where during the design and implementation of the production plant the capacity of the production plant would be increased to the level of 25,000 tons, as well as to the level of 30,000 tons of produced biodiesel. It was also shown how the use of a sufficient level of soybean oil would affect the cost of the unit of the biodiesel product.

Introduction

Oil reserves are constantly decreasing at the world level, so in the developed countries of the world, in the last twenty years, intensive work has one on the development and application of processes to produce biofuels from biomass. Exhaustion of crude oil reserves, permanent increase in crude oil consumption, price increase as well as environmental problems related to oil processing and use such as global warming are the main reasons why the population should turn to biofuels such as biodiesel.

In Europe, rapeseed oil (82.8%) is used as the dominant raw material for biodiesel production and sunflower oil (12.5%), while in the United States of America soybeans are used for biodiesel production (Petrović and Babić I., 2013). State policy and biofuel production costs, as well as the demand for competitiveness, can significantly affect the prices of biofuels and agricultural raw materials (increases in the price of raw materials affect the increase in biofuel production costs). Serbia has accepted international obligations and has the available potential of biomass, so it is necessary to

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take all the above incentive measures as soon as possible to reach the binding goals in transportation for biofuels (Petrović and Babić I., 2013).

Biodiesel is used as a substitute for mineral diesel because the use of pure biodiesel reduces the emission of harmful gases (NOx, CO_2, SO_2) and solid particles because biodiesel does not contain sulfur. The production trend of this fuel is constantly increasing. Its production in 2005 exceeded several million tons. The European Union (EU) predicted that the share of biofuels in the EU countries after 2020 will be 10%.

As input raw materials, more than half of the plants built in the United States of America and Europe use "clean" crude oil and high-quality methanol. Most of the plants built so far that use vegetable oils for the production of biodiesel use crude refined vegetable oil. Depending on the applied technology, some factories also use unrefined vegetable oil. Various alternative input raw materials require changes in the production process itself.

Biodiesel is a motor fuel that is obtained by transforming rapeseed, soybean or other vegetable oils into methyl esters of fatty acids through an esterification reaction with methanol. The characteristics of biodiesel are very similar to the characteristics of diesel fuel obtained from mineral oil. For this reason, biodiesel is a non-toxic, biodegradable and ecologically clean substitute for mineral diesel fuel or in a certain mixture with it (Babić I., 2013).

Biodiesel is defined as mono-alkyl ester of fatty acids obtained from vegetable oils or animal fats. Biodiesel is obtained when vegetable oil or animal fats chemically react with alcohol producing a new substance, which is known as fatty acid monoalkaline ester (Fatty Acid Methyl Ester - FAME) according to (Standard, EN 14214, 2004). This reaction requires the presence of a catalyst, and glycerol is obtained as a by-product. For example, from 100 kg of vegetable oil and 10 kg of methanol we get 100 kg of biodiesel and 10 kg of glycerol (Babić I., Đurišić, 2008).

The advantage of using biodiesel is reflected in the fact that the consumer can get reliable and high-quality fuel at a lower price. We can count on more widespread use of biodiesel only if it is competitive with fossil diesel, which means that it is its price is 8-10% lower than the price of diesel. This difference is appreciated explains the lower energy value of biodiesel in comparison on mineral diesel as a result of which there is proportional increase in fuel consumption (Jovanović et al., 2005, Kiš et al., 2023).

The difference in the prices of diesel and biodiesel at gas stations in the EU is about 10 euro cents, with the fact that it fluctuates depending on the prices of oil and petroleum on the world market. The upward trend in the price of crude oil is significantly higher than that of edible oils, so we can expect that biodiesel will be even more competitive in the future (Hu et al., 2025, Mohammadshirazi et al., 2014, Gebremariam AND Marchetti, 2018). Also, it should be noted that competitiveness in the price of biodiesel was also achieved by reducing taxes because excise duties on biofuels were abolished, as well as by receiving subsidies to producers of input production raw materials (Tamas and Gyarmat, 2021).

Renewable fuels reduce dependence on fossil fuel imports. This affects exports at the same time, and as far as Serbia is concerned, it is possible to export part of the biodiesel production to the nearest EU market. For biodiesel to be profitable, experts have estimated that it must have an 8% lower price than fossil fuels. At the same time, 5% is an indicator of lower energy efficiency of this fuel, and 3% is the estimated required level to attract consumers (Babić M., 2024).

Materials and methods

The biodiesel plant with a projected capacity of 20,000 tons of biodiesel per year is analyzed in this paper. The analyzed biodiesel plant is located in Skopje in North Macedonia. These annual capacities satisfy domestic needs and enable export. The data from the from this biodiesel plant project were used as a data source in this research (Babić M., 2024).

In this paper, as part of the economic analysis, an analysis of the cost price of the production of a unit of biodiesel products is given. Also, a comparative analysis of different cases was done: the case where during the design and implementation of the production plant the capacity of the production plant would be increased to the level of 25,000 tons of produced biodiesel, as well as to the level of 30,000 tons of produced biodiesel.

The costs of producing a unit of biodiesel fuel products depend on the value of the costs of input raw materials, energy costs, and the cost of human labor. In relation with that, it was also shown how the use a sufficient level of soybean oil as input of raw materials, would affect on the cost price of the unit of the biodiesel product.

Biodiesel is being produced from crude oil obtained from rapeseed, according to a world standard (Standard, EN 14214, 2004) that allows mixing with fossil diesel fuel. The fuel quality is being controlled in the factory laboratory. The entire production process in the biodiesel plant is automated.

Analysis of the production cost of a unit of biodiesel product

The cost price of the unit of the product produced in the biodiesel production plant C_K is:

$$C_K = \frac{T_P}{Q_P} \qquad (1)$$

where: T_P – cost of production, Q_P – plant capacity.

The cost of production T_P is the sum of the cost of input raw materials T_{US}, the energy costs T_{EN} and the cost of human labor T_R:

$$T_P = T_{US} + T_{EN} + T_R \quad (2)$$

The cost of input raw materials is the total realized cost in the process of procuring input raw materials, namely: purchase cost, transportation cost, customs and other state fees, shipping cost, insurance cost, financing cost and labor cost with associated costs of the procurement process. The total cost of input raw materials can be defined as:

$$T_{US} = \sum_i C_i Q_i \quad (3)$$

where: C_i − the gross i price of that input raw material, Q_i − gross amount of i input raw material.

The cost of energy is the cost of consumed electricity, which on an annual basis amounts to $T_{EN} \approx 57{,}000.00$ EUR, while the cost of human labor is the cost of the gross personal income of employees and other overhead costs, which on an annual basis amounts to: $T_R \approx 224{,}400.00$ EUR. These values are given from Makpetrol biodiesel plant in Skopje, Macedonia (Babić M., 2024).

The annual cost of production T_P must be reduced by the income obtained from the sale of glycerine solution, a by-product, which is obtained during the production process, and it amounts to:

$$P_{GL} = Q_{GL} C_{GL} \quad (4)$$

where : Q_{GL} is gross amount of glycerin, C_{GL} is cost price of the unit of the glycerin.

Now the actual cost of production T_P^1:

$$P_P^1 = \sum_i C_i Q_i + T_{EN} + T_R - P_{GL} \quad (5)$$

Based on the above-mentioned equations, finally, we get an expression for the cost price of the production of a unit of product, that is, the cost price of the production of one ton of biodiesel:

$$C_K = \sum_i \frac{Q_i}{Q_P} C_i + \frac{T_{EN}}{Q_P} + \frac{T_R}{Q_P} - \frac{Q_{GL}}{Q_P} C_{GL} \quad (6)$$

or in its developed form, the equation of the cost price of producing one ton of biodiesel on an annual basis is:

$$C_K = w_{SU} C_{SU} + w_{ME} C_{ME} + w_{NH} C_{NH} + w_{KH} C_{KH} + w_{LK} C_{LK} + \frac{T_{EN}}{Q_P} + \frac{T_R}{Q_P} - \frac{P_{GL}}{Q_P} \quad (7)$$

Where we have: weight function of crude rapeseed oil w_{SU}, weight function of methanol w_{ME}, weight function of sodium hydroxide w_{NH}, weight function of potassium hydroxide w_{KH}, weight function of citric acid w_{LK}.

The weighting functions w_{XY} in the equations determine the share of the gross price of certain input raw materials in the cost price of the product and they reflect the efficiency, the quality and the optimization of a technological procedure.

The weighting functions w_{XY}, i.e. their values, depend on several important factors :

1. Technologies of the production process, expressed through the efficiency of the technology
2. Quality of incoming raw materials
3. The quality of managing the production process, expressed through the level of automation and optimization of the production process.

The values of the weighting functions determined on the basis of the projected material balance, that is, the projected efficiency of the technology, the quality of the input raw materials specified in the technological requirements and the level of the projected automation of the production process are given in the Table 1 (Babić M., 2024).

Table 1. The values of the weighting functions

The weighting functions	Value
The weight function of crude rapeseed oil (w_{SU})	1.018
The weight function of methanol (w_{ME})	0.11785
The weight function of sodium hydroxide (w_{NH})	0.00753
The weight function of potassium hydroxide (w_{KH})	0.0018135
The weight function of citric acid (w_{LK})	0.000125

Source: Author's interpretation

The values of the weighting functions which are given in Table 1. are obtained based on the following expressions:

- The weight function of crude rapeseed oil: $w_{SU} = \frac{Q_{SU}}{Q_P}$

- The weight function of methanol: $w_{ME} = \frac{Q_{ME}}{Q_P}$

- The weight function of sodium hydroxide: $w_{NH} = \frac{Q_{NH}}{Q_P}$

- The weight function of potassium hydroxide: $w_{KH} = \frac{Q_{KH}}{Q_P}$

- The weight function of citric acid: $w_{LK} = \frac{Q_{LK}}{Q_P}$.

Starting from the data on the costs of input raw materials, energy and human labor costs, specified in the business plan for the construction of a Makpetrol biodiesel plant in Skopje, Macedonia and based on the cost price equation, we got the prices in the Table 2. (Babić M., 2024).

All prices shown in the Table 2. are updated for the year 2010 according to (Product Exchange ad Novi Sad - NSCOMEX, 2010).

Table 2. Price values of input quantities

The values of input quantities	**The price (EUR)**
The crude rapeseed oil (C_{SU})	661
Methanol (C_{ME})	317
The sodium hydroxide (C_{NH})	419
Potassium hydroxide (C_{KH})	450
Citric acid (C_{LK})	750
The energy (T_{EN})	57,000
The human labor (T_{R})	224,400
Glycerin (C_{GL})	350

Source: Author's interpretation

The values from the table, which we obtained on the basis of the actual data of the biodiesel plant, need to be multiplied by the values of the weighting functions, in order to obtain the cost price of producing one ton of biodiesel on an annual basis:

- The crude oil share: $C_K^{SU} = w_{SU} C_{SU} = 672.898$ EUR
- The methanol share: $C_K^{ME} = w_{ME} C_{ME} = 37.35845$ EUR
- The sodium hydroxide share: $C_K^{NH} = w_{NH} C_{NH} = 3.15507$ EUR
- Potassium hydroxide share: $C_K^{KH} = w_{KH} C_{KH} = 0.816075$ EUR
- Citric acid share: $C_K^{LK} = w_{LK} C_{LK} = 0{,}09375$ EUR
- The energy share: $C_K^{EN} = \frac{T_{EN}}{Q_P} = 2.85$ EUR
- The human labor share: $C_K^{R} = \frac{T_R}{Q_P} = 11.22$ EUR
- Glycerin share: $C_K^{GL} = \frac{Q_{GL}}{Q_P} C_{GL} = 25.9399$ EUR

Based on the equation (7) and the values given in the Tabel 2, the cost price is finally obtained:

$$C_K = C_K^{SU} + C_K^{ME} + C_K^{NH} + C_K^{KH} + C_K^{LK} + C_K^{EN} + C_K^{R} - C_K^{GL} \quad (8)$$

$$C_K = 702.45 \text{ EUR}$$

Starting from the the average selling price of biodiesel at factory parity for the year 2010 according to (Product Exchange ad Novi Sad - NSCOMEX, 2010), in the amount of $C_P = 780\ \text{EUR/t}$ the realized profit is obtained on an annual level in the amount of $\Delta = 1{,}551{,}000.00\ \text{EUR}$ for a capacity of 20,000 tons on an annual production.

Cost price and profit at a plant capacity of 25,000 tons per year

The case was analyzed when, during the design and implementation of the production plant, the carrier of the basic technology and the supplier of the technological production line would increase the capacity of the production plant to the level of 25,000 tons of produced biodiesel.

Based on the fact that during production, considering the type of technological process, the same level of energy per unit of product will be consumed as in the previous case with a plant capacity of 20,000 tons per year, as well as that the cost of human labor will not increase, i.e. it will remain the same the number of executors, and thus the cost of human labor per unit of product will be reduced, we will have that:

$$C_K^{25} = C_K^{20} - \left(\frac{T_R}{Q_P^{20}} - \frac{T_R}{Q_P^{25}}\right) \quad (9)$$

where: C_K^{25} - product cost price at a plant capacity of 20,000 tons, Q_P^{20} - plant capacity of 20,000 tons per year,, Q_P^{25} - plant capacity of 25,000 tons per year, T_R - gross labor cost.

Based on the above the equation (9), it is obtained that the unit cost price of the product at the plant capacity of 25,000 tons per year is:

$$C_K^{25} = 700.21\ \text{EUR}.$$

So the realized profit on an annual level is obtained from:

$$\Delta^{25} = \left(C_P - C_K^{25}\right) \times Q_P^{25} = 1{,}994{,}750.00\ \text{EUR}. \quad (10)$$

The percentage increase in profit is:

$$\%(\Delta) = \frac{\Delta^{25} - \Delta^{20}}{\Delta^{20}} \times 100 = 28.61\% \quad (11)$$

which is in absolute terms $\partial\Delta = \Delta^{25} - \Delta^{20} = 443{,}730.00\ \text{EUR}.$

Competitiveness from the point of view of the price of input raw materials can be analyzed. If the realized amount of profit increase was put into the function of covering the costs of input raw materials, it would mean an increase in the competitiveness of production, in addition to the increase in the prices of input raw materials, e.g. the price of crude oil, up to the following price level, the maximum value of which is determined based on the equation:

$$C_{SU}^{max} = \frac{1}{w_{SU}}\left[\left(C_P - \frac{\Delta^{20}}{Q_P^{25}}\right) - \left(\sum_{i \neq SU} w_i\, C_i + C_K^{EN} + \frac{T_R}{Q_P^{25}} - C_K^{GL}\right)\right] \quad (12)$$

By substituting numerical values into the above equation, we get that $C_{SU}^{max} = 678.44$ EUR.

It can be concluded that if the production process is entered with the gross price of crude oil $C_{SU} = 678.44$ EUR at the plant capacity of $Q_P^{25} = 25{,}000\ t/year$, the profit will be the same value, as in the case of the production process with the gross price crude oil $C_{SU1} = 661$ EUR at plant capacity of $Q_P^{20} = 20{,}000\ t/year$, $\Delta^{25} = \Delta^{20} = 1{,}551{,}000.00$ EUR.

Competitiveness from the point of view of the price of the output product, biodiesel, can be analyzed. If the realized amount of profit increase based on the increase in production capacity were put into the function of increasing the competitiveness of the final product, the selling price of biodiesel at factory parity could have a minimum value of:

$$C_P^{min} = C_K^{25} + \frac{\Delta^{20}}{Q_P^{25}} = 762{,}21 \text{ EUR} \quad (13)$$

This would mean that if the production capacity is $Q_P^{25} = 25{,}000\ t/year$ and if the cost price is $C_K^{25} = 700.21$ eur per unit of the final product, then at the above-mentioned selling price of biodiesel, the same profit is achieved as with the production plant with the capacity $Q_P^{20} = 20{,}000\ t/year$ and at the selling price of biodiesel of $C_P = 780$ EUR.

Cost price and profit at a plant capacity of 30,000 tons per year

During the design of the system of measurement, supervision and management of the technological process of production, certain improvements were suggested and new measurement methods were introduced, which should affect the additional increase of the capacity of the plant. $Q_P^{30} = 30{,}000\ t/year$.

The cost price of a product unit at a plant capacity of 30,000 t/year is:

$$C_K^{30} = C_K^{20} - \left(\frac{T_R}{Q_P^{20}} - \frac{T_R}{Q_P^{30}}\right) = 698.71 \text{ EUR.} \quad (14)$$

The annual profit at this production price, and the selling price as in previous cases, would be:

$$\Delta^{30} = (C_P - C_K^{30}) \times Q_P^{30} = 2{,}438{,}700.00 \text{ EUR}. \quad (15)$$

The percentage increase in profit is:

$$\%(\Delta) = \frac{\Delta^{30} - \Delta^{20}}{\Delta^{20}} \times 100 = 57.23\% . \quad (16)$$

which is in absolute terms: $\partial\Delta = \Delta^{30} - \Delta^{20} = 887{,}700.00$ eur.

During this analysis, among other things, one can observe a very strong influence of the weight function of the input raw material, crude oil, on the production price of the final product, that is, on the overall economy of the biodiesel production plant.

As shown $\partial\Delta = \Delta^{25} - \Delta^{20} = 443.730{,}00$ eur can be lost, for example, if the basic input raw material, crude oil, is procured with twice the content of free fatty acids, i.e. with twice the acid number than prescribed by the technological specification, which causes a change in the value of the weight function w_{SU} from the value $w_{SU}^{(1)} = 1.018$ to the value $w_{SU}^{(2)} = 1.045$. This is one of the main strengths of the chosen technologies. With an increase in annual production capacity comes a decrease in of the cost price of producing one ton of biodiesel on an annual basis.

Using the permitted level of soybean oil

One of the factors on which the production costs of a unit of biodiesel fuel depend is the value of the costs of input raw materials (Apostolakou A.A. et al., 2009, You et al., 2007). As we have already mentioned in this research, the impact of the type of input raw material is huge and it has a very strong influence on the production price of the final product, i.e. on the overall cost-effectiveness of the biodiesel production plant (Myint, L.L. and El-Halwagi M.M, 2009, Barreiros T. et al., 2020). Regarding that fact, now we will analyze how using the permitted level of soybean would affect the cost price of the unit of the biodiesel product.

As it was described in the previus chapters of this research, it is possible to calculate the cost price of the product unit, ie. production price of biodiesel based on the equation (8). It is necessary to determine what should be the selling price of glycerine C_{GL}, that is, the income from the sale of glycerine C_K^{GL}, in order to cover the costs of sodium hydroxide, potassium hydroxide, citric acid, electricity and labor, or expressed mathematically:

$$C_K^{GL} = C_K^{NH} + C_K^{KH} + C_K^{LK} + C_K^{EN} + C_K^{R} \qquad (17)$$

Starting from the cost price, at factory parity for: $C_{NH} = 385$ eur/t, $C_{KH} = 825$ EUR/t and $C_{LK} = 680$ EUR/t as well as the cost of electricity and the cost of human labor $C_K^{EN} = 2{,}85$ EUR/t and $C_K^{R} = 11{,}22$ EUR/t it is obtained that $C_K^{GL} = 18{,}55$ EUR/t and $C_{GL} \approx 250$ EUR/t. All prices are for the year 2010 from (Product Exchange ad Novi Sad - NSCOMEX, 2010).

This would mean that if the price of glycerine eco-fuel was reached at the level of approx. 250 EUR/t with the income from the sale of glycerin would cover the costs of sodium hydroxide, potassium hydroxide, citric acid, electricity and human labor. In that case, the cost price, or production price of a product unit, of biodiesel is:

$$C_K \approx C_K^{SU} + C_K^{ME} \quad (18)$$

In the case of the price of crude oil $C_{ReU} = 685$ EUR/t and the price of methanol $C_{ME} = 317$ EUR/t the production price of biodiesel produced from pure crude rapeseed oil in that case is

$$C_K^{'} = w_{SU} C_{ReU} + w_{ME} C_{ME} = 734{,}69 \text{ EUR/t} \qquad (19)$$

Now we will analyze the case when the produced biodiesel is a mixture of biodiesel produced from pure rapeseed oil (MERU = Rapeseed Methyl Esters - RME) and biodiesel produced from pure soybean oil (MESU = Soy Methyl Esters - SME), (Standard, EN 14214, 2004).

If the relative mass composition of biodiesel is from rapeseed oil (g_{ReU}), while the relative mass composition of biodiesel is from soybean oil (g_{SoU}), we have that the cost of crude oil is:

$$C_K^{SU} = g_{ReU} w_{ReU} C_{ReU} + g_{SoU} w_{SoU} C_{SoU}\ , (20)$$

where $g_{ReU} + g_{SoU} = 1$

if the selected raw materials (rapeseed oil and soybean oil) have the same acid number ($\approx$ 2mgKOH/g) the relation also applies: $w_{ReU} = w_{SoU} = w_{SU} = 1{,}018$.

Based on the above facts, it follows that the production price of biodiesel, obtained by mixing biodiesel from rapeseed oil and biodiesel from soybean oil, is:

$$C_K^{"} = g_{ReU} w_{SU} C_{ReU} + g_{SoU} w_{SU} C_{SoU} + C_K^{ME} \ (21)$$

Based on the following facts:

- the allowed level of adjustment of soybean oil biodiesel, without significantly changing the essential parameters (primarily fuel filterability) of rapeseed oil biodiesel as a base fue, is currently acceptable 35%, which defines $g_{ReU} = 0{,}65$ and $g_{SoU} = 0{,}35$
- the price of raw rapeseed oil, at factory parity, is: $C_{ReU} = 685$ EUR
- the price of raw soybean oil, at factory parity, is: $C_{SoU} = 545$ EUR

we have that the production price of biodiesel in that case is:

$$C_K^{"} = 684.80 \text{ EUR.}$$

Based on the projected capacity of the plant at the level of annual production, the realized profit at the annual level, based on the use of the permitted level of soybean oil, for the input production raw material of biodiesel is: $\Delta = \left(C_K^{'} - C_K^{"}\right) \cdot Q_P = 1{,}496{,}700.00$ EUR. A significant increase in the economy of the production facility using soy crude oil can be noticed.

The price of crude rapeseed oil C_{ReU} depending on the price of rapeseed and taking the levels of defined costs, can be expressed as follows

$$C_{ReU} = K_{tr}\, C_{rep} \quad (22)$$

Where: C_{rep} is the rapeseed price (EUR/t), K_{tr} is the cost coefficient of the delivery and processing of rapeseed and its value based on the specified items in the proposed agreement and the sale of rapeseed meal at the price of 160 EUR/t and amounts to, for the value of the input raw material C_{rep} = 300 (EUR/t), K_{tr} = 2.237. For each increase in the price of rapeseed by 10%, the coefficient increases by 0.03, that is, for a price lower by 10%, the coefficient is lower by 0.03

In the Table 3. the values of the price of crude rapeseed are given for the different values of the rapeseed price and the cost coefficient of the delivery and processing. All prices shown in the Table 3. are updated for the year 2010 from (Product Exchange ad Novi Sad - NSCOMEX, 2010).

Table 3. The values of the price of crude rapeseed

Rapeseed price C_{rep} (eur/t)	**Processing coefficient K_{tr}**	**Crude rapeseed oil price C_{ReU} (eur/t)**
340	2.276	773.84
330	2.267	748.11
320	2.258	722.56
310	2.247	696.57
300	2.237	671.11
290	2.227	645.83
280	2.218	621.04
270	2.207	595.89
260	2.196	570.96

Source: Author's interpretation

The most unfavorable estimate (160 EUR/t) was used for the price of rapeseed meal. The current price of rapeseed meal with 32% protein is 210 EUR/t, which is the maximum price of meal at the end of the given annual cycle. The price of the shot has a significant effecton the price of crude rapeseed oil, so it is very important to estimate its value at which it can be sold.

Conclusion

Biodiesel is a renewable and biodegradable fuel made from vegetable oils, animal fats, or recycled cooking grease. It can be used in diesel engines with little or no modification and is often blended with petroleum diesel.

In this paper, as part of the economic analysis, an analysis of the cost price of the production of a unit of biodiesel products is given. Makpatrol biodiesel plant, located in Skopje in Macedonia, with a projected capacity of 20,000 tons of biodiesel per year is analyzed. Within the framework of the economic analysis, all relevant aspects were considered costs that influence the formation of the cost price of biodiesel fuel for plant with a capacity of 20,000 tons of annual production. The costs of producing a unit of biodiesel fuel products depend on the value of the costs of input raw materials, energy costs, and the cost of human labor.

