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CONTENT

STRATEGIC APPROACH TO ASSESSING THE EFFICIENCY OF AGRICULTURAL AND TOURISM BUSINESS IN THE ECONOMY OF SERBIA

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A B S T R A C T

The authors will present a strategic approach to assessing the performance of agriculture and tourism in the Republic of Serbia. The purpose of the analysis is to determine which of the given economic activities has better economic performance and, accordingly, has a greater impact on the economic growth and development of the Republic of Serbia. The research covered the financial statements of large and medium-sized enterprises in the areas being analyzed. The results of the ratio analysis indicate that both activities jointly contribute to the economic growth and development of the Republic of Serbia. When it comes to determining bankruptcy, the Altman Z` score model has been adapted for developing economies. According to this model, agriculture and tourism, at the level of calculated average values, operate in a zone of moderate risk, which is a golden mean and a good indicator of their business performance.

Introduction

The subject of research in this paper is a strategic approach to assessing the efficiency of the agricultural and tourism sectors. The strategic assessment of the efficiency of agriculture and tourism is based on the analysis of their operations and the implementation of corrective actions, in order to improve their business performance in a dynamic environment (Plavšić & Paunović, 2011). Based on the established strategy, the value of the company is maximized and a competitive advantage is achieved (Masrom

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et al., 2022). A successful strategy serves as the foundation on which a company's operations, as well as the entire industry, rest. The task of management is to identify the risks that threaten the company and to find the causes that preceded their emergence in order to assess the strengths and weaknesses of the business. Based on this, the authors will present the individual contribution of each of the given activities to the economic development of the Republic of Serbia. These two sectors of the economy are covered by the given analysis, as each of them individually holds a special place and impact on the economy of Serbia. The agricultural sector plays an important role in the economic structure of the Republic of Serbia, as evidenced by the fact that Serbia is rich in agricultural land and favorable natural conditions, which, when considered together, lead to a high share of agricultural GDP in the country's total gross added value (Milošević & Milić, 2024). The development of tourism in Serbia during the second half of the 20th century and the beginning of the 21st century was largely conditioned by its overall socio-economic development. However, due to the characteristics that tourism has as an economic activity, and especially because of the characteristics of tourist needs, tourism in Serbia has not developed at the same pace as the economy as a whole (Gligorijević et al., 2020).

The research problem is contained in the following research questions. What methods should be applied when making a strategic assessment of the efficiency of agriculture and tourism? What is the probability of financial difficulties arising at the average level of each of the given activities? The aim of the research is to provide a strategic overview of the development of these two sectors of the economy based on indicators of liquidity, solvency, indebtedness, and profitability, and to indicate the measures that need to be taken for their improvement. The paper will use ratio analysis methods to determine each of the coefficients at the level of these two activities. In addition to them, the Altman Z-score method will be applied, which uses certain indicators to detect financial problems and the likelihood of bankruptcy risk. There are two types of this model: the initial Altman Z-score model and the Altman Z-score model adjusted for developing countries. The application of this model is carried out for both activities based on five coefficients multiplied by certain weights.

Based on the above, the paper presents three research hypotheses, namely one main (H_0) and two auxiliary (H_1 and H_2), which are as follows:

H_0: The strategic approach in assessing the efficiency of agriculture and tourism serves to determine, based on the obtained results, what their business performances are and what impact they have on the economic development of the Republic of Serbia.

H_1: The assessment of the financial structure and earning power is obtained based on the ratio analysis of profitability, liquidity, total asset turnover, net working capital, indebtedness, and solvency.

H_2: The assessment of the risk of bankruptcy for a company in the next two years is conducted using the initial Altman Z-score model and the adjusted Altman Z-score ($Z`$) model.

Materials and methods

The study presents a strategic assessment of the agricultural and tourism sectors and their overall impact on the economic development of the Republic of Serbia. The analysis covered the positions of the balance sheet and the income statement, based on which the average values were calculated at the level of the given activities. Accordingly, financial indicators have been established, which have provided an assessment of the financial structure and financial results of the observed enterprises, which will be useful for the authors in making decisions about the efficiency of the agriculture and tourism sectors. Accordingly, this research examines the relationships between specific balance sheet items in order to obtain an assessment of profitability, liquidity, indebtedness, and solvency at the average level in each of the given activities (Fabris, 2023; Robinson et al., 2015).

Profitability is determined based on the net profit margin, which is calculated from the ratio of net profit to operating income. This ratio shows the proportion of net profit to operating income, i.e., how much net profit the company has earned for every dinar of operating income. The height of this rate depends on the following factors: selling price, sales volume, cost management, and the amount of expenses for interest. The specificity of managing expenses for interest indicates that even though a company achieves a high amount of operating profit, a large share of debts with high interest rates can lead to a small net profit or, ultimately, a net loss (Asiani & Rahayu, 2024).

To determine liquidity as the ability to unconditionally settle due short-term obligations, the rigorous liquidity ratio "quick ratio" was used, which is calculated by comparing current assets (cash, cash equivalents, and current receivables) with short-term liabilities (Malinić et al., 2023). In this case, current assets are reduced by the amount of inventory, as the least liquid current assets, in order to calculate the current assets that can be converted into cash the fastest. This ratio provides information on how much liquid assets cover each dinar of short-term liabilities (Paramitha & Sucipto, 2024; Horne & Wachowicz, 2007). The height of the ratio is influenced by the continuity of short-term obligations and the regularity of collecting receivables from customers. It is based on the acid (quick) test of liquidity, which requires that the ratio between liquid assets and short-term liabilities be 1:1 (Hiadlovský et al., 2016).

The activity of certain companies has been calculated based on the turnover ratio of total assets, which is obtained from the relationship between sales revenue and average total assets. This indicator provides data on how many times the average total assets are turned over during the year, i.e., how much assets are engaged for one dinar of sales revenue (Innocent et al., 2013; Rochmah et al., 2024). In the event that the coefficient is lower than the average in the activity, a detailed analysis should be conducted to identify the cause of this and to take corrective measures. This coefficient can be compared with other companies or industries, average values in the economy of a country, as well as with the same coefficients from previous years (Ivanišević, 2008; Todorović & Ivanišević, 2012).

Net working capital is calculated as the difference between long-term sources and fixed assets. The financial structure of the company is based on the golden balance sheet rule in a broader sense, which defines long-term financial stability. The rule states that long-term assets (real estate, facilities, equipment, intangible investments) and permanent current assets (inventory) are financed from long-term sources (equity, long-term reserves, long-term liabilities), while other current assets are financed from short-term liabilities. Net working capital represents a part of current assets that is financed in the long term (Stančić, 2006). The net working capital level depends on the following factors: the company's activities, profit policy, procurement and sales policy, and management practices. In the case that net working capital has a positive value, it means that a portion of current assets (inventory) is financed from long-term sources and that long-term financial balance has been achieved. If the net working capital is negative, it indicates that the company is in a difficult financial situation and is experiencing operational problems, which implies that when the company uses long-term sources to cover its fixed assets, it does not have enough resources to cover its net working capital. It primarily refers to inventory coverage.

The analysis of indebtedness is carried out using indicators of financial structure, namely the debt ratio (leverage), which represents the relationship between total liabilities and total assets (Kartikaningrum, 2024; Chakraborty et al., 2024). This ratio is expressed as a percentage and answers the question of how much of the total assets is financed by debt. If there is a large share of debt in the financial structure, the company is exposed to the risks of paying back the principal and interest on loans. On the contrary, if there is a lower proportion of debt in the financial structure, the company will be able to more easily obtain loans from creditors, as it has a greater borrowing capacity (Jovanović Škarić, 2018). This indicator is an essential measure that analysts and potential investors use to assess the financial position of a company. It can be compared to the average in the industry, with other industries, or with historical trends in the industry and the company.

The solvency ratio is obtained by comparing total assets to total liabilities. Solvency represents long-term liquidity and is used to determine a company's ability to pay all due obligations. Conversely, if it cannot meet all its due obligations, it is confirmed that the company is insolvent and that its liabilities exceed its assets. The coefficient is calculated from the ratio of total assets to total liabilities (Rodić et al., 2017). This indicator ranges from 1 and above. It is understood that a company is solvent when this indicator is equal to or greater than 1, and if it is less than 1, the company is insolvent. Insolvency arises as a result of the over-indebtedness of a company.

After conducting an analysis of the financial structure, the authors performed a credit analysis using the Altman Z-score model (both the original and the adjusted), which represents a multivariate statistical formula, in order to assess the condition of companies operating in the tourism and agriculture sectors, specifically how exposed each sector's companies are, on average, to the risk of bankruptcy in the next two years (Apoorva et al., 2019). The formula for this model was invented by American finance professor Edward Altman during the Great Depression when many companies

were at risk of bankruptcy. The value of Z-scoring is calculated based on the sum of predetermined indicators multiplied by assigned weights (Ali et al., 2016). This shows that the Z score model is obtained by combining indicators of liquidity, profitability, efficiency, volatility, and the total asset turnover ratio, which are calculated in the following way (Mohammed, 2016):

$$\text{Liquidity ratio } X_1 = \frac{Net\ working\ capital}{Total\ assets}$$

$$\text{Profitability coefficient } X_2 = \frac{Net\ profit}{Total\ assets}$$

$$\text{Efficiency coefficient } X_3 = \frac{Earnings\ before\ interest\ and\ taxes}{Total\ assets}$$

$$\text{Volatility coefficient } X_4 = \frac{Market\ value\ or\ book\ value\ of\ a\ company's\ shares}{Book\ value\ of\ total\ liabilities}$$

$$\text{The total asset turnover ratio } X_5 = \frac{Revenue\ from\ sales}{Total\ assets}$$

Initial Altman Z-score (Z) model $= 1.21X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.99X_5$

The initial Altman Z-score model is used for ranking companies, as shown in Table 1.

Table 1. Classification of bankruptcy results of companies according to the initial Altman Z-score model

Z > 2.99	Safe (green) zone
1.81 < Z < 2.99	Moderate risk zone (Gray zone)
Z < 1.81	High-risk area (Red zone)

Source: Altman et al., 2013.

In Table 1, the classification of bankruptcy results for companies according to the initial Altman Z-score model presents the values of the Z-score model. If the Z-score model value is less than 1.81, it indicates that companies in each industry are individually, on average, exposed to the risk of bankruptcy, and that there is a 95% probability of their bankruptcy within the next two years (Filipović & Mirjanić, 2016). If the Z-score model value ranges between 1.81 and 2.99, companies in each industry individually are generally in the moderate risk zone (the gray zone), where the possibility of bankruptcy is reduced (Milić et al., 2021). If the obtained Z-score value of the model is greater than 2.99, companies in each activity sector are, on average, in a safe (green) zone, and there is a minimal probability of bankruptcy risk (Srebro et al., 2021). Based on the initial Altman Z-score model, a corrected Altman Z'-score model has been obtained. This model is obtained by modifying the original model by including parameter 3.25 and excluding indicator X_5, which is presented as follows:

Adjusted Altman Z-score (Z`) model $= 3.25 + 6.56\ X_1 + 3.26\ X_2 + 6.72\ X_3 + 1.05\ X_4$

Below is Table 2, which shows the ranking of bankruptcy risk for companies in each industry individually, averaged by zones according to the adjusted Altman Z-score model.

Tabela 2. Classification of bankruptcy results of companies according to the adjusted Altman Z-score (Z`) model

Z` > 5.85	Safe (green) zone
3.75 < Z` < 5.85	Moderate risk zone (Gray zone)
Z` < 3.75	High-risk area (Red zone)

Source: Altman, 2017.

Table 2 shows the ranking of companies according to the adjusted Altman Z-score (Z`) model. If the value of the Z-score model is less than 3.75, it means that companies individually, on average, are in the high-risk zone. In the event that the value of the Z-score model falls within the range of 3.75 to 5.85, then companies individually, on average for each activity, are in the moderate risk zone (gray zone). If the Z-score model value is greater than 5.85, companies in every industry individually find themselves in the safe (green) zone when there is a minimal probability of bankruptcy risk.

Results

The aim of the study is to provide an adequate picture of the strategic assessment of the efficiency of the agricultural and tourism sectors and their impact on the economy of the Republic of Serbia, based on a comparative analysis of the financial structure data and the success of enterprise. The study used data from the official website of the Business Registers Agency for a period of five years, from 2019 to 2023 (Business Registers Agency). The research sample encompasses medium and large enterprises. Below is a quantitative assessment of the financial performance of each of these activities individually, in order to enable their comparability over a period of 5 years, respectively. The analyzed financial data were taken from the balance sheet and income statement for companies operating in agriculture and tourism. The obtained data represent the basis for a financial analysis that includes the following indicators: net profit margin, quick ratio, total asset turnover ratio, net working capital, debt ratio, and solvency ratio (Vuković et al., 2024). First, a temporal analysis of each activity was presented individually, based on which a comparative financial analysis was conducted. In that sense, the data is a comparative analysis of agriculture and tourism using Altman's Z-score model, in order to assess the exposure at the average level of each sector to potential bankruptcy risk (Koshti, 2019). Based on the obtained results, an explanation and a graphical representation of the movement of the initial Z-score model and the corrected Z'-score model are provided. Table 3 contains the average values of balance sheet items in agriculture.

Table 3. Average value by sector - agriculture (u 000 RSD)

Balance sheet positions	2019.	2020.	2021.	2022.	2023.
Total assets	11,030,898	11,307,546	9,274,707	10,855,722	11,603,496
Net profit	723,449	568,343	252,361	21,969	573,649
Business income	7,486,360	7,432,255	7,425,905	8,965,481	10,268,725
Working capital	3,794,316	3,426,502	3,304,834	3,949,137	4,509,381
Supplies	1,122,933	1,186,490	1,265,960	1,837,987	1,803,554
Working capital - Supplies (liquid assets)	2,671,382	2,240,012	2,038,874	2,111,149	2,812,445
Short-term liabilities	2,661,667	2,735,660	2,966,953	3,947,463	3,725,177
Long-term sources	8,250,957	8,404,098	7,686,412	7,024,249	8,201,269
Permanent assets	7,194,552	7,838,199	6,932,898	6,859,620	7,057,956
Total liabilities	6,892,857	6,830,033	7,574,257	8,094,288	7,728,865
Sales revenue	1,172,064	1,115,667	841,671	1,124,501	1,029,359
Retained earnings	2,023,998	1,699,701	1,805,705	2,188,378	2,036,515
Earnings before interest and taxes	936,685	1,013,102	566,775	641,732	1,329,878
Market value of a company's shares	4,922,832	2,438,051	1,825,256	1,809,751	1,928,452

Source: Author's

As shown in Table 3, the average value of total assets in agriculture has not significantly changed during this time period. The net profit had its lowest value in 2022, averaging around 21,969 RSD. The reason for the decline in net profit is the rise in costs and obligations at a time when the war in Ukraine occurred and the crisis spilled over to the entire world. Based on the analysis of business revenues, a gradual increase is noticeable up to 2023, reaching 10,268,725 RSD, as during that time the volume of work and the number of tourists from package sales increased. Current assets also show an increase to 4,509,381 RSD, indicating a rise in inventories, receivables, and cash. Considering that this growth includes inventory, a deeper analysis should be conducted, as long-term storage of inventory leads to a decline in quality and makes them unsellable. Short-term liabilities (liabilities to suppliers, wage liabilities, tax liabilities) gradually increase from 2,661,667 RSD in 2019 to 3,725,177 RSD in 2023, when they exceed liquid assets, thus the acid test is not respected. Long-term sources have small fluctuations during the observed period, and their value in 2023 amounts to 8,201,269 RSD. However, a deeper analysis needs to be conducted to see whether equity or long-term liabilities prevail in long-term sources. Fixed assets have a constant value and do not show significant fluctuations, as they are long-term tied to a predetermined rate of depreciation (Malinić et al., 2023). Total liabilities have increased from 6,892,857 RSD in 2019 to 7,728,865 RSD in 2023, so attention should be paid to the financial structure of the company when borrowing. Undistributed profit saw the largest decline in 2020, after which it gradually increased, reaching 2,036,515 RSD in 2023, meaning it is reinvested by being carried over into the accounting periods of the following years (Malinić, 2007). Profit before interest and taxes decreased from 936,685 RSD in 2019 to 566,775 RSD in 2020. However, in 2023, it rises to 1,329,878 RSD, which is a good

sign and an indication of value growth. Based on the analysis of the market value of the company's shares, this value has significantly decreased from 4,922,832 RSD in 2019 to 1,928,452 RSD in 2023, which is why a deeper investigation into the factors that led to this trend should be conducted. the cause may be the increase in total liabilities, as well as the gradual decline in net profit, which reaches its minimum in 2022, amounting to 21,969 rsd. table 4 presents the average values at the industry level - tourism.