Also, a comparative analysis of different cases was done: the case where during the design and implementation of the production plant the capacity of the production plant would be increased to the level of 25,000 tons of produced biodiesel, as well as to the level of 30,000 tons of produced biodiesel.

It is shown which parameters affect the cost price of the unit of the product produced in the biodiesel production plant. With an increase in annual production capacity comes a decrease in of the cost price of producing one ton of biodiesel on an annual basis, it was concluded based on the obtained results for the cost price of the unit of the product produced in the biodiesel production plant.

The cost price of the unit of the product produced in the biodiesel production plant capacity of 20,000 tons per year is $C_K = 702{,}45$ eur for the plant capacity of 20,000 tons per year.

For case the plant capacity of 25,000 tons per year, the realized profit on an annual level is obtained from $\Delta^{25} = 1{,}994{,}750.00$ eur. The percentage increase in profit is: $\Delta = 28{,}61\%$ which is in absolute terms $\partial\Delta = \Delta^{25} - \Delta^{20} = 443{,}730.00$ eur. It is obtained that the unit cost price of the product at the plant capacity of 25,000 tons per year is $C_K^{25} = 700.21$ eur.

For case the plant capacity of 30,000 tons per year, the annual profit at this production price, and the selling price as in previous cases, would be: $\Delta^{30} = 2{,}438{,}700.00$ eur. The percentage increase in profit is: $\Delta = 57.23\%$ which is in absolute terms $\partial\Delta = \Delta^{30} - \Delta^{20} = 887{,}700.00$ eur. The cost price of a product unit at a plant capacity of 30,000 t/year is $C_K^{30} = 698.71$ eur.

During this analysis, a very strong influence of the weight function of the input raw material, crude oil, can be observed on the production price of the final product, that is, on the overall economy of the biodiesel production plant. With an increase in annual production capacity comes a decrease in of the cost price of producing one ton of biodiesel on an annual basis.

In this paper, it is also shown that using a sufficient level of soybean oil can achieve a range of the cost price of the unit of the biodiesel product. The allowed level of adjustmen of soybean oil biodiesel, without significantly changing the essential parameter of rapeseed oil biodiesel as a base fuel, is currently acceptable 35%. In that case a production price of biodiesel is $C_K^{"} = 684.80$ eur. With a use of the permitted level of soybean oil the realized profit at the annual level is $\Delta = 1{,}496{,}700.00$ eur.

It can be concluted that it is possible to notice a significant increase in the economy of the production facility using soy crude oil thanks to the great flexibility of the applied technology.

Conflict of interests

The authors declare no conflict of interest.

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THE SUSTAINABILITY OF AGRITOURISM IN ROMANIA IN THE OPINION OF PENSION ADMINISTRATORS

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ABSTRACT

Sustainable tourism should encompass all tourism forms, support local communities, and protect the environment while meeting diverse tourist demands. Agritourism offers a viable alternative, with growing interest in rural areas and eco-friendly agricultural products. This study analyzes agritourism sustainability by evaluating the share of self-produced agricultural consumption in guesthouses, based on a survey among administrators from five key Romanian counties: Argeș, Brașov, Dâmbovița, Prahova, and Teleorman. Results highlight the critical role of ecological products and green strategies in promoting sustainable tourism behavior. The findings underline the need to integrate cultural and ecological elements into tourism to foster responsible practices. This research offers tourism managers and policymakers a practical foundation for encouraging environmentally conscious tourism development and supporting green consumption.

Introduction

Tourism can contribute to a wider and more dense measure to sustainable development and to the eradication of social and economic poverty. For this, initiatives in favor of sustainable development are useful: the global-local association, so vital in the field of transport, decentralized cooperation, the transversality of tourism, economic balancing through environmental development, through governance, the transition from friendly pact to democratic practice. (Pranita et al, 2022; Băbăț et al., 2023; Andrei 2014; Vasile 2016). The dimensions of sustainable development force responsible tourism to enter

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into a collective logic, around group objectives (Kapera 2018; Penjišević et al., 2024; Madeira et al, 2023). Rural tourism with a focus on sustainability and responsible consumption represents a key approach in the context of global concerns related to the conservation of natural resources (Kabil et al., 2021; Xu et al., 2022; Lee 2010). In an era where climate change and environmental impact are becoming increasingly evident, this type of tourism is becoming a strategic and responsible option (Funduk et al, 2024; Bhuiyan, 2022; Xu, 2023).

In this sense, quality management of agritourism activities, integrating ecological and social principles, is essential for protecting rural ecosystems and supporting local communities, so that tourism brings sustainable benefits. Agritourism, by promoting authentic rural experiences and offering organic agricultural products, contributes to the development of a sustainable form of agritourism, supporting both the environment and local communities (Priatmoko et al. 2023; Oltean and Gabor 2022; Bacoş and Gabor, 2021; Crăciun et al., 2022). Romanian guesthouse managers believe that the sustainability of agritourism depends on the integration of sustainable agricultural practices that capitalize on local resources and promote traditional products. Adding details about the agriculture specific to each area contributes to the authenticity of the experiences offered, thus strengthening the attractiveness and long-term viability of Romanian agritourism (Priatmoko et al. 2023; Oltean and Gabor 2022). In recent years, agritourism has experienced significant growth in Romania. According to the National Institute of Statistics, the number of agritourism accommodation units increased by approximately 20% between 2015 and 2020, highlighting the growing interest in rural and sustainable tourism.

Romania has a growing organic agricultural area, occupying over 3% of total agricultural land, according to Eurostat data. Organic farmers contribute to the conservation of biodiversity and the maintenance of a healthy rural environment, which makes agritourism more attractive to tourists looking for authentic and sustainable experiences.

According to a study conducted by the National Association of Rural, Ecological and Cultural Tourism (ANTREC), over 70% of guesthouse managers believe that integrating local products and sustainable agricultural practices is essential for the long-term success of their business. They emphasize that tourists are increasingly interested in sustainability and the consumption of traditional products.

The current research largely aligns with the existing literature that argues that sustainable tourism should be applicable to all forms of tourism, supporting local communities, protecting the environment, and meeting the needs of as many tourists as possible. In particular, agritourism is recognized as a viable alternative in the context of sustainable tourism, offering tourists the opportunity to spend time in rural areas and consume organic agricultural products.

However, our study makes a specific contribution by focusing on Romanian agritourism and by analyzing in detail the share of consumption of own agricultural products in agritourism guesthouses. The survey results indicate that the use of organic products and the implementation of organic strategies are essential for promoting sustainable behavior, reinforcing the idea that agritourism can significantly contribute to sustainable tourism.

Unlike other works that may address sustainable tourism in a more general manner, this study emphasizes the importance of integrating cultural and ecological aspects into agritourism practice.

Literature review

Studies have shown that tourism can only exist thanks to a clean environment, because tourists seek peace, clean air, etc. (Grecu, 2023; Robu et al. 2019; Radovanović et al, 2024; Bacos 2021; Morales-Urrutia et al, 2020). The first attempts to promote this were made at the Rio Conference in 1992, which allowed the use of the concept of sustainable development in the field of tourism. Bădulescu et al. (2015) consider that an important aspect of sustainable rural tourism is the promotion of ecological products and responsible consumption. Agritourism guesthouses can play a role in this direction, offering tourists local agricultural products, produced sustainably and without affecting the ecological balance of the area (Ciolac et al., 2021; Ciolac et al, 2020).

According to Palazzo et al. (2018), pollution reduction is another challenge and priority in the context of sustainable rural tourism. Efficient waste management and the use of renewable energy sources are key elements in efforts to minimize negative environmental impacts.

The need for quality management in agritourism guesthouse activities includes not only environmental aspects, but also social and cultural implications (Andrei and Dragoi 2020). Protecting local traditions and involving communities in the tourism process are essential to ensuring sustainable development of this sector (Priatmoko et al. 2023; Đaković et al., 2024; Rahmat, 2021). Sustainable rural tourism represents a viable and responsible solution for tourists seeking to experience the beauty of the rural environment as well as the consumption of organic agricultural products (Su et al, 2023; Firoiu, 2019).

Also, Tong et al. (2024) believe that the development of rural tourism is important in the fusion of culture and the tourism industry, facilitating rural revitalization. Thus, agritourism can significantly contribute to resource conservation, increasing the consumption of local agricultural products, and caring for the environment and local communities (Stefan, 2021; Shafiee et al, 2019). The article by Gargia-Garcia et al. (2023) suggests further exploration of how sustainability can be incorporated as a focal point for development, thereby mitigating the impact of tourism on destinations. The reasons for our scientific approach are the following: by studying the specialized literature, we found that there are certain inconsistencies between the concepts with which rural tourism operates, overlaps or insufficient information to understand it; the desire to support environmental organizations in their approach to orienting the population towards the consumption/use of ecological products; providing a study base for administrators in the rural environment; encouraging Romanian tourists to get to know their country, traditions, customs; last but not least, we wanted to sound an alarm regarding the need to establish objectives within rural tourism from a sustainability perspective.

In preparing the study, we relied on the conclusions of scientific papers (Gabor 2023; Oltean and Gabor 2021) and sought to answer a series of questions related to the need for quality management in agritourism guesthouse activities, which takes into account environmental protection.

Materials and methods

The data collection period was 01.02.2023 – 01.12.2023. We chose a long period for two reasons: the involvement of tourists in agricultural activities occurs predominantly in the analyzed period and the sample size. The questionnaire was processed using the SPSS (Statistical Package for the Social Sciences) program, which allowed the calculation of statistical indicators used to interpret the survey results from the point of view of their relevance and to create a structural equation model using the Smart PLS program. SPSS ensured rigorous preliminary data processing and facilitated their preparation for advanced modeling. The data were statistically validated before being imported into Smart PLS. Smart PLS complements the analysis performed in SPSS, allowing the modeling of complex causal relationships between the analyzed variables, providing a deeper understanding of the mechanisms underlying the phenomenon studied.

The researched population is represented by all rural guesthouses in Romania. The observation unit is made up of managers from rural guesthouses in Braşov, Dâmboviţa, Prahova, Argeş and Teleorman counties, chosen for their representativeness in Romanian agritourism. The survey unit follows the administrators of agritourism guesthouses in the reference counties. Sampling method and sample size. Simple random sampling was used. The sample included 300 agritourism guesthouses, and the number of validated questionnaires was 291, which represents a 97% response rate. Data collection technique. Data collection was carried out by the opinion poll method, face-to-face survey. The questionnaire used contains 26 questions, of which: 5 to establish the profile of the agritourism guesthouse, 11 closed, 2 open and 8 mixed. Central hypothesis "The sustainability of agritourism is directly proportional to the involvement of agritourism guesthouse administrators in increasing the consumption of organic products and capitalizing on local historical and cultural heritage".

The research is based on five hypotheses resulting from free discussions held with agritourism guesthouse administrators in the studied counties, but also based on the questionnaire. Thus, the following hypotheses were formulated:

H1 - There is a high degree of use in agricultural production, in the operation of the guesthouse of techniques/procedures with an impact on environmental protection (reduction of water and energy consumption; reduction of waste production);

H2 - Agritourism guesthouse administrators are concerned with capitalizing on the historical and cultural heritage of the territory;

H3 - The consumption of organic products is positively influenced by their own production;

H4 - Promoting environmental awareness, recommending visitors to protect the environment, using eco-design of buildings, knowing about certified ecological products and obtaining eco-labels determines an increase in ecological and sustainable behavior among the community;

H5 - There is a positive association between administrators' concern for the use of strategies/policies in the field of activity organization and an increase in the number of accommodation nights.

Following hypothesis testing, we find that all hypotheses were verified, the results being presented in Table 1.

Table 1. Testing hypotheses

Hypothese	The tested value	Number of degrees of freedom, df	The statistics results (t)	Mean Difference	Confidence Interval of the Difference	Sig. <0.05	Verifying the hypotheses
H1	0,08	290	40,77	3,44	3,27-3,60	0	Check
H2	0,08	290	42,26	3,64	3,47-3,81	0	Check
H3	0,61	290	70,67	4,35	4,23-4,47	0	Check
H4	0,06	290	70,67	4,35	4,23-4,47	0	Check
H5	0,04	290	42,26, respective 20,95	3,64, respective 0,87	3,47-3,81, respective 0,79-0,96	0	Check

Source: processing of authors

The sample included agrotourism guesthouses, distributed by counties, as follows: 94 from Dambovita county, 92 from Brasov county, 83 from Prahova county, 15 from Arges county and 7 from Teleorman county. The sample structure is shown in Table 2.

Table 2. Sample structure

Boarding house								
			1 daisy	**2 daisy**	**3 daisy**	**4 daisy**	**5 daisy**	**Total**
County	**BV**	Count	2	16	65	8	1	92
		% of Total	0.7%	5.5%	22.3%	2.7%	0.3%	31.6%
	PH	Count	2	26	41	11	3	83
		% of Total	0.7%	8.9%	14.1%	3.8%	1.0%	28.5%
	DB	Count	4	36	45	9	0	94
		% of Total	1.4%	12.4%	15.5%	3.1%	0.0%	32.3%
	AG	Count	0	7	4	4	0	15
		% of Total	0.0%	2.4%	1.4%	1.4%	0.0%	5.2%
	TR	Count	0	0	7	0	0	7
		% of Total	0.0%	0.0%	2.4%	0.0%	.0%	2.4%
Total		Count	8	85	162	32	4	291
		% of Total	2.7%	29.2%	55.7%	11.0%	1.4%	100.0%
Accommodation places								
			0-20 places	**21-40 places**	**41-60 places**	**61-80 places**	**81-100 places**	**Total**
County	**BV**	Count	51	29	9	2	1	92
		% of Total	17.5%	10.0%	3.1%	0.7%	0.3%	31.6%
	PH	Count	44	33	5	0	1	83
		% of Total	15.1%	11.3%	1.7%	0.0%	0.3%	28.5%
	DB	Count	45	41	4	2	2	94
		% of Total	15.5%	14.1%	1.4%	.7%	0.7%	32.3%
	AG	Count	6	2	7	0	0	15
		% of Total	2.1%	.7%	2.4%	0.0%	0.0%	5.2%
	TR	Count	7	0	0	0	0	7
		% of Total	2.4%	0.0%	0.0%	0.0%	0.0%	2.4%
Total		Count	153	105	25	4	4	291
		% of Total	52.6%	36.1%	8.6%	1.4%	1.4%	100.0%

Source: author processing

H1 - There is a high degree of use in agricultural production, in the operation of the guesthouse of techniques/procedures with an impact on environmental protection (reduction of water and energy consumption; reduction of waste production);

Table 3 presents the distribution of responses regarding the reduction of water and energy consumption by county (BV, PH, DB, AG, TR) and the level of satisfaction (to a very small extent; to a small extent, neither, nor, to a large extent, to a very large extent). 21% of administrators in Prahova county and 14.4% administrators in Brașov and Dâmbovița counties resort to various solutions to minimize consumption. Implementing energy efficiency and water saving measures will not only reduce the ecological impact of the guesthouse, but will also be able to attract customers who appreciate the commitment to sustainability. Through these efforts, agrotourism guesthouses can become examples of good practices in responsible tourism, while offering a pleasant and environmentally friendly experience for visitors (table 3).

Table 3. Reducing enery and water consumption

			In a very small degree	in small degree	neithe, nor	in big degree	in very big degree	Total
County	BV	Count	7	17	10	16	42	92
		% of Total	2.4%	5.8%	3.4%	5.5%	14.4%	31.6%
	PH	Count	4	3	9	6	61	83
		% of Total	1.4%	1.0%	3.1%	2.1%	21.0%	28.5%
	DB	Count	8	14	13	17	42	94
		% of Total	2.7%	4.8%	4.5%	5.8%	14.4%	32.3%
	AG	Count	0	0	1	1	13	15
		% of Total	0.0%	0.0%	0.3%	0.3%	4.5%	5.2%
	TR	Count	0	0	0	1	6	7
		% of Total	0.0%	0.0%	0.0%	0.3%	2.1%	2.4%
Total		Count	19	34	33	41	164	291
		% of Total	6.5%	11.7%	11.3%	14.1%	56.4%	100.0%

Source: processing of authors

Overall, the results reflect the administrators' concern for savings to a very high degree. The table highlights that selective collection is the main method of waste sorting, with higher application in Brașov (16.5%), Prahova (16.5%) and Dâmbovița (21.0%) counties, these counties being leaders in adopting responsible practices. However, Argeș (1.0%) and Teleorman (2.4%) counties have a low involvement in selective collection, which suggests the need for better implemented local policies for waste management. The lack of response or absence of sustainable practices is notable in Brașov (14.8%), Prahova (10.0%) and Dâmbovița (11.0%) counties, which indicates the existence of gaps even in the more active regions. Innovative solutions, such as the use of solar panels or partnerships with sanitation companies, are almost non-existent, suggesting an exclusive focus on traditional methods (table 4).

Table 4. Waste sorting methods

			Lack of answer	selective collection	solar panels, eco dumpers	partnerships with sanitation companies	Total
County	BV	Count	43	48	0	1	92
		% of Total	14.8%	16.5%	0.0%	0.3%	31.6%
	PH	Count	29	48	0	6	83
		% of Total	10.0%	16.5%	0.0%	2.1%	28.5%
	DB	Count	32	61	1	0	94
		% of Total	11.0%	21.0%	0.3%	0.0%	32.3%
	AG	Count	12	3	0	0	15
		% of Total	4.1%	1.0%	0.0%	0.0%	5.2%
	TR	Count	0	7	0	0	7
		% of Total	0.0%	2.4%	0.0%	0.0%	2.4%
Total		Count	116	167	1	7	291
		% of Total	39.9%	57.4%	0.3%	2.4%	100.0%

Source: processing of authors

Most agrotourism guesthouse administrators state that they largely apply measures to reduce waste production, especially since waste management has become a major problem due to the increase in its quantity and diversity, as well as its negative impact on the natural environment. Other measures applied by administrators but less commonly used are the use of biodegradable, returnable packaging, the use of ecological products and informing tourists on waste-related issues.

H2 - Agritourism guesthouse administrators are concerned with capitalizing on the historical and cultural heritage of the territory;

In each county under research, there are tourist attractions that the administrators of agrotourism guesthouses are aware of and recommend for visiting. In Argeş county, monasteries, caves, lakes, museums predominate; in Braşov county, tourists can visit monasteries, Bran Castle, Poiana Braşov, ski slopes; in Dâmboviţa county, most tourist attractions are monasteries, but also the Curtea Domnească National Museum Complex, bison reserves, Ialomicioarei Cave, Bolboci Lake, sheepfolds, etc.; in Prahova county, tourists can visit Peleş Castle, monasteries, animal farms, and in Teleorman county, tourists can visit monasteries and Poiana Izvoarelor.

In the rural area, being a small community and concerned with local activities, the managers recommend for visiting the monuments and sites that make up the historical and cultural heritage of the region. Representatives of agrotourism guesthouses greatly capitalize on the „riches" of the locality (table 5).

Table 5. Actions to capitalize on heritage

			A	B	C	D	E	F	Total
County	BV	Count	50	26	1	15	0	0	92
		% of Total	17.2%	8.9%	0.3%	5.2%	0.0%	0.0%	31.6%
	PH	Count	51	17	0	11	2	2	83
		% of Total	17.5%	5.8%	0.0%	3.8%	0.7%	0.7%	28.5%
	DB	Count	57	26	4	4	3	0	94
		% of Total	19.6%	8.9%	1.4%	1.4%	1.0%	0.0%	32.3%
	AG	Count	15	0	0	0	0	0	15
		% of Total	5.2%	0.0%	0.0%	0.0%	0.0%	0.0%	5.2%
	TR	Count	2	2	0	0	0	3	7
		% of Total	0.7%	0.7%	0.0%	0.0%	0.0%	1.0%	2.4%
Total		Count	175	71	5	30	5	5	291
		% of Total	60.1%	24.4%	1.7%	10.3%	1.7%	1.7%	100.0%

Legend:
A - lack of response
B-brochures, leaflets, advertising, museum, informing tourists
C - local events: Honoring the Heroes, Ravasitul oilor, Fundatia Ruralia
D - hiking, field car rides, trips to tourist attractions, environmental protection, team building
E - development of the area through collaboration with local authorities, I donate money
F - knowledge of local traditional crafts

Source: processing of authors

Table 5 reveals that the majority of respondents (60.1%) did not provide a concrete answer regarding actions to valorize heritage, which indicates a poorly exploited potential in many counties. The most popular activities reported include the use of promotional materials and informing tourists (24.4%), with a more visible involvement in Brașov (8.9%) and Dâmbovița (8.9%) counties. Local activities such as hiking, walking or environmental protection are very limited (1.7%), while initiatives involving collaboration with local authorities or knowledge of traditional crafts are almost non-existent, being reported only sporadically in Teleorman and Prahova counties. These results highlight the need for clearer and more diverse strategies for promoting and valorizing local heritage.

H3 - The consumption of organic products is positively influenced by their own production;

Table 6 reflects the consumption of organic products from own production, divided by product types and counties. In general, Brașov (BV), Prahova (PH) and Dâmbovița (DB) counties have a high share of organic products consumed, most of which are imported from foreign businesses (over 70% in most product categories). For example, for dairy, meat and vegetables, most of the products consumed come from imports (70.4% for dairy, 72.9% for meat and 77.7% for vegetables). However, in smaller counties, such as Argeș and Teleorman, the share of imported products is significantly lower. In Brașov county, the consumption of local organic products is more diversified, and at the level of product types, there is a trend of consuming more organic products, with a higher percentage of products of local origin (especially vegetables and fruits).

Table 6. Consumption of organic products from own production

a) Dairy						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	59	9	24	92
		% of Total	20.3%	3.1%	8.2%	31.6%
	PH	Count	75	2	6	83
		% of Total	25.8%	.7%	2.1%	28.5%
	DB	Count	60	5	29	94
		% of Total	20.6%	1.7%	10.0%	32.3%
	AG	Count	8	0	7	15
		% of Total	2.7%	.0%	2.4%	5.2%
	TR	Count	3	0	4	7
		% of Total	1.0%	.0%	1.4%	2.4%
Total		Count	205	16	70	291
		% of Total	70.4%	5.5%	24.1%	100.0%
b) Meat						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	63	9	20	92
		% of Total	21.6%	3.1%	6.9%	31.6%
	PH	Count	78	2	3	83
		% of Total	26.8%	.7%	1.0%	28.5%
	DB	Count	61	9	24	94
		% of Total	21.0%	3.1%	8.2%	32.3%
	AG	Count	9	3	3	15
		% of Total	3.1%	1.0%	1.0%	5.2%
	TR	Count	1	4	2	7
		% of Total	.3%	1.4%	.7%	2.4%
Total		Count	212	27	52	291
		% of Total	72.9%	9.3%	17.9%	100.0%
c) Eggs						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	57	7	28	92
		% of Total	19.6%	2.4%	9.6%	31.6%
	PH	Count	77	2	4	83
		% of Total	26.5%	.7%	1.4%	28.5%
	DB	Count	56	6	32	94
		% of Total	19.2%	2.1%	11.0%	32.3%
	AG	Count	10	0	5	15
		% of Total	3.4%	.0%	1.7%	5.2%
	TR	Count	1	4	2	7
		% of Total	.3%	1.4%	.7%	2.4%

Total		Count	201	19	71	291
		% of Total	69.1%	6.5%	24.4%	100.0%
d) Vegetables						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	73	8	11	92
		% of Total	25.1%	2.7%	3.8%	31.6%
	PH	Count	77	3	3	83
		% of Total	26.5%	1.0%	1.0%	28.5%
	DB	Count	64	7	23	94
		% of Total	22.0%	2.4%	7.9%	32.3%
	AG	Count	11	1	3	15
		% of Total	3.8%	.3%	1.0%	5.2%
	TR	Count	1	4	2	7
		% of Total	.3%	1.4%	.7%	2.4%
Total		Count	226	23	42	291
		% of Total	77.7%	7.9%	14.4%	100.0%
e) Fruits						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	75	8	9	92
		% of Total	25.8%	2.7%	3.1%	31.6%
	PH	Count	76	3	4	83
		% of Total	26.1%	1.0%	1.3%	28.5%
	DB	Count	57	12	25	94
		% of Total	19.6%	4.1%	8.6%	32.3%
	AG	Count	12	1	2	15
		% of Total	4.1%	.3%	.7%	5.2%
	TR	Count	3	2	2	7
		% of Total	1.0%	.7%	.7%	2.4%
Total		Count	223	26	42	291
		% of Total	76.6%	8.9%	14.4%	100.0%

Source: processing of authors

To supplement the raw materials used in preparing tourists' food, administrators turn to products from the local market or from shopping centers. Thus, over 73% of the guesthouses participating in the research purchase culinary products from outside the household (table 7).