Table 4. Average value by sector - tourism (in 000 RSD)

Balance sheet positions	2019.	2020.	2021.	2022.	2023.
Total assets	2,729,212	3,672,218	4,268,595	4,413,273	4,081,475
Net profit	55,013	-182,026	-630	169,112	183,959
Business income	549,594	354,140	831,313	1,183,754	1,136,814
Working capital	378,956	301,586	658,552	857,742	589,362
Supplies	31,992	58,253	145,455	113,260	110,174
Working capital - Inventory (liquid assets)	346,964	243,332	513,096	744,481	479,187
Short-term obligations	512,402	298,507	621,741	634,503	521,613
Long-term sources	2,217,393	3,414,557	3,619,039	3,744,161	2,740,869
Fixed assets	2,366,929	3,390,563	3,634,070	3,553,596	3,546,214
Total liabilities	1,980,534	2,387,942	2,420,942	2,197,178	2,066,988
Revenue from sales	480,943	215,255	768,004	1,092,735	936,513
Undistributed profit	434,625	-132,219	437,931	611,542	698,963
Earnings before interest and taxes	143,385	141,553	142,971	204,279	235,247
Market value of a company's shares	1,128,831	1,777,685	2,334,980	2,570,662	2,570,617

Source: Author's

In Table 4, the average total assets gradually increased over the observed period, from 2,729,212 RSD in 2019 to 4,081,475 RSD in 2023, which represents good performance for companies operating in tourism. Net profit, despite fluctuations during the observed period, rises from 55,013 RSD in 2019 to 183,959 RSD in 2023. Business revenues are increasing in value from 549,594 RSD in 2019 to 1,136,814 RSD in 2023. Current assets are increasing year by year, from 378,956 RSD in 2019 to 589,362 RSD in 2023, indicating growth in inventories, receivables, and cash. Fixed assets increased by 34%, total liabilities rose by 5%, sales revenue grew by 49%, earnings before interest and taxes increased by 40%, and the market value of the company's shares went up by 47%. These indicators are good signs and speak to a stable financial structure of the tourism company, skilled management, an increase in the market value of the company's shares, and a rise in revenue.

When comparing these two activities, the total assets of agricultural enterprises were greater than those of tourism enterprises by 8,301,686 RSD in 2019, and by 2023, that difference decreased to 7,522,021 RSD. The net profit of agricultural enterprises is higher than the net profit of tourism enterprises by 668,436 RSD in 2019, and by 389,690 RSD in 2023. The business revenues of agricultural enterprises were higher than those

of tourism enterprises by 6,936,766 RSD in 2019, and by 9,131,911 RSD in 2023. The working capital of agricultural enterprises is greater than that of tourism enterprises by 3,415,360 RSD in 2019, and in 2023, that difference amounts to 3,920,019 RSD. Short-term liabilities are higher for agricultural enterprises in 2019 by 2,149,265 RSD, and in 2023 by 3,203,564 RSD. Long-term sources do not show any significant fluctuations, so the difference in favor of agriculture in 2019 amounted to 6,033,564 RSD, while in 2023 it was 5,460,400 dinars. Fixed assets in agriculture increased by 4,827,623 RSD in 2019, and by 3,511,742 RSD in 2023. By comparing these activities, a noticeable increase in total liabilities is observed during the observed period, rising from 4,912,323 RSD in 2019 to 5,661,877 RSD in 2024. By comparing sales revenue, it is noticeable that the difference is decreasing, which was 691,121 RSD in 2019, and is now 92,846 RSD in 2023. By comparing the undistributed profits of these two activities, a reduction in the differences over the years is observed, as in 2019 it amounted to 1,589,373 RSD, while in 2023 it stands at 1,337,552 RSD in favor of the average in the agricultural sector. By comparing the movement of earnings before interest and taxes between these two sectors, it has been established that the average for agriculture is higher than that for tourism, with the difference amounting to 793,300 RSD in 2019 and 1,094,631 RSD in 2023. The comparison of the movement of the market value of company shares in 2019 indicates that agriculture had the advantage, with a difference of 3,794,001 RSD. However, in 2023, that difference favors tourism, amounting to 642,165 RSD. Below is a comparative tabular representation of the movement of average coefficients for agriculture and tourism over a five-year period (2019-2023).

Accordingly, Table 5 follows, which shows the average coefficients in agriculture.

Table 5. Ratio indicators in agriculture

Coefficients	2019.	2020.	2021.	2022.	2023.
Net profit margin	0.96635	0.07646	0.33983	0.00245	0.05586
Ratio accelerated liquidity	1.00228	0.81882	0.68719	0.53481	0.75498
Total asset turnover ratio	0.10625	0.10512	0.0793	0.10595	0.09699
Net working capital	1,056,404	565,899	753,513	164,629	1,143,913
Debt ratiO	0.62486	0.60405	0.81881	0.74652	0.66608
Solvency coefficient	1.60033	1.65548	1.22128	1.34116	1.50132

Source: Author's

Based on the presented table, it shows the movement of the average value of coefficients over the given time period for agricultural enterprises. The net profit margin used to determine the profitability of the company had its highest value in 2019, and in each subsequent year, it decreases with smaller fluctuations, indicating that the profitability of the company in that sector is also declining. The liquidity ratio reached its highest value in 2019, when it amounted to 1.00228, indicating that at that time, companies had the most liquid assets in their portfolio. The reduction of the accelerated liquidity ratio indicates a decrease in receivables and cash, which necessitates an analysis of the dynamics of short-term debt repayment. The total asset turnover ratio had its highest

value in 2019, when it amounted to 0.10625, and with gradual fluctuations, it decreased to 0.09699, indicating a negative trend in turnover reduction. Net working capital has the highest value in 2023, amounting to 1,143,913 RSD, which means that companies in agriculture have a stable financial structure, adhering to the golden balance sheet rule in a broader sense. This indicates that management is following a proper profit policy for the company. The leverage ratio analyzes the indebtedness of a company and reached its highest amount in 2020 at 1.65548, which means that during that period, total liabilities were the highest in relation to total assets. In the following period, it shows a gradual decline, which indicates a reduction in the tension of the financial structure and risks for creditors (Stančić, 2006). The solvency ratio reached its highest value in 2020, amounting to 1.65548, which means that the companies operating in that sector were the healthiest during that period and capable of settling all due obligations on time.

Table 6. Ratio indicators in tourism

Coefficients	2019.	2020.	2021.	2022.	2023.
Net profit margin	0.10009	-0.51399	-0.00075	0.14286	0.16182
Ratio accelerated liquidity	0.67713	0.81516	0.82525	1.17333	0.91866
Total asset turnover ratio	0.35033	0.06924	0.24289	0.23914	0.20619
Net working capital	-149,536	23,994	-15,031	190,565	-805,345
Debt ratio	0.72568	0.65027	0.56715	0.49786	0.50643
Solvency coefficient	1.37802	1.53782	1.76319	2.00861	1.97460

Source: Author's

Table 6 shows the movement of indicators over the given time period for tourism companies. The net profit margin is the highest in 2023, with a value of 0.16182, indicating that the profitability of the company is increasing year by year and represents the most important measure of investment security for long-term creditors (Malinić, 2007). The liquidity coverage ratio has its highest value in 2022, when it amounts to 1.17333. However, in 2023, it is declining, which indicates that the amount of short-term liabilities is increasing, and thus the risk as well. The total asset turnover ratio reached its highest value in 2019, amounting to 0.35033, indicating that in that year, the average business assets were utilized the most. However, in the following years, this turnover declined, suggesting a decrease in the efficiency of total asset utilization (Stančić, 2006). Net working capital has the highest value in 2023, amounting to 190,565 RSD. However, in 2023, it suddenly drops to -805,345 RSD. This confirms that companies have a poorer financial structure, as there are not enough long-term resources to finance net working capital. The ratio reached its highest value in 2019, amounting to 0.72568, and subsequently declines in later periods, meaning that liabilities in relation to total assets are also decreasing, which is in accordance with the principle of maintaining invested capital (Malinić, 2007). The solvency ratio gradually increases and reaches its maximum amount in 2022, when it stands at 2.00861. Considering that the solvency ratio has been greater than 1 in all time periods, this means that companies in the tourism sector operate at an average level and possess long-term financial stability. Below is a graphical representation of the movement of the net profit rate.

Figure 1. Comparative movement of the net profit rates of tourism and agriculture
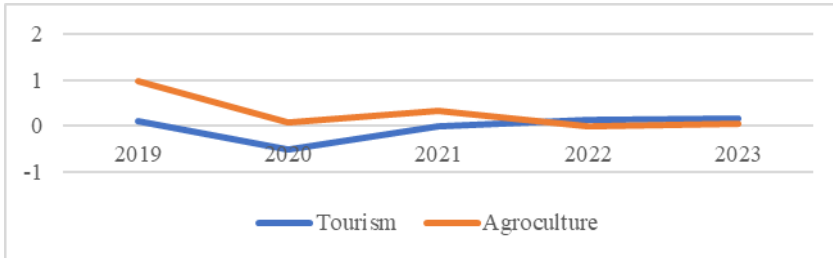
Source: Author's

As can be seen from Figure 1, the movement of the net profit rate in the agriculture sector up to mid-2022 is favorable for agriculture. However, since 2022, that rate has gradually declined below the average tourism rate. When comparing coefficients, tourism has a lower net profit margin in the first three years, which amounts to -0.51399 (2019) and -0.00075 (2021). In the next two years (2022 and 2023), it shows a slight increase to 0.14286 and 0.16182 respectively, and in those years, it has a higher amount than the agricultural coefficient, which amounts to 0.00245 and 0.05586. This means that tourism businesses are achieving higher revenue growth from sales, which allows them to more easily cope with the burden of debt. Below is a Figure of the accelerated liquidity ratio.

Figure 2. Comparative movement of the accelerated liquidity ratio of tourism and agriculture
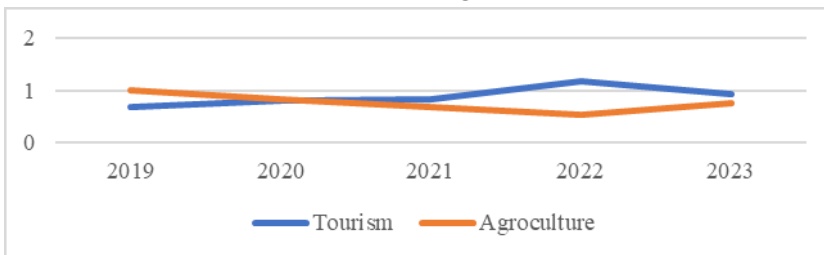
Source: Author's creation

Figure 2 shows that the average liquidity in agriculture declines until mid-2021, falling below the quick liquidity ratio of tourism. Since 2022, it has shown a gradual increase, but it is still lower than the accelerated liquidity ratio of tourism. When it comes to tourism, the liquidity ratio shows a gradual increase from 0.67713 in 2019 to 0.91866 in 2023. In agriculture, the liquidity ratio gradually decreases from 1.002288 to 0.53481 in 2022 and then rises again to 0.75498 in 2023. The biggest difference occurs in 2022, when the accelerated liquidity ratio in tourism is 1.17333, while in agriculture it is 0.53481. This indicates that the structure of working capital and the maturity periods of short-term liabilities should be reconsidered for agricultural enterprises.

Figure 3. Comparative movement of the total asset turnover ratio in tourism and agriculture
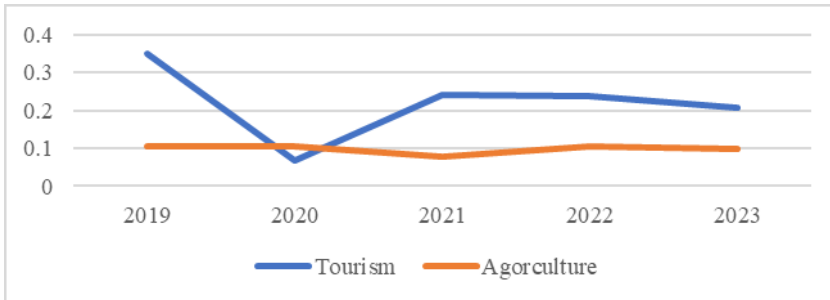
Source: Author's

Figure 3 presents the parallel movement of the total asset turnover ratio at the agricultural level, which generally maintains a constant value without significant fluctuations. However, its value is lower than the value of the total asset turnover ratio in tourism. The turnover ratio of total assets in tourism shows a higher amount in all years compared to agriculture. This coefficient saw a drastic drop in 2020 (0.06924) during the coronavirus pandemic, which led to a decrease in the sales of tourist packages and had a significant impact on the tourism sector.

Figure 4. Comparative movement of net working capital in tourism and agriculture
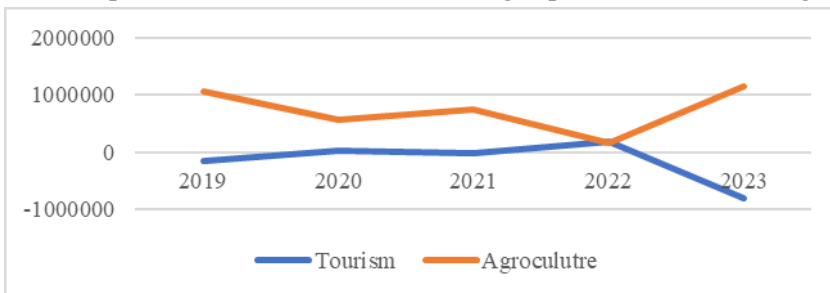
Source: Author's

Based on Figure 4, the movement of net working capital in agriculture is higher than that of net working capital in tourism. However, this value declines in 2022 and reaches a lower level in relation to tourism. When it comes to tourism, the lowest amount of net working capital in 2023 was recorded, as it had a negative value of -805.345 RSD, while in agriculture, net working capital saw significant growth in 2023, amounting to 1.143.913 RSD. This indicates the stability of the financial structure and confirms the coverage of net working assets by long-term sources.

Figure 5. Comparative movement of the debt ratio of tourism and agriculture
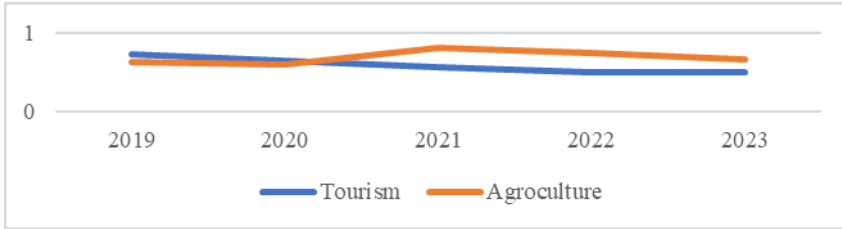
Source: Author's

Graph 5 shows the movement of the debt ratio in agriculture, which is slightly lower compared to tourism until mid-2021, when it reached a higher, but not enviable level, while in 2023 it shows a gradual decline. The ratio of these two activities is quite balanced. However, the biggest difference between them is in the year 2021, when in tourism it amounts to 0.56715, while in agriculture it is 0.81881. In 2023, their values are once again converging. Since the ratio has been less than 1 for both activities all the time, it means that assets are still greater than liabilities, indicating a good financial structure of the company. However, one should be cautious regarding borrowing capacity.

Figure 6. Movement of the solvency coefficient in tourism and agriculture
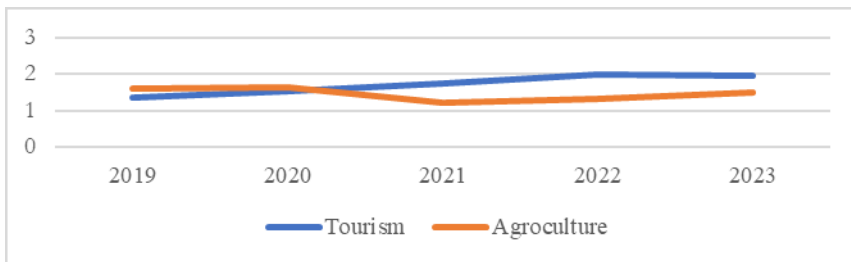
Source: Author's

Based on Figure 6, it is clear that the movement of the solvency ratio in agriculture declines until 2020, and this decline continues as the curve moves below the tourism curve. The movement of the tourism solvency coefficient shown in the observed years increases from 1.37802 in 2019 to 1.9746 in 2023. In agricultural activities, this coefficient initially shows a slight increase to 1.65548 in 2020, and then it sharply declines to 1.22128 in 2021, after which it begins to gradually rise, but it does not reach the value of the solvency coefficient in tourism. This indicates that businesses in tourism are less exposed to the risk of insolvency and have more available cash to meet their due obligations.