Table 7 details the consumption of organic products from local production, presenting data by counties and product categories (dairy products, meat, eggs, vegetables and fruits).

Table 7. Consumption of organic products from local production

a) dairy						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	59	9	24	92
		% of Total	20.3%	3.1%	8.2%	31.6%
	PH	Count	75	2	6	83
		% of Total	25.8%	.7%	2.1%	28.5%
	DB	Count	60	5	29	94
		% of Total	20.6%	1.7%	10.0%	32.3%
	AG	Count	8	0	7	15
		% of Total	2.7%	0.0%	2.4%	5.2%
	TR	Count	3	0	4	7
		% of Total	1.0%	0.0%	1.4%	2.4%
Total		Count	205	16	70	291
		% of Total	70.4%	5.5%	24.1%	100.0%

b) meat						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	63	9	20	92
		% of Total	21.6%	3.1%	6.9%	31.6%
	PH	Count	78	2	3	83
		% of Total	26.8%	.7%	1.0%	28.5%
	DB	Count	61	9	24	94
		% of Total	21.0%	3.1%	8.2%	32.3%
	AG	Count	9	3	3	15
		% of Total	3.1%	1.0%	1.0%	5.2%
	TR	Count	1	4	2	7
		% of Total	.3%	1.4%	.7%	2.4%
Total		Count	212	27	52	291
		% of Total	72.9%	9.3%	17.9%	100.0%

c) eggs						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	57	7	28	92
		% of Total	19.6%	2.4%	9.6%	31.6%
	PH	Count	77	2	4	83
		% of Total	26.5%	0.7%	1.4%	28.5%
	DB	Count	56	6	32	94
		% of Total	19.2%	2.1%	11.0%	32.3%
	AG	Count	10	0	5	15
		% of Total	3.4%	0.0%	1.7%	5.2%
	TR	Count	1	4	2	7
		% of Total	.3%	1.4%	0.7%	2.4%
Total		Count	201	19	71	291
		% of Total	69.1%	6.5%	24.4%	100.0%

d) vegetables						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	73	8	11	92
		% of Total	25.1%	2.7%	3.8%	31.6%
	PH	Count	77	3	3	83
		% of Total	26.5%	1.0%	1.0%	28.5%
	DB	Count	64	7	23	94
		% of Total	22.0%	2.4%	7.9%	32.3%
	AG	Count	11	1	3	15
		% of Total	3.8%	0.3%	1.0%	5.2%
	TR	Count	1	4	2	7
		% of Total	0.3%	1.4%	0.7%	2.4%
Total		Count	226	23	42	291
		% of Total	77.7%	7.9%	14.4%	100.0%
e) fruits						
			Do not buy from local production	**<50%**	**>50%**	**Total**
County	BV	Count	75	8	9	92
		% of Total	25.8%	2.7%	3.1%	31.6%
	PH	Count	76	3	4	83
		% of Total	26.1%	1.0%	1.3%	28.5%
	DB	Count	57	12	25	94
		% of Total	19.6%	4.1%	8.6%	32.3%
	AG	Count	12	1	2	15
		% of Total	4.1%	0.3%	0.7%	5.2%
	TR	Count	3	2	2	7
		% of Total	1.0%	0.7%	0.7%	2.4%
Total		Count	223	26	42	291
		% of Total	76.6%	8.9%	14.4%	0.3%

Source: processing of authors

The rural environment is characterized by a small size of space but also by the existence of a local community formed by relatives, friends, acquaintances, creating likes and dislikes. In Brașov County, most respondents do not buy dairy products, meat, eggs, vegetables or fruits from local production, with percentages of 20.3% for dairy products, 21.6% for meat, 19.6% for eggs, 25.1% for vegetables and 25.8% for fruits.

In Prahova County, most respondents do not buy dairy products, meat, eggs, vegetables or fruits from local production. The percentages are 25.8% for dairy products, 26.8% for meat, 26.5% for eggs, 26.5% for vegetables and 26.1% for fruits.

Dâmbovița County stands out for a significant percentage of respondents who buy locally produced products.

In Argeș County, the percentage of respondents who buy locally produced products is the lowest. Only 2.4% buy locally produced dairy products in a proportion of more than 50%. Fruits are purchased locally produced in a proportion of more than 50% by 0.7% of respondents.

In Teleorman County, the percentages for purchasing locally produced products are also low. 1.4% of respondents buy dairy products in a proportion of more than 50%, 0.7% buy meat, 0.7% buy eggs, 0.7% buy vegetables and 0.7% buy locally produced fruits. These percentages reflect a minimal tendency to purchase local products compared to the other counties.

In conclusion, Dâmbovița County stands out for a significant purchase of locally produced products in most categories, while Argeș County and Teleorman County present the lowest percentages for local products, indicating a lower preference for locally produced products compared to other counties.

H4 - Promoting environmental awareness, recommending visitors to protect the environment, using eco-design of buildings, knowing about certified ecological products and obtaining eco-labels determines an increase in ecological and sustainable behavior among the community.

With an overall score of 4.50, the administrators of agrotourism guesthouses demonstrate that they have knowledge about the environment. All administrators in Teleorman County and 47% of those in Dâmboviţa County know aspects related to the protection of forests, vegetation, atmosphere, water, fauna as well as protected areas and natural monuments (table 8).

Table 8. The degree of knowledge of the concept of environmental protection

Items	Score
Knowledge of the environment	4.50
Recommend visitors to protect the environment	4.55
Use of eco-design of buildings	3.34

Source: processing of authors

When we talk about the environment, it is necessary to bring into discussion the term „sustainable development” which aims to improve people’s lives and provide a clean natural environment for future generations through efficient environmental management.

In the top of administrators who recommend tourists to protect the environment is Teleorman County (100%), followed by Argeş (86%), Prahova (69%), Braşov (63%) and Dâmboviţa (59%). The overall score is 4.55.

H5 - There is a positive association between administrators’ concern for the use of strategies/policies in the field of activity organization and an increase in the number of accommodation nights.

Table 9 highlights the measures for facilitating tourist travel in each county. In Brașov County, the most frequent responses are concentrated in the no response category with 49 cases (16.8% of the total). Regarding infrastructure and resources, microbuses, ATVs, off-road vehicles and car rentals are mentioned by 18 respondents (6.2%), and for the rehabilitation of access roads, 12 cases (4.1%) are mentioned.

Table 9. Measures to facilitate the travel of tourists

			A	B	C	D	E	F	Total
County	BV	Count	49	18	7	12	1	5	92
		% of Total	16.8%	6.2%	2.4%	4.1%	0.3%	1.7%	31.6%
	PH	Count	54	17	0	6	0	6	83
		% of Total	18.6%	5.8%	0.0%	2.1%	0.0%	2.1%	28.5%
	DB	Count	61	9	6	8	0	10	94
		% of Total	21.0%	3.1%	2.1%	2.7%	0.0%	3.4%	32.3%
	AG	Count	11	0	0	4	0	0	15
		% of Total	3.8%	0.0%	0.0%	1.4%	0.0%	0.0%	5.2%
	TR	Count	0	2	0	5	0	0	7
		% of Total	0.0%	0.7%	0.0%	1.7%	0.0%	0.0%	2.4%
Total		Count	175	46	13	35	1	21	291
		% of Total	60.1%	15.8%	4.5%	12.0%	0.3%	7.2%	100.0%

Legend:
A - lack of response
B - microbus, ATV, land cars, carriage, car rental, partnerships transport companies
C-alley, parking, private road, rehabilitation access road
D - alley ramp
E – elevator
F - map, indicators, information, posters, internet, qualified personnel

Source: processing of authors

In Teleorman County, the lack of response is not represented (0%). Microbuses and ATVs are mentioned only by 2 respondents (0.7%), and the rehabilitation of access roads by 5 respondents (1.7%). The other options, including the access ramp, the elevator and the map, the signs and

Taking into account the aforementioned, the administrators of agrotourism guesthouses create, to a large extent, special offers aimed at people with modest incomes (table 10); moreover, from the discussions held with the representatives we conclude that they expressly address these people and less to very wealthy tourists (few in number).

Table 10. Creating offers for people with modest incomes

			lack of answer	in a very small measure	in small measure	neither, nor	in big measure	Total
County	BV	Count	10	11	22	10	39	92
		% of Total	3.4%	3.8%	7.6%	3.4%	13.4%	31.6%
	PH	Count	25	9	9	6	34	83
		% of Total	8.6%	3.1%	3.1%	2.1%	11.7%	28.5%
	DB	Count	18	10	26	17	23	94
		% of Total	6.2%	3.4%	8.9%	5.8%	7.9%	32.3%
	AG	Count	0	1	1	7	6	15
		% of Total	0.0%	0.3%	0.3%	2.4%	2.1%	5.2%
	TR	Count	1	2	0	4	0	7
		% of Total	0.3%	0.7%	0.0%	1.4%	0.0%	2.4%
Total		Count	54	33	58	44	102	291
		% of Total	18.6%	11.3%	19.9%	15.1%	35.1%	100.0%

Source: processing of authors

In Brașov County, guesthouse administrators largely consider that there are offers for people with modest incomes, with a percentage of 13.4% in this category. 11.7% of guesthouse administrators in Prahova County consider that the offers for people with modest incomes are adequate to a large extent. In Argeș County, guesthouse administrators provided the lowest ratings in all categories, with the lowest percentage of largely positive responses (2.1%). In conclusion, Brașov County and Prahova County have the highest percentages of largely positive responses, indicating a relatively positive perception by guesthouse administrators of the offers for people with modest incomes. The number of overnight stays over the last three years is important to analyze because it provides a clear picture of tourism trends and the attractiveness of the destination. By analyzing these results, the impact of different marketing and promotional strategies can be assessed, and adjustments can be made to improve the offer and services. This information is also important for resource planning and the development of tourism infrastructure, contributing to more efficient business management in the field (table 11).

Table 11. Number of nights in the last three years

			increasing	stagnation	decreasing	Total
County	BV	Count	48	20	24	92
		% of Total	16.5%	6.9%	8.2%	31.6%
	PH	Count	34	31	18	83
		% of Total	11.7%	10.7%	6.2%	28.5%
	DB	Count	43	40	11	94
		% of Total	14.8%	13.7%	3.8%	32.3%
	AG	Count	9	1	5	15
		% of Total	3.1%	.3%	1.7%	5.2%
	TR	Count	4	3	0	7
		% of Total	1.4%	1.0%	0.0%	2.4%
Total		Count	138	95	58	291
		% of Total	47.4%	32.6%	19.9%	100.0%

Source: processing of authors

In Brasov County, 16.5% of respondents believe that activity is growing, which suggests a positive perception on development and expansion in this county. This suggests a favorable general perception of development and expansion in this county, perhaps indicating a positive atmosphere and development opportunities for local hostels. In Prahova County, 11.7% of respondents notice an increase in activity, but with a percentage of more than 10.7% considering that the activity is stagnating. This suggests that while there is an appreciation for growth, a significant portion of administrators feel that no significant changes are made, and a small 6.2% perceive a decrease in activity. Prahova County has a more balanced profile between growth and stagnation compared to other counties.

Results and discussion

A number of important details for further investigation are disclosed after the data gathered from the 291 agro-tourism boarding houses that served as the collective subject of this study's analysis.

In comparison to earlier times, we have witnessed the enhancement and diversification of the range of services provided by agri-tourist pensions, along with a rise in the need to reduce water and energy usage and discover substitutes. Furthermore, a low level of education and lack of interest in selective garbage collection is evidenced by the small proportion of managers surveyed who had contracts with sanitation businesses. The view is further supported by managers' inaction when it comes to suggesting methods for garbage sorting..

Managers of agro-tourism pensions place a high value on employing low-impact processes in agricultural production. These procedures mostly involve lowering waste generation and recycling trash into secondary raw materials or energy sources through burning or other techniques. It is observed that the use of organic products and biodegradable packaging is trending. The management of agrotourism hostels prioritize maintaining a clean environment over disposing of natural trash, so they make available to guests modes of transportation like bicycles, carts, and sleighs.

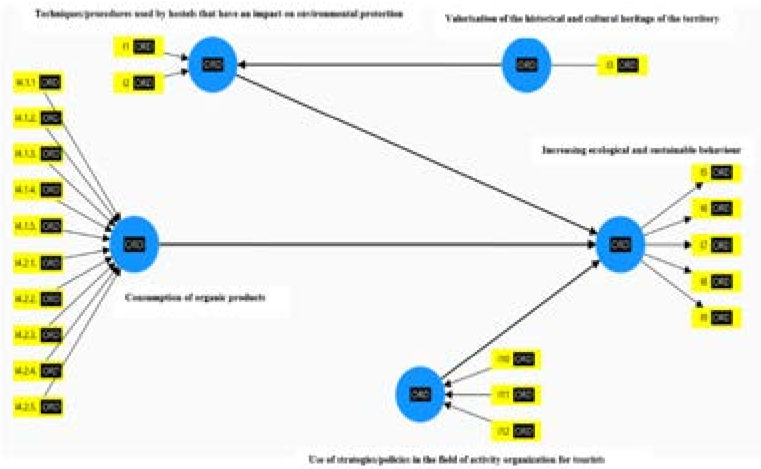
The agro-tourist pensions' representatives work to preserve the history by organizing events, distributing pamphlets and brochures to visitors, organizing hikes and excursions to nearby tourist destinations, and encouraging visitors to participate in traditional local crafts.

The degree to which agrotourism prepares food using its own and local produce directly relates to how sustainable it is.

Structural model - sustainability of agrotourism in Romania

Analysing the relationships between latent variables related to the use of organic products and the ecological and sustainable behavior of tourists is important to better understand consumer behavior and develop marketing strategies and policies that encourage ecological practices. To carry out this analysis, Smart PLS (Partial Least Squares Structural Equation Modeling) was used and the assumptions made previously, based on the literature and the results of the study, were taken into account. The model presented in Figure 1 is a partial structural equation model (PLS-SEM) developed using SmartPLS software. The model is designed to analyze the relationships between various latent variables related to the use of green products and the green and sustainable behavior of tourists.

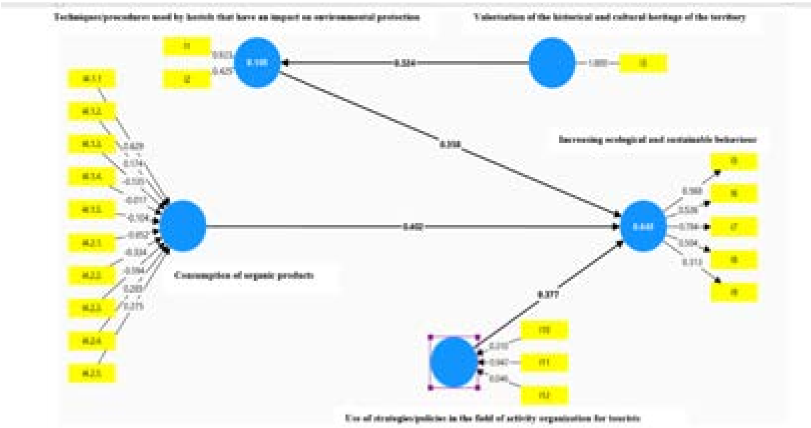
Figure 1: Structural model



Source: processing authors

Smart PLS results highlight causal relationships and statistical significance between latent variables. They demonstrate the reliability and validity of the constructs. These results of the structural model are shown in Figure 2.

Figure 2. Results of the structural model



Source: processing authors

❖ Description and interpretation of the model

The model includes the following latent (construct) variables:

1. Techniques/procedures used by hostels that have an impact on environmental protection (Techniques/Procedures): I1, I2 (indicators)
2. Valorisation of the historical and cultural heritage of the territory (Institrimony Valorisation): I3 (indicator)
3. Consumption of organic products (Environmental consumption): I4.1.1, I4.1.2, I4.1.3, I4.1.4, I4.1.5, I4.1.6, I4.2.1, I4.2.2, I4.2.4, I4.2.5 (indicators)
4. Increasing ecological and sustainable behaviour (Eco-Behavior): I5, I6, I7, I8, I9 (indicators)
5. Use of strategies/policies in the field of activity organization for tourists (Strategies/policies): I10, I11, I12 (indicators)

❖ Relationships and track coefficients

- Techniques/Procedures Ecological consumption (0.105): This suggests that the techniques and procedures used by hostels for environmental protection have a positive but modest impact on the consumption of organic products.
- Ecological behaviour (0.324): The valorisation of historical and cultural heritage contributes significantly to the growth of ecological and sustainable behaviour.
- Ecological Behavior (0.358): There is a positive and significant relationship between the consumption of organic products and the ecological behavior.
- Strategy/policy (0.402): This indicates that a high consumption of organic

products positively influences the use of strategies and policies in the organization of activities for tourists.

- Strategy/policies <TAG1> Ecological behaviour (0.377): The use of tourism strategies and policies has a significant impact on the growth of the environmental and sustainable behaviou

❖ **R-Squared**

- R^2 = 0.105): About 10.5% of the variation in the consumption of organic products is explained by the model.
- (R^2 = 0.643): About 64.3% of the variation in ecological and sustainable behavior is explained by the model, which suggests a fairly strong model.
- 2 Strategies/policies (R^2 is not mentioned, but probably around the average, because it is significantly influenced by the consumption of organic products).

The model suggests that there is an important relationship between the valorisation of cultural heritage and the ecological behaviour of tourists. Consumption of organic products also plays a central role in this model, directly and indirectly influencing environmental behaviour through strategies and policies applied in tourism.

The use of ecological products and the adoption of ecological strategies in tourism are necessary to promote sustainable behavior. The model emphasizes the importance of integrating cultural and ecological aspects in the tourism industry to stimulate sustainable behaviors.

This model can be useful for tourism managers and local authorities, providing a framework for the development of sustainable policies and practices that promote the consumption of ecological products and environmental protection.

Conclusions

In Romania, agritourism is an important element of rural space and has a strong impact on village life. Therefore, an efficient management of agritourism is particularly important, which capitalizes on the advantages offered by the rural environment and associates them with services (difficult to develop in other forms of tourism), increasing the chances of local partnerships.

According to the research hypotheses, implementing sustainable practices can offer guesthouse managers numerous advantages. Adopting green techniques, such as reducing water and energy consumption and efficient waste management (H1), allows managers to significantly reduce the operational costs of guesthouses. This economic efficiency contributes to increasing long-term financial sustainability. Capitalizing on the historical and cultural heritage of the region (H2) and promoting eco-friendly products (H3) increase the attractiveness of guesthouses for tourists interested in authentic and sustainable experiences. This contributes to strengthening a positive reputation, which attracts a larger number of customers and stimulates their loyalty. Offering eco-friendly products of own production and obtaining eco-certifications (H3, H4) allow managers to access a market segment willing to pay a premium for sustainable services and high-quality products. Implementing sustainable strategies and policies (H5) and promoting environmentally friendly behavior not only improves the tourist experience, but also contributes to increasing their loyalty. Satisfied tourists tend to return and recommend the guesthouse, which stimulates the increase in the number of overnight stays and, implicitly, revenues. Promoting guesthouses as eco-friendly and environmentally responsible destinations offers a significant competitive advantage in an increasingly sustainability-oriented market. This positioning can attract support from local communities and facilitate access to funds or subsidies dedicated to sustainable tourism.

Increasing the efficacy of sustainable agritourism management can support sustainable development and the elimination of social and economic poverty on a larger and more comprehensive scale. In order to achieve sustainable development, managers of sustainable agrotourism must engage in a collective logic around group objectives, such as: protecting and maintaining habitat, species, and associated ecosystems; preventing and eliminating improper agricultural practices; creating and maintaining socio-cultural practices and manifestations; providing tourists with leisure equipment; monitoring the well-being of the local community.

Making sustainable agritourism management more efficient can contribute to a broader and denser extent to sustainable development and to the eradication of social and economic poverty. The research underlines the relevance of sustainable tourism as a solution applicable to all forms of tourism, emphasizing the economic, social and environmental benefits for local communities, and agritourism is presented as a viable alternative that capitalizes on the rural environment, organic agricultural products and authentic contact with nature, thus offering a concrete perspective on sustainability by analyzing the consumption of own agricultural production in guesthouses in counties representative of Romanian agritourism.

During the research, we encountered numerous difficulties that made our work difficult: the lack of information and statistical data on the website of the National Institute of Territorial Statistics regarding the specific number of agrotourism guesthouses for the five counties (Braşov, Dâmboviţa, Prahova, Argeş, Teleorman).

The paper brings superior elements in relation to other researchers through its detailed focus on agritourism in Romania, specifically analyzing the share of consumption of own agricultural products in agritourism guesthouses. Unlike other studies that deal with sustainable tourism in a more general way, this research emphasizes the importance of integrating cultural and ecological aspects in agritourism practice. Another innovative element consists in identifying a direct association between hostel managers‘ concern for the use of sustainable strategies and the increase in the number of accommodation nights, thus providing a framework of values for the development of public policies.

We intend to continue the current research by analyzing trends in creating niches, very tight customer segments, and practicing an elite of destinations, products, territories, and customers, and developing viable strategies for sustainable agritourism management.

Conflict of interests

The authors declare no conflict of interest.

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PATTERNS OF AGRI-FOOD INTRA-INDUSTRY TRADE BETWEEN CZECHIA AND EU MEMBER STATES: TWO DECADES OF THE EU MEMBERSHIP

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A R T I C L E   I N F O

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A B S T R A C T

The article assesses the dynamic of Czechia's agri-food intra-industry trade (IIT) with other EU countries. Methods such as Grubel-Lloyd index, Greenaway, Hine and Milner method, and Fontagné and Freudenberg method were applied using EUROSTAT bilateral trade data at 6-digit HS code from 1999 to 2022. Although the inter-industry trade still prevails in the structure of Czechia's agri-food trade, the IIT intensity has increased. Nonetheless, the increase started to slow down and stopped in the last decade. The IIT is mostly vertical in nature and significant variations across specific agri-food sectors exist. Increased intensity of IIT indicates potentially positive welfare effects when compared to inter-industry trade and advocates the integration into the economic structures of the Single European Market. Findings inform policymakers in countries aspiring to EU membership when assessing the potential nature of the trade dynamic during participation in the Single European Market.

Introduction

The accession of Czechia into the EU in 2004 meant liberalization of agri-food (A-F) trade with former and new Member States, as well as further unification of the institutional framework by the adoption of, e.g., Common Trade and Agriculture policies. These changes led to an increase in the value and volume of A-F trade between Czechia and other EU Member States. The A-F trade in the region has increased and the share of EU countries in the territorial shape of Czechia's A-F trade has grown to about 90% (Smutka et al., 2018; Kuzmenko et al., 2022; Zdráhal et.al, 2024).

Multiple studies (Burianová, 2010; Smutka et al., 2012; Svatoš and Smutka, 2012; Bielik et al., 2013; Smutka et al., 2018; Bajan et al., 2021; Kuzmenko et al., 2022; Rumankova et al., 2022; Vondráček et al., 2022) assessed the nature and competitiveness of the

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Czechia's A-F trade using the traditional Ricardian approach that predicts trade as inter-industrial. Inter-industry trade means trade flows between two countries are expected to be according to the comparative advantages of industries and with complementary goods with differing factor intensities. These studies analysed competitiveness from different vantage points. Among others, Burianová et al. (2010) studied the competitiveness and commodity structure of A-F trade after Czechia acceded to the EU using revealed comparative advantage methodology (2004 to 2008). They found Czechia to be most competitive in milk, sugar and sweets, oilseeds, and cereals. Study of Smutka et al. (2016) concluded that Czechia reveals comparative advantages in cereals, live animals, oilseeds, tobacco, dairy, sugar, animal and vegetable fats, and beverages.

There are several reasons for intensively studying the intra-industry trade (IIT) in A-F trade. Intra industry trade is simultaneous exports and imports within industries between countries of similar development levels and was one of the most important empirical finding of the 1960s concerning international trade (Fontagné et al., 2006).