In the following section, the authors will present an analysis using Altman's Z-scoring model, which serves as an indicator for determining the risk of bankruptcy for companies in the next two years (Mirković, 2013). The value of the Z-score model is calculated using a linear combination of a greater number of financial indicators of liquidity, solvency, profitability, leverage, and activity weighted by coefficients. These indicators are relevant for assessing the financial performance of a company, determining the level

of risk, and providing warnings about the likelihood of the company's insolvency. The paper will conduct a comparative analysis of the original Altman Z-score model and the adjusted Altman Z'-score model (for emerging markets) on companies operating in the agricultural and tourism sectors in the Serbian economy. The values of the Z-score model have been calculated in the presented tables, based on which a comparison of the observed activities has been made. It should be noted that the higher the Z-score value, the less exposed an average company in each of these sectors is to the risk of bankruptcy.

Table 7. The value of variables in the Z-score model in agriculture

Variables	2019.	2020.	2021.	2022.	2023.
X_1	0.09576	0.05004	0.08124	0.01517	0.095858
X_2	0.18348	0.15031	0.19469	0.20159	0.17551
X_3	0.08491	0.08959	0.06111	0.05911	0.11461
X_4	0.71419	0.35694	0.24035	0.22358	0.24951
X_5	0.10625	0.09866	0.09075	0.10359	0.08871
Z	1.18668	0.87850	0.80659	0.73235	0.98074
Z`	5.79692	5.04520	5.08068	4.63867	5.50104

Source: Author's

The table presents the movement of the values of the Altman Z-score model (initial and adjusted) for agricultural enterprises over a five-year period. The liquidity coefficient X1 shows that it fell to 0.05004 in 2020, after which it gradually increased to 0.095858 in 2023. Since this ratio continues to remain below 1, it can be interpreted as a weak financial structure of the company in this industry. The profitability coefficient X2 reaches its maximum in 2022 when it amounts to 0.20159. However, in 2023, it drops to 0.17551, indicating that there is a low net asset growth and raising questions about whether companies can finance their needs from retained earnings. The efficiency indicator X3 shows a gradual decline to 0.05911 in 2022, followed by an increase to 0.24951 in 2023, indicating that earnings before interest and taxes are growing faster than total assets, which means that the financial strength of the company in this sector is increasing. The total asset turnover ratio X5 shows a gradual decline from 0.10625 to 0.08871 in 2023, indicating a decrease in sales relative to total assets and, consequently, lower liquidity, solvency, and profitability.

The analysis presents the obtained results of the Z-score in the observed time intervals. In 2019, the Z-score in agriculture is 1.18668, indicating that this sector is in a high-risk zone (red zone) since the Z-score is below 1.81. In the coming years, this coefficient continues to remain below the threshold value, indicating that agriculture remains in the high-risk zone (red zone). When applying the initial Altman Z`-score model, the results show that the Z`-score values range from 3.75 to 5.85 in the observed years, indicating that agriculture is in the moderate risk zone (gray zone). Since the threshold values of these two models are different, the question of which model to apply in the analysis depends on whether it is a highly developed economy or an emerging economy. Based on this analysis, a graphical representation of the initial Z-score and the adjusted Z'-score model follows.

Figure 7. Movement of Z-score and Z' score values in agriculture
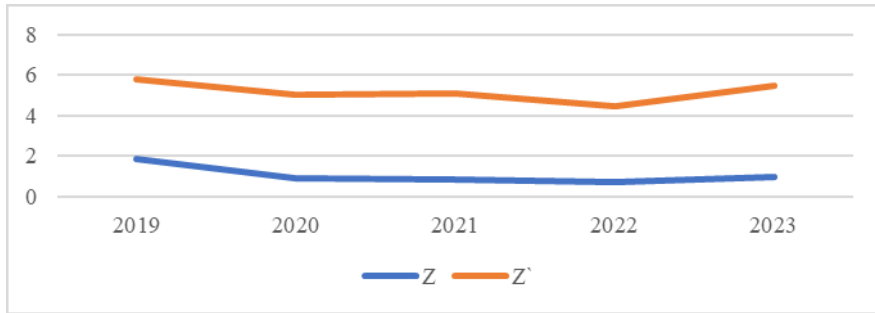
Source: Author's

Figure 7 shows the movement of these two coefficients, with the Z-score consistently remaining in a lower range compared to the Z'-score, as its boundary values are also lower. Both coefficients show small oscillations in the same direction in their movement while maintaining their constant value. Table 8 shows the values of the variables in the Z-score model for tourism.

Table 8. The value of variables in the Z-score model in tourism

Variables	2019.	2020.	2021.	2022.	2023.
X_1	-0.05479	0.00653	-0.00352	0.04318	-0.19732
X_2	0.15924	-0.03601	0.10259	0.13857	0.17125
X_3	0.05253	0.03855	0.03349	0.04629	0.05764
X_4	0.56996	0.74444	0.96449	1.16998	1.24365
X_5	0.17622	0.05862	0.17992	0.2476	0.22945
Z	0.84646	0.5894	1.00671	1.34611	1.16456
Z'	4.36123	4.21619	4.79915	5.52453	4.20704

Source: Author's

The table shows the movement of the initial Z-score model values for tourism over a five-year period. The liquidity coefficient X1 is the lowest in 2019, when it amounts to -0.05479, and with slight fluctuations, it remains negative in 2023, when it stands at -0.19732, indicating that there are low investments in current assets. The profitability coefficient X2 had its lowest value in 2020, at -0.03601, and has been gradually increasing since then, reaching a value of 0.17125 in 2023. This indicates an annual growth in assets, as well as an increase in retained earnings. The efficiency indicator X3 shows slight fluctuations in its movement, with a value of 0.05253 in 2019, and a similar value of 0.05764 in 2023. This indicates that earnings before interest and taxes are growing more slowly compared to total assets. Therefore, it is necessary to determine whether to take measures for more efficient cost management or to increase prices and the volume of services. The total asset turnover ratio X5 had its lowest value in 2020, amounting to 0.05862, while the highest value was recorded in 2023 at 0.22945, due to an increase in sales relative to total assets.

The results obtained from the initial Altman Z-score model during the observed period show that the Z-score value in 2019 is below the threshold of 1.81, standing at 0.84646, which means that tourism is in the high-risk zone (red zone). In all the following years, high-risk business operations continue as the Z-scoring values remain below 1.81. When applying the business performance assessment in the sector according to the modified Z`-model, it is observed that the average values of Z` range from 3.75 to 5.85, indicating that tourism is in the moderate risk zone (gray zone). In Graph 8, a comparative representation of the movement of the values of the Z-score and Z'-model for tourism is presented.

Figure 8. Movement of Z-score and Z' score in tourism
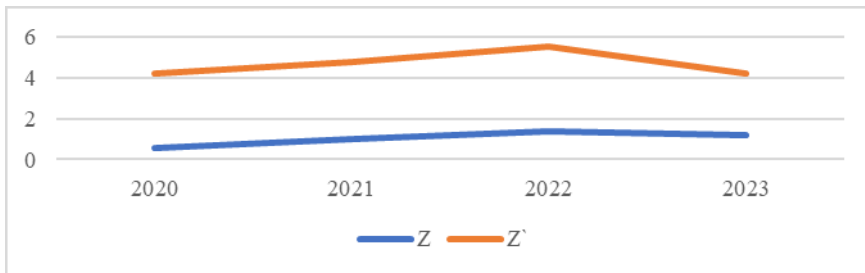
Source: Author's

In Figure 8, a parallel increase in the values of the Z-score and Z'-score in tourism can be observed up to the year 2022. In that year, these values reach their peak, after which they begin to decline, with the Z-score in tourism having a steeper slope, and consequently a greater decrease in values.

Conclusions

Based on the research conducted, it can be concluded that agricultural enterprises have stronger financial performance compared to tourism enterprises, which can be confirmed by their achieved final results in 2023. This is supported by the fact that at the average level, total assets are higher by 7,522,021 RSD, net profit by 389,690 RSD, business income by 9,131,911 RSD, long-term sources by 5,460,400 RSD and retained earnings by 1,337,552 RSD. This indicates that agricultural activity has much greater financial potential and impact on the economic development of the economy of the Republic of Serbia. In the following, the authors delve deeper into this financial analysis, supporting it with ratio indicators based on which they obtained their results. The final results obtained in 2023 indicate that the rate of net profit gradually decreases in the agricultural activity to 0.0024, while in tourism there is a slight increase to 0.0558. This means that certain measures should be taken in agriculture in order to reduce accumulated costs, non-current inventory and liabilities. The coefficient of turnover of total assets has been higher in tourism in the last three years than in agriculture, so that in 2023 it is 0.20619, and in agriculture 0.09699. This indicates that the invested assets are not being used efficiently enough in agriculture. Net working capital in agriculture in the last observed year of 2023 at the average level is 1,143,913 RSD, while in tourism

it is 805,345 RSD. Considering that this coefficient is drastically higher in agriculture than in tourism, it is a sign of a stronger financial structure in agricultural companies. However, it should be kept in mind that these are different types of business activities, as tourism is primarily concerned with selling services, which is why there is no need for a significant amount of net working capital. The debt ratio (leverage), which shows the relationship between liabilities and assets, is less than 1 in both industries, which is not a good sign because it calls into question the payment of liabilities. Namely, at the end of 2023, this coefficient in tourism is 0.50643, while in agriculture it is 0.66608. However, the solvency ratio, which evaluates liquidity in the long term in the last year of 2023, is 1.9746 in tourism and 1.5013 in agriculture. Given that this coefficient is greater than 1 on average in both observed branches, it shows their long-term financial stability in business.

By comparing the obtained results of the initial Altman Z-score model, agriculture and tourism are in the high risk zone (red zone), because their coefficients are lower than the limit value of 1.81 and in the final year of 2023, they amount to 0.98074 (agriculture) and 1.6456 (tourism). However, using the corrected Altman Z'-score model, the observed activities are in the zone of moderate risk (gray zone) in the same time interval, so that in the last observed year 2023, they amount to 5.50104 (agriculture) and 4.20704 (tourism). Since there are different boundary values for these two models, which model to apply in the analysis depends on whether it is a highly developed economy or a developing country. For Serbia, it is a better solution to apply Altman's corrected Z`-score model, because it is adapted to developing countries.

Based on that research, the authors believe the hypotheses they proposed have been proven. The results obtained at the average level over the observed five-year period (2019-2023) will be presented below. First, the basic hypothesis H_0, which is based on the claim that the strategic approach to assessing the efficiency of agriculture and tourism determines their impact on the development of the economy of the Republic of Serbia, is supported. This has been proven based on research conducted in which a quantitative evaluation of the financial performance of agricultural activities and tourism was carried out. Accordingly, there was an increase in the average value in agricultural activity and tourism when observing the movement of net assets by 572,598 RSD (agriculture) and 1,352,263 RSD (tourism), business income by 2,782,365 RSD (agriculture) and 587,220 RSD (tourism), and retained earnings by 12,517 RSD (agriculture) and 264,338 RSD (tourism). However, the average value of long-term sources decreased by 49,688 RSD in agriculture, while it increased by 523,476 RSD in tourism. Based on this, a deeper analysis of the financial statements should be conducted to determine whether equity or long-term liabilities predominate in the structure.

Next, hypothesis H_1, which is based on the use of profitability, liquidity, total asset turnover, net working capital, leverage, and solvency analysis, was proven using concrete financial data from agricultural and tourism companies. In the following, the authors will provide the average movement amounts of the coefficients for the observed five-year period (2019-2023). Profitability is shown using the net profit rate, which

in agricultural activity decreases by 0.91049, and in tourism it increases by 0.06173. Liquidity is shown based on the quick ratio, which decreased by 0.2453 in agriculture and increased by 0.24153 in tourism. The total asset turnover was determined based on the total asset turnover ratio, which decreased by 0.96551 and 0.14414 in agricultural activities and tourism, respectively. The movement of net working capital in agricultural activity shows an average increase of 87,509 RSD, while the flow in tourism decreases by 655,809 RSD. When it comes to changes in the level of indebtedness, it is determined based on debt ratios, which increase by 0.04122 and 0.21925 respectively in the agricultural and tourism sectors. Solvency analysis indicates that the solvency ratio in agriculture decreases by 0.09901, while in tourism it increases by 0.5964. Based on the indicators presented, the authors conclude that tourism performs better in terms of profitability and liquidity trends, while agriculture has a higher amount of net working capital, higher asset turnover (although there is a decline in both sectors), and a lower level of indebtedness

Finally, hypothesis H_2, which refers to the application of Altman's initial Z-score model and the corrected Altman's Z'-score model for determining bankruptcy risk, established the extent to which companies at the industry level are exposed to this risk, thus confirming the hypothesis. The results obtained using Altman's Z-score model indicate that the value of Altman's Z-score model decreases in both agriculture by 0.88606 and tourism by 0.29588. However, the results based on Altman's modified Z-score model, which is applicable to developing economies, show that the Z-score value increases in agriculture by 0.3181 and in tourism by 0.15419. Based on a deeper analysis of Altman's Z-score model, the Z-score value is higher in the first three years in agriculture and lower in the last two years compared to tourism. When it comes to the movement of the value of Altman's Z'-score model, in the first three years the Z'-score value is also higher in agriculture, while in 2022 it decreases annually. Furthermore, in 2023 the Z-score value for agriculture is in the safe (green) zone, while the Z-score value for tourism is in the moderate risk zone (gray zone). This indicates that the values of the variables in Altman's Z-score model adjusted for tourism need to be studied more deeply in order to be in the safe (green) zone.

The authors conclude that, although agricultural enterprises have a greater market potential, the presented activities together impact the economy of the Republic of Serbia, which can be supported by the results obtained from the analysis of ratio indicators and the Altman Z-score and Z'-score models. These activities complement each other when it comes to their impact on economic growth and development, as in those parts of the analysis where the results are around critical values for one activity, the other activity neutralizes this with its indicators, and together they influence the development of the Serbian economy. The contribution of the research is reflected in its ability to assess the current performance of companies, predict their future performance, and facilitate comparisons among them. The implication of this analysis is reflected in its expansion to comparisons between companies in different economic sectors (industry, construction, trade, etc.) in order to determine the efficiency of their operations and, based on that, to ascertain the impact of a specific

economic activity on the economy. In the end, the research can be applied in the strategic assessment of macroeconomic data between individual economies, in order to determine the level of success and the achievement of set goals over a specific period of time.

Conflict of interests

The authors declare no conflict of interest.

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RECONCILIATION OF AMOUNTS IN BUDGET EXECUTION REPORTS AND FINANCIAL STATEMENTS USING THE EXAMPLE OF THE UNITED NATIONS' FOOD AND AGRICULTURE ORGANIZATION (FAO)

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A B S T R A C T

Budget execution reports and financial statements have a complementary function, but present different data on revenues, expenditures and liabilities. In order to make the differences between these reports clearer, the International Public Sector Accounting Standards (IPSAS) require reconciliation of actual amounts from budget execution reports with data in financial statements. This paper analyzes how different entities approach this reconciliation process, which makes comparisons difficult. The paper points to the need for more detailed guidance to increase comparability between these reports. An analysis of available financial statements of international organizations in the public sector, prepared in accordance with IPSAS, has identified differences in practices and insufficient explanations of these differences. Particular emphasis will be placed on the interpretation of the financial report of the UN Food and Agriculture Organization (FAO). The purpose of such measures is to strengthen transparency and ensure greater comparability of public sector financial reports, which contributes to greater credibility of financial reporting in this sector.