Traditional trade theory assumes constant returns to scale, a homogeneous product, and perfect competition. However, fundamental changes in the business environment in A-F value chains limit the applicability of these models as these general assumptions may no longer fully correspond to the reality of current food systems where product differentiation, economies of scale, and imperfect market structures have taken place (Reardon et al. 2003; Henderson and Isaac, 2017). The theoretical IIT models emphasize the existence of product differentiation, economies of scale, and imperfect market structures as major factors determining IIT. This is probably a reason why until recently most IIT studies have not paid much attention to the A-F trade. There is also general agreement that the activities of multinational companies and global value chains had a significant influence on the trade dynamic in recent years (Gereffi, 2014), even in the A-F trade segment (De Backer and Miroudot, 2013). This provides another reason to study IIT because the fragmentation of production and multinational companies organizing regional and global A-F value chains were identified as one of the drivers behind the dynamic of IIT (Falvey and Kierzkowski, 1987; Jones and Kierzkowski, 1990).

Last, but not least, it is two decades since the Czech Republic became an EU member State in 2004 and started fully participating in the Single European Market. Existing studies of IIT proposed a positive relationship between the process of economic integration in the EU and IIT's appearance. This has important implications because the increasing intensity of IIT leads to the positive welfare effects of economic integration because of the smaller social costs of IIT when compared to the social costs of structural changes stimulated by inter-industry specialization (Brülhart and Elliot, 1998; Cabral and Silva, 2006).

Against this backdrop, the article aims to assess the dynamic of Czechia's agri-food intra-industry trade and reveals the country's A-F IIT patterns with other EU countries during the participation in the Single European Market in the last two decades of Czechia's EU membership.

Although Czechia has already been included in some comparative studies on IIT (e.g. Jambor 2014; Łapińska, 2014; Ferto and Jambor, 2015; Jambor and Leitao, 2016), this article expands these analyses in terms of time coverage and details.

Theoretical background

Traditional economic theory explains ongoing trade between countries based on the theory of comparative advantages (so-called inter-industry trade). On the other hand, IIT is simultaneous exports and imports within industries between countries of similar development levels and was one of the most important empirical findings of the 1960s concerning international trade (Fontagné et al., 2006). Empirical studies have shown that IIT has been a phenomenon of growing importance in the structure of international trade (McCorrison and Sheldon, 1991; Fontagné et al., 2006; Krugman et al. 2012) and has been expanding also in the segment of A-F trade (e.g. Bojnec, 2001; Ferto, 2015; Jambor and Leitão, 2016; Benešová et al. 2020).

While some authors expressed doubt that IIT exists because of its inconsistency with predictions of the Hechsher-Ohlin model, further shifts in trade theories started to develop theoretical explanations for trade in similar goods (e.g. Lancaster, 1980; Krugman, 1979, 1980, 1991; Brander, 1981; Shaked and Sutton, 1984; Helpman and Krugman, 1985; Falvey and Kierzkowski, 1987; Jones and Kierzkowski, 1990, 2000; Lüthje, 2001). When compared to the Hecksher-Ohlin model, this new stream of trade theories indicates that the determinants behind IIT are product differentiation, economies of scale, imperfect market structures and the fragmentation of production process, and activities and sourcing strategies of multinational companies.

The existence of IIT is important because of its welfare implications. Traditional inter-industry trade stimulates specialization of a country's economic structure as predicted by the theory of comparative advantage. In other words, it is a process of specialization (for) those industries that reveal comparative advantages. Such a structural change involves significant adjustment costs of adaptation. The proponents of the so-called smooth adjustment hypothesis (Brülhart and Elliott, 1998; Cabral and Silva, 2006) suggest that IIT stimulates specialization, but inside the industry, not among industries. Thus, subsequent changes do not attract similar social costs as in the case of inter-industry specialization and trade.

Materials and methods

Various methods exist to measure the intensity of intra-industry trade (IIT). A classic method of identifying intra-industry trade is a group of indicators based on the Ballasa index (Ballasa, 1965). Among these indicators, the most used is Grubel-Lloyd index (GL). The GL is defined as follows (Grubel and Lloyd, 1975):

$$GL_i = 1 - \frac{|EX_i - IM_i|}{(EX_i + IM_i)} \tag{1}$$

where i is an industry, j is a year, EX^{EX_i} (IM^{IM_i}) is the export (import) value of a particular country. The GL index indicates the share of IIT in total trade and its calculation is based on a decomposition of total trade in trade overlaps (representing intra-industry trade) and the imbalance (inter-industry trade). The flows related to inter-industry trade are explained by traditional (Ricardian) trade theory, whereas intra-industry trade is explained by the new international trade theory (Fontagné and Freudenberg, 1997). The index can range between 0 (only inter-industry trade) and 1 (only intra-industry trade). The index can also be aggregated to the level of sectors and countries:

$$GL = \sum_{i=1}^{n} GL_{ij} \times w_{ij} \quad \text{where} \quad w_i = \frac{(X_i + M_i)}{\sum_{i=1}^{n}(X_i + M_i)} \tag{2}$$

where wi represents the share of industry i in the country's total trade for the given product group.

The GL index has been extensively used despite continued criticism of both of its theoretical and empirical aspects. One of the reasons is a distortion in the event of a trade imbalance. As the imbalance increases, a higher share of inter-industry trade is reported and thus the share of IIT drops. The GL index also causes an analytical-interpretive problem. Even if the trade flow decomposition is done, there is still the possibility of two different theoretical explanations (traditional trade theory or new international economics) for the same trade flow (Fontagné and Freudenberg, 1997). Also, the Grubel-Lloyd index allows distinguishing between horizontal and vertical IIT. Modified indices were proposed (e.g. Aquino, 1978) to overcome some of the problems. Nonetheless, resorting to the GL index while the alternative indices are available, implies that alternatives to GL index are probably still far from satisfactory.

An alternative methodology was introduced by Abd-El-Rahman (1986) and refined by Fontagné and Freudenberg (Fontagné and Freudenberg, 1997; (FF method) for inter- and intra-industry trade analysis. This methodology is based on the comparison of minority and majority trade flows. The trade flow is defined either as intra-industry (two-way trade) trade if the value of the minority trade flow represents at least a certain share of the majority trade flow; or is defined as inter-industry (one-way trade) trade, if the minority flow represents a lower share of the majority flow. A benchmark value (a share of a minority in the majority flow value) of 10% or 15% is typically chosen arbitrarily. The formal notation is as follows:

$$\frac{Min(EX_{p,s}, IM_{p,s})}{Max(EX_{p,s}, IM_{p,s})} > \gamma\% \text{, where } \gamma = 0.1 \ or \ 0.15 \tag{3}$$

If the value of the minority flow compared to the value of the majority flow is below this threshold, the trade exchange (export and import) is classified as inter-industry. If it is greater, it is classified as intra-industry (Fontagné and Freudenberg, 1997).

Both the GL and FF methodologies are sensitive to product and geographical aggregation bias. IIT is sensitive to the choice of product aggregation and may thus suffer from aggregate/sectoral bias (Fontagné and Freudenberg, 1997). The more products are grouped together, the more intensive IIT will be identified. If calculations are not performed at the bilateral level, the intensity of IIT may be overestimated. The IIT is typically analyzed from trade data at the 4–6-digit HS numeric code or 3-5 digit SITC code level. A study by Finger (1975) suggested that the occurrence of IIT is normal because the existing classifications place goods of heterogeneous factor endowments in a single group. However, the evidence shows that intra-industry trade still occurs even when industries are highly disaggregated. Nonetheless to deal with Finger's (Finger, 1975) argument 6-digit HS numeric codes are used in this article. The IIT was also calculated using 5-digit SITC code level to check the robustness of the results. The analysis of trade patterns is conducted on a strictly bilateral basis (between Czechia and each EU28 member state) to avoid geographical bias.

Unit prices of products are used (Abd-el-Rahman, 1991) to distinguish between horizontal and vertical IIT trade (and thus assess the quality of traded products). The initial idea is the assumption that relative prices should reflect the relative quality of products (Stiglitz, 1987). Horizontal IIT (HIIT) is therefore a trade with horizontally differentiated products, i.e. homogeneous products (perfect substitutes) of the same quality. Vertical IIT (VIIT) is then traded with vertically differentiated products with different prices that reflect different quality (Falwey, 1981).

However, several authors point out that unit prices may not fully reflect differences in product quality (e.g., Crespo and Fontoura, 2004). The procedure for the separation of horizontal and vertical IIT was proposed by Greenaway, et al. (1994, 1995). Later the procedure was modified (Azhar and Elliott, 2006) to gain symmetrical form. IIT is considered horizontal if the following criterion of the ratio of unit prices (UV) of exports and imports is met. Otherwise, it is a vertical IIT. The procedure was further advanced by Blanes and Martin (2000) to do the decomposition of VIIT to high and low VIIT. Formally:

$$\frac{1}{1+\alpha} \leq \frac{UV^{ex}}{UV^{im}} \leq 1+\alpha \tag{4}$$

Where UV is the unit price of the traded product. In the literature, the α is typically set as 15% or 25% (arbitrarily) to distinguish horizontal and vertical (low and high) product differentiation. A threshold of 15% is considered sufficient if differences in unit price correspond only to differences in quality (assuming perfect information). In a situation of imperfect information, the threshold of 15% would be too narrow and it would be more appropriate to set it at the level of 25%. However, setting this threshold value is arbitrary. A threshold of 25% is recommended for trade analysis of developing countries. We assume that a threshold of 15% should be appropriate because the EU's single market area and the integration of institutions and rules limit situations of imperfect information. However, we perform a sensitivity analysis to assess the robustness of the results.

The specific procedure for distinguishing horizontal and vertical (low and high) IIT depends on the applied method. One alternative is the Greenaway, Hine and Milner method (Greenaway et al, 1994, 1995; GHM) and is based on the decomposition of the Grubel-Lloyd index. Formally:

$$GHM_k^p = \frac{\sum_i \left[\left(EX_{i,k}^p + IM_{i,k}^p\right) - \left|EX_{i,k}^p - IM_{i,k}^p\right|\right]}{\sum_i \left(EX_{i,k} + IM_{i,k}\right)} \quad (5)$$

where p is either a horizontal or vertical (low, high) trade type, i is a product group/ industry (i=1,...n) and k is a trading partner. Another alternative is the procedure suggested by Fontagné and Freudenberg (1997). Formally:

$$FF_k^p = \frac{\sum_i \left(\left(EX_{i,k}^p + IM_{i,k}^p\right)\right)}{\left(EX_{i,k} + IM_{i,k}\right)} \quad (6)$$

The FF index is rather complementary than substitutive of the GHM. The FF index inclines to reach higher values than the GHM, and the values of the GHM index are typically between the values of the GL index and the FF index (Fontagné and Freudenberg, 1997).

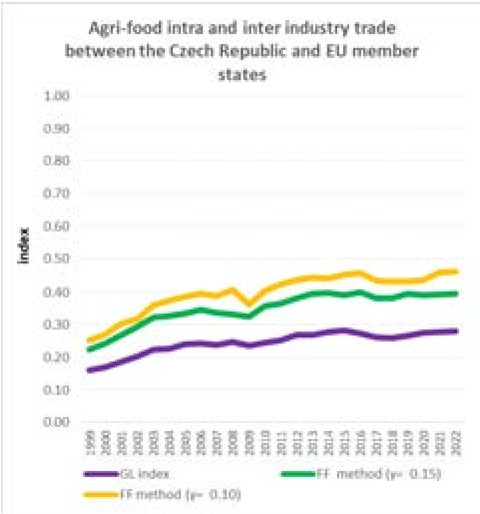
The analysis of the dynamic of Czechia's A-F IIT with other EU countries is using bilateral trade data from EUROSTAT database (EUROSTAT, 2024) at 6-digit HS numeric codes in the period 1999-2022. The nominal values of the trade flows are in current prices in EUR.

Results

Intensity and forms of A-F IIT

Although, with variations across methods (Figure 1), the inter-industry trade still prevails in the structure of the A-F trade between Czechia and EU Member States. Nonetheless, the intensity of the A-F IIT increased between 1999 and 2022. The figure (Figure 1) shows an increase in FF and GL indices indicating an increasing share of IIT in the structure of the A-F trade between Czechia and other EU Member States (while simultaneously a decreasing share of inter-industry trade). The analysis revealed two different trajectories in the dynamics of the A-F IIT intensity. First, scores of GL and FF (γ=0.10 and γ=0.15) indices suggest an increased intensity in Czechia's A-F IIT with other EU Member States even before 2004. This corresponds with the process of partial and gradual liberalization of the A-F markets even before Czechia joined the EU and the EU common market. This increase in the intensity of IIT continued after Czechia acceded to the EU, until around 2014. The results also suggest that the Great Recession didn't significantly influence the trend of increasing intensity of IIT. This is consistent with findings of existing empirical studies concluding that the intensity of A-F IIT in new EU Member States has increased in the new millennium following the liberalization at the global and regional level and the integration of the region into the structures of the EU (e.g. Łapińska, 2014; Jámbor, 2015; Jámbor et al., 2016). Second, from about 2014 to the end of the period under review, the increase in the intensity essentially stalled. In other words, the proportion of IIT in the structure of Czechia's A-F trade with other EU Member States has remained static. The outbreak of COVID-19 and the subsequent policy restrictive measures did not seem to influence this A-F IIT trajectory significantly.

Figure 1. Disentangling the A-F intra and inter-industry trade between Czechia and other EU member states; GL and FF indices; 1999-2022

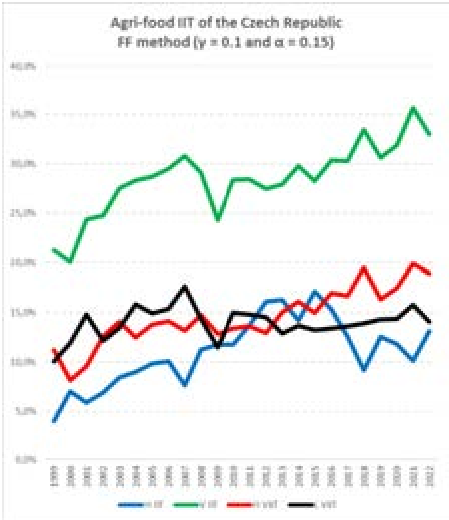


Source: Own calculation and construction based on data retrieved from EUROSTAT (2024)

Next, the IIT was decomposed into its horizontal and (high and low) vertical components, applying both Fontagné and Freudenberg (FF) method and the Greenway, Hine and Milner (GHM) method (Figure 2).

Both methods rely on the same assumption regarding the association of price, unit values, and the quality of traded products. The difference is that the GHM method further decomposes the GL index, while the FF method categorizes trade flows and computes the share of each category in total trade. The results suggest that Czechia's A-F IIT mostly consists of vertical IIT. The increased intensity of the A-F IIT in the structure of Czechia's A-F trade was due to the growth of both horizontally and vertically differentiated A-F products; however, the intensity of vertical IIT reached almost double the share when compared to the share of horizontal IIT (depending on the methods and parameters). The intensity of the vertical IIT increased throughout the period under review, indicating the exchange of products of different quality and revealing the specialization process taking place along the quality spectrum. The intensity of horizontal IIT started to decrease and stagnate in the second half of the period under scrutiny.

Figure 2. Disentangling horizontal and (high and low) vertical IIT of Czechia with other EU member states using FF and GHM methodologies, 1999-2022



Source: Own calculation based on EUROSTAT (2024)

Note: H IIT – horizontal IIT, V IIT – vertical IIT, H VIIT – high vertical IIT, L VIIT - low vertical IIT

The vertical IIT was further disentangled into high- and low-quality categories, using the method of Blanes and Martin (2000). The results revealed that high-quality A-F IIT started to prevail in the last decade. In other words, within bilateral two-way A-F flows with other EU Member States, Czechia exported higher quality A-F products than it imported lower quality ones. More in detail, despite both low and high vertical IIT showed similar shares in the structure of A-F trade and shares of both forms were slightly increasing during the first half of the period under scrutiny, in the second half of the period the low vertical IIT started to stagnate and the high vertical IIT continued to grow.

Other structural characteristics of IIT and sensitivity analysis

Results show that the minority trade overlaps are more and more represented as a structural feature of Czechia's A-F trade. The trade flows are defined either as IIT (two-way trade) trade (the value of the minority trade flow represents at least a certain share of the majority trade flow) or as inter-industry (one-way trade) trade (minority flow represents a lower share of the majority flow) in FF methodology. The table (table 1) presents the share of two-way trade (IIT) and one-way trade (inter-industry) flows in the total A-F trade between the Czech and other EU Member States, according to the degree of overlap (the minority flow as a percentage of the majority flow) used in FF methodology and calculated at the 6-digit HS level.

The data shows that cases of extreme overlap between Czechia's A-F exports and imports are rare. For example, less than 4% of A-F bilateral trade between Czechia and other EU member states has an overlap of more than 90% through the period under review. On the other hand, 30.2% of Czechia's A-F trade with other EU Member States was, in a strict sense, one-way (inter-industry) during 1999 (i.e. exports with no corresponding imports, and vice versa). In 2022, the one-way trade contributed only 10.3% to Czechia's A-F trade. The overlap of more than 10% represented about 25.3% of Czechia's A-F trade in 1999 and about 46.2% of A-F trade in 2022.

Existing IIT empirical studies (Greenaway et al., 1995; Ferto and Jambor, 2015) propose that the choice of γ is arbitrary and the results for a threshold of 0.1 or 0.2 are the same or very similar. While results for γ=0.1 and γ=0.2 were about the same at the beginning of the period under review, results for both γ differ by about 7 percentage points at the end of the period.

Table 1. FF method - sensitivity of IIT depending on the degree of overlap (γ) between export and import - 1999, 2011, 2022

Degree of trade overlap (%)	1999		2011		2022	
	TWT (%)	OWT (%)	TWT (%)	OWT (%)	TWT (%)	OWT (%)
95	1.1	98.9	1.5	98.5	1.7	98.3
90	3.0	97.0	2.5	97.5	3.7	96.3
85	3.2	96.8	3.7	96.3	4.8	95.2
80	3.8	96.2	4.3	95.7	6.2	93.8
75	4.2	95.8	5.5	94.5	7.0	93.0
70	5.4	94.6	6.8	93.2	8.2	91.8
65	6.0	94.0	8.8	91.2	11.4	88.6
60	7.4	92.6	10.6	89.4	13.5	86.5
55	8.0	92.0	11.4	88.6	15.9	84.1
50	8.5	91.5	14.2	85.8	17.8	82.2
45	9.0	91.0	16.8	83.2	20.1	79.9
40	13.3	86.7	19.8	80.2	23.3	76.7
35	14.2	85.8	21.9	78.1	25.7	74.3
30	16.5	83.5	25.5	74.5	27.6	72.4
25	19.0	81.0	27.8	72.2	30.6	69.4
20	20.5	79.5	31.6	68.4	35.4	64.6
15	22.4	77.6	36.4	63.6	39.6	60.4
10	25.3	74.7	42.4	57.6	46.2	53.8
5	30.2	69.8	50.8	49.2	53.8	46.2
0	30.2	69.8	13.2	86.8	10.3	89.7

Source: Own calculation based on EUROSTAT (2023)

Note: TWT – two-way trade, OWT – one way trade

Similarly, the choice of α also matters (Table 2), although literature proposes that α=15 or α=20 should provide similar results. However, the sensitivity analysis of the relative importance of horizontal and vertical two-way trade (Table 2) shows the difference to be 15.9 percentage points in 1999 and 11.3 percentage points in 2022 when using α=15% and α=20%, respectively. The sensitivity analysis revealed that the results are slightly sensitive to the choice of the threshold values. Figure A1 (in the Appendix) shows that a higher value of α leads to a decrease in the level of identified IIT and to an increase in inter-industry trade.

Table 2: FF method - sensitivity of relative importance of horizontal and vertical two-way trade in total IIT, 1999, 2011, 2022

Unit value threshold α (%)	1999		2011		2022	
	TWTH (%)	TWTV (%)	TWTH (%)	TWTV (%)	TWTH (%)	TWTV (%)
95	82.8	17.2	84.3	15.7	82.4	17.6
90	82.3	17.7	82.5	17.5	80.9	19.1
85	82.0	18.0	82.3	17.7	77.7	22.3
80	80.3	19.7	81.8	18.2	74.7	25.3
75	78.8	21.2	79.6	20.4	74.0	26.0
70	75.6	24.4	76.1	23.9	72.0	28.0
65	72.2	27.8	73.3	26.7	69.5	30.5
60	70.1	29.9	70.6	29.4	67.0	33.0
55	68.5	31.5	66.6	33.4	61.7	38.3
50	61.9	38.1	65.0	35.0	59.5	40.5
45	60.4	39.6	62.4	37.6	56.9	43.1
40	58.0	42.0	56.6	43.4	55.1	44.9
35	53.3	46.7	52.4	47.6	52.9	47.1
30	48.5	51.5	46.4	53.6	47.9	52.1
25	26.9	73.1	42.4	57.6	39.9	60.1
20	22.0	78.0	36.8	63.2	35.1	64.9
15	15.9	84.1	32.5	67.5	28.6	71.4
10	10.7	89.3	21.5	78.5	20.7	79.3
5	4.1	95.9	11.9	88.1	11.7	88.3

Source: Own calculation based on EUROSTAT (2023)

Sectoral analysis of IIT

The scores of FF and GL indices of the A-F IIT were analyzed on the sectoral level between Czechia and other EU Member States (Table 3). Sectors are described in the table in the Appendix (Table A1). The consistency test (Balance, 1987) of the indices as ordinal categories (cross-sector ranking) and calculated rank correlation coefficients for each pairing of both indices (FF and GL) revealed a high level of correlation (0.925), suggesting that FF and GL scores are highly consistent giving similar rankings of sectors regarding the intensity of IIT in a particular year. Therefore, we present here only the results for one method (the FF method).

The results suggest that the intensity of A-F IIT between Czechia and other EU Member States in particular sectors differ (on average over the period under scrutiny) from 0.107 (FF) HS03 to 0.697 (FF) HS18. Using FF scores, sectors such as HS05, HS09, HS17, HS18, HS19, and HS21 revealed FF scores higher than 0.5. This means that the IIT makes up more than half of the trade turnover of these sectors between Czechia and other EU Member States. On the other hand, sectors such as HS01, HS03, HS07, HS08, and HS10 revealed FF scores lower than 0.2 and inter-industry trade prevails in these sectors.

Table 3. Intensity of IIT for product groups (HS 2-digit) between Czechia and other EU member states, results of FF method ($\gamma = 0.1$; $\alpha=0.15$) and GL method, index, selected years

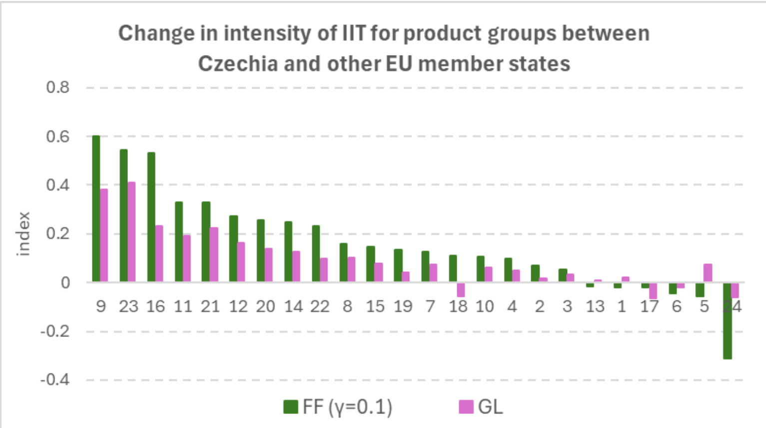
	FF (γ=0.1)				GL			
	average				average			
	1999-2022	1999-2002	2009-2012	2019-2022	1999-2022	1999-2002	2009-2012	2019-2022
1	0.189	0.158	0.183	0.14	0.1	0.074	0.111	0.093
2	0.208	0.126	0.232	0.195	0.124	0.088	0.145	0.105
3	0.107	0.023	0.168	0.078	0.062	0.023	0.074	0.055
4	0.415	0.318	0.391	0.416	0.264	0.219	0.263	0.267
5	0.642	0.643	0.667	0.587	0.367	0.269	0.408	0.343
6	0.218	0.217	0.217	0.173	0.107	0.119	0.094	0.099
7	0.199	0.097	0.226	0.225	0.12	0.06	0.127	0.134
8	0.189	0.052	0.2	0.21	0.125	0.035	0.137	0.136
9	0.579	0.166	0.6	0.765	0.368	0.12	0.364	0.503
10	0.136	0.04	0.168	0.147	0.091	0.037	0.112	0.097
11	0.255	0.056	0.259	0.386	0.154	0.04	0.148	0.231
12	0.387	0.208	0.48	0.48	0.234	0.113	0.344	0.275
13	0.402	0.384	0.404	0.369	0.237	0.198	0.245	0.206
14	0.368	0.256	0.299	0.505	0.197	0.1	0.212	0.228
15	0.368	0.244	0.368	0.389	0.23	0.15	0.224	0.229
16	0.359	0.028	0.44	0.558	0.181	0.021	0.218	0.251
17	0.629	0.611	0.672	0.592	0.408	0.422	0.442	0.358
18	0.697	0.61	0.719	0.719	0.447	0.456	0.473	0.398
19	0.657	0.597	0.61	0.731	0.363	0.357	0.337	0.397
20	0.343	0.21	0.352	0.467	0.215	0.142	0.213	0.28
21	0.687	0.467	0.744	0.794	0.43	0.303	0.458	0.525
22	0.431	0.266	0.503	0.498	0.26	0.167	0.294	0.266
23	0.349	0.06	0.358	0.605	0.24	0.041	0.226	0.452
24	0.286	0.538	0.261	0.225	0.154	0.228	0.131	0.166

Source: Own calculation based on EUROSTAT (2024)

Note: blue color indicates low scores and red color indicates high scores

In the first half of the period (when the intensity of A-F IIT increased at the national level) the intensity of IIT increased in most sectors (except for HS06, HS13, and HS 24) in the A-F trade between Czechia and EU Member States. In the second half of the period under scrutiny (when the intensity of A-F IIT started to stagnate at the national level) most of the sectors slightly decreased the intensity of IIT or slowed down the increase in intensity except for HS14 and HS19. At the end of the period, 9 out of 24 sectors revealed an FF score higher than 0.5. Some sectors as HS09 and HS21 revealed FF scores even higher than 0.75 (prevailing strong intra-industry trade).

Figure 3. Change in intensity of IIT for product groups (HS 2-digit) between Czechia and other EU member states, results of FF method (γ = 0.1; α=0.15) and GL method, index, selected years

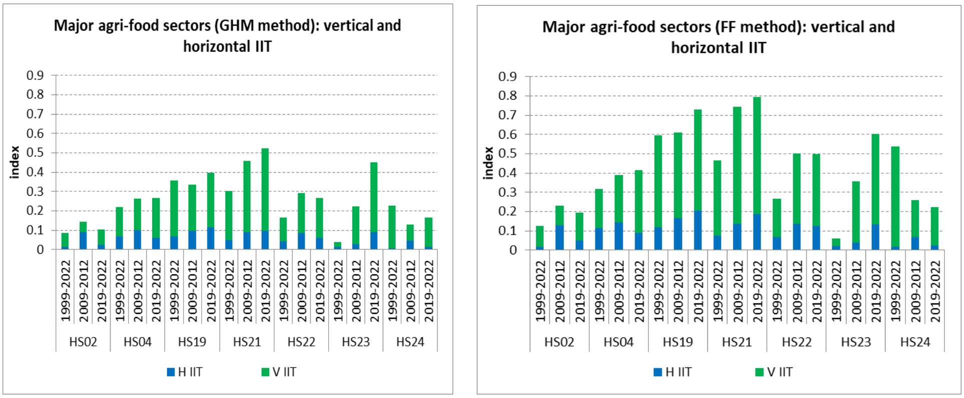


Source: Own calculation based on EUROSTAT (2024)

The trade flows of major sectors were decomposed into horizontal and vertical IIT components (figure 4). Seven major sectors in Czechia's A-F trade with other EU Member States are HS04, HS23, HS21, HS02, HS19, HS22, and HS24 were contributing to 53.4% of the overall Czech Republic's A-F trade turnover with other EU Member States in 2022. These sectors revealed mixed characteristics regarding the change in IIT's intensity and composition when comparing the beginning and the end of the period under scrutiny. Both horizontal as well as vertical IIT have significantly increased in the product group HS21. The HS19 revealed a decrease in the intensity of vertical IIT on the one hand and an increase in the intensity of the horizontal IIT. The intensity of IIT (mostly vertical IIT) has decreased in the product group HS24. These results suggest that the specialization pattern differs among these sectors as well as it indicates the influence of sector-specific factors and their effect on IIT dynamics (besides the nationwide and general A-F sector-specific factors).

Figure 4. Disentangling horizontal and vertical A-F IIT ($\gamma = 0.1$; $\alpha=0.15$) of Czechia with EU Member States; major A-F sectors; selected years

FF method GHM method



Source: Own calculation based on EUROSTAT (2024)

Discussions and conclusions

The article aimed to assess the intensity and forms of Czechia's A-F IIT with other EU Member States after two decades of membership in the EU.

The accession of Czechia into the EU in 2004 led to an increase in values and volumes of A-F trade between Czechia and former and new Member States. The intensity of trade in the region has increased and the share of EU countries in the territorial shape of Czechia's A-F trade has become dominant.

Although with variations across methods the inter-industry (one-way trade) trade still prevails in the structure of the A-F trade between Czechia and EU Member States. Nonetheless, during the period under review, the intensity of the A-F IIT was increasing corresponding with the process of partial and gradual liberalization of the A-F markets when Czechia joined the EU. The Czechia's A-F IIT mostly consists of vertical IIT indicating the exchange of products of different quality. The positive feature is that within the bilateral two-way A-F flows, Czechia exported higher quality A-F products than it imported lower quality ones. These results are in line with previous studies (e.g. Łapińska, 2014; Jambor, 2014; Jambor et al., 2016; Jambor and Leitão, 2016) on the A-F IIT in the region identifying the increased intensity and vertical nature of IIT in the new EU Member States. It also corroborates the positive relationship found between economic integration and IIT appearance (e.g. Krugman, 1991; Ecochard et al. 2006).

In the last decade, the increase in the intensity of IIT essentially stalled. The possible explanation for this stagnation in the A-F IIT intensity could be the e.g. slowed economic growth in the EU after the Great Recession, change in global value chains activities, and uncertain external and domestic environments that have reshaped trade patterns (e.g.

Kobrin, 2020; Pawlak et al., 2021). Identification of the reasons behind this change in trend opens questions for further research and was not the aim of this article.

The importance of inter-industry trade identified in this study suggests that the comparative advantages of individual A-F sectors are still substantially shaping the dynamic of Czechia's A-F trade. Nonetheless, the increased intensity of the IIT in Czechia's structure of A-F trade suggests the increased importance of other determinants (product differentiation, economies of scale, activities of multinational companies, and fragmentation of the production process) shaping Czechia's A-F trade. This puts existing studies on Czechia's distribution of comparative advantages among A-F sectors (e.g. Burianová et al., 2010; Smutka et al., 2016; Smutka et al., 2018; Vondráček et al., 2022; Kuzmenko et al., 2022) into perspective. These studies found Czechia to be most competitive (revealed comparative advantages) in live animals (HS01), milk (HS04), cereals (HS10), sugar and confectionery (HS17), oilseeds, vegetable oils (HS12) and beverages (HS22). Results in this article show dominance of inter-industry trade in these HS categories, except for sugar and confectionery (HS17) and beverages (HS22) that contain differentiated products and thus the IIT is relatively high. Traditional trade theories suggest that Czechia A-F exports are going to evolve around those products/industries revealing comparative advantages. The results in this article suggest the increasing relevance of IIT theoretical models and more complex Czechia's A-F trade pattern with other EU member states.

Surprisingly and contrary to some existing empirical studies (Greenaway et al., 1995; Ferto and Jambor, 2015), the choice of parameters γ and α in FF and GHM methods matters. The minority trade overlaps are increasingly represented in Czechia's A-F trade and α=15 and α=20 do not provide similar results. Also, from a methodology point of view, the result of the analysis indicates that using different methodologies to assess the IIT reveals and/or confirms that Fontagné and Freudenberg (1997) method provides higher intensity scores of IIT when compared to results of GL index.

Given the evidence of beneficial economic outcomes from the increased intensity of IIT, this study advocates the positive welfare effects of European economic integration in the A-F sectors of Czechia because of the smaller social costs than the structural changes stimulated by inter-industry specialization. In other words, the increased intensity of A-F IIT that followed Czechia's integration into the EU softened the integration process by allowing the country's A-F sectors to partially avoid harsh adjustments. Nonetheless, the results of this study show the diversity of IIT intensity in particular A-F sectors. The results suggest that the increased intensity of the IIT in the structure of Czechia's A-F trade with other EU Member States was mostly due to the growth of trade with vertically differentiated A-F products. It indicates ongoing specialization along the quality spectrum.

Findings in this study can help inform industrial, agricultural, and trade policymakers when assessing the nature of liberalization and structural transformation of A-F sectors in Czechia as well as when assessing the potential benefits and risks. Also, findings in this study help to inform countries aspiring to EU membership when assessing the nature of A-F trade dynamics during participation in the Single European Market.

Having said this, the results indicate that the increase in the intensity of Czechia's A-F IIT with other EU Member States essentially stalled in the last decade. This opens questions for further research 1) Is it a specific change in Czechia or it is a more general trend among the EU Member States; 2) what factors are causing this change in the trend; 3) what IIT theoretical models explain the dynamic and structural features of the Czechia's A-F IIT trade.

Conflict of interests

The author declare no conflict of interest.

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Appendix

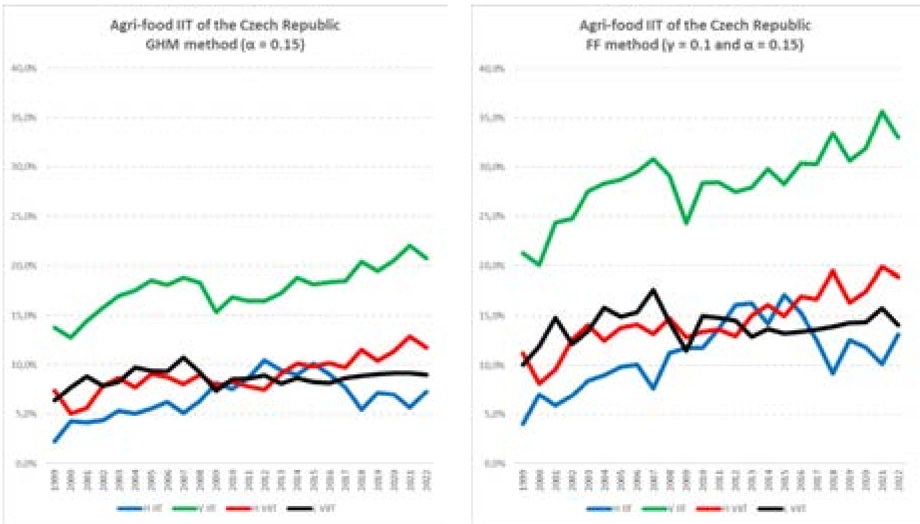
Table A1: Specific product groups according to Harmonized System (HS) classification

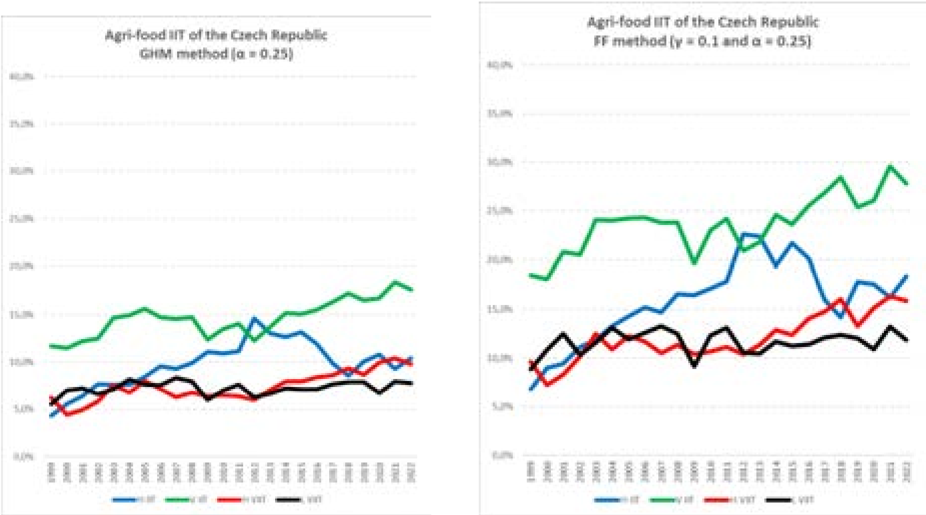
Code	Description
01	LIVE ANIMALS
02	MEAT AND EDIBLE MEAT OFFAL
03	FISH AND CRUSTACEANS, MOLLUSCS AND OTHER AQUATIC INVERTEBRATES
04	DAIRY PRODUCE; BIRDS' EGGS; NATURAL HONEY; EDIBLE PRODUCTS OF ANIMAL ORIGIN, NOT ELSEWHERE SPECIFIED OR INCLUDED
05	PRODUCTS OF ANIMAL ORIGIN, NOT ELSEWHERE SPECIFIED OR INCLUDED
06	LIVE TREES AND OTHER PLANTS; BULBS, ROOTS AND THE LIKE; CUT FLOWERS AND ORNAMENTAL FOLIAGE
07	EDIBLE VEGETABLES AND CERTAIN ROOTS AND TUBERS
08	EDIBLE FRUIT AND NUTS; PEEL OF CITRUS FRUIT OR MELONS
09	COFFEE, TEA, MATE AND SPICES
10	CEREALS
11	PRODUCTS OF THE MILLING INDUSTRY; MALT; STARCHES; INULIN; WHEAT GLUTEN
12	OIL SEEDS AND OLEAGINOUS FRUITS; MISCELLANEOUS GRAINS, SEEDS AND FRUIT; INDUSTRIAL OR MEDICINAL PLANTS; STRAW AND FODDER
13	LAC; GUMS, RESINS AND OTHER VEGETABLE SAPS AND EXTRACTS

14	VEGETABLE PLAITING MATERIALS; VEGETABLE PRODUCTS NOT ELSEWHERE SPECIFIED OR INCLUDED
15	ANIMAL OR VEGETABLE FATS AND OILS AND THEIR CLEAVAGE PRODUCTS; PREPARED EDIBLE FATS; ANIMAL OR VEGETABLE WAXES
16	PREPARATIONS OF MEAT, OF FISH OR OF CRUSTACEANS, MOLLUSCS OR OTHER AQUATIC INVERTEBRATES
17	SUGARS AND SUGAR CONFECTIONERY
18	COCOA AND COCOA PREPARATIONS
19	PREPARATIONS OF CEREALS, FLOUR, STARCH OR MILK; PASTRYCOOKS' PRODUCTS
20	PREPARATIONS OF VEGETABLES, FRUIT, NUTS OR OTHER PARTS OF PLANTS
21	MISCELLANEOUS EDIBLE PREPARATIONS
22	BEVERAGES, SPIRITS AND VINEGAR
23	RESIDUES AND WASTE FROM THE FOOD INDUSTRIES; PREPARED ANIMAL FODDER
24	TOBACCO AND MANUFACTURED TOBACCO SUBSTITUTES

Source: EUROSTAT 2024

Figure A1: Disentangling horizontal and (high and low) vertical IIT of the Czech Republic with other EU member states using FF and GHM methodologies, 1999-2022





Source: Own calculation based on EUROSTAT (2023)

Note: H IIT – horizontal IIT, V IIT – vertical IIT, H VIIT – high vertical IIT, L VIIT - low vertical IIT

HARMONIZATION OF THE AGRICULTURAL POLICY OF THE REPUBLIC OF SERBIA WITH THE AGRICULTURAL POLICY OF THE EUROPEAN UNION

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ABSTRACT

This paper focuses on agricultural policy as a set of measures that influence the functioning, growth, and improvement of agriculture in a country like the Republic of Serbia. Serbia's agricultural policy is intertwined with various national policy activities and depends on the common budget resources, facing constant pressures and challenges. The key objective is to analize the alignment of Serbia's agricultural policy (SAP) measures with the agricultural policy of the European Union. The results of this research indicate that although the SAP has experienced decline and serious crises, structural and systemic changes in agricultural policy have occurred in recent years through integration, the adoption of standards and regulations, and significant financial investments. Harmonization with EU laws, accompanied by increasing financial assistance, enables further development of Serbia's agricultural policy. However, several limiting factors still exist in Serbia concerning alignment with the EU's agricultural policy, such as the unfavorable position of rural areas, low educational levels of the population, and depopulation of rural regions.

Introduction

The surplus in the agricultural sector has a positive influence on the economic growth of the Republic of Serbia. Consequently, increasing emphasis is placed on the proper

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implementation of agricultural policy prcedures and the funding of this sector. In recent years, it has been observed that the primary reason for the uneven and discontinuous progress of the agricultural area is an inadequate set of financing measures. For future optimal growth and development of agriculture, as well as for increasing its efficiency and productivity, increased investments with adequate state support are essential. The current state of the agricultural sector indicates the necessity for additional financial resources from Serbia's overall budget and using other financial tools such as IPA and IPARD programs. Over the past decades, the agricultural sector has stagnated due to various institutional and economic factors.

The SAP was presented through its institutional framework, strategic documents, analyisis of the present condition, and financial measures. The purposes are to determine the level of alignment between SAP's and the European Union's agricultural policy by examining the functioning and funding mechanisms of SAP's as supported by the EU.

The research questions explored in the paper are as follows:

1. What is the current state of the SAP?
2. What are the EU's methods of financing SAP'a, and how do they impact agriculture?
3. To what extend is current SAP aligned with the EU's agricultural plicy?
4. What is the major challenges SAP has faced in recent years?

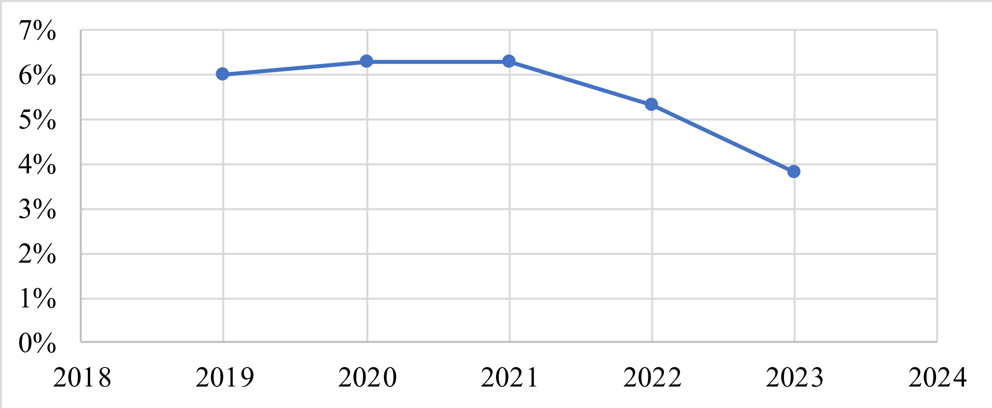
The contribution of this research lies in analyzing the current state of Serbia's agricultural sector and agricultural policy, as well as examining its alignment with the EU's agricultural policy. Since IPARD III is in effect until 2027, it is crucial to analyze the measures and their impact on Serbia's agricultural sector for the entire previous four-year period (2021–2025). Previous studies focused on analyses up to 2021, primarily addressing the impact of COVID-19 on Serbia's agricultural sector and exploring effective crisis management solutions. Considering that the European Union was also in crisis during this period, neither positive financial assistance effects nor alignment of common policies at the desired level could be expected.

Theoretical background

Agricultural Policy of the Republic of Serbia - Current Status and Institutional Framework

Agriculture is a noteworthy economic sector in the Republic of Serbia, owing to the country's ample cultivated land and auspicious natural environments (Đurić, 2021; Babić et al., 2022). In line with this, the following graph illustrates the contribution of SAP i GDP from 2019 to 2023.

Figure 1. Contribution of SAP in GDP (2019-2023)



Source: Government of the Republic of Serbia. (2024). Republic Statistical Office. https://data.stat.gov.rs/Home/Result/0902010301

Based on Figure 1, it can be concluded that the highest contribution of SAP to GDP occurred in 2020, and 2021. This is unsurprising given the widespread impact of COVID-19, which had a particularly adverse effect on other economic sectors during this period. The relatively high contribution of agriculture to GDP during and after the pandemic was also supported by the slow and unbalanced development of secondary and tertiary sectors in subsequent years.

The preceding graph is supplemented by import and export data by sectors and industries for 2023 and 2024. This data aims to determine the trade balance, as well as surpluses or deficits in these years by sector, leading to conclusions about the influence of SAP on the overall economy of the Republic of Serbia.

Table 1. Imports and Exports by Economic Sectors (2023 and 2024)

Economic Sectors in the Republic of Serbia	Imports (in billion RSD)		Exports (in billion RSD)		Balance (in billion RSD)	
	2023	2024	2023	2024	2023	2024
Agriculture, Forestry and Fishing	115,7	149,1	114,6	142,1	1,1	7,0
Mining	169,9	187,8	454,3	390,0	-284,4	-202,2
Manufacturing Industry	2.893,5	2968,7	3.126,6	3.384,7	-233,1	-416,0
Electricity, Gas, and Steam Supply	149,4	79,9	91,9	76,2	57,6	3,7
Water Supply and Waste Management	19,5	20,9	19,2	23,0	0,3	-2,1
Information and Communications	9,4	7,8	10,9	9,1	-1,5	-1,3

Economic Sectors in the Republic of Serbia	Imports (in billion RSD)		Exports (in billion RSD)		Balance (in billion RSD)	
	2023	2024	2023	2024	2023	2024
Professional, Scientific, Innovation, and Technical Activities	0,0	0,0	0,0	0,1	0,0	-0,1
Arts, Entertainment, and Recreation	0,1	0,2	0,1	0,1	0,1	0,1
Unclassified by Production Principle	0,1	0,1	504,6	544,3	-504,1	-544,2
Total	335,7	3.414,6	4.322,2	4.569,5	-964,5	-1.155,0

Source: Government of the Republic of Serbia. (2024). Republic Statistical Office. https://www.stat.gov.rs/oblasti/spoljna-trgovina/spoljnotrgovinski-robni-promet

The imports of the agriculture, forestry, and fishing sectors in 2024 were higher than in 2023, as was its exports. Despite not achieving the highest export figures compared to other industries, such as manufacturing, agriculture achieved the largest surplus in 2024, amounting to 7 billion RSD, surpassing other sectors. This was not the case in 2023, where the sector with the highest surplus was electricity, gas, and steam supply, with a significant 57.6 billion RSD surplus.

In recent decades, a lack of a consistent agricultural policy and strategy that aligns with the EU's agricultural policy has been observed. The absence of such strategic alignment has restricted the growth of Serbia's agricultural sector's competitiveness while maintaining an unpredictable and unstable budget framework (Semečenko et al., 2021). To create and implement an optimal agricultural policy, coordinated actions involving numerous stakeholders are necessary, accompanied by a comprehensive set of laws fostering a favorable institutional environment (Radović et al., 2024). Legislative regulations and the effective operation of institutions are critical to the success of agricultural policy (Pejanović & Radović, 2011; Vapa-Tankosić & Stojisavljević, 2017). The Law on Agriculture and Rural Development (https://www.paragraf.rs/propisi/zakon_o_poljoprivredi_i_ruralnom_razvoju.html) outlines the objectives of agricultural policy, rural development, methods for achieving these goals, agricultural registration, and supervision of the law's implementation. Over the past five years, agricultural policy measures in Serbia have aimed at the following: growth in production and income stability for producers, increased competitiveness with market adaptation, technical and technological advancement of the agricultural sector (Milošević & Milić, 2024; Radović et al., 2024).