Introduction

One of the distinctive aspects of public sector accounting is the disclosure of budget information in financial reports, since the budget execution report is primarily intended for the general public. The budget is a key instrument in overseeing public organizations,

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with legislatures worldwide often focusing more on budgetary allocations than on the actual financial reports. While budget execution reporting has been established for a long time, the use of financial reports in the public sector was adopted at a later stage. IPSAS 24, issued by the International Public Sector Accounting Standards Board (IPSASB) in 2006, establishes guidelines for presenting budget-related information within financial reports. This standard is relevant for entities that compile their financial reports following the guidelines set by IPSASB and include budget information in public reports. However, the IPSASB does not assume responsibility for the process of planning, programming and executing the budget, as this is outside its remit. Researchers, economists, and standard setters continue to discuss whether the principles of budgeting and accounting should be aligned. There are two dominant approaches: one advocates applying the accrual basis to both systems, while the other supports maintaining cash-based budgeting, even when accounting is conducted on an accrual basis. In practice, most countries use a combination of accrual accounting and cash budgeting, which requires a reconciliation process between the two systems. Reconciliation allows financial statement users, researchers, and standard setters to identify and compare the discrepancies between budgeting and accounting practices, both across different organizations and through different time periods. The standards mandate that the actual figures reported during budget execution (management accounting) be reconciled with the financial position statement or statement of cash flows (financial accounting), especially when this information is not prepared on the same basis.

The primary purpose of reconciliation is to clarify the discrepancies between budgetary and accounting information, enabling users of financial reports to comprehend the underlying causes of these differences. In the absence of such a process, the distinctions between budgeted and accrued revenues and expenditures, as well as between cash inflows and outflows, may not be clearly understood. Reconciliation also contributes to the credibility and consistency of financial statements, providing useful data control. This study investigates a central research question: to what extent does the implementation of IPSAS 24 facilitate the proper reconciliation between budget execution reports and statements of financial position? If not, how should the reconciliation be designed so that the differences are presented clearly and comparably? The answers to this question are of importance to the application of the standard, preparers of financial statements and researchers. Authors such as Bellanca (2014) and Adam (2018) emphasize the importance of comparability of financial statements prepared under IPSAS, which is also important for the development of European Public Sector Accounting Standards (EPSAs).

A significant portion of existing research has concentrated on national and subnational government levels, while research on budget and accounting reconciliation in intergovernmental organizations is rare. This paper addresses this aspect, using examples from previous research, including Bergman (2010), Bergman & Fuchs (2017) and Mattei et al. (2020). The paper differs from research that has analyzed the reconciliation of accounting and statistics, such as those by authors such as Jones (2003) and Caruana

(2016), because it focuses on the differences between budgeting and accounting. The research aims to enhance the comprehension, clarity, and reliability of public sector financial reporting, thereby supporting the development of accounting standards and facilitating the international comparability of financial reports.

Methodological approach

This research applied the methodology of analyzing the financial statements of 44 intergovernmental organizations that prepared reports consistent with the International Public Sector Accounting Standards (IPSAS). The organizations included in the analysis are listed in Table 1, and the criterion for their selection was the accessibility of financial reports that are compiled using the accrual accounting method. Of the total number of financial statements analyzed, the majority (95%) refer to 2019, while the remaining refer to 2018 (2%) and 2017 (2%). This distribution indicates that the focus of the research was mainly on the most recent data available at the time of the study.

Table 1. List of intergovernmental organizations that participated in the research

No.	Name of organization	No.	Name of organization
1.	European Organization for Nuclear Research (CERN)	23.	United Nations Development Programme (UNDP)
2.	European Union (EU)	24.	United Nations Environment Programme (UNEP)
3.	International Residual Mechanism for Criminal Tribunals	25.	United Nations Educational, Scientific and Cultural Organization (UNESCO)
4.	EU Agency for Law Enforcement Cooperation (Europol)	26.	United Nations Population Fund (UNFPA)
5.	**Food and Agriculture Organization of the UN (FAO)**	27.	UN Human Settlements Programme (UN-Habitat)
6.	International Atomic Energy Agency (IAEA)	28.	UN High Commissioner for Refugees - UNHCR
7.	International Civil Aviation Organization (ICAO)	29.	United Nations Children's Fund (UNICEF)
8.	International Criminal Court (ICC)	30.	UN Industrial Development Organization (UNIDO)
9.	International Labour Organization (ILO)	31.	European Union Intellectual Property Office (EUIPO)
10.	*International Maritime Organization (IMO)*	32.	UN Institute for Training and Research (UNITAR)
11.	Inter Parliamentary Union (IPU)	33.	United Nations Joint Staff Pension Fund (UNJSPF)
12.	International Organization for Migration (IOM)	34.	United Nations Office on Drugs and Crime (UNODC)
13.	International Renewable Energy Agency (IRENA)	35.	United Nations Office for Project Services (UNOPS)
14.	International Trade Centre (ITC)	36.	United Nations University (UNU)

No.	Name of organization	No.	Name of organization
15.	International nuclear fusion research and engineering megaproject (ITER)	37.	United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA)
16.	International Telecommunication Union (ITU)	38.	UN Women
17.	Allied Command Operations (ACO)	39.	UN Tourism
18.	Office of Public Counsel for the Victims (OPCV)	40.	Universal Postal Union (UPU)
19.	Organization for Security and Cooperation in Europe (OSCE)	41.	World Food Programme (WFP)
20.	Pan American Health Organization (PAHO)	42.	World Health Organization (WHO)
21.	United Nations (UN)	43.	World Intellectual Property Organization (WIPO)
22.	Joint United Nations Programme on HIV/AIDS (UNAIDS)	44.	World Meteorological Organization (WMO)

Source: Prepared by the author

Of the 44 organisations analysed, the majority (41 organisations, or 93%) state in the notes to their financial reports indicate that the accounts have been prepared following the requirements of IPSAS. Three organisations (7%) – the European Union (EU), EUIPO and Europol – state that the accounts are prepared in accordance using "accounting guidelines derived from IPSAS". Beginning in 2018, the European Commissioner for Budget and Human Resources has indicated in the preface to the financial statements that the European Union's consolidated annual accounts are prepared in line with IPSAS standards.

Auditors' assessments confirm the high level of credibility of the financial statements. Out of the 44 reports, 42 (95%) have an unqualified opinion, while two (4%) have qualifications not related to budgetary information. Courts of Auditors or Auditors General of the Member States issued opinions on 38 reports, international auditors on five, and one report was conducted by an independent auditing company. The study examined key challenges in presenting budgetary information within financial reports, emphasizing the inconsistencies that hinder comparability between different organizations. Key aspects of budgeting and accounting reconciliation were examined, and the initial review of financial reports revealed significant issues, especially concerning:

– Settling balances – including budgeted revenues, expenditures, or surpluses/deficits, with actual accounting figures or cash flow reports,

– Reconciling items – which affect the understanding and design of the reconciliation process.

The impact of these issues on reconciliation was considered in the context of the requirements of IPSAS 24, which are discussed more thoroughly in the following chapter of this paper. Examples of inconsistencies and problems with comparability of financial statements were analyzed, investigating whether these problems were the result of:

– Insufficiently defined options within IPSAS, or

– Inconsistencies in the application of the standard.

These issues are key to understanding the challenges in ensuring transparency and comparability of budget and accounting data in financial reports, which forms the foundation for the subsequent development and alignment of standards.

Research results

Compliance with IPSAS 24 requirements

An analysis was conducted on the reconciliation between the figures presented in the budget execution report and those in the financial statements, in accordance with IPSAS 24, which prescribes the principles for disclosing budgetary information in financial reports. This study focuses on the principal elements outlined in IPSAS 24 requirements:

Analyzing the differences between budgeted and actual figures

According to IPSAS 24 (paragraphs 14, 21, and 31), financial reports prepared under its standards are required to present a comparison between the original budget, any revised budget, and the actual amounts achieved. The purpose of this comparison is to offer financial reports users a precise understanding of the differences between budgeted and actual outcomes, thus enhancing transparency and accountability within the public sector. Key requirements for comparison:

– Same accounting basis - Comparisons should be conducted using the same accounting method applied in the preparation of the budget, whether it is cash-based, accrual-based, liability-based, or any other method particular to the organization.

– Same classification basis - Both budgeted and actual figures should be organized according to the same classification scheme. For example, the classification may be economic (revenue and expenditure by type), functional (by sector such as health, education) or programmatic (by specific projects or programmes).

– Same entity and period - The comparison should involve the same type of entity (such as central or local government, or another public organization) and pertain to the same time frame (e.g., calendar year or fiscal year).

According to IPSAS 24, financial reports may present comparisons between budgeted and actual figures using two distinct approaches:

– A distinct report outlining the comparison between budgeted figures and actual expenditures - This is the most commonly used approach and allows a clear separation of budget information from other financial statements.

– A supplementary column included in the financial reports - This option can be applied only when both the budget execution report and the financial statement are prepared in a fully consistent manner, meaning they follow the same accounting principles and classification structure.

The application of these requirements allows users of financial statements (parliaments, auditors, researchers and citizens) to analyze differences between budget plans and actual results. This plays a key role in evaluating how effectively public resources are managed, detecting discrepancies, and enhancing accountability within the public sector.

According to research (Savić et al., 2023), many organizations still face challenges in reconciling budget and actual amounts, especially in cases where they use different accounting bases. These differences further highlight the importance of consistent application of IPSAS 24 and providing clear guidance for better understanding and comparability of budget data.

Examining the discrepancies between budgeted projections and actual outcomes

According to paragraph 14(c) of IPSAS 24, entities are obliged to report and provide explanations for significant variances between the budgeted figures and the actual outcomes, provided that the comparison is made on a comparable basis. These explanations provide context for the differences, helping users of financial statements to understand the reasons why planned budgeted amounts differ from actual results. Key components of the requirement (Zupur & Janjetović, 2023):

– Material differences - Material differences are those differences between budgeted and actual amounts that are significant enough to influence the decisions or estimates of users of financial statements. Such differences may include unforeseen expenses, uncollected revenues, changes in the economic environment or extraordinary circumstances.

– Form of disclosure - Variations can be clarified within the financial reports themselves, often through the accompanying notes that provide additional detail on the figures. Alternatively, the disclosure may be presented in another document accompanying the financial reports, as long as the notes explicitly direct users to that document.

– Comparable basis - Differences should be examined using the same accounting methods, classifications, time frames, and entity parameters as those employed in the comparison between budgeted and actual figures.

The primary aim of this disclosure is to provide financial statement users with insights into the nature and underlying reasons for the observed variances, assess budgetary discipline and efficiency in resource management, and gain insight into the factors that influenced budget execution. The explanation of material variances increases the transparency and credibility of financial reporting. It provides users (parliaments, auditors, citizens, and researchers) with relevant information which can support informed decision-making and enhance the administration of public resources. Research shows that one of the most common challenges in this process is insufficiently detailed explanation of variances. This complicates users' ability to completely comprehend the underlying causes of the variances. Enhancing the uniformity and standard of disclosures in line with IPSAS 24 requirements represents a key measure for fostering greater transparency and accountability within the public sector.

Explanation of the differences between the initial and final budget

The third requirement of IPSAS 24 (paragraph 29) requires an entity to explain differences between the original and final budgets. It is also necessary to state whether these differences are the result of reallocations within the budget or are caused by other factors (Zdravković et al., 2024). Without this explanation, the value of comparisons between budget plans and actual amounts may be limited, particularly in cases when the organization adjusts its budget within the fiscal year to better reflect actual projections.

Publication of the budget base, period and scope

The fourth requirement of IPSAS 24 concerns the required disclosures related to the budget, including the budget basis (paragraph 39), the classification basis (paragraph 39), the period (paragraph 43) and the entities included in the adopted budget (paragraph 45). The budget basis refers to the accounting basis used for the budget, which may be accrual, cash or some other basis adopted by the legislature (IPSAS 24, paragraph 7). An example of a classification approach could be an "economic classification following the GFSM 2014 framework" or a "functional classification based on COFOG" (IMF, 2014).

Aligning actual figures on a consistent basis with the amounts presented in the financial report

Entities that fail to prepare their financial statements and budgets on a comparable basis are the only ones to which the fifth requirement applies. Entities are required to present in their financial reports a reconciliation that links the actual amounts prepared on a comparable basis with those reported in the financial statements. Table 2 provides an overview of the reconciliation requirements under paragraph 47 of IPSAS 24.

Table 2. Requirements for compliance under paragraph 47 of IPSAS 24

Preparing financial statements and the budget on a comparable basis implies applying the same accounting framework, identical classification criteria, an identical scope of entities, and the same reporting period as defined in the approved budget. In this case, the financial statements and budget are reconciled and can be directly compared, which allows for easier monitoring and analysis of differences between planned and actual amounts.	The circumstances necessary for reconciliation are absent.
If the budget is formulated according to the accrual principle.	The budgetary framework needs to be aligned with: – Overall income and expenditures – This means that actual revenues and expenses must be compared with planned budget income and expenditures, for the purpose of show the differences and select the appropriate procedures for further analysis. – Net movements of cash arising from operations, investments, and financing transactions – Reconciliation is also done with actual cash flows coming from different areas of the business. This step assists in understanding actual cash inflows and outflows compared to budget plans. These reconciliations allow for better analysis and control of budget reality compared to actual flows.
If a different basis from accrual accounting is chosen for the budget.	The budget must align with the net cash flows generated through operating, investing, and financing activities. This means that actual financial inflows originating from various activities must be brought into agreement with budget plans to provide an accurate picture of how actual cash flows match budget forecasts. This process helps assess the accuracy of budget forecasts in terms of cash flows and allows for the identification of potential variances or the need for adjustments.

Source: paragraph 47 of IPSAS 24

When the budget is prepared on an accrual basis, IPSAS 24 mandates reconciliation of the budgeted figures with total revenue and expenditure, but it does not necessitate reconciliation with the accounting surplus or deficit. This approach diverges from the stipulations of IPSAS 1 (Presentation of Financial Statements), which does not mandate the disclosure of total costs. Conversely, IPSAS 24 requires matching of accounts n of the actual budget amount with net cash flows but does not necessitate matching of accounts with overall inflows and outflows. This aligns with IPSAS 1 and 2, as neither standard obliges the reporting of overall inflows and outflows. According to IPSAS on a cash flow basis (IPSASB, 2017), actual budget amounts should be reconciled to total receipts and payments. This study aims to matching of accounts, according

to the IPSASB, is "to enable an entity to better and more responsibly discharge its obligations by identifying the main sources of differences between actual amounts on a budget basis and the amounts recognized in the financial statements" (IPSAS 24, paragraph 49) and "to enable users to identify the relationship between the budget and the financial statements" (IPSAS 24, paragraph 17).

Aligning the figures reported in the budget with those recorded in the accounting records or reflected in the financial statements

Under IPSAS, entities are required to match the actual amounts reported on a budget-comparable format with overall cash movement, but does not clarify which specific amounts should be reconciled. The standard, while accommodating different budget formats, refers only to "the main totals presented in the budget statement and the actual comparison" (paragraph 51). It also highlights that "this standard does not preclude the reconciliation of each main total and subtotal, or each group of items, presented in the comparison of budget and actual amounts to the equivalent amounts in the financial statements" (paragraph 49). Understanding the concept of "real figures shown in a manner comparable to the budget" varied among the financial statements reviewed. These amounts were either budgeted expenditure/receipts only or budgeted surplus/deficit (Vladisavljević et al., 2023). Organizations that present financial statements in accordance with IPSAS should provide a clear definition of 'expenditure,' since the term is not a standard accounting concept and is not explicitly defined within IPSAS. GFSM 2014 (IMF, 2014) defines expenditure for statistical purposes as "total costs and net investments in non-financial assets".

All the reports reviewed include a section comparing planned financial figures with the amounts actually reported. Table 3 presents these comparisons by category, based on the selected sample. Among the 44 international organizations examined, nine prepare two separate comparisons, while three provide comparisons that do not fit into any predefined category (see Table 3). In total, 51 comparisons were evaluated. Some show the alignment of planned figures with actual cash movements in accordance with the relevant standard, others with actual income and expenditures, and a few present both approaches. Notably, some reports do not include the standard-required comparison of planned figures with cash movements, instead presenting only a comparison with revenues and expenses.

Table 3. Comparison of budgeted actuals with accounting or cash figures in the financial reports in accordance with IPSAS

RECONCILIATION	Budget expenditures	Positive or negative budget balance	Overall
Outlays	8 (15%)	-	8 (15%)
Positive or negative accounting balance	1 (2%)	15 (29%)	16 (31%)
Net movements of cash from operations, investments, and financing	18 (35%)	10 (19%)	28 (54%)
Overall	27 (52%)	25 (48%)	52 (100%)

Source: Prepared by the author based on analyzed financial reports of international institutions

Most organizations start their reports by comparing figures with the approved budget (top line) and finish with income and expenses in the statement of financial position (bottom line). However, some entities, such as FAO, follow the opposite order, which deviates from the IPSAS requirement that "actual amounts presented on a comparable basis to the budget shall be reconciled to the actual amounts presented in the financial reports." To make reconciliations more comparable, all organizations should report in accordance with the standard and present the actual budget as the top line of the reconciliation (Savić & Bonić, 2022). Furthermore, in cash flow alignments, organizations are expected to display the budgeted actuals at the top and the net cash flows at the bottom of the report.

Of the 51 reconciliations analyzed, 27 (53%) present only expenditures in their budget and no revenues (Budget Expenditure column in Table 3), while 24 (47%) present a surplus/deficit in their budget (Budget Surplus/Deficit column in Table 3). his variability is inherent in the budget preparation process, resulting in an unavoidable lack of comparability between the reported figures. For example, seven international organizations (14%) reconcile only budget expenditures, which is not aligned with the IPSAS 24 standards, paragraph 47(a). One organization, the Universal Postal Union (UPU), prepares a budget-to-actual analysis expenditures and accounting positive/ negative variance (2%), extending the standard practice, while 19 organizations (37%) reconcile budget expenditures to rather than the net cash movements arising. This is a practice that may be in accordance with IPSAS 24, paragraph 47, although the standard does not specify which amounts should be reconciled. In addition, 14 organizations (27%) provide a reconciliation between the budgeted and accrual-based surplus or deficit. This approach offers additional insight, extending beyond the requirements of IPSAS 24, which mandates reconciliation with total revenues and expenditures rather than with the positive or negative variance. For example, the EU presents a reconciliation of budget positive/negative variance and accrual positive/negative variance, but does not reconcile to net cash flows (Škrbić et al., 2023). Ten organizations, representing 20% of the sample, provide a reconciliation of the budget positive or negative variance than the net cash movements arising. For all entities using the accrual basis of budgeting, it is

necessary to reconcile budget amounts to net cash flows. For instance, the ILO provides three separate comparisons between budgeted and actual figures and reconciles the total budget positive variance to net cash flows. Ten other international organizations prepare two types of budget-to-actual reconciliations: one aligning with the report of financial position and another with the report of cash flows. While preparing both alignments is mandated for entities applying the accrual basis for budgeting, none of these organizations follows the accrual method. The alignment to the report of financial position goes beyond the standard's requirements.

Differences between actual amounts in the budget and financial statements

Under IPSAS, the actual figures reported in the budget are required to be reconciled with the actual amounts shown in the financial reports, with any discrepancies clearly identified according to their basis, timing, and organizational entity. This requirement does not preclude the identification of other differences that may arise, and many organizations identify differences in presentation when reporting (Pejišević et al., 2024). Nevertheless, the majority of organizations consider it sufficient to report only the total amounts of differences in terms of accounting methods, period variations, organizational factors, and reporting formats. Some organizations, however, provide a more detailed analysis of each type of difference. The IPSASB could enhance the comparability of reconciliations across entities by offering clearer guidance on certain requirements, thereby specifying more precisely how these differences should be presented. For instance, the EU (2008) reconciles the figures reported in the budget and financial statements, but does so by separately highlighting the main revenue and expense differences rather than categorizing them according to accounting methods, period variations, and organizational factors as stipulated by the standard.

The EU (2019) emphasizes that comparing actual budget figures with recorded accounting amounts is an important method for ensuring consistency. This check is only effective if the organization does not rely on balancing items when performing the comparison. Problems can occur when different systems are used to record budgeted figures and the amounts reported in the financial records and liquidity reports, and any unexplained differences should be assigned to other comparison categories. To guarantee data reliability, balancing items should be avoided in any comparison, as their use may reduce the accuracy and comparability between budget data and financial records.

Discrepancies in the calculation basis

According to IPSAS 24, paragraph 48(a), differences in the basis of accounting arise when the authorized budget is formulated using an accounting basis other than either accrual or cash. These differences can significantly affect the understandability of the budget and its consistency with the information in the financial reports, especially when the financial reports do not provide sufficient explanation for a budget that has been prepared on an accrual basis. This reduces the value of this information for its users, as it is not clear to them how the underlying accounting differences have been reflected

in the budget data. n many UN organizations, budgets are typically prepared on a cash basis, while financial reports are usually compiled on an earned basis. This method allows the use of the earned basis exclusively for financial reporting, while the budget remains cash-based. An example of this is the World Food Programme (WFP), which describes its budget basis as an "accrual basis", with expenses and liabilities recognised only when the entity incurs the obligation. However, budget liabilities are not recognised in the financial statements, which creates a difference in reporting between the budget and the financial statements (Neševski & Bojičić, 2024). The European Union prepares its financial statements by recognizing revenues and expenses when they are incurred, whereas its budget is prepared using a combination of this approach and the cash basis. Some UN organizations, such as the ILO, IMO, UNOPS, UNWTO, UPU and WIPO, use a modified accrual basis for their budgets, while many others (such as UNCDF, UNEP, UNITAR and UNDP) refer to their basis as the modified cash basis. The ambiguity in terminology, along with the absence of widely accepted accounting definitions for these adjusted bases, often leads to confusion for financial statement users. Numerous international organizations describe their budgetary basis in general terms, such as "modified cash basis," without clarifying the specific deviations from the underlying accounting principles. This is not in line with IPSAS, which requires such differences to be clearly presented to ensure understandability and comparability. The lack of a clear explanation of these fundamental differences reduces the consistency of financial reports and makes it difficult for users to make informed decisions based on them.

Weather differences

According to IPSAS 24, paragraph 48(b), timing differences occur when the duration of the budget period does not coincide with the reporting period covered by the financial reports. This problem becomes particularly acute when organizations prepare biennial budgets, which leads to discrepancies between the period for which the budget is approved and the timeframe of the financial reports, which according to IPSAS 24 must be prepared at least annually. Many UN organizations, as mentioned, prepare biennial budgets but do not separate the amounts for the two different periods. This creates a challenge in reconciling with the financial statements that cover only one period, which makes it difficult to compare data and can create misunderstandings among users of those reports. Among the 37 UN organizations included in the sample, 28 (76%) adopt a biennial budgeting approach. However, only a few of them, such as the ILO, report timing differences in reconciling the budget with the financial reports. Variations exist in how timing differences across the budget period are present and the financial statement period can reduce the understandability and comparability of the financial statements. In this way, users cannot clearly see the extent to which differences in timing affect budget data and these data illustrate the connection between the reported figures and both the statement of financial position and the cash flow statement. Taking these challenges into account, IPSAS 24 requires organizations to consistently identify and report timing differences, in order to ensure greater comparability and clarity of financial statements.

Differences in entities

As stated in IPSAS 24, paragraph 48(c), differences occur when certain programs or components, which belong to a larger reporting entity, are excluded from the budget while the financial reports cover the entire entity. These differences typically arise from the fact that a budget may only cover a specific part of an entity or organization, whereas consolidated financial statements present a comprehensive view of the financial position of the entire entity, including all its parts (Mitrović et al., 2024). In international organizations, such as the UN and the ICC, situations may arise where entities that are part of the budget are reported but are excluded from the consolidated financial reports, which can lead to inconsistencies and complicates the comparison between the budgeted figures and the amounts reported. For example, UNOPS might provide a reconciliation between budgeted and actual figures for both its management budget and specific project allocations, but differences in the coverage of entities may cause discrepancies between those reconciled figures and those in the consolidated financial statements. These cases illustrate that variations among entities are not consistently reported, which can significantly limit the comparability of financial statements and make it difficult for users to identify all aspects of the organization's financial position. IPSAS 24 requires organizations to clearly identify and report all differences across entities, to guarantee uniformity and clarity in the analysis of budgetary and financial data, which is crucial for making informed decisions.

Differences in presentation

IPSAS 24 does not explicitly require the identification of differences in presentation, but notes that such differences may arise from the different formats and classifications used in budgets and financial statements (paragraph 28). Many organizations, particularly within the UN system, report revenue as a difference in presentation because the budget execution report often contains only expenditures (Milenković et al., 2023). This means that revenue, although part of the total financial flows, is not included in the budget execution report but is shown as a difference in the process of matching actual budget results to actual cash movements. For example, UNRWA and UNICEF state that revenue is not included in the budget reconciliation but is treated as a difference in presentation, which is not always consistent across organizations. This approach can make comparability of financial statements difficult because differences in presentation are not always clearly identified or reconciled across organizations, thereby reducing transparency and comparability.

Also, although IPSAS 24 allows reconciliations either displayed on the front page of the budget execution report or described in the notes accompanying the financial reports, only a small number of organizations (4%) separate the reconciliation on the front page of the document. This practice can contribute to inconsistencies in the way reconciliations are presented and reduce the clarity of the information. To increase consistency and comparability, it could be useful to introduce a requirement for all organizations to report reconciliations in the Explanatory sections of the financial

reports. This would facilitate the comparison of financial data across organizations and provide greater openness in reporting of budgetary and financial information.

Example of reconciling amounts in the budget execution report and financial statements

This section offers practical examples of reconciling budgetary data with financial reports, aligned with the main qualitative characteristics of financial information, such as relevance, faithful representation, clarity, timeliness, comparability, and verifiability. Qualitative characteristics enable users of financial statements to interpret and use the information appropriately, while constraints such as materiality and cost require a balance between these characteristics and practical applicability (Majstorović & Obrić, 2023).

The Food and Agriculture Organization of the United Nations (FAO) serves as a clear example of an entity that adheres to these guidelines. Its reconciliations are examples of best practice because they provide sufficient detail to clarify differences between budgeted and actual amounts, while avoiding information overload (Golubović & Janković, 2023). The specification of order items and the precise reconciliation to the accounting surplus/deficit allow for a clear presentation of differences and clarification of differences between budgeted and actual amounts, which is key to transparency and effective decision-making.

Table 4, presenting the reconciliation of actual figures on a comparable basis when aligning budgeted amounts with the accounting surplus or deficit, adds significant analytical value. It enables a meaningful comparison between planned and actual outcomes using defined accounting criteria.

Table 4. FAO reconciliation of the current budget and the accounting surplus/deficit

		u 000 dolara
Financial Operating Surplus Statement		1,717
Variations in Volume		
Other Ownership Surplus	(1,225)	
Surplus of Program Trust Fund	(21,986)	
Surplus of Staff Trust Fund	(4,008)	
Total		**(27,219)**
General Fund Deficit		**(25,502)**
Adjustment for Accounting Methods		
Income Recognition		
Inflation or Constant Currency Adjustment	(4,995)	
Allocation-Based Budget Adjustment	(55,002)	
Foreign Exchange and Supplementary Income	(13,920)	
	(73,917)	
Expenses		

Staff Compensation	42,950	
Constant Dollar Adjustment	3,432	
Exchange Rate Losses	2,345	
Prior Year Budget Expenditure	3,940	
Additional Allowance for Unpaid Contributions from Member States	69,018	
Payment related to 38 C/5 surplus allocated in 2019	4,045	
Addition, depreciation and amortization of fixed assets	15,002	
Repayment of renovation loan	(6,800)	
	133,932	
Adjustment of budget base		
Outstanding liabilities	(7,950)	
Total adjustments		**52,065**
Outcome of the budget using a modified cash approach		**26,563**

Source: Prepared by the author based on FAO financial report (https://www.fao.org)

Table 4, presenting the reconciliation of the budget outcome on a modified cash basis with the outcome on an accrual basis, highlights notable variations in how results are reported depending on the accounting basis used. The budget surplus/deficit on a modified cash basis usually exceeds the accrual surplus/deficit, which is common for public sector organizations (Dašić et al., 2023). This is because many entities, such as public institutions, do not budget for post-employment benefits or other liabilities that are recognized on an accrual basis but not on a cash basis. These differences can be significant in interpreting an organization's financial position, as significant discrepancies can arise in the amounts presented in the financial reports compared to the planned amounts in the budget.

Table 5, presenting a reconciliation between the budgeted figures and the cash flow statement amounts (broken down by core, investment-related, and financing activities), also offers valuable insights into the alignment between budgeted amounts and actual cash flows. This reconciliation helps to understand how actual cash flows, which reflect the organization's actual liquidity, correlate with budgeted expenditures and revenues. Displaying this information provides better insight into the efficiency of resource management, compared to what was planned in the budget

Table 5. FAO reconciliation of budget amounts and cash flow statements

	Core	Investment-related	Financing activities	Total (in 000 dollars)
Realized Net Surplus Report comparing budget and actual amounts	26,563			26,563
Basic Differences				
Unpaid Liabilities	8,315			8,315

	Core	Investment-related	Financing activities	Total (in 000 dollars)
Unreceived Contributions for the Year	(88,920)			(88,920)
Other Basic Differences	49,401			49,401
Presentation Differences	8,504	(1,404)	(7,100)	
Cash Budget Result	2,808	(1,301)	(7,010)	(5,503)
Entity Differences	37,045	(64,844)		(27,799)
Actual Amounts Report	38,920	(6,980)	(7,010)	(33,302)

Source: Prepared by the author based on FAO financial report (https://www.fao.org)

The explanation provided by FAO in its financial statements clearly indicates several key adjustments that occur when reconciling budget and financial amounts. Each of these adjustments plays a significant role in how budget data and financial statements are compared and how financial information is accurately presented (Bakić, 2024).

– Capitalization of capital expenditures: In the budget, capital expenditures are usually recognized as expenses in the current year, whereas under accrual accounting, these expenditures must be recorded as capital assets and depreciated over their estimated useful life. This means that expenditures that are recognized immediately as an expense in the budget will be recognized in the financial statements in accordance with depreciation, resulting in a difference between the amounts shown in the budget and those in the financial statements (Gojkov, 2024).

– Conversion of currency contributions and expenditures: When estimated contributions received in euros are converted into US dollars for budget purposes, a constant dollar exchange rate is used. In its financial reports, however, FAO applies the UN operational exchange rate effective on the transaction date. Differences in exchange rates can result in variances between amounts reported in the budget and those shown in the financial reports.

– Employee benefit obligations: In accrual-based accounting, obligations related to employee benefits are recorded on the Statement of Financial Position (balance sheet), whereas any changes in these obligations are reported in the Statement of Financial Performance (income statement). These obligations are not recognized in the budget, but are recognized in the financial statements, which creates a difference between the budget presentation and the actual amounts in the financial statements (Gojković, 2024).

– Outstanding liabilities: The budget recognizes outstanding liabilities, which include obligations that have not resulted in the delivery of services by the reporting date, in addition to accrued amounts for goods and services that have not yet been billed. However, these pending liabilities are not reflected in the financial reports, whereas actual accruals are recorded in line with IPSAS requirements. Such differences in liability recognition also lead to variations between budgeted amounts and those reported in the financial reports.

These explanations indicate that adjustments made between budget and financial statements must be carefully explained and documented to enable clear comparability and understanding of financial data. Proper understanding of these differences is critical to interpreting the reconciliation between budget and financial reports, along with analyzing the organization's financial stability.

Conclusions

This paper examines financial reports that are prepared in accordance with the IPSAS (International Public Sector Accounting Standard) and highlights differences in the way actual budget amounts are reconciled to actual amounts, which can vary significantly across entities. Some entities reconcile budget amounts to cash flows, while others do so to income and expenses or accounting surplus/deficit. Differences in methods also include the level of detail in the presentation of the differences, with some entities providing only basic information and others providing a detailed overview. Moreover, the definitions of certain terms in IPSAS 24 can be subject to multiple interpretations, which may result in inconsistencies in how different public sector entities reconcile budgeted amounts with accounting figures.

Based on the research, the following recommendations were proposed to the IPSASB:

– Mandate the preparation of two separate reconciliations between budgeted and accounting figures: one linking budgeted and actual amounts to the accounting surplus or deficit, and another linking them to net cash flows from operating, investing, and financing activities.

– Specify that any significant variances between actual budgeted amounts and the corresponding figures in the financial reports should be clearly explained.

– Highlight that differences identified in the reconciliations should not be used to offset each other, in line with IPSAS 1, which prohibits the netting of assets and liabilities.

– The Board should require that reconciliations between budget and accounting amounts be disclosed in the notes to the financial reports.

– Provide clarification on the concept of timing differences.

– Encourage further research regarding the disclosure of the budget basis, due to frequent inconsistencies in the use of terminology.