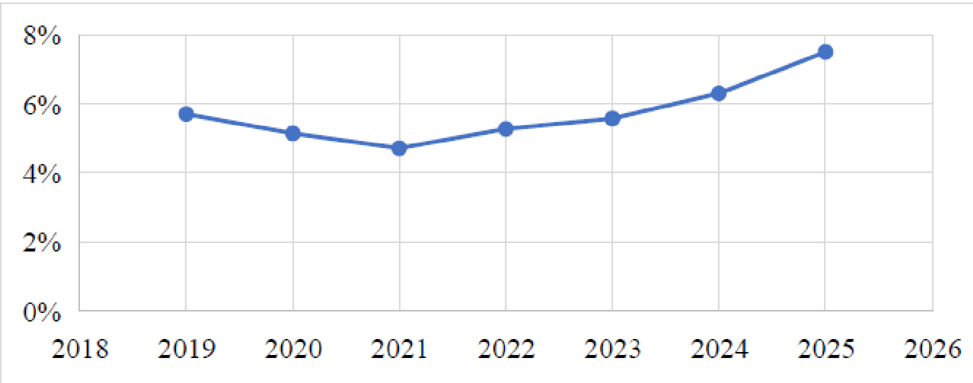
Agriculture in Serbia faces both internal and external challenges that must be addressed to ensure its continued development (Vujičić et al., 2012; Đurić, 2021). Internal challenges faced by agriculture are: sustainable resource management, knowledge transfer and technological advancement, enhancing competitiveness, logical support for the agricultural sector strengthening the social structure (Bogdanov et al., 2017; Đurić et al., 2019). In addition, agriculture is also exposed to external challenges, which include: climate change, economic globalization, potential World Trade Organization (WTO) membership, common Agricultural Policy (CAP) requirements as part of EU integration and obligations placed on Serbia and other potential EU member states (Blanuša et al., 2021; Simić et al., 2021).

Funding Measures for SAP

The analysis of the current state of agriculture, along with its potential and specific needs in rural areas, financial measures are primarily directed at fostering and maintaining competitiveness in the agricultural sector (Kuzman et al., 2017). Financial measures within Serbia's agricultural policy address the need to strengthen the economic and social position of agricultural regions (Đurić, 2022). Agricultural incentives are categorized into the following financial measures: direct incentives, market incentives, and structural incentives, all of which are available for use by agricultural producers (Stanković et al., 2023). Direct incentives are provided directly to agricultural producers, market incentives are implemented through export support, storage cost subsidies, or credit assistance, while structural incentives include rural development measures, initiatives to improve and protect soil quality, and institutional support measures. (Dimitijević, 2023).

The share of the SAP's budget overall budget varies from year to year, typically ranging between 4.5% and 6% in recent years. Notably, the 2025 national budget allocated 7.5% to agriculture, marking the highest percentage of budgetary allocation for the agricultural sector in the past seven years.

Figure 2: Budget Allocations for SAP (2019-2025)



Source: Government of the Republic of Serbia (2018-2024). Budget Law of the Republic of Serbia for the Period 2019-2025, Official Gazette of the Republic of Serbia. https://www.paragraf.rs/propisi/zakon-o-budzetu-republike-srbije.html

The structure of SAP budget varies, but a consistent growth trend has been observed from 2021 to 2025. However, the level of financial funding allocated to the SAP is more reflective of Serbia's economic circumstances than the actual needs of agriculture, which requires substantially higher financial resources (Đurić, 2021; Đurić, 2022; Stanković et al., 2023).

Budgetary allocations for agriculture predominantly consist of funds directed toward agricultural and rural development incentives, regulated by the Law on Agricultural and Rural Development Incentives(https://www.paragraf.rs/propisi/zakon_o_podsticajima_u_poljoprivredi_i_ruralnom_razvoju.html). The law also specifies the procedures for using these incentives, general eligibility conditions, and minimum incentive amounts. The specific incentive amounts and budget allocations per type of support, including maximum funds for each measure, are defined annually (https://pravno-informacioni-sistem.rs/eli/rep/sgrs/vlada/uredba/2024/3/1/reg). Detailed conditions and criteria for specific measures are outlined in bylaws and other secondary legislation. Direct payments are the most significant component of agricultural and rural development incentives, accounting for approximately 87% of allocated funds (Radičić, 2022; Paraušić, 2023). The SAP, despite being a significant factor in the overall national economy, does not show sufficient capacity utilization (Novaković, 2018).

The adoption of legal and strategic expansion documents has contributed to clearer and more structured grouping of measures within different types of support (Đurić et al., 2021). At the same time, there has been an expansion of support types and an increase in the number of potential beneficiaries, aiming to align Serbia's national agricultural and rural development policies with the EU's Common Agricultural Policy (CAP) (Stanković, 2012; Stanković et al., 2023). Further state involvement is necessary to increase agricultural production efficiency. As the leading actor in shaping economic policies related to agriculture, the state plays a significant role in maintaining production levels at the desired standard (Dimitrijević, 2024).

Discussion

Agricultural Policy of the EU

The Common Agricultural Policy (CAP) focuses on agricultural development and rural growth (Cvijanović et al., 2011; Lakić, 2021; Nikolić Popadić & Milenković, 2023). In modern conditions, CAP represents a multifaceted scheme of legal guidelines, budgetary funding, and straight municipal interventions that influence the rural communities (Đurić, 2021). The efficiency of CAP lies in jointly formulating objectives and synchronizing the timing and application of agricultural measures. This is crucial considering the vast number of farmers in the EU, who operate at varying levels of social and economic development (Dabović, 2024). Furthermore, CAP constitutes the largest portion of the EU budget (Donald et al., 2002; Fusco, 2021; Vučkovski et al., 2024). The financing sources for CAP include: agricultural levies, fixed shares of member states' GDP, custom duties and value-added tax (VAT). Among these, the fixed GDP share of EU member states is the primary funding source (Runge et al., 2022; Cuadros-Casanova et al., 2023). CAP's financial system includes import tariffs, import quotas, production quotas, intervention prices, and direct payments to producers (Homet et al., 2024). The key determination of CAP is to benefit both producers (farmers) by ensuring income stability and consumers by providing high-quality, affordable products (Menning, 2024). The primary objectives of CAP for the period 2021-2027 include: enhancing competitiveness: knowledge transfer, modernization, risk managing and collaboration across food production, and distribution chains; promoting sustainability: green expenses, resource productivity and explore initiatives; increasing efficiency: rearrangement of capitals, targeted resource allocation and simplification of procedures (Đurić et al., 2021; Heyl et al., 2021; Homet et al., 2024).

In previous years, financial allocations for CAP were significantly higher. However, the COVID-19 pandemic led to reduced investments (Bisoffi et al., 2021). The modernized long-term budget, proposed by the International Monetary Fund, allocates 31.9% of the EU's budget to CAP for 2021-2027 (Cuadros-Casanova et al., 2023). Significant investments have been allocated for: environmental protection and recovery facilities, research and innovation programs, neighborhood, development, and international cooperation initiatives and regional policy measures, etc (Erjavec et al., 2017; Ristić et al., 2022).

Table 2. Absolute and Relative Participation of Individual Investment Categories in the CAP Fund of the EU

Categories	Absolute Participation (in Millions of Euros)	Percentage Participation
Environmental Protection and Recovery Facilities	195,6	35%
EU Investment Program	2,7	1%
European Agricultural Guarantee Fund	95,4	17%
European Agricultural Fund for Rural Development	48,9	9%
Draft Program for Research and Innovation	32,2	6%
Neighborhood, Development, and International Cooperation	27,9	5%
Regional Policy	80,4	14%
Other	73,8	13%
Total	556,9	100%

Source: European Commission (2024). Budget Funds for the Common Agricultural Policy. https://agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/cap-funds_en

The table 2 shows that the largest investments are directed toward environmental protection and recovery facilities, accounting for slightly over one-third (35%) of the budget, followed by the European Agricultural Guarantee Fund, which comprises almost one-fifth (17%). These two categories alone absorb more than 50% of the total funds from the modernized long-term budget.

Although 99.1% of the CAP budget, including income support, market measures, and rural development funds, operates below joint organization among the European Commission and EU, the European Commission maintains a superintendent character (Dabović, 2024; Schiavon et al., 2021). The Commission ensures compliance with management and control system arrangements by: verifying the efficient operation of the system and applying financial corrections where necessary.

Table 3. Budgetary Allocations for the CAP of EU (2023-2027)

Draft Budget (in Millions of Euros)					**Total (2021-2027)**	**Share in Total Expenditures (%)**	**Targeted Share in the Basic Act (%)**
2023.	**2024.**	**2025.**	**2026.**	**2027.**			
12.880,3	24.168,1	24.168,1	24.168,1	24.168,1	144.320,9	37%	40%

Source: European Commission (2024). Budget Funds for the Common Agricultural Policy. https://agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/cap-funds_en

It can be observed that an increase in the budget for the CAP is planned for 2024 to 2027, while the funds allocated for 2023 are somewhat lower related to the previous period. This is a draft budget for the upcoming period, not the final version. Adjustments may be made through budget revisions if necessary.

Measures to Improve SAP Financing Based on EU Programs

The EU provides embattled and efficient funding conditional on the developmental trajectory and membership status of candidate countries (Pavlović, 2024). A prerequisite for accessing financial resources is membership status and an accredited DIS (Decentralized Implementation System) approved by the European Commission (Radović, 2015; Đurić et al., 2021). Funds are allocated grounded on a prearranged and detailed database aligned with the urgencies outlined in the EU's deliberate permits (Đurić et al., 2020). These programs follow a development series module with five stages: software design, identification, preparation, application, and valuation, and revision. Candidate countries are separated into two clusters: membership applicants: Iceland, Turkey, Croatia, and North Macedonia *(Some of these countries have since become full EU members)* and potential applicants: Serbia, Montenegro, Bosnia and Herzegovina, Albania, and Kosovo (as per UN resolution 1244) *(Some of these countries have since become full EU members)* (EU Pre-Accession Assistance Handbook, 2011, p. 7). Serbia's agriculture and rural regions face numerous challenges that hinder economic growth and obstruct progress toward EU membership (Đurić et al., 2021).

The Instrument for Pre-Accession Assistance (IPA) is a unique EU financial instrument established by Council Regulation No. 1085/2006 (https://www.mei.gov.rs/srp/fondovi/fondovi-evropske-unije/ipa-instrument-za-pretpristupnu-pomoc/instrument-za-pretpristupnu-pomoc-2021-2027/). Decentralized management of IPA funds is only approved if minimum requirements described in the annex of the IPA Implementation

Regulation are met (https://mfin.gov.rs/propisi/uredba-o-upravljanju-programima-pretpristupne-pomoi-evropske-unije-u-okviru-instrumenta-za-pretpristupnu-pomo-ipa-iii-za-period-20212027-godine).

The following table presents the budgets approved under the financial plans for IPA I, IPA II, and IPA III programs. The budget for IPA III (2021-2027) is €14.1 billion, as outlined in the new financial plan.

Table 4. IPA Budget Allocation (2007-2027)

Period	Budget (in Billion Euros)
2007-2013 (IPA I)	11,5
2014-2020 (IPA II)	12,8
2021-2027 (IPA III)	14,1

Source: European Commission (2024). Budget Funds. https://commission.europa.eu/strategy-and-policy/eu-budget/performance-and-reporting/programme-performance-statements/instrument-pre-accession-assistance-ipa-iii-performance_en#budget

By reviewing Table 4, it can be concluded that the budget for the IPA is increasing and has reached its highest level under the new financial plan for the period 2021-2027.

The analysis reveals that the budget for the Instrument for Pre-Accession Assistance (IPA) has increased and is at its highest level for the period 2021-2027 under the new financial plan. IPA III objectives are to: stimulate long-term economic recovery, support green and digital transitions and remote regional integration and alignment with the European Union (https://mfin.gov.rs/propisi/uredba-o-upravljanju-programima-pretpristupne-pomoi-evropske-unije-u-okviru-instrumenta-za-pretpristupnu-pomo-ipa-iii-za-period-20212027-godine). Funds financed by IPA are managed in two primary ways: direct management: the budget is straight implemented by the European Commission without the involvement of nationwide establishments; indirect management: the execution of the budget is delegated to designated entities such as: member state agencies, international organizations and specialized (but non-executive) EU agencies (Pishgar-Komleh et al., 2021). The ultimate goal of IPA is to establish indirect management as the norm over time. Tasks can also be substitute to EU member when cross-border assistance with EU is involved (Đurić, 2021).

Table 5 presents the planned annual allocations in millions of euros for the period 2021-2027.

Table 5. Planned IPA III Allocations by Sectors for the Period 2021-2027

Sector	2021.	2022.	2023.	2024.	2025.	2026.	2027.
	Budget (in Millions of Euros)						
Rule of Law and Democracy	281	287	292	298	304	310	317
Governance, Good Neighborly Relations, and Strategic Communication	308	314	321	327	333	340	347
Green Agenda and Sustainable Development	788	804	820	837	853	870	888

Sector	2021.	2022.	2023.	2024.	2025.	2026.	2027.
	Budget (in Millions of Euros)						
Competitiveness and Inclusive Growth	414	422	431	440	448	457	467
Territorial and Cross-Border Cooperation	65	66	58	69	71	72	73
Total	**1.855**	**1.894**	**1.932**	**1.971**	**2.010**	**2.051**	**2.093**

Source: European Commission (2024). Budget Funds. https://commission.europa.eu/strategy-and-policy/eu-budget/performance-and-reporting/programme-performance-statements/instrument-pre-accession-assistance-ipa-iii-performance_en#budget

According to the IPA III plan for the period 2021-2027, the largest share of funds (42%) is allocated to the Green Agenda and Sustainable Development (https://commission.europa.eu/strategy-and-policy/eu-budget/performance-and-reporting/programme-performance-statements/instrument-pre-accession-assistance-ipa-iii-performance_en#budget). An analysis of the "Total" position in Table 5 shows that allocations are expected to increase each year.

IPARD is one of the components of the IPA and was initially designed solely for EU membership candidate countries (Gajić, 2023). However, over time, potential candidate countries have also been included. The IPARD instrument focuses on three main areas (Gluščević et al., 2017). Within these axes, various measures are distinguished to achieve the objectives of this instrument. Preparatory activities for implementing measures are environmental and rural landscape measures and preparing local public-private partnerships for the implementation of development strategies (Prodanović et al., 2018). Rural economic development includes development and growth of rural infrastructure, modification of rural financial activities and training and technical support (Stojanović et al., 2018; Dabović, 2023). In early 2021, the European Commission approved the IPARD III program for SAP for 2021-2027, with a total value of €288 million.

Table 6. IPARD III Budget Allocations for Serbia (2021-2027)

Year	2021.	2022.	2023.	2024.	2025.	2026.	2027.	Total
Planned Allocations (in Millions of Euros)	20	25	31	43	54	57	58	288

Source: Ministry of Agriculture, Forestry, and Water Management (2022). IPARD III Budget Allocations for the Republic of Serbia. https://ipard.rs/ipard-mera-3

Based on Table 7, budget allocations have increased annually. The funds are directed toward seven areas.

Table 7. Areas Targeted by IPARD III Budget Allocations for the Republic of Serbia (2021-2027)

Areas Where Measures Will Be Implemented	Budget (in Millions of Euros)	%
Investments in Physical Resources of Agricultural Holdings	86,4	30%
Investments in Physical Resources for Processing and Marketing of Agricultural Products	60,5	21%
Agri-Environment Measures – Climate and Organic Agriculture Focus	14,4	5%
Implementation of Local Development Strategies	14,4	5%
Investments in Rural Public Infrastructure	51,8	18%
Farm Diversification and Business Development	51,8	18%
Technical Assistance	8,7	3%
Total	288	100%

Source: Ministry of Agriculture, Forestry, and Water Management (2022). IPARD III Budget Allocations for the Republic of Serbia.
https://ipard.rs/ipard-mera-3

The table indicates that from 2021 to 2027, the largest investments will be allocated to: Physical resources of agricultural holdings (30%) and Physical resources for processing and marketing of agricultural products (21%). These two categories together account for over 50% of total investments, amounting to €146.9 million.

Table 8. Areas Targeted by IPARD III Budget Allocations for the Republic of Serbia in 2025

Areas Where Measures Will Be Implemented	Budget (in Millions of Euros)	%
Investments in Physical Resources of Agricultural Holdings	7,93	47%
Investments in Physical Resources for Processing and Marketing of Agricultural Products	1,17	7%
Procurement of Machinery, Equipment, and Mechanization	1,20	7%
Farm Diversification and Business Development	6,54	39%
Total	16,76	100%

Source: Ministry of Agriculture, Forestry, and Water Management (2022). IPARD III Budget Allocations for the Republic of Serbia. https://ipard.rs/ipard-mera-3

The largest investments shown in Table 8 are allocated to: investments in physical resources for processing and marketing of agricultural products (47%) and Farm diversification and business development (39%). Beyond the announced 2025 budget, it is crucial to monitor the results directly influenced by these financial allocations. Future research should focus on assessing the effects derived from the subsidization measures to better understand influence on the agricultural sector.

Misalignment Between the SAP and EU

Several limiting factors contribute to the misalignment between SAP and CAP. These include: unfavorable position of rural areas, very low levels of education in rural regions, fragmented land ownership, low processing capacities and insufficient technical and technological equipment (Dimitrijević, 2023). To overcome these challenges, Serbia has implemented the project "Strengthening and Aligning Administrative Capacities for Establishing Agricultural Market Regulation", financed through the EU IPA. This project underscores the EU's ongoing support for Serbia's European integration process and its efforts to align SAP with the EU framework. The project includes activities focused on six key components aimed at strengthening the SAP in line with the EU's common agricultural market organization and agricultural policies (https://www.minpolj.gov.rs/realizacija-tvining-projekta-jacanje-i-uskladjivanje-administrativnih-kapaciteta-za-uspostavljanje-uredjenja-trzista-poljoprivrednih-proizvoda-znacajan-korak-u-uskladjivanju-sektora/).

Considering the importance of agriculture as a key economic sector in Serbia, it is of crucial importance that the state effectively responds to the challenges it faces (Zelenović et al., 2018; Aničić & Paraušević, 2020; Stanković et al., 2023). By adopting the EU agricultural policy and legislative framework, Serbia could create a stable business environment and achieve the highest levels of efficiency and competitiveness (Nikolić Popadić & Milenković, 2023). The Ministry of Agriculture, Forestry, and Water Management plays a decisive role in Serbia's EU accession process. It is responsible for aligning SAP's with the EU's legal framework and ensuring the implementation of the required regulations (Blanuša et al., 2023). European Union has provided significant support and assistance to Serbia in aligning with CAP standards and is committed to continuing this support at least until 2027 (Pavlović, 2024).

Conclusion

To align the SAP with the EU CAP, it is essential to adapt its laws, regulations, institutional measures, and documents to EU agricultural system standards. This would provide long-term perspectives and growth opportunities for Serbian farmers. In 2025, Serbian farmers were provided opportunities to develop processing capacities, improve equipment, diversify, and enhance their agricultural enterprises. However, a significant concern is the potential elimination of certain subsidies, both by the Serbian government (due to budget cuts in the agricultural sector) and the European Union. Such reductions would negatively impact further harmonization and development of Serbia's agricultural policy, possibly widening the gap between Serbia and the EU regarding agricultural alignment.

To overcome these challenges, it is crucial to establish competitive and self-sustainable agricultural enterprises and organizations by investing in processing capacities and focusing on the production of value-added final products for consumers. Key recommendations include: subsidization Focus: Direct future agricultural subsidies toward fostering innovation, modernization, and technological advancements through digitalization to keep Serbia's agriculture competitive with the EU and global standards; application of knowledge and best practices: address both regulatory and practical issues by applying positive business practices and expert knowledge; youth engagement and rural development: offer adequate support to attract young people to agriculture and rural areas, positively influencing the development of agricultural and other rural activities.

To further align SAP with EU agricultural policy, it is necessary to develop additional subsidization models. Horizontal and vertical networking could enhance financing, ultimately increasing production, dispensation, and the construction of value-added goods for end consumers while also boosting exports.

Conflict of interests

The authors declare no conflict of interest.

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AN ASSESSMENT OF SERBIAN INTERNATIONAL SUNFLOWER OIL TRADE

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A B S T R A C T

The objective of this study is to assess Serbia's international market position in the sector of sunflower derivatives and edible fats from 2014 to 2023, with particular focus on competitiveness and stability as global trade partner. Using method Revealed Comparative Advantage (RCA) and calculating the Self-Sufficiency Ratio (SSR) the study evaluates Serbia competitiveness and its ability to meet domestic needs through domestic production. The analysis covers key products such as margarine, sunflower seeds, and sunflower oil (both crude and refined). Over the past decade Serbia has experienced significant growth in production and export of sunflower based products, particularly in category of refined oil. Sunflower industry stands out as a stable partner in the global market of sunflower products, following price dynamics and adapting to market challenges. The findings of this research provide a foundation for further discussion on measure to enhance Serbia's competitiveness, with an emphasis on adapting to global market changes and challenges.

Introduction

The sunflowers oil industry is one of the key sectors in global agricultural trade, particularly important for the countries like Serbia, which faces challenges in keeping competitiveness in international markets. Globally, more than 70 types of oils are used for human consumption, and sunflower oil ranks fourth. Beyond use in diet, sunflower oil and its derivatives are widely used in the production of margarine, vegetable fats, soap, cosmetics, biodiesel, pharmaceuticals, and even as a raw material for paints and varnishes (Đerčan et al., 2023).

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Sunflower seeds hold approximately 40-60% oil, 14-22% protein, 13-32% cellulose, 7-11% nitrogen-free extract, and 3% minerals making them highly valued in global market (Rabrenović, Vujasinović, 2021). Sunflower oil production is primarily concentrated in Ukraine, Russia, and Argentina, which are recognized as the world's leading producers and major players in international trade. These countries play a crucial role in ensuring supply stability in the global market, while Serbia contributes to overall production with a stable supply-demand balance due to its domestic sunflower production (Knežević, Popović, 2011). Innovations in production and processing technologies have been identified as key factors in supporting long-term competitiveness and resilience to market fluctuations (Rabrenović, Vujasinović, 2021). This study aims to analyse Serbia's international trade of sunflower derivatives and edible fats, with focus on competitiveness from 2014 to 2023. The methods employed in this research are based on the Revealed Comparative Advantage (RCA) method and the calculation of the Self-Sufficiency Ratio (SSR). These methods provide assessment of self-sufficiency level and competitiveness on foreign market. Prior studies on competitiveness have highlighted Serbia's significant potential for increasing sunflower oil exports while also emphasizing the need for a more efficient use of processing capacities and market diversification to enhance competitiveness (Matkovski et al., 2020). In the first part of this study were analysed global trends and research literature about sunflower oil production and trade. Then in the methodology section are presented the applied methods and data sources, establishing the analytical framework. The core of this study focuses on the interpretation of results, including trends in foreign trade, market structure, and an assessment of Serbia's sunflower oil competitiveness compared to global market. Finally, the conclusion summarizes the key findings and provides recommendations for improving Serbia's competitiveness and adapting to global market challenges.

Literature review

The sunflower oil industry stands for one of the key sectors in international trade of agricultural products. Sunflower is the third oilseed produced in the world, the fourth vegetable oil and third oilseed meal among protein feed sources. In recent decades competition has been intense in the highly dynamic markets of vegetable oils and oilseed meal, driven by palm oil and soybean meal (Pilorgé, 2020). Global market trends and the competitiveness of sunflower oil are often analysed with models, such as the Revealed Comparative Advantage (RCA) method, which assesses the ability of countries to compete effectively against leading global producers. Over the past decade, sunflower prices have been volatile, driven by a range of factors including supply and demand dynamics, climate variations, and geopolitical situation. Looking ahead, initiative-taking and strategic planning will be imperatives for maintaining the stability and prosperity of sunflower cultivation on a global level (Đerčan et al., 2023). Vegetable oil is an exchange commodity and Serbia taking part on international market. Although it was a founder of the World Trade Organization, Serbia isn't yet a member (Gulan, 2022). Knežević, Popović, (2011) explained that the growth of sunflower production is largely determined by the price and demand for oil. High profitability in sunflowers production primarily comes from revenue factors. The Republic of Serbia, as one of the leading regional producers of sunflower oil, facing challenge in keeping competitiveness at the global market. Serbia's market operates like interconnected vessels, influenced by external markets. The price trends of oilseeds and their products in Serbia closely follow those in the European market (Čurović, 2023). Beyond market conditions, environmental and climatic factors, including droughts and extreme weather conditions, significantly affect sunflower yield and quality. Sunflower, a spring-sown crop could be particularly sensitive to direct heat stress during flowering and drought conditions throughout the growing season. These factors lead to a significant reduction in yield, a decrease in oil content, and changes in fatty acid composition (Debaeke et al., 2017). The Republic Hydrometeorological Service of Serbia (RHMZ, 2024.), reported that during 2023/2024, precipitation levels were average for the region but poorly distributed, negatively affecting spring-sown crops. As a result, the yield of spring crops in 2023 was significantly lower than in previous years. Sunflower crops have adaptation potential to various climate and soil conditions. Its increasing prevalence in Serbia's fields is due to frequent hot temperatures and droughts, which this crop tolerates better than other spring crops (Krstić et al., 2023). Ecological and climatic challenges in sunflower production pose barriers to keep market competitiveness but also highlight the need for effective adaptation strategies. Research by Stričević et al. (2021) suggest that key adaptation measures in field crop production will include irrigation, adjusting sowing dates based on weather conditions, and selection suitable crops, varieties, and hybrids. Sunflower has managed to save its competitiveness in the oilseed market over the past decades, thanks to continuous innovations in genetics, production, and trade, as well as increasing market segmentation. Future opportunities for sunflower processors could emerge through the bio-refinery concept, enabling greater utilization of the entire plant and diversification of oil applications (for food, food industry, biofuels, biomaterials), proteins (for animal feed, including aquaculture, human nutrition, and potentially biomaterials), and even cellulose fractions (Pilorgé, 2020). In international trade analysis, research studies rely on methods to assess the competitiveness of countries and sectors. Ferto, Hubbard, (2003) used the RCA index to examine the competitiveness of Hungarian agricultural and food product in the European Union (EU) market from 1992 to 1998. They found that Hungary had a comparative advantage in several agricultural and food products, including livestock and meat. Rytko (2014) also applied the same method to define the competitive position of Polish and Slovak agricultural and food product in the European market and, for comparison, in third-country markets and across different product groups. From 1999 to 2012, the results shown that after joining the European Union, the significance of foreign trade in agri-food products increased for both countries within the EU, while only Poland experienced growth in third-county markets. The RCA index showed significant difference between these countries – Poland had a comparative advantage, while Slovakia didn't. Tawheed, Tushinder (2019) also used the RCA index to analyse the comparative advantages of the Indian agricultural sector compared to the top five agricultural exporting countries (SAD, UK, UAE, Singapore and China) from 1995. to 2017. The RCA and RSCA indicates revealed that India had a comparative advantage in products such as fruits and vegetables, fish and fish preparations, sugar and sugar preparations, various food products, and timber.