Recommendations for entities preparing financial statements under IPSAS include:

– Ensure that a reconciliation between budgeted amounts and net cash flows is prepared in every instance.

– Disclose the budget basis and clearly define the terminology used.

– Report any timing differences when the budget period does not coincide with the reporting period.

Although the research has certain limitations, such as a limited sample (international organizations only) and a focus on comparability only, the research could be replicated within the broader framework of public sector organizations. This study could also expand the analysis to consider how differences in the design of budget and accounting reconciliations affect how users perceive the reports' relevance and clarity.

Based on the findings of this study, it is recommended that the IPSAS Board provide clearer guidance to enhance the consistency between budgeted figures and reported accounting amounts.

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Conflict of interests

The authors declare no conflict of interest.

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TEA CULTURE BRAND MARKETING TO ACHIEVE FARMERS' INCOME ENHANCEMENT BASED ON BIG DATA VISUAL ANALYSIS--A CASE STUDY OF HEZHOU LIUBAO TEA IN CHINA

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A B S T R A C T

The main objective of this study is to examine how big data visualization can enhance the brand marketing of Hezhou Liubao Tea, a representative Chinese black tea, to increase the income of local tea farmers. Despite its unique production methods and cultural significance, Liubao Tea faces challenges in brand recognition and market expansion. Using big data tools, this research analyzes market demand, consumer behavior, and sales channel performance to identify key factors driving brand development. The methodology includes data collection from e-commerce platforms, social media, and surveys, combined with visualization tools like Tableau and Gephi to process and present the findings. Key findings show that investments in brand development, production efficiency, and market expansion significantly contribute to increased farmer income. The study highlights the potential of data-driven marketing strategies to improve brand awareness, optimize sales channels, and enhance product quality, offering practical recommendations for both local and international market growth. This research provides insights into leveraging modern technology for sustainable development in the tea industry and rural revitalization.

Introduction

The global tea industry has shown continuous growth in recent years. According to statistics from the International Tea Committee, the total market value of the global tea industry reached nearly 50 billion USD in 2023, with an expected annual growth rate of approximately 6% by 2027 (Li et al., 2024). In Asia, tea production and related

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industries are not only an important economic source but also a significant part of cultural and social life. In China, as the world's largest tea producer and consumer, the market size of the tea industry continues to expand. According to the China Tea Circulation Association, China's total tea production in 2022 was approximately 2.8 million tons, with a market value of around 200 billion RMB (Arhin et al., 2024). However, despite the overall growth in the tea industry, there remains a significant disparity between different types of tea and regions, with local specialty teas like Hezhou Liubao Tea having relatively low brand recognition and market share both domestically and internationally.

The transmission and development of Chinese tea culture spans thousands of years, with tea being deeply rooted in Chinese society and serving as a bridge for cultural exchange globally. However, with the acceleration of modernization and the intensification of global market competition, traditional tea culture faces the risk of marginalization (Tang et al., 2023). In particular, the traditional business models in the tea industry often struggle to innovate and enhance the value of tea brands in today's competitive market. Hezhou Liubao Tea, as one of China's representative black teas with unique production techniques and regional cultural significance, holds considerable market potential. However, the brand still faces challenges such as low brand recognition and limited market expansion, necessitating effective branding and marketing strategies to enhance its market performance and increase farmer income.

The uniqueness of Hezhou Liubao Tea is not only reflected in its geographical certification but also in its deep cultural heritage and traditional production methods. The distinctive production process, which includes fermentation and compression, gives it a unique flavor highly favored by tea enthusiasts. However, despite its superior quality, the brand has yet to make significant strides in brand development. According to the "2023 Liubao Tea Industry Development Report" released by the local government, Hezhou Liubao Tea's market recognition is still low, with its national market share below 2%, mainly concentrated in surrounding regions such as Guangdong and Guangxi (Xu et al., 2025). While local governments have made efforts to promote the brand in recent years, Hezhou Liubao Tea has still not achieved effective brand communication or market breakthrough across China, resulting in a mismatch between its brand recognition and the quality of its products.

Farmer income increase has long been a key goal in China's agricultural policy. Tea cultivation, as an important cash crop, directly affects the livelihood and income of many tea farmers. The increase in tea farmers' income primarily depends on the market price and sales volume of tea (Qin & Zhou, 2024). However, traditional tea sales methods are still mostly limited to wholesale and local markets, lacking an efficient marketing system and innovative sales channels, which has hindered the income growth of many tea farmers. The income situation of Hezhou Liubao Tea farmers faces similar challenges. Although the price of Liubao Tea is higher than that of some common tea varieties, its income has not significantly increased due to the insufficient brand effect. Therefore, enhancing the brand recognition and market penetration of Hezhou Liubao

Tea is essential for promoting the income of local tea farmers and achieving sustainable industry development.

Tea culture brand marketing is not merely about selling products, it represents a synthesis of culture, quality, region, and consumer demand. With the advancement of information technology, the emergence of big data and visualization techniques has brought revolutionary changes to brand marketing (Mao et al., 2024). Big data visualization can help businesses make informed decisions by deeply analyzing and presenting market data, consumer behavior, and sales channel data. In the agricultural sector, particularly in tea brand development, big data visualization can assist tea companies in brand positioning, consumer preference analysis, and sales channel selection, among other things (Qi, 2023). Data-driven marketing allows Hezhou Liubao Tea to adopt an innovative development path, improve its market share through precise market positioning and promotional strategies, and increase the income of tea farmers by breaking the limitations of traditional marketing methods.

It is important to recognize the gaps in existing research, particularly in the area of cultural adaptability in global markets. While much of the literature on tea culture and brand marketing has focused on the historical and traditional aspects of tea, there is a notable lack of studies exploring how these cultural elements can be effectively adapted and marketed in diverse international markets. Most existing research tends to view tea culture as a fixed, unchanging entity, without fully considering the dynamic and evolving consumer preferences that arise from globalization and cross-cultural exchange (Qin & Zhou, 2024). Moreover, while certain successful tea brands, such as Japan's Uji Tea, have integrated cultural values into their marketing strategies, many local specialty teas, like Hezhou Liubao Tea, still struggle with limited brand recognition and market reach beyond their regional contexts (Tang et al., 2023). The ability to adapt cultural elements while maintaining authenticity is a critical factor in the success of tea brands in international markets. This study fills this gap by focusing on how big data and visualization techniques can not only enhance brand marketing but also address the challenges of cultural adaptation, offering insights into how Liubao Tea can break into global markets while preserving its unique cultural heritage.

This research aims to explore how big data visualization can be used to develop an innovative brand marketing strategy for Hezhou Liubao Tea to promote its expansion in domestic and international markets, thereby increasing farmer income. Specifically, the study will analyze the market demand, consumer behavior, and competitive environment of Hezhou Liubao Tea. It will apply big data visualization techniques to reveal the key factors of brand development and propose targeted marketing strategies. Additionally, the study will examine the practical applications of big data visualization in brand marketing, analyzing its advantages and challenges. In an increasingly competitive global market, combining modern information technology with brand marketing will allow Hezhou Liubao Tea to break through and emerge as a strong competitor, ultimately achieving the upgrading of the tea industry and the goal of increasing farmers' income.

Literature review

Tea Culture and Branding

Tea culture is an essential component of Chinese traditional culture, deeply embedded in history and marked by unique regional characteristics (Sigley, 2015). Tea is not only an important consumer product in daily life but also a symbol of China's long-standing tea culture, encompassing cultivation, harvesting, production, consumption, and associated rituals and philosophies (Wang et al., 2024; Zhou et al., 2023). In recent years, with the increasing global focus on health and cultural products, tea culture has become a significant competitive advantage in brand marketing. Tea brands can shape distinctive brand images and attract consumer attention by integrating tea culture into their marketing strategies (Kato et al., 2024). Tea culture imparts profound spiritual meaning to brands, enhancing their cultural value and strengthening consumer brand identification. This suggests that the transmission and innovation of tea culture are key factors in brand building, especially in modern brand marketing, where tea culture serves as one of the core selling points, creating emotional connections and cultural resonance with consumers (Verma, 2013).

While many studies emphasize the positive role of tea culture in brand marketing, the relationship between cultural elements and market demand remains underexplored. Many studies tend to focus too much on the traditional and historical aspects of tea culture and neglect the dynamic interaction between culture and actual consumer needs (Bohne, 2021). There is also a lack of in-depth discussion on the diversity and changes in modern consumers' perceptions of tea culture in the context of globalization and modernization (Koay & Leong, 2024). The applicability of tea culture as a universal competitive advantage for all markets, particularly how it can be adapted to the needs of different consumer groups, still requires more systematic exploration.

Some foreign tea brands have successfully incorporated tea culture into their brand communication, achieving significant market success. For example, Japan's "Uji tea" has skillfully integrated the tea ceremony's concepts of "harmony, respect, purity, and tranquility" into its brand culture, injecting profound cultural value into the brand and establishing a strong position in the global market (Ashardiono, 2019). This cultural empowerment not only satisfies consumer demands for quality but also creates a deep emotional connection with consumers (Froner, 2017). However, this strategy of cultural empowerment does not always apply in markets with significant cultural differences. Tea culture may fail to resonate with consumers in these markets, especially in the West where tea culture differs significantly from traditional Chinese tea practices (Mao et al., 2024). This gap in the literature highlights the importance of further research into the cultural adaptability of tea brands in cross-national markets.

In contrast, China's tea culture brand marketing began relatively late but has gradually made breakthroughs as market demand and consumer cultural identification have evolved (Xie et al., 2023). The in-depth exploration of tea culture and the integration of

regional characteristics have become crucial factors in enhancing the competitiveness of tea brands. In the case of local tea brands, combining tea culture with production techniques provides a unique market positioning (Wang et al., 2022). However, while cultural value is foundational, the challenge remains in integrating this culture with modern consumer demands and trends. As consumers' understanding of traditional culture becomes more diverse, the singular transmission of tradition may no longer meet the needs of younger consumers who seek personalization and innovation. Thus, balancing cultural preservation with brand innovation is a critical challenge in tea culture brand marketing.

Many successful cases in tea industry brand building and market expansion show that relying solely on traditional tea quality and production techniques can no longer meet modern market demands (Mao et al., 2024). Brand building must integrate culture, history, and techniques to stand out in the marketplace. For example, the brand development of Yunnan Pu'er tea demonstrates the significant role of its historical background and fermentation process, successfully enhancing the global recognition of the brand (Ning et al., 2011). The success of Pu'er tea lies not only in product quality but also in the cultural and storytelling aspects that resonate with consumers. This strategy suggests that local specialty teas, when deeply integrated with culture and innovation, can enhance market competitiveness and expand market share (Wang et al., 2024). However, the experiences of Pu'er tea cannot be fully applied to all local tea brands, as many face the challenge of balancing the preservation of traditional techniques with innovative market demands. Some studies have focused on cultural transmission without fully considering consumer demand for innovation and freshness, leaving the question of whether cultural value can truly translate into market competitiveness unresolved. More empirical research is needed on the relationship between cultural transmission and market competitiveness in the context of modern consumer behavior.

Cultural Dissonance and Market Adaptation

The incorporation of tea culture into branding strategies often meets challenges in global markets due to cultural dissonance. While some tea brands have effectively integrated culture into their marketing (e.g., Japan's Uji tea), the approach does not always translate well across markets with distinct cultural backgrounds (Ashardiono, 2019). Tea culture may not resonate with all consumers, particularly in markets where cultural differences are significant, as in the case of Chinese tea culture and Western consumer perceptions (Mao et al., 2024). Understanding and addressing these cultural differences is crucial for the international success of tea brands. The lack of studies exploring the impact of cultural dissonance between Chinese tea culture and Western markets underlines the need for more research on cultural adaptability in brand marketing.

Big Data in Tea Brand Marketing

The application of big data in tea brand marketing is gaining attention for its potential to enhance brand competitiveness. Big data visualization technology allows companies

to analyze large volumes of data quickly, providing insights into consumer behavior, market demand, and sales channels (Hu & Huang, 2021). In the tea industry, big data helps companies develop scientifically based product positioning and marketing strategies (Olfati & Paydar, 2023). The ability to predict consumer preferences allows tea brands to optimize product designs and marketing strategies, increasing market share and brand influence (Fan et al., 2024).

While big data visualization has been widely applied in consumer goods and agriculture, its potential for tea brand marketing remains underexplored. Existing studies demonstrate that big data can help brands identify consumer preferences, optimize product offerings, and implement targeted marketing strategies (Ding et al., 2023). However, there is little research on how to integrate big data with cultural branding strategies, especially to address cultural dissonance in international markets. More research is needed to understand how big data can help overcome cultural barriers and enhance global market penetration.

Integration of Tea Production Techniques and Culture

Tea production techniques are a core component of tea culture brand marketing, as they directly influence both the quality of the product and its cultural value (Ye et al., 2022). Traditional handmade production techniques, often tied to regional characteristics, contribute to the distinct flavor and quality of tea. As competition in the global tea market intensifies, the success of tea brands increasingly depends on how well they can integrate traditional production techniques with cultural values, enhancing both the market value and emotional connection with consumers.

However, existing research tends to focus heavily on preserving traditional production techniques without fully considering how these methods meet the evolving demands of modern consumers (Aaqil et al., 2023). In globalized markets, younger consumers often prioritize convenience and speed over tradition (Tian et al., 2022). Thus, there is a need for more research on how traditional tea production techniques can be innovated and adapted to meet modern consumer demands, particularly in international markets where consumer expectations differ from those associated with traditional cultural practices.

Cultural and Production Innovation in Global Tea Markets

Tea brands that successfully integrate cultural values and production innovation often achieve greater market success. The global recognition of Yunnan Pu'er tea, which blends its historical background with modern production techniques, is an example of this integration (Ning et al., 2011). Similarly, local specialty teas, when combined with both cultural and innovative elements, can enhance their market competitiveness (Wang et al., 2024). However, not all tea brands have successfully navigated this balance, and many still face challenges in aligning traditional cultural elements with modern market demands. This gap in the literature highlights the need for more empirical studies on how cultural branding, combined with modern production techniques, can drive market success.

The literature review highlights the significant role of tea culture in brand marketing but also reveals gaps in research related to cultural adaptability and the use of big data in overcoming market challenges. While some tea brands have successfully integrated cultural elements into their marketing strategies, much more is needed to explore the interaction between cultural branding, consumer behavior, and big data. This study aims to fill this gap by exploring how big data can be used to develop culturally adaptable branding strategies for Hezhou Liubao Tea, helping it succeed in both domestic and international markets.

Research method

This research primarily employs big data visualization analysis to explore how big data technology can enhance the market competitiveness of the Hezhou Liubao tea brand and promote farmer income growth. Liubao tea, as one of China's traditional black teas, has a long history and deep cultural heritage. Although it holds a certain level of recognition in the local market, its brand influence is relatively weak in both national and international markets. Therefore, this study focuses on how big data visualization can enhance Liubao tea's brand awareness and consumer recognition, thereby driving its brand marketing development and increasing farmer income.

The research object is the Liubao tea brand from Hezhou, and the scope primarily covers its performance in the domestic market and its expansion potential in international markets. This study focuses on the brand marketing, consumer behavior, market demand, and sales channels of Liubao tea, aiming to provide precise market positioning and strategic recommendations through big data analysis. The scope of data collection includes sales and consumer data for Liubao tea over the past three years, to identify the key factors influencing brand promotion and provide practical strategies for optimizing brand marketing.

Data collection sources include online e-commerce platforms, social media, and sales records from Liubao tea producers and retailers. Online data includes consumer purchase behavior, reviews, purchase frequency, and geographic distribution, which were obtained through data scraping and analysis from e-commerce platforms and social media. Additionally, to gather consumer attitudes and perceptions, online surveys and face-to-face interviews were conducted to collect data on brand recognition and consumer preferences for Liubao tea across different consumer groups. Sales data was collected from Liubao tea producers and retailers, covering sales performance, price fluctuations, promotional activities, and distribution strategies across different sales channels.

The data collection for this study primarily focuses on online consumer behavior and sales data to understand the brand marketing and consumer preferences of Hezhou Liubao tea. Online data were gathered from popular e-commerce platforms and social media channels, which represent a significant portion of modern consumer interaction. These platforms include major e-commerce sites such as Taobao, JD.com, and Pinduoduo, where consumer behavior, reviews, purchase frequency, and

geographic distribution were collected using data scraping techniques. Social media channels, including WeChat, Weibo, and Douyin, were also utilized to assess consumer engagement with the brand, sentiment analysis of reviews, and social trends related to Liubao tea. These platforms provide a rich source of data reflecting current consumer interactions, preferences, and market dynamics.

Additionally, the study employed online surveys and face-to-face interviews to gather direct insights from consumers about their brand recognition, product preferences, and cultural perceptions of Liubao tea. The survey respondents were carefully selected to include diverse demographic groups, including age, gender, geographic location, and purchasing behavior. A total of 1,000 respondents participated in the survey, with a balanced distribution across regions such as Guangdong, Guangxi, and Beijing. The interviews were conducted with 50 consumers, providing qualitative insights into consumer attitudes and brand perception.

Sales data was also gathered from Liubao tea producers and retailers, which included information on sales performance, price fluctuations, promotional activities, and distribution strategies across various sales channels. This data, collected from both online and offline channels, allowed for a comprehensive analysis of Liubao tea's market positioning and consumer demand across different regions.

In the data analysis process, various big data tools and visualization techniques were employed. To efficiently process large-scale data from various sources, tools such as Python and Apache Hadoop were used for data extraction, cleaning, and preprocessing. The data cleaning process ensured consistency and accuracy, removing irrelevant or duplicate records to improve the quality of data analysis. Based on this, data visualization tools such as Tableau and Gephi were used to present the results in intuitive charts and network graphs, helping researchers identify consumer purchasing behavior patterns and market demand trends. These visualization tools not only displayed the market performance of Liubao tea but also delved deeper into consumer preferences, providing strong support for brand marketing.

For data visualization and analysis, tools like Tableau and Gephi were used. Tableau was selected for its user-friendly interface and advanced data visualization capabilities, allowing for the creation of interactive dashboards that presented the market performance of Liubao tea in intuitive charts and graphs. Gephi was used to analyze and visualize network relationships and consumer behavior patterns across different segments and regions, providing insights into how various factors such as product quality, brand awareness, and cultural affiliation influence consumer purchasing decisions. These tools were chosen because of their ability to transform complex datasets into actionable insights, which were essential for developing targeted marketing strategies for Liubao tea.

The results from big data visualization analysis provided valuable insights and data support for this study. In terms of brand marketing, the study analyzed consumer behavior data and identified the differences in brand recognition of Liubao tea across various consumer groups. The key factors influencing consumer purchasing decisions

were revealed, including brand awareness, product quality, and cultural affiliation. Additionally, through sales channel analysis, the study identified performance differences in various sales channels, further guiding brand marketing strategies, especially in areas such as pricing, promotional campaigns, and advertising placements. Furthermore, spatial analysis revealed the regional sales potential of Liubao tea both domestically and internationally, providing data support for market expansion and internationalization strategies.

Ultimately, this research, through big data analysis and visualization, produced a comprehensive report on Liubao tea brand marketing, offering specific strategic recommendations. The study shows that through effective market segmentation and precise consumer profiling, Liubao tea can find its positioning in a competitive market, attracting more consumer attention. At the same time, by strengthening the brand image and communicating cultural values, Liubao tea can enhance consumer loyalty, driving sales growth and creating more income opportunities for local tea farmers. This process demonstrates the significant application value of big data technology in the tea industry, particularly in enhancing brand recognition and promoting farmer income growth.

Results

The data presented in this study were collected from Hezhou Liubao tea over a five-year period, from 2020 to 2024, providing insights into the ongoing development of the tea industry, particularly focusing on the impact of tea culture brand construction on tea farmers' income. The data sources include market reports, production statistics, financial records, and consumer reviews, all of which were systematically analyzed to assess the factors influencing tea farmer income. Key variables examined include tea garden area, production techniques, cultural development efforts, marketing expenditures, and the number of sales channels, all of which play critical roles in shaping the income dynamics of tea farmers. Additionally, data on consumer perceptions were collected through word cloud analysis, reflecting public sentiment towards Liubao tea's quality and cultural value. The findings from the heatmap, spending breakdown, and customer reviews, along with the factor analysis and structural equation modeling, form the basis of the discussion, illustrating how different aspects of Liubao tea's brand development contribute to the enhancement of farmers' incomes. These analyses emphasize the importance of brand image, production efficiency, and market expansion in driving economic growth within the tea farming sector.

Figure 1 is reflecting Hezhou Liubao tea industry continued progress in production, brand development, and market expansion. The gradual increase in tea garden area, from 12 hectares to 16 hectares, indicates an expansion in the scale of Liubao tea cultivation, which not only enhances production capacity but also ensures a stable supply for future product demands. This change reflects greater investment by tea farmers and an increasing market demand. Simultaneously, the steady improvement in production techniques, with a score rising from 3 to 7, demonstrates Liubao tea's ongoing innovation in production technology, which is crucial for improving product

quality and enhancing market competitiveness. With continuous advancements in production processes, Liubao tea can offer higher-quality products, attracting more consumers and boosting brand recognition.

Figure 1. Liubao tea development (2020-2024)
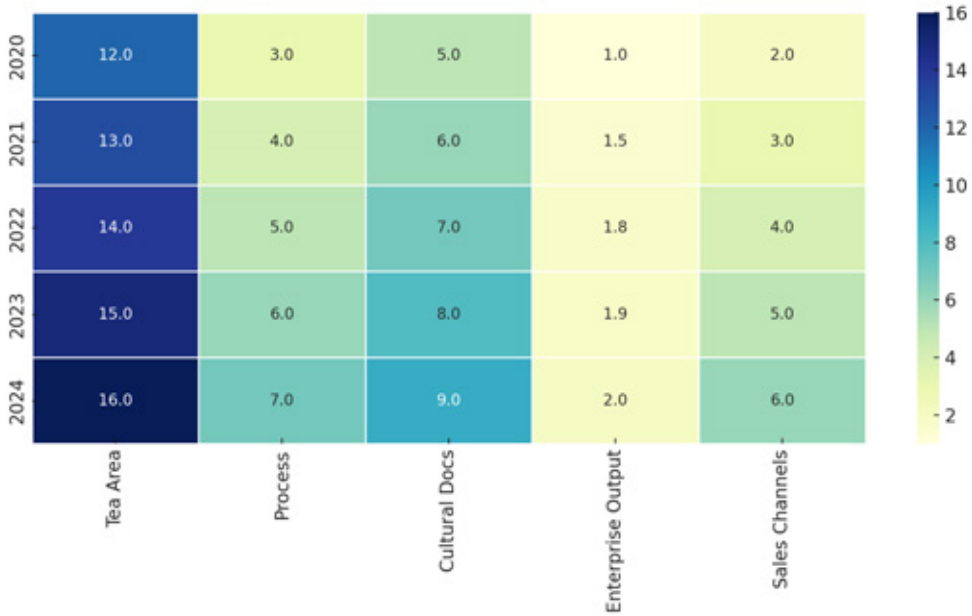
Source: Authors' calculations

In addition, the increase in cultural development documents from 5 to 9 signifies the growing investment in cultural promotion and brand image building. By strengthening cultural development, Liubao tea not only enhances its brand's cultural connotation but also deepens its emotional connection with consumers, which is essential for the long-term growth of the brand. The enterprise output, which increased from $1 million to $2 million, reflects a steady growth in market penetration, suggesting that the brand's market influence has gradually expanded, particularly through the combined effect of branding and quality improvements. Finally, the increase in the number of sales channels, from 2 to 6, indicates Liubao tea's expansion and optimization of its sales network, allowing it to reach a broader consumer base and expand its market. Overall, the data displayed in the heatmap reflects Liubao tea's continued progress across various dimensions, with these changes interacting synergistically to drive the overall development of the brand and increase its market recognition.

Figure 2 analyzes the spending structure of Hezhou Liubao tea, revealing the distribution of resources across various sectors. According to the chart, the highest proportion of expenditure is allocated to production, accounting for 40%. This indicates that the Liubao tea brand invests a significant amount of resources in ensuring product

quality and expanding production capacity. This high allocation supports the brand's foundational infrastructure and product supply capability, enabling it to meet the growing market demand. Following closely is marketing expenditure, which accounts for 25%, reflecting Liubao tea's significant investment in enhancing brand awareness, expanding sales channels, and promoting the brand. The relatively high marketing expenditure highlights the brand's focus on shaping its image and reaching a broader consumer base in a competitive market.

Figure 2. Liubao tea spending breakdown
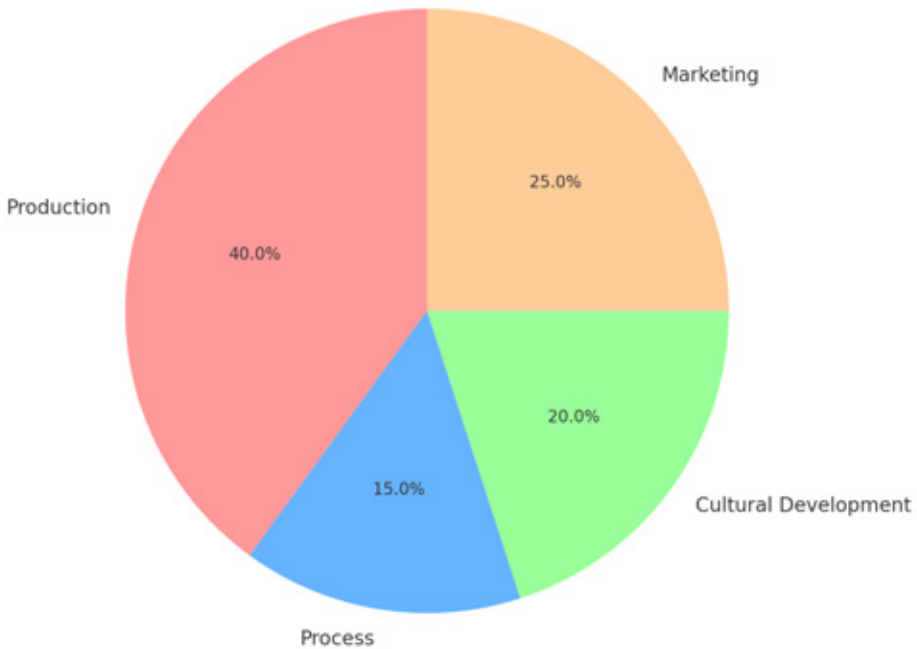
Source: Authors' calculations

Additionally, cultural development expenditure accounts for 20%, a proportion that, while not as large as production and marketing, demonstrates Liubao tea's emphasis on brand culture. Through cultural development, Liubao tea strengthens its brand's cultural connotation and enhances its emotional connection with consumers, thereby increasing its market appeal. The expenditure on process improvement is 15%, a relatively smaller share, but it still reflects the brand's ongoing commitment to optimizing production processes and improving product quality. Overall, the analysis of Figure 2 demonstrates that Liubao tea allocates its resources across production, marketing, cultural development, and process improvement, indicating a balanced strategy to enhance its market competitiveness on multiple fronts.

Figure 3 presents the word cloud of customer reviews for Hezhou Liubao tea, reflecting the commonly used keywords and emotional tendencies expressed by consumers after purchasing and tasting the tea. The word cloud reveals that words like "delicious," "healthy," "traditional," "best," and "quality" frequently appear, indicating that consumers generally hold Liubao tea in high regard for its taste and health benefits. Many consumers describe it as delicious with a rich traditional flavor, highlighting the unique taste and historical cultural background of Liubao tea. Additionally, words like "great quality," "aroma," and "smooth" further emphasize consumers' recognition of the tea's quality, particularly in terms of its aroma and taste.

Figure 3. Customer reviews of Liubao tea

Source: Authors' calculations

The word cloud also features terms such as "organic," "refreshing," and "premium," reflecting consumers' impressions of Liubao tea as a natural, high-quality product. These words suggest that consumers view Liubao tea as not only a traditional tea product but also a healthy and pure beverage. Overall, the word cloud analysis shows that Liubao tea has established a brand image in the minds of consumers as a high-quality, traditional, and healthy product, with its advantages in taste, aroma, and quality being widely recognized and praised.

Figure 4 provides a clear visual representation of the growth in both the number of tea farmers and their per capita income from 2020 to 2024, offering valuable insights into the development of the tea farming sector in Hezhou. The blue bars, which represent the growth in the number of tea farmers, show a steady increase over the five-year period, from 500 farmers in 2020 to 700 farmers in 2024. This growth indicates that the tea farming industry in Hezhou is expanding, with more individuals entering the

sector. This could be a result of the increasing demand for Liubao tea and the financial opportunities it offers. The steady increase in the number of tea farmers suggests that the industry is becoming more attractive and that there is a growing interest in tea cultivation as a livelihood.

Figure 4. Farmer numbers and per capita income growth
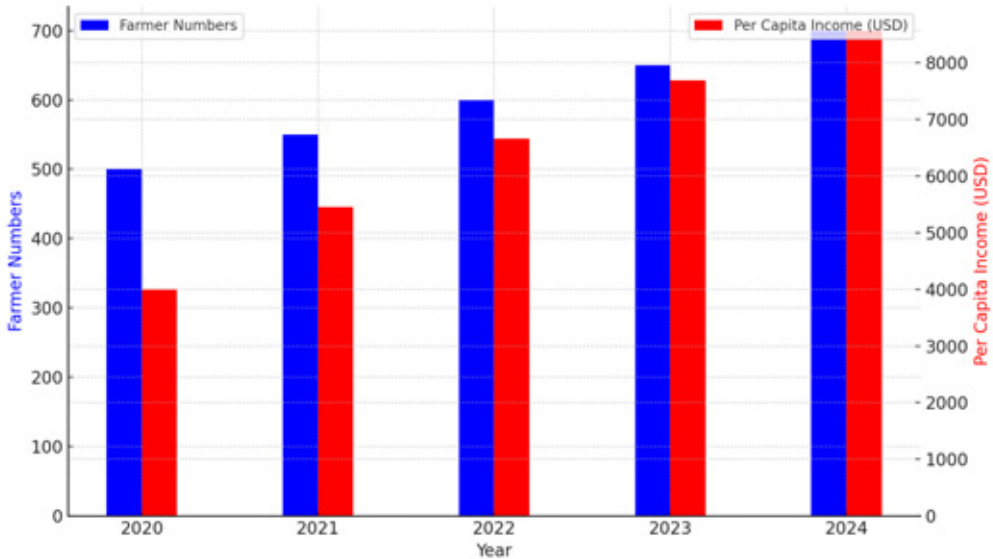
Source: Authors' calculations

On the other hand, the red bars, which represent the per capita income growth for tea farmers, also show a positive upward trend over the same period, from $4,000 in 2020 to approximately $8,571 in 2024. This significant growth in per capita income reflects the positive economic impact of Liubao tea's market expansion and the improved quality of tea production. The rise in income suggests that not only has the overall number of farmers increased, but the profitability of tea farming has also improved, likely due to enhanced production techniques, better marketing strategies, and the increasing recognition of Liubao tea's cultural and quality value.

Together, the trends in both the number of tea farmers and their per capita income highlight a growing, profitable tea farming industry in Hezhou, where both the expansion of the workforce and rising incomes reflect the broader success and sustainability of the Liubao tea sector. These trends indicate that the industry is not only attracting more farmers but also providing them with better economic returns, contributing to the overall economic growth of the region.

The combination of factor analysis and Structural Equation Modeling (SEM) provides an effective framework for studying the impact of tea culture brand construction on the

income increase of tea farmers. Factor analysis allows for the extraction of latent factors that explain the correlations between various variables. In this study, we hypothesize the extraction of three main factors: Brand Effect Factor, Production Efficiency Factor, and Market Penetration Factor. The Brand Effect Factor is composed of tea culture brand construction scores and marketing expenditure, the Production Efficiency Factor consists of production area and process improvement scores, and the Market Penetration Factor reflects the diversity of sales channels. The results of factor analysis indicate that these factors significantly contribute to the income increase of tea farmers.