In analysis of Serbia's foreign trade position, significant contributions were made by Ignjatijević et al. (2012) who applied both Balassa's and adjusted revealed comparative advantage model. Their findings confirmed that Serbia has a strong comparative advantage in export of corn, soybean oil, sugar, and flour to the European market. Significant comparative advantages were also found for mineral and carbonated waters without sugar, sour cherries, malt beer, seed and hybrid corn, soft drinks, biscuits, crude sunflower oil, and cocoa products. Author's such as Matkovski et al. (2020) analysed competitiveness by examining export position Republic of Serbia on oilseed sector within the international market. Their study concluded that sunflower holds a higher level of comparative advantage in the global market compared to soybean and rapeseed. Another research confirmed the stability and growth of sunflower oil exports in recent years (Matkovski et al., 2020). Cvetković, Petrović-Ranđelović (2017) used RCA in research to find Serbia's comparative advantages in trade with Western Balkan countries. The results showed that Serbia has strong comparative advantages over Western Balkan countries (Bosnia and Herzegovina, North Macedonia, Albania, and Montenegro), except Croatia. Competitiveness analysis method, such as RCA and the SSR, allow an assessment of Serbia ability to meet domestic demand through domestic production. Based on earlier research, this paper will use proved theoretical framework to conduct a detailed analysis of Serbia s international trade in sunflower derivates and edible fats from 2014. to 2023.

Materials and methods

This study uses data from the Statistical Office of the Serbia (SORS, 2025), UN Comtrade Data trade (UNCOMTRADE, 2025) for analyses Serbia international trade in sector of sunflower derivates and edible fats from 2014 to 2023, with the aim of assessing Serbia's international trade position and competitiveness. The methodology is based on analysis of secondary data collected from official sources such as statistical reports, trade flows reports and other relevant databases. The Revealed Comparative Advantage (RCA) method which will be use in this research, figure out whether there are comparative advantages for the four key category: margarine, sunflower seed, unrefined sunflower oil and refined sunflower oil based on collected data of export results.

For this research we applied a method based on The Revealed Comparative Advantage from Balassa (1965). This index enables researchers to calculate comparative advantage or disadvantage of a product or group of products compared to an industry or export market. Its goal is to illustrate the competitiveness and comparative advantage of a specific market player concerning certain products, based on historical trade date (Balogh, Menesi, 2019). The RCA compares the share of a specific product in a country's export with the share of specific product in global exports. It is proposed that the RCA be calculated as follows (Balogh, Menes, 2019):

$$RCAij = Bij = \left(\frac{X_{ij}}{X_{it}}\right) / \left(\frac{X_{nj}}{X_{nt}}\right)$$

Equation 1

Where x stands for export volume, i and j denote the selected country and product, respectively, while t and n represent a specific product group and group of countries, respectively (Balassa, 1965). In theory, index can range from 0 to infinity. According to the author, if the result is above 1, it suggests that the selected country has a comparative advantage for a particular product compared to competing suppliers, which should be reflected in a high market share in exports. On the other hand, result between 0 and 1, suggest a comparative disadvantage for the selected country compared to competing suppliers, suggesting a low market share in export (Balogh, Menesi, 2019).

Self-Sufficiency Ratio (SSR): this method is applied to analyse capabilities of Serbia to satisfy domestic demand for sunflower oil thought own production. This analysis je crucial for assessing stability of domestic agricultural production in relation to consumption and international trade. To calculate the SSR for refined sunflower oil in 2023 we use next formula (Slaboch, Kotyza, 2015):

$$SSR = \frac{Domestic\ production}{Domestic\ consuption} \times 100$$

Equation 2

*We used the Conversion factor to figure out the total amount of refined sunflower oil

Domestic production oil can be calculated according to next formula:

$$Domestic\ production = \sum sunflower\ seed\ production \times \%\ oil\ extraction\ from\ seed$$

Equation 3

Conversion factors: in production of the sunflower oil crucial factor is coefficient calculated between seed mass and oil output. Based on available data: 1 kg of commercial sunflower seed holds 38% to 42% oil – a characteristic declared by seed producer, without GMOs, with an average value of 40% (SRPS E.B4.410 1990 Sunflower seed for industrial processing). Crude sunflower oil (degummed) typically (based on technology, equipment, and processing efficiency) holds about 98% “pure oil” i.e. oil without impurities and moisture (Moslavac et al., 2010). By using this factor, we can definite the amount of refined oil obtained from sunflower seed. Based on the calculation 1 kg of sunflower seeds holds about 39% refined oil (0,40 * 0,98 = 0,39). This formula allows an estimation of the total oil output from the produced and traded sunflower seed. International trade plays a significant role in economic growth and development of a country taking part in trade (Vrdoljak, 2019). In an international trade sunflowers oil, analysis will rely on descriptive statistics, to show key parameters, as average values and trade flow trends.

Data were obtained from the Republic office of Serbia’s database, which allows do analyse volume and value export and import sunflower oil by product categories (e.g. crude and refined sunflowers oil, margarine, sunflower seed). This official data provides a reliable bases for evaluating Serbia’s international trade. The data used in this research include quantities and values of exports and imports for the following product category according to the National Statistical Textual category code (NSST):

0910100 - Margarine (excluding liquid margarine): this code refers to margarine, which has become a key product in the edible fats category. It does not include liquid margarine.

2224090 – Sunflowers seeds, other: This code covers types of sunflower seeds not used for sowing.

4215100 – Sunflowers or safflowers oil, crude: This code refers to crude sunflower or safflower oil that has not yet undergone refining.

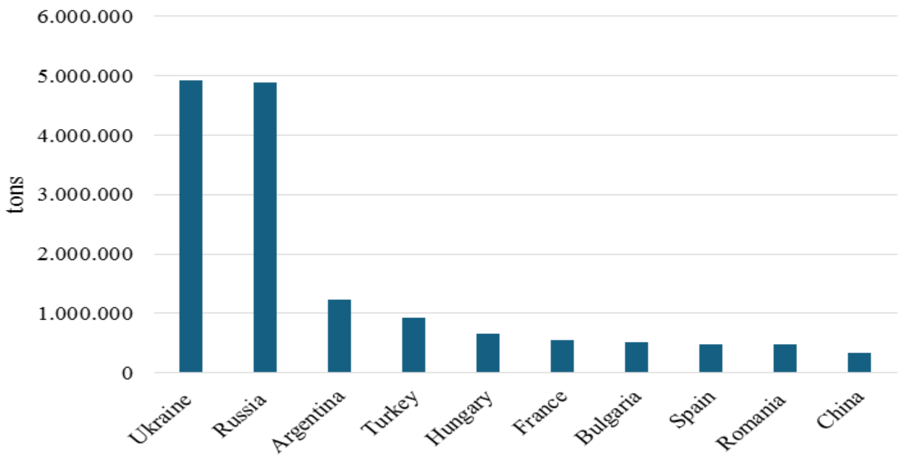
4215900 - Sunflowers or safflowers oil, refined: This code refers to refined sunflowers or safflower oil, which has undergone processing to achieve a higher quality and longer shelf life.

Additionally, international databases such as FAO and UN Comtrade Database were used for comparative analysis export on global level, which enabled a precise evaluation of Serbia's role in the global sunflower oil trade. The study is limited to available statistical data from official sources, also analysis is focusing on quantitative aspects export and import, as qualitative factors as political, economic, and social changes that could affects trade flows are not examined in this study.

Results

Today, the production and processing of sunflower seed is widespread across the world, with the most significant production regions in Europe, Asia, Nort and South America. Ukraine, Russia and Argentina are stand out as leading producers of sunflower-seed oil (crude), and they are playing key role on global production, as shown in Figure 1.

Figure 1. Top 10 countries in sunflower-seed oil (crude) production (in tons)



Source: FAOSTAT (2025)

Serbia is one of the leading counties in the Balkan region, both in production and in scientific-research development of sunflower hybrids in the Balkans (Kaya, 2014). The export of sunflower oil is a largely determined by the level of processing industry development. Export price must be competitive with global vegetable oil prices. These prices influence the formation of domestic prices of sunflower oil; otherwise, the oil will not be competitive (Čurović, 2018). From 2014. to 2023, the export prices of sunflower oil from Serbia show variations, but generally aligned with global price movements, as shown in Table 1.

Table 1. Dynamics of export prices of sunflower oil in relation to the price of sunflower seed and global sunflower oil prices USD/t

Year	Export prices of sunflower oil	Purchase prices of sunflower seed	Price of sunflower oil on global market
2014	1,068	240	1,204
2015	959	330	1,105
2016	948	275	1,083
2017	945	298	1,023
2018	909	268	1,014
2019	835	252	957
2020	992	291	1,084
2021	1,454	464	1,489
2022	1,770	519	1,860
2023	1,250	318	1,483

Source: SORS (2025); UNCOMTRADE (2025)

For example, in 2022, the purchase price of sunflower was reached 519 USD/t, showing an increase in production costs, but the export price of sunflower oil that year was much higher in relation to foregoing period (1,770 USD/t). Prices dropped in 2023, when the export price of sunflower oil was 1,250 USD/t, following sunflower seed price 317.5 USD/t. The price increase of sunflower oil begins with COVID-19 is noted both globally and domestically, starting with 10% in 2020, then continuing to 50% and by the end of 2022 reaching 80% increase on domestic market. The increase was stopped by the Decision on the price level and restrictions of basic foodstuff, which was returned to the level from November 15, 2021, and this regulation was valid until the end of March 2023. This regulation was triggered by the behavior of European countries that closed their markets, so the Republic of Serbia also implemented similar measures to protect standard of living by limiting basic food prices. Agriculture producers because these measures did not have consequences, because production of sunflower seed were subsidized with 7.8 RSD/kg up to 200 t/farm. However, oil factories because high purchase price of sunflower seed and the fixed price of oil being capped at 152-160 RSD/l, found themselves in a worse position as they only achieved “technical parity” (Čurović, 2023).

International trade of sunflower derivates and edible fats from 2014 to 2023 (in USD)

Detailed data of Serbian export and import of sunflower seed and its oils and fats, from 2014 to 2023 are shown in Table 2. Focus on research is on key product category which dominates in international trade. Through this approach the goal is to enable a comprehensive insight into the Serbian trade of sunflowers derivates and edible fats, to better understand the trends that occurred during the observed period, both on export and import side.

Table 2. Serbian export and import of sunflower derivates and edible fats from 2014 -2023 (in 000 USD)

Year	0910100 - Margarine (excluding liquid margarine)	2224090 – Sunflower seed, other	4215100 – Sunflower or safflower oil, crude	4215900 - Sunflower or safflower oil, refined
Export				
2014	9,656	19,946	15,311	82,864
2015	7,556	32,978	26,579	64,367
2016	8,690	49,093	47,782	68,968
2017	8,494	36,269	51,257	65,308
2018	8,471	50,497	52,395	63,748
2019	8,155	43,537	86,102	67,342
2020	7,046	55,806	73,031	66,816
2021	9,634	50,076	98,058	86,035
2022	11,395	51,036	76,937	102,131
2023	14,327	33,900	66,191	103,389
Import				
2014	3,322	6,580	2,290	3,779
2015	2,498	13,168	1	8,121
2016	3,039	1,321	1,312	11,614
2017	2,751	28,614	7,572	7,872
2018	3,129	12,025	5,795	3,261
2019	3,595	7,476	106	3,107
2020	3,119	7,895	10	12,870
2021	3,991	16,414	6,941	5,642
2022	4,435	15,268	725	5,179
2023	5,209	13,815	152	14,440

Source: SORS (2025)

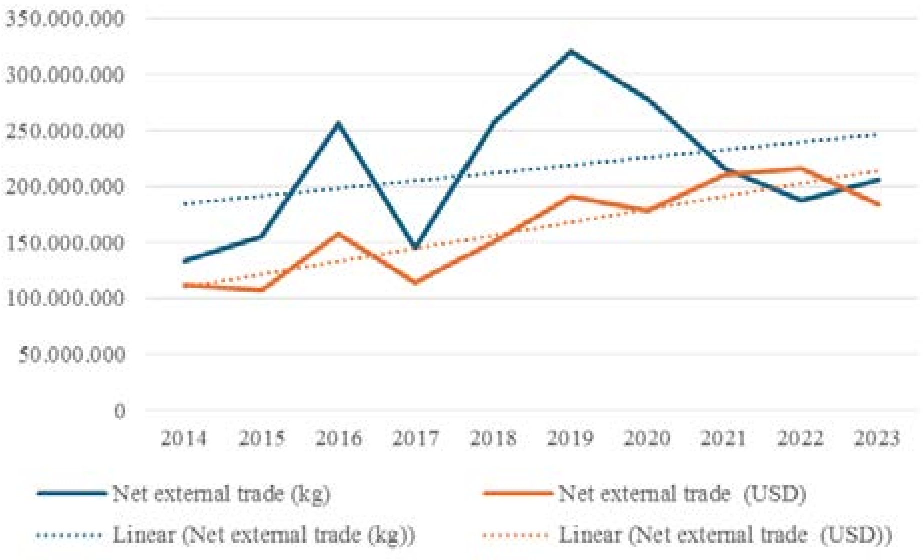
0910100 - Margarine (excluding liquid margarine) -The import of margarine is relative stable, with slightly increased quantities in the last two years. During the analysed period, the export of margarine shows stability with slight fluctuations. The growth in export value is particularly noticed since 2020, primarily as result of increase in prices, as the quantities have not changed significantly.

2224090 - Sunflowers seed, other – The export of sunflower seeds has fluctuated with a decline in last three years. An analogous situation is seen with the import of sunflower seeds, which shows a downward trend compared to 2021. This may show fluctuations in volume of domestic production.

4215100 - Sunflower or safflower oil, crude – The import of crude sunflower oil is symbolic, averaging only 4% compared to the average export value. On another hand, the export has shown a growing trend, with a record value in 2021, followed by a downward trend. However, it should be noted that this is a s semi-finished product, and such a situation is generally not a good indicator of the competitiveness of oil producers in the international market. This is influenced by the interest of foreign owners of oil factories in Serbia (e.g. Dijamant, Bimal) and the specific of market in the region.

4215900 - Sunflower or safflower oil, refined – The volume and value of import peaked in three years: 2016, 2020 and 2023, due to a drop in average sunflower yields on the domestic market. The export of refined oil during the analysed period has shown a stable with positive trend. Overall, the export of sunflower derivates and edible fats shows growth and fluctuations in quantities, but Serbia stays a net exporter of these products, showing its growing significance in global market in this category.

Figure 2. Dynamic and trend net external trade of sunflower derivates and edible fats



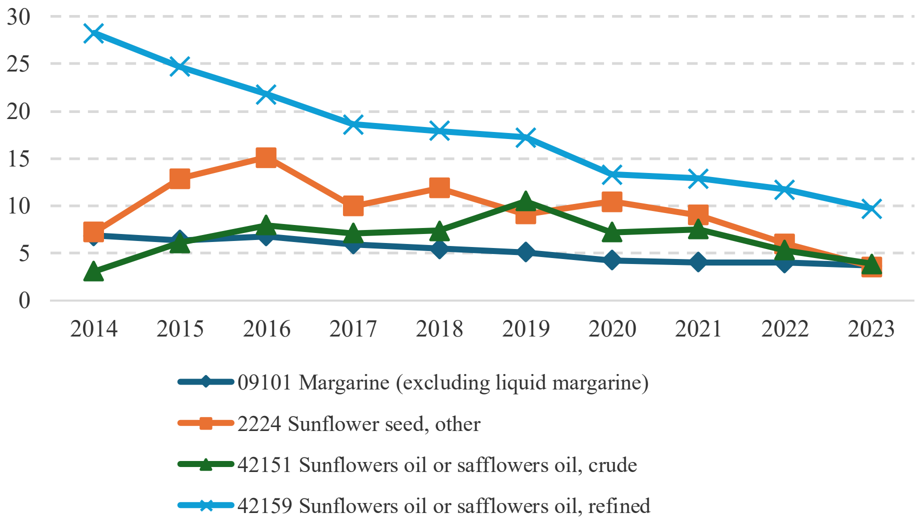
Source: SORS (2025)

The value of net trade has increased even when quantities were declining, which may indicate a rise in product prices (Figure 2). In bought indicator (volume and value) net trade generally grown during observed period, and it can be concluded that Serbia has a positive growing trade balance. However, there are certain variations that may be driven by climate or economic factors influencing trade.

RCA analysis for the period 2014-2023

For the period 2014-2023, Serbia's comparative advantage in the export of four key product categories: margarine, sunflower seed, sunflower oil (crude and refined), are analysed using the RCA index. The aim of this analysis is to assess the market value of each of these products and their competitiveness in the global market.

Figure 3. Dynamic and trends of RCA index



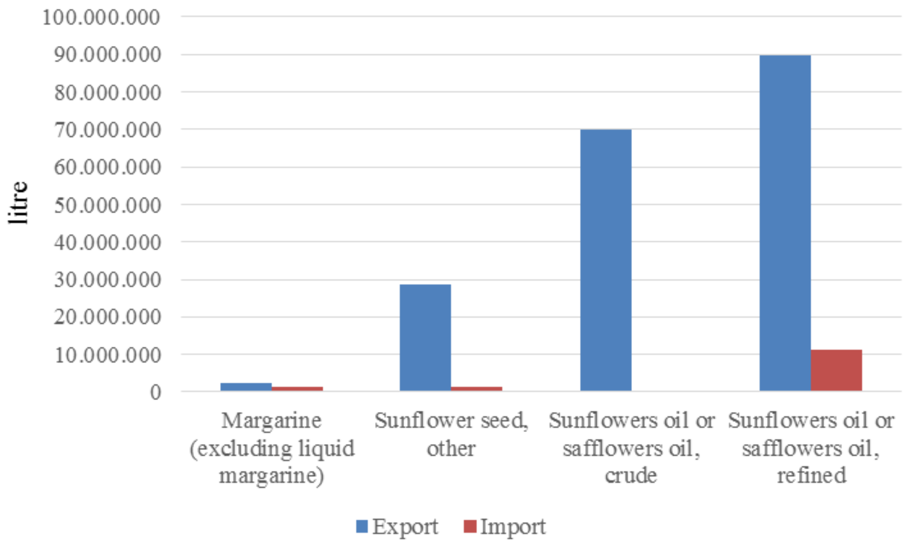
Source: SORS (2025); UNCOMTRADE (2025)

The values of the RCA index presented in Figure 3 were above 1, saying that Serbia had a comparative advantage in the export of all analysed products during the observed period. However, a declining trend in RCA index values for all observed categories from 2014-2023 is noticeable, suggesting that Serbia's competitiveness in global trade is decreasing. The highest RCA index level is for refined oil. Margarine has the lowest RCA index level but generally remained stable throughout the analysed period. The RCA index values for sunflower seed show fluctuations, but after 2020, they follow a declining trend. It can also be observed that the RCA values for crude oil decreased after 2019 and nearly aligned with the values from 2014 by 2023, but they are still above 1, meaning Serbia maintained competitiveness in this segment. Although edible fats, the decrease in RCA values may signal a reduction in competitiveness, possibly due to a decrease in demand and the global market or increase competition from other large producers. It is essential to enter non-traditional markets and improve positions in existing market segments.

The Self-Sufficiency analysis Serbia market of sunflower oil in 2023

The self-sufficiency of the Republic of Serbia's market in the sunflower oil sector was calculated based on the conversion factor of sunflower derivative product and edible fats into refined sunflower oil. The SSR indicates positive trends in this segment (Figure 4).

Figure 4. The Self-Sufficiency analysis of sunflower oil on Serbian market in 2023 (in l)



Source: Authors' calculations based on SORS (2025)

Data presented in Figure 4 revealed the Serbian self-sufficiency position for 2023. The quantities of all products were converted into litres of refined oil, considering the average oil density (0,9235), as cited by Oštrić Matijašević, Turkulov (1980) who note that the specific density at 20°C 0,920-0,927. The analysis by categories include:

- Margarine: Exports exceed imports, suggesting Serbia has a positive trade balance in produce of margarine.
- Sunflower seed: Exports (28,676,912litres) significantly exceed imports (1,364,253 litres), confirming Serbia's role as an exporter of sunflower seed.
- Sunflower crude oil: Exports (70,049,572 litres) is much higher than import (103.996 litres), indicating a significant export of crude sunflowers oil compared to imports, However, it also suggests that Serbia is losing potential profit selling crude oil to foreign refineries, which process and sell the oil at higher prices. A greater focus on domestic processing capacities, could mean more jobs in the sector and higher added value.
- Sunflower refined oil: Exports of refined oil (89,576,611 litres) far exceed import (11,286,410litres), proving that Serbia has a strong export capacity in this category.

The self-sufficiency rate for sunflower oil in 2023 was 254%, meaning domestic production was 1,54 times greater than domestic consumption. In other words, Serbia not only meets its domestic needs but also produces a significant surplus. The average per capita consumption of sunflower oil, including oil used in margarine production, was 17,3 litres in 2023. The data indicates that Serbia is a significant exporter of sunflower derivates and edible fats, while import remain relatively low compared to exports, pointing to a self-sufficient production system. The Balkan market is dominant in exports, with Bosnia and Herzegovina, Montenegro, and North Macedonia as key destinations, while the largest import share comes from Russia.

Discussion

The results of this analysis align with findings from other authors approve similar conclusions about the competitiveness of Serbia on international market of sunflower oil. For example, Matkovski et al. (2020) confirm Serbia's comparative advantage in sunflower oil exports but also stress the need for technological innovation and market diversification to hold competitiveness. The study by Ignjatijević et al. (2012) highlighted Serbia's comparative advantage in various agricultural products, including refined sunflower oil. Similarly, Knežević and Popović (2011) emphasized that the grown of sunflower production is largely driven by oil prices and demand, with price trends matching those in the European market, as also noted by Čurović (2023). In early 2024, Serbia imposes restrictions on the export of crude sunflower oil. Therefore, the period up to 2024 is more proper for assessing the actual situation in foreign trade relations involving sunflower oil and its derivates. The research findings show that Serbia largest exports share go to the Balkan region, while imports primarily comes from Russia. This market concentration could pose a challenge in the future, particularly in the context of changing international political and economic relations.

Conclusions

The research has shown that Serbia holds a significant position in the global market for sunflower derivates and edible fats, particularly in the refined oil sector. The use of econometric methods, such as RCA and SSR, has enabled a deeper understanding of Serbia's competitiveness in this sector. Our results showed that the RCA values were always above 1 during the observation period, proving that Serbia has a comparative advantage in the export of all analysed products. However, a downward trend in the RCA index values over time was also observed, suggesting that Serbia's competitiveness in global trade is declining. The degree of self-sufficiency for refined sunflower oil in 2023 was 254% meaning that domestic production is 154% higher that domestic consumption. In other words, Serbia not only meets domestic needs but is also a significant exporter of sunflower oil. These data show a stable international trade position, although challenges exist in term of dependence on a several key markets, primarily the Balkans and Russia, which could create vulnerability in case of global political and economic disturbances. Several limitations were discovered in this research. First, the analysis did not cover the trade of mayonnaise, which hold 70% of edible sunflower oil, a factor that could offer added insight into the fats sector. Furthermore, when finding comparative advantages, data on total global exports for the analysed product categories are missing. Although the quantitative data is detailed, the lack of qualitative information, such as changes in consumer preferences and the impact of innovation, points to space for future research. In addition, sunflower oil is the dominant type of oil on the Serbia and surrounding markets, but taking in account other types of oil will provide a more comprehensive understanding of the competitiveness of edible oils and derivatives on the international market. The conclusion of this paper is that Serbia has comparative advantages in sunflower oil market, but further market diversification is necessary to keep competitiveness and increase resilience to global changes.

Conflict of interests

The authors declare no conflict of interest.

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ECONOMIC CHALLENGES AND POTENTIALS FOR SUSTAINABLE DEVELOPMENT IN RURAL AREAS OF SERBIA

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ABSTRACT

Rural areas of Serbia face serious economic challenges, including depopulation, low levels of investment, and limited access to infrastructure. Nevertheless, these areas also possess significant potential for sustainable development, particularly in agriculture, renewable energy, rural tourism, and digital transformation. The key to improving the economic position of these regions lies in the integration of sustainable development policies that promote local entrepreneurship, preserve natural resources, and enhance the quality of life for the population. This paper analyzes the existing problems, identifies key potentials, and proposes development directions that could contribute to the long-term economic and social recovery of rural communities in Serbia.

Introduction

Rural areas of Serbia face complex challenges stemming from economic, demographic, and infrastructural factors. Depopulation, population aging, declining agricultural productivity, and a lack of investment in infrastructure contribute to the marginalization of these regions. According to data from the Statistical Office of the Republic of Serbia, in 2021, Serbia recorded a markedly negative natural population growth. The number of live births was 62,180, while the number of deaths reached 136,622, resulting in a natural population decline of -74,442 (RZS, 2022). This demographic profile points to deeply rooted challenges concerning sustainable demographic development, especially

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in rural areas, where negative trends are further exacerbated by the migration of young people to urban centers and abroad.

According to the research of Joksimović (2025), certain regions in Serbia have been almost entirely abandoned, with fewer than 20 inhabitants per settlement, indicating a severe demographic crisis and an urgent need for intervention.

Economic inequality between urban and rural areas is further deepened by limited access to markets, capital, and modern technologies. This spatial disparity is not unique to Serbia; global trends show similar patterns where rural communities often lag in economic development compared to urban centers. A study by Radosavljević, Kočović, and De Santo (2024) highlights that climate change, including increasingly frequent heatwaves, has further endangered agricultural production, necessitating the introduction of mechanisms such as agricultural insurance to mitigate risks and promote sustainable development.

Demographic challenges, such as the migration of young people from rural to urban areas, further complicate the situation. The phenomenon of rural exodus—where young people leave villages in search of better economic opportunities—is present both in Serbia and globally. This migration leads to a shrinking labor force in rural areas and hampers their development. One of the key factors for the successful sustainable development of rural areas is the strengthening of human capital and entrepreneurship. Radosavljević et al. (2022) emphasize that developing entrepreneurial skills and education in rural regions can significantly contribute to the economic revitalization of these areas.

Furthermore, introducing the concept of a circular economy into agricultural practices can enhance the sustainability of rural areas. Vukelić et al. (2023) propose the development of a model for assessing the capacity of rural regions to transition to a circular economy, which would allow for more efficient resource use and a reduction in negative environmental impacts.

Despite these challenges, rural areas in Serbia possess significant potential for sustainable development (Dašić et al., 2020; Dabetić et al., 2024; Pantović et al., 2023). According to the study by Martinović and Ratkaja (2015), identifying different types of rural areas enables the adaptation of development strategies to the specific needs of each region, thus fostering economic growth and improving the quality of life for the population.

Literature review

Rural communities often rely on agriculture, making them vulnerable to economic and climate changes. The diversification of economic activities can enhance the resilience of these communities (Castellano-Álvarez et al., 2024; Lazović et al., 2024). Rural tourism is increasingly recognized as an important instrument for the sustainable development of rural areas, particularly in transitional countries such as Serbia (Lane & Kastenholz, 2015; Sznajder et al., 2009). The introduction of tourism activities into rural areas contributes to economic diversification, increases the income of farming households, helps preserve cultural heritage, and strengthens local identity. Dašić and colleagues (2020) examine the role of rural tourism as a driver of rural development in Serbia. It is argued that rural tourism can contribute to the economic empowerment of villages, the preservation of tradition, and the reduction of migration. Based on the analysis of statistical data and existing strategies, both potentials and numerous obstacles are highlighted, such as poor infrastructure and lack of institutional support. The lack of adequate infrastructure, such as roads and electricity, limits the economic development of rural areas (Li et al., 2023). Some studies emphasize the need for more systematic institutional support and the education of local populations (Ivanović et al., 2020; Milačić, 2024).

Contemporary scientific insights also point to the importance of cultural and historical heritage as a key element in shaping the tourist attractiveness of destinations and strengthening their competitive position within cultural tourism. Heritage, as a carrier of collective memory and national identity, is increasingly recognized as a strategic resource in economic development and territorial branding processes. There is a growing emphasis on the need for a responsible approach to the valorization and preservation of cultural assets to ensure long-term sustainability and increase the visibility of destinations in the tourism market. At the same time, current literature highlights the importance of applying dynamic models in the analysis of rural development, especially in the context of tourism growth as an economic activity. Increasing attention is being paid to the risks associated with the process of 'touristification'—a concept describing the over-reliance of rural areas on tourism (Cvijanović et al., 2023; Ignjatijević et al., 2024; Đukić & Kojić, 2023), which often leads to the degradation of local resources, environmental burdens, and the erosion of cultural authenticity (Salazar, 2012). These challenges require a balanced approach that enables economic growth, the preservation of cultural heritage, and the responsible management of spatial and sociocultural resources (Durkalić et al., 2019; Dašić & Savić, 2020).

Thus, while tourism carries significant economic potential, including the creation of new jobs, an increase in gross domestic product, and the diversification of economic activities in rural areas, the necessity of clear regulatory mechanisms and measures for protecting local resources is emphasized. Research recommends the development of balanced models that will allow for long-term and sustainable economic progress, while preserving cultural and natural heritage as the foundation of local identity (Iannucci et al., 2022).

In the context of contemporary approaches to rural development, the importance of systematic communication management is increasingly emphasized as a means of improving the economic and social aspects of local communities. Effective planning of communication activities and the implementation of tailored strategies can contribute to increased public participation, better information dissemination, and greater transparency in decision-making processes. Communication management is recognized as a key factor in connecting various local actors, building trust, and encouraging intersectoral cooperation, thereby enhancing the impact and effectiveness of development initiatives (Zolak, 2024).

At the same time, current scientific trends highlight the growing role of digital marketing and the evolving position of consumers in the digital environment, which influences a shift in the communication paradigm in rural development (Dašić et al., 2024). Special attention is given to the opportunities provided by digital communication channels, such as personalized messages, interactive content, and rapid feedback, which allow for more effective connection between brands and target groups. In this new marketing reality, consumers are becoming active participants in the communication process—not only message recipients but also influencers through social media, reviews, and recommendations (Dašić, 2024). Virtual consumers increasingly shape market offerings, as their experiences and opinions directly affect the positioning of products and services. In this context, digital strategies represent a key tool for adapting to rapid market changes and building long-term relationships with modern, digitally literate consumers (Dašić et al., 2023).

Numerous studies seek to examine the link between economic conditions and the sustainability of rural tourism. Findings indicate that the improvement of key economic indicators—such as developed infrastructure, increased employment, and investment growth—significantly contributes to the successful development of rural tourism as an important economic activity. However, research also warns that unplanned or insufficiently controlled development may lead to negative consequences such as overcrowding, overexploitation of natural resources, and increased social inequality. It is concluded that economic sustainability cannot be viewed in isolation but must be considered within a broader concept that integrates economic, social, and environmental aspects, requiring an integrated approach to development management (Chen et al., 2023).

Recent research increasingly recognizes the significance of green finance as a tool for promoting sustainable development in rural areas. Based on panel data collected from 283 cities in China, it is shown that financial mechanisms directed toward environmentally responsible practices—such as subsidies for sustainable agriculture, investments in renewable energy, and the development of green infrastructure—can have a strong positive impact on poverty reduction, increased employment, and mitigation of ecological risks. The results of such studies suggest that green financing needs to be institutionalized and integrated as an essential and mandatory part of rural development policies, with the aim of building sustainable, economically stable, and ecologically preserved communities (Yi et al., 2025).

Studies focused on sustainable rural development in Serbia point to numerous economic and social challenges, especially in the regions of Southern and Eastern Serbia, as well as Šumadija and Western Serbia. Key issues include negative demographic trends, underdeveloped infrastructure, low productivity in the agricultural sector, and limited investment volume. Literature increasingly recommends an approach that includes all three dimensions of sustainable development—economic, social, and environmental.

In particular, the introduction of circular economy models and the active involvement of local communities in planning and decision-making processes are emphasized as essential to ensuring long-term sustainability and resilience of rural areas (Vučić, 2024).

Over the past decade, scientific and professional literature has increasingly focused on rural development through multidisciplinary approaches. Particular emphasis has been placed on the economic dimension of sustainability, with numerous challenges identified, such as lack of financial resources, underdeveloped institutions, limited market access, and insufficient infrastructure. Analyses show that in practice—especially in some international contexts—the most successful strategies have been those that integrate various sectors, primarily agricultural production, rural tourism, and support for local entrepreneurship. Within the framework of recommendations for rural area improvement, the need to create policies that take into account the specificities of rural environments and encourage the development of local initiatives and partnerships as drivers of positive change is emphasized (Suárez Roldan et al., 2023).

Research aimed at assessing the level of sustainable rural development in Serbia indicates the presence of significant development potentials, as well as numerous structural and institutional obstacles. In the context of ongoing integration processes and aspirations to align with European Union standards, there is an increasing need to modernize rural development policies, which must fully recognize the specific characteristics of Serbian rural communities. A comprehensive approach is recommended, involving substantial financial investment, systematic education of both the population and institutions, and active involvement of all relevant stakeholders—from the national to the local level. Such a holistic approach is considered crucial for long-term, sustainable, and evenly distributed development of rural areas (Ristić, 2013).

Research focused on the implementation of the Sustainable Development Goals (SDGs) highlights the complexity of balancing different priorities in the areas of economic, social, and environmental development. Global-level analyses reveal that many countries struggle to overcome conflicts between specific goals and to establish synergistic relationships among them. While some goals reinforce one another—such as improving education and reducing poverty—others may be in conflict, such as when economic growth leads to increased pressure on the environment. Contemporary scientific literature increasingly emphasizes the need for political coherence and the application of integrated approaches in planning and implementing public policies, particularly in the context of achieving the SDGs. Instead of fragmented and sectorally limited interventions, a systemic approach is recommended—one that recognizes the complex and interdependent nature of the economic, social, and environmental dimensions of sustainability.

Special emphasis is placed on the importance of intersectoral cooperation—both at the horizontal level between various institutions, and at the vertical level among national, regional, and local actors. Such cooperation enables not only the alignment of priorities but also the resolution of potential conflicts (trade-offs) through the creation of synergies that can lead to mutually reinforcing effects. Understanding the interlinkages among sustainable development goals is key to formulating strategies that contribute to the long-term resilience and sustainability of public policies (Nilsson et al., 2018; Sachs et al., 2022; Kroll et al., 2019).

Research Methodology:

The aim of this paper is to analyze the economic and demographic factors influencing the sustainable development of rural areas in Serbia. Particular focus will be placed on identifying strategies that can contribute to the revitalization of these regions, including infrastructure improvement, support for family farming, and the development of local communities. Various methodological techniques were applied in the research to provide a comprehensive overview of rural development in Serbia and the surrounding region. Primarily, content analysis was used to systematically review relevant literature, statistical data, and strategic documents, enabling the identification of key theoretical and practical frameworks.

In addition, desk research based on secondary data included the analysis of official information from the Statistical Office of the Republic of Serbia, as well as data from scientific journals and reports from relevant institutions. This multi-method approach contributed to the validity and relevance of the obtained results.

H1: *Insufficient infrastructure connectivity, weak institutional support, and depopulation represent the main obstacles to rural development in Serbia; however, with adequate investment and the activation of local resources, there is significant potential for sustainable growth.*

Results and Discussion

Economic and Demographic Challenges of Rural Development in Serbia

Rural areas in Serbia face profound economic and demographic issues that severely hinder their development potential. One of the key challenges is economic underdevelopment and a high unemployment rate. According to data from the Statistical Office of the Republic of Serbia, the unemployment rate in rural areas is approximately 5% higher than in urban areas, and employment is predominantly concentrated in primary sectors such as agriculture and forestry, which lack sufficient technological modernization and added value (RZS, 2022).

At the same time, rural areas are experiencing a dramatic demographic decline—more than 1,200 villages in Serbia have fewer than 100 inhabitants, and as many as 200 villages have no residents at all. Population aging and the migration of young people to cities are contributing to increasing social and economic depopulation, which limits the potential for revitalizing local communities.

One of the most serious demographic challenges in Serbia's rural areas is the ongoing aging of the population and the intensive migration of youth toward urban centers. The average age of residents in rural regions exceeds 45 years, while in some parts, such as eastern Serbia, this average is even higher. According to the Statistical Office of the Republic of Serbia, over the past decade, more than 400,000 young people have left rural areas, mostly in search of better employment and educational opportunities (RZS, 2021). Nikitović (2022) emphasizes that the natural population decline, first recorded in 1992, has continued to worsen, reaching -8.0‰ in 2020. This demographic downturn has far-reaching consequences for rural areas, including the shrinking of the labor force, closure of schools, and reduced availability of public services.

Another key factor hindering the sustainable development of rural areas in Serbia is underdeveloped infrastructure and limited access to basic public services such as healthcare, education, and internet connectivity (Ahmić et al., 2016; Stanojević, 2019). Research shows that as many as 20% of villages in Serbia do not have adequate access to paved roads, and more than 1,000 villages lack a permanent health clinic. In addition, many primary schools in rural areas operate with a minimal number of students or have been completely closed due to declining numbers of children.

Kvrgić and Ristić (2018) emphasize that internal challenges—such as sustainable resource management, technological progress, and strengthening the social fabric—are crucial for the development of rural areas. A lack of infrastructure, limited access to financial resources, and low competitiveness of agricultural products further hinder economic development.

In the area of digital connectivity, there is a pronounced digital divide—fewer than 60% of households in rural areas have access to high-speed internet, compared to more than 85% in urban areas (Ministry of Telecommunications, 2022). This significantly limits opportunities for distance education, digital agriculture, and entrepreneurial development (Petrović, 2017).

The structure of agricultural production in Serbia's rural areas is still dominated by small-scale farms, with an average landholding size of just 5.4 hectares per household, which significantly limits economies of scale and production efficiency (RZS, 2022). More than 75% of agricultural households produce exclusively for their own needs or for local markets, without integration into broader processing or export chains. At the same time, the level of processing of agricultural products in rural areas is low, as small and medium-sized processing enterprises that could add value to raw materials (e.g., cheese, cured meat, processed fruits) are rare. The lack of cold storage, warehouses, certification systems, and marketing support further weakens the market position of small producers.

One of the main reasons for the economic stagnation of rural areas in Serbia is the insufficient volume of investment in the local economy and the chronic lack of support for entrepreneurship and innovation. According to data from the National Agency for Regional Development, less than 10% of total investments in small and medium-sized enterprises in Serbia are directed toward rural areas, with most investments excluding innovation, start-ups, and processing capacities (NARR, 2021).

The Strategy for Agriculture and Rural Development of the Republic of Serbia for the period 2014–2024 recognizes the need for an integrated approach to rural development. However, a lack of coordination among various levels of government and limited capacity for policy implementation remain significant obstacles (SPRR, 2014).

Despite the availability of certain programs, such as EU IPARD support, a large number of farmers and rural entrepreneurs lack the administrative capacity or knowledge to apply for these funds. In addition, agricultural and rural business loans often come with unfavorable conditions, which further discourages private initiative globally (Smit et al., 2024).

Neighboring countries face similar challenges. Rural areas in Croatia are confronted with issues such as depopulation, population aging, and economic inactivity. According to OECD data, although the country's macroeconomic situation has improved following EU accession, regional disparities remain a significant problem, particularly in rural areas (OECD, 2024). Research by Rogelj and colleagues (2024) shows that young farmers in Croatia have limited access to financial resources and infrastructure, which hampers generational renewal and the sustainable development of rural regions.

Rural areas in Bosnia and Herzegovina also face high levels of poverty and unemployment. According to research by Tandir et al. (2016), there are significant socio-economic disparities between rural municipalities, even among those with similar population density.

North Macedonia is likewise facing major demographic challenges, including a declining natural birth rate, aging population, and intensive emigration, particularly of young and educated individuals (Petkovski et al., 2024).

Potentials for Sustainable Economic Development of Rural Areas in Serbia

One of the most promising directions for the sustainable economic development of rural areas in Serbia is the advancement of organic and sustainable agriculture, which is gaining increasing importance both in domestic and international markets. Organic production in Serbia covers over 21,000 hectares of land, with a continuous rise in the number of certified producers—more than 7,000 were registered in 2022, representing a 20% increase compared to the previous year (eKapija, 2021).

Organic agriculture contributes to the preservation of natural resources, healthier nutrition, and long-term economic sustainability. At the same time, it creates opportunities for premium market placement and higher added value. In rural areas, where small farms dominate, this model of production represents a viable alternative to conventional agriculture, especially when combined with local branding and rural tourism.

Strengthening the agri-processing sector is a key lever for increasing added value in agricultural production and retaining income within rural communities. In Serbia, raw material exports still dominate, while only about 30% of domestic agricultural products are processed within the country. This limits the potential for job creation and the growth of the local economy.

In this context, the development of short supply chains—direct sales from producers to consumers without intermediaries—offers added value for small farmers. These models allow for better prices, transparency of origin, and greater consumer trust. In Serbia, there are an increasing number of examples where cooperatives, farmers' markets, and online platforms connect producers and consumers, thereby strengthening the local economy and reducing dependency on large market systems.

Rural tourism represents one of the most promising forms of economic diversification in rural areas, as it provides local residents with additional income through accommodation services, gastronomy, homemade products, and cultural activities. Serbia has rich natural and cultural resources—from mountains and spas to traditional architecture and culinary heritage—which provide a strong foundation for the development of ethno-villages and agrotourism (Đorđević-Milošević & Milovanović, 2012).

According to available data, the number of registered rural tourism households in Serbia has significantly increased in recent years. For example, as of June 2023, there were 758 rural tourism households registered in the e-Tourist system. By February 2024, that number had risen to 798, with an additional eight *salaš*-style estates and seven ethno houses, marking an increase of about 32% compared to the previous two years. In July 2024, the Ministry of Tourism and Youth announced that the number of registered rural tourism households had increased by nearly 300, surpassing 1,000 (Seoski turizam, 2023). This growth indicates a rising interest in rural tourism as a sustainable source of income and a way to improve quality of life in rural communities. Rural tourism not only contributes to the economic strengthening of rural areas but also supports the preservation of cultural heritage, traditions, and environmental awareness.

Renewable energy sources represent a significant potential for the sustainable development of rural areas, as they enable energy independence, cost savings, and new opportunities for local economies. Serbia possesses rich biomass resources (agricultural and forestry waste), as well as a high number of sunny days, making biomass and solar energy the most promising options for rural households and public facilities in villages.

Information technologies and digitalization are playing an increasingly important role in the transformation of rural areas, enabling access to new markets, education, e-governance, and innovation in agriculture and entrepreneurship. Digital connectivity is a prerequisite for introducing precision agriculture, online sales, digital training, and linking local producers with consumers and partners across the country and globally.

According to the most recent available data, in 2021, 75% of households in rural areas of Serbia had internet access, compared to 86% in urban areas. These figures indicate the existence of a digital divide between rural and urban regions, which can affect economic development and access to information in rural communities (International Telecommunication Union, 2023).

European Union funds—especially the IPARD program (Instrument for Pre-Accession Assistance for Rural Development)—represent one of the most significant sources of financing for the modernization of agriculture and the development of rural infrastructure in Serbia. Since the start of the IPARD II program (2014–2020), Serbia has had access to over €175 million in non-refundable funds intended for investments in physical assets, processing, marketing, and rural tourism (Delegation of the EU to Serbia, 2021).

In addition to IPARD, the government has provided incentives through the National Investment Plan and the Rural Development Program, supporting the purchase of village houses, acquisition of machinery, and the launching of small agricultural businesses. However, the utilization of these funds remains limited due to administrative barriers, a lack of information, and complex documentation procedures—factors that especially affect small farms in less developed municipalities.

According to Kvrgić (2018), territorial capital, which includes natural resources, cultural heritage, and human capacities, forms the foundation for the sustainable development of rural areas. Creative entrepreneurship, based on local specificities and innovations, can contribute to the economic revitalization of villages and the reduction of social inequalities.

Conclusion

The sustainable development of rural areas in Serbia represents one of the key challenges of contemporary economic policy, but also an important opportunity for regional cohesion, demographic stabilization, and the overall economic progress of the country. An analysis of economic and demographic challenges shows that rural areas are characterized by low levels of economic activity, high rates of youth migration, insufficient infrastructural connectivity, and underdeveloped support sectors such as services, education, and healthcare. In addition, a large number of rural households rely on primary agriculture with low levels of technological innovation and added value.

On the other hand, Serbia possesses significant potential for the development of the rural economy. Modern trends in sustainable agriculture, rural tourism, and the use of renewable energy sources open up new opportunities for income diversification and population retention in villages. The improvement of the agri-processing industry and the incentives provided by EU funds—such as the IPARD program—can greatly contribute to the social and economic revitalization of rural communities.

To scale such examples, it is necessary to develop integrated public policies that include support for small farmers, incentives for rural tourism, investments in infrastructure and digital connectivity, as well as educational programs that promote entrepreneurship in rural areas. Research shows that the key to improving rural communities lies in the implementation of integrated strategies that combine economic, demographic, institutional, and environmental aspects. The role of government institutions, local communities, and the academic sector is crucial in creating policies that will enable more balanced development and reduce regional disparities. Only through such coordinated efforts can long-term sustainability and improved quality of life in rural areas be ensured.

Conflict of interests

Authors declare no conflict of interest.

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Table 1. The distribution cost of packaged goods from Subotica to retail-store objects

Indicators	Period			Total
	Month 1	Month 2	Month 3	
Distance crossed (km)	12.926	11.295	13.208	37.429
Fuel consumption (litre)	3.231	2.823	3.302	9.356
Value of fuel consumption (RSD)	242.378	211.790	247.653	701.821
Total time spend on touring (hour)	314	266	417	997
Value of total time spend on touring (RSD)	47.048	39.890	62.570	149.508
Number of tours	98	77	102	277
Toll value (RSD)	0	0	0	0
Number of pallets transported (piece)	1.179	976	1358	3.513
Total weight transported (kg)	602.600	429.225	711.116	1.742.941
Vehicle maintenance costs (RSD)	203.858	164.970	224.806	593.634
Lease costs (RSD)	480.938	454.214	565.784	1.500.936
Total sum (RSD)	974.222	870.864	1.100.813	2.945.899

Source: Petrović, 2012

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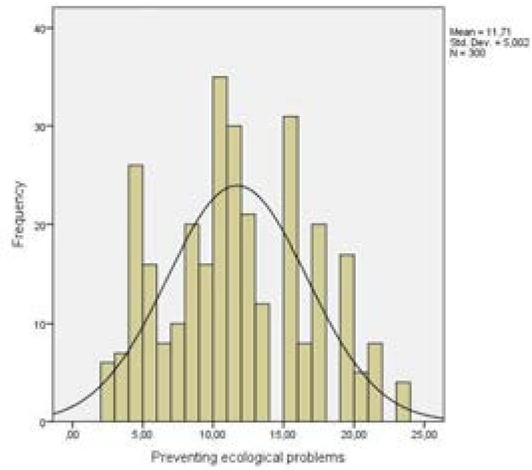

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