In order to conduct factor analysis, data need to be standardized. This is because different variables may have different scales, e.g. income may be thousands of dollars while production area is a few hectares. Therefore, standardizing the data makes the scales of each variable consistent and avoids differences in the scales of the dependent variables from affecting the results of the factor analysis. The standardized data formula is as follows:

$$y = \frac{x - \mu}{\sigma}$$

where x is the raw data, μ is the mean, σ is the standard deviation, and y is the normalized data. **Table 1** is the analysis result extracted from the factor analysis and SEM:

Table 1. Results of correlation impact analysis on tea farmers' income increase

Correlation Impact Path	Path Coefficient	Standard Error	t-value	p-value
Tea Culture Brand Construction → Tea Farmer Income	200	40	5	0.003
Production Area → Tea Farmer Income	100	30	3.33	0.01
Process Improvement → Tea Farmer Income	150	50	3	0.02
Marketing Expenditure → Tea Farmer Income	0.004	0.001	4	0.004
Sales Channels → Tea Farmer Income	400	150	2.67	0.03
R-Squared	0.92			

Based on the analysis results in the table, Tea Culture Brand Construction has the most significant impact on tea farmer income. The path coefficient is 200, with a p-value of 0.003, indicating that for each 1-point increase in tea culture brand construction score, tea farmer income increases by 200 USD. This result shows that strengthening tea culture brand construction, particularly improving brand image and cultural promotion, directly facilitates consumer recognition of the brand and thus drives the increase in tea farmers' income.

Both Production Area and Process Improvement also have a significant impact on tea farmers' income, with path coefficients of 100 and 150, respectively, and p-values less than 0.05. This indicates that expanding production area and improving production

processes are key factors in driving income increase. The expansion of production area and the improvement of production processes directly enhance the yield and quality of tea, increasing market competitiveness, thereby driving income growth.

Marketing Expenditure has a relatively smaller but still significant effect on income, with a path coefficient of 0.004 and a p-value of 0.004. This shows that for every additional dollar spent on marketing, tea farmers' income increases by 0.004 USD. Although the direct effect of marketing expenditure is small, it indirectly promotes income growth by increasing brand exposure, expanding market reach, and enhancing consumer brand recognition.

The number of Sales Channels also has a significant impact on tea farmers' income, with a path coefficient of 400 and a p-value of 0.03. This means that for every additional sales channel, tea farmers' income increases by 400 USD. The increase in sales channels enhances market penetration, allowing more consumers to access the product, thus boosting sales and income growth.

Overall, the combination of factor analysis and structural equation modeling provides a clear path for understanding how tea culture brand construction, production efficiency, and market penetration factors interact to promote tea farmers' income growth. The brand effect, production efficiency, and market penetration factors work together to increase tea farmers' income. Tea culture brand construction, by directly impacting brand recognition and cultural promotion, combined with marketing expenditure and the expansion of sales channels, enhances the brand's market competitiveness. Production efficiency drives income growth directly by increasing production area and improving processes. Market penetration further expands market share and income opportunities through diverse sales channels.

Discussions

The development of Hezhou Liubao tea over the past five years highlights the key factors driving its growth, including brand construction, production improvement, and market expansion. From a broader perspective, the growth of Liubao tea is not just a commercial success for the brand but also a critical case for rural revitalization, farmer income improvement, and agricultural development in Hezhou. The strategies employed by the brand provide valuable insights into how agricultural products, particularly in traditional industries, can thrive through strategic development in branding, technology, and market integration, benefiting both producers and the broader rural economy.

One of the core aspects of Liubao tea's success lies in its brand construction and cultural development. For tea farmers, brand recognition is a key factor in driving income. As demonstrated in the data, investments in brand development—particularly in strengthening cultural connotations and enhancing the brand's image—have been directly linked to the growth in farmer income. By positioning the brand not only as a product but also as a cultural heritage, Liubao tea has effectively attracted a niche market that values traditional craftsmanship and the cultural story behind the product. This

strategy resonates with the broader goal of rural revitalization, as it ties the product to regional identity and history, creating economic opportunities while preserving cultural heritage. The integration of cultural elements into branding has been shown to increase consumer loyalty and willingness to pay a premium for products that embody local culture (Mao et al., 2024). This approach contributes to the long-term sustainability of rural economies by providing farmers with a steady stream of income through differentiated products.

The improvement of production efficiency also plays a crucial role in driving the success of Liubao tea. The expansion of tea garden areas and the adoption of advanced production techniques have enabled the brand to scale up production while maintaining quality standards. This is particularly important in the context of rural revitalization, where increasing agricultural productivity is a primary objective for enhancing the livelihood of farmers. By improving agricultural processes, reducing costs, and increasing yields, Liubao tea not only boosts its competitiveness in the market but also strengthens the economic foundation of tea farming families. As previous research has highlighted, rural development cannot be solely based on traditional farming methods but must embrace innovation and technological adoption (Ye et al., 2022). In this case, Liubao tea's commitment to production process improvements and capacity expansion has created a sustainable model that could serve as a blueprint for other agricultural sectors aiming for modernization.

Moreover, market expansion and penetration are pivotal strategies that have propelled the growth of Liubao tea. The brand's increased investment in expanding sales channels and its efforts to establish a presence in both domestic and international markets have created broader economic opportunities for farmers. The increased number of sales channels—from local markets to e-commerce platforms—has allowed Liubao tea to reach a wider audience, thus ensuring that more farmers can benefit from the increasing demand for their product. This market expansion is essential for rural economic development as it provides local farmers with access to larger and more diverse markets, which in turn increases their income potential. The rise of e-commerce has particularly been a game-changer for rural products, allowing them to overcome geographical barriers and access national and international buyers (Chen et al., 2025). Liubao tea's strategic use of digital platforms for marketing and sales is an example of how rural businesses can leverage modern technology to enhance market reach and economic resilience.

From an agricultural policy perspective, the case of Liubao tea suggests that a balanced approach between production efficiency, cultural branding, and market expansion can have a profound impact on the livelihoods of farmers and rural development. Policymakers should prioritize the integration of culture and heritage into agricultural products, as this not only adds value to the product but also promotes sustainable rural development. Furthermore, encouraging technological innovation in farming practices, as demonstrated by Liubao tea, should be a key focus in rural revitalization strategies. By supporting the adoption of modern farming technologies, farmers can

improve productivity while maintaining ecological balance and preserving traditional agricultural practices. Governments could play a crucial role by providing incentives for agricultural innovation, facilitating access to new markets, and supporting the establishment of rural cooperatives that can help small-scale farmers access the benefits of market expansion and brand development.

The findings of this study can be contextualized by comparing them with the successful brand development of Yunnan's Pu'er tea, which offers valuable lessons for Liubao tea's marketing strategy. Similar to Liubao tea, Pu'er tea has a rich cultural heritage and a strong local identity. However, Pu'er tea's success lies not only in its product quality but also in its effective cultural branding and global market expansion. Pu'er tea has strategically highlighted its historical fermentation process and deep cultural significance, appealing to both domestic and international consumers. This emphasis on cultural storytelling, combined with modern production techniques, has enhanced its market visibility and consumer loyalty (Ning et al., 2011). Liubao tea can benefit from a similar approach, integrating its unique production techniques and cultural values into a compelling narrative that resonates with modern consumers. By learning from Pu'er tea's ability to combine tradition with innovation, Liubao tea can enhance its brand recognition and market share, both within China and internationally.

To support the growth of Liubao tea and the income of local farmers, several policy recommendations are critical. One potential avenue is providing subsidies for the adoption of modern technologies in tea cultivation and production. Government incentives could help tea producers invest in advanced processing techniques and improve production efficiency, which would not only raise the quality of the product but also reduce costs and increase profitability. Furthermore, promoting Liubao tea through cultural tourism initiatives could attract more consumers by linking tea production with cultural experiences. Establishing tea-related cultural festivals or tea farm tours would not only boost brand awareness but also create opportunities for direct consumer engagement and sales growth. Additionally, developing infrastructure for better access to international markets, including digital platforms for e-commerce, could significantly expand Liubao tea's reach, enhancing its competitive edge in global markets.

This study makes significant theoretical contributions to both cultural branding and agricultural economics. In the field of cultural branding, it advances our understanding of how local cultural elements, when strategically integrated into a brand's marketing, can create emotional connections with consumers and enhance brand loyalty. By applying big data visualization to analyze consumer behavior, this research provides new insights into how cultural heritage can be effectively communicated to diverse consumer groups. Furthermore, from the perspective of agricultural economics, this study explores the role of branding and technology in increasing farmer income. It emphasizes how the modernization of agricultural practices, supported by data-driven marketing strategies, can enhance the economic viability of small-scale farmers, offering a sustainable path for rural development. These theoretical contributions add value by demonstrating the intersection of cultural heritage, technological innovation,

and economic development within the agricultural sector, providing a model for other regions to replicate.

The long-term strategy for rural revitalization should focus on creating an ecosystem where agricultural production, market expansion, and cultural development go hand in hand. The success of Liubao tea underscores the importance of creating value through cultural differentiation, improving productivity, and ensuring access to larger markets. In this way, rural areas can not only enhance their agricultural output but also create a unique identity that attracts both local and global consumers. This multifaceted approach helps achieve broader economic goals, such as improving farmer incomes, enhancing rural economic resilience, and supporting sustainable development in the countryside. By applying these strategies to other agricultural sectors, a more diversified and prosperous rural economy can be built, fostering long-term sustainable growth and prosperity for rural communities.

Conclusions

This study provides a comprehensive analysis of how big data visualization can enhance the brand marketing of Hezhou Liubao tea and increase farmer income. The findings highlight the significant role of big data in shaping marketing strategies by revealing key consumer behavior patterns, market demand trends, and sales channel performance. By integrating both quantitative data and cultural elements, Liubao tea's brand strategy can be improved, enhancing its market competitiveness and fostering growth in the local tea farming industry. However, this study has some limitations that should be acknowledged.

First, the regional focus on Hezhou Liubao tea limits the generalizability of the findings to other tea-producing regions in China and abroad. While Liubao tea offers a valuable case study, the unique climatic, cultural, and economic conditions of other tea-growing regions may result in different branding and marketing dynamics. For instance, regions like Fujian and Zhejiang, known for their distinct tea varieties and production techniques, may require different strategies to adapt to their specific market demands. Moreover, while the reliance on big data provides valuable insights into consumer behavior and preferences, it may overlook important qualitative nuances, such as the cultural significance of tea or consumer attitudes that are not easily captured in online data. These qualitative aspects, particularly the emotional and cultural connections consumers have with tea, are often difficult to quantify but crucial for understanding consumer behavior in the tea market.

To address these limitations, future research should consider expanding the geographic scope to include a more diverse range of tea-producing regions. Studies could explore how climatic, cultural, and economic variations affect branding strategies in different regions. Additionally, future research could adopt an interdisciplinary approach, combining ethnographic methods with big data analysis to capture the qualitative dimensions of tea culture that may be underrepresented in quantitative data. By

integrating fieldwork and cultural insights with data-driven approaches, researchers could gain a more holistic understanding of the factors driving consumer preferences and brand success in the tea industry.

Furthermore, investigating the role of government policies in supporting the development of tea brands, particularly in rural areas, would also be valuable. Policymakers could use such research to design strategies that support the integration of cultural heritage with modern marketing practices, helping to improve farmers' livelihoods and foster sustainable industry growth. Overall, this study lays the groundwork for further exploration into the intersection of cultural branding, technological innovation, and economic development in the tea industry, with implications for both the agricultural sector and the broader global market.

Funding Statement

Conflict of interests

The authors declare no conflict of interest.

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THE ECONOMIC SIGNIFICANCE OF TRADITIONAL AND REGIONAL FOOD IN THE REGION OF CRETE

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A R T I C L E I N F O	A B S T R A C T
	Traditional foods play a key role in the economies of all countries, culture and everyday life. Crete is famous for its rich, delicious, also simple ingredients traditional dishes, based on local natural resources. The intention of the research is to identify the traditional and regional products of Crete also the economic status of its food products. The survey was carried out in 2022 with 607 respondents and responses were processed using SPSS and Excel. The results show that the consumption habits of residents at home are related to how often they choose traditional foods in restaurants. Older generations are more committed to local foods, while younger people consume them less often in restaurants. The research highlights the fact that consumption of traditional and regional foods can contribute to the region's economic development also it is positively correlated with emotional attachment to the region.

Introduction

The ancient and traditional dietary habits of the Cretan people were developed in connection with the raw materials that the Cretan land offered in abundance, mainly olive oil, grain, wine, honey also herbs and spices, which became essential ingredients in Cretan cuisine.

In addition to the region's tourist attractions and products, traditional and regional Cretan food products, typical of the Cretan landscape, also contribute to the development of the region's economic and social situation. Consumers' preference for quality over quantity is reflected in the purchasing decisions of the local population and is reflected in the food products on offer. Residents are committed consumers of traditional and local Greek food, an attitude which is generally shared in their daily lives.

Traditional foods are undeniably an integral part of the Cretan diet, which is a high quality and representative example of the Mediterranean diet (Trichopoulou et al.,

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2006). The diet itself is based mainly on the consumption of vegetables, fruits, legumes, grains and olive oil, which is used in the preparation of almost every plate of food. The nutrient-rich ingredients, which are available in abundance, contribute to a long and healthy life and well-being (Prefectural Administration of Heraklion, 2007).

As a preliminary stage to the Cretan research, I had earlier conducted a comparable study on traditional and regional food products in Hungary, especially within the Northern Great Plain region. The same methodological framework was applied in the research conducted in Crete to ensure analytical consistency and enable meaningful comparison between the two regions.

The study examines region-level particularities alongside the perceptions of residents in connection with the consumption of traditional food products. The questionnaire primarily explored consumer preferences, levels of knowledge, purchasing practices and risk-related considerations in relation to traditional and regional products. The Cretan survey is a fundamental basis for determining the local key economic conditions underlying food production, as well as the characteristic features of traditional food consumption among inhabitants and the identification of their willingness to pay (Halasi, 2025).

Traditional and regional foods in the region of Crete

Nowadays the various effects of globalization – both positive and negative – are forming consumers' daily activities, influencing their needs and choices in their regular food and basic material purchases. The presence and regular consumption also awareness of traditional products in a wide range of society is an important issue. Through the exponentially increasing market development and diversification of multinational companies, the distinctive characteristics, tastes and other specific distinguishing features of food products are becoming increasingly uniform and similar throughout the world. This process can obstruct the marketing of traditional and regional food, which can lead to various negative economic trends, such as loss of jobs and livelihoods for local populations also reduction of product diversity, tax revenues or local economic growth, forced migration, increased unemployment, or reduction of national, regional or local heritage (Nábrádi, 2010). Traditional and region-specific food products have a distinctive position in the global food market because of their traditional production, unique taste and appearance, which are desirable to the consumers (Halasi, 2025).

Traditional food products are key elements of each country's food economy. The term "traditional" itself is defined by Regulation (EU) 2023/2411 of the European Parliament and of the Council as the proven use, over a period of time in history, of a product originating in a geographical area by producers within a community, which allows its transmission from generation to generation (European Parliament and the Council, 2023). Regulation (EU) 2024/1143 of the European Parliament and of the Council (11 April 2024) established a scheme for traditional specialities guaranteed to assist producers in the marketing of their products and in making them known to consumers,

with a view to preserving traditional production methods and recipes. According to the Regulation, traditional specialities guaranteed are characterised by the fact that they are produced or processed using methods which are traditionally used or with a traditional composition; or are made from raw materials or components traditionally used (European Parliament and the Council, 2024). Bertozzi (1998) defines a traditional food product as belonging to a particular group and area, and as part of a culture that involves the cooperation of individuals working there. Traditional food products are agricultural and food products whose processing, storage and maturing methods are consolidated over time through uniform and constant local use (Ministero Agricoltura, 1999). Guerrero (2009) highlights that traditional food products are an important part of European culture, identity and heritage, which require continuous development in order to maintain and increase their market share.

The Cretan region is one of the thirteen regions of Greece, covering an area of 8.336 km^2, which represents 6.3% of the total area of the country. The island of Crete occupies the largest part of the region, but it also includes smaller islands of Gavdos, Gavdopoula, Zeus, Chrissi, Koufonissi and Dionysades. The region of Crete is one of the most popular destinations for tourism. The high quality/safety and reputation of traditional and local food products are essential to maintain the international recognition of the brand name 'Crete' and the 'Cretan diet' (Kokkinakis et al., 2011).

Nowadays traditional Cretan gastronomy - its ingredients and preparation methods - is considered one of the healthiest cuisines in the world. Over the centuries, the richness and high quality of the region's food products have created a distinctive and unique cuisine, fresh and delicious, which combines with the natural environment in an exceptional seasonal harmony. Cheeses, honey, herbs and many other foods from the mountains and farmland of the Cretan region are the basis of the local gastronomy (Prefectural Administration of Heraklion, 2007). Meals play a very important role in the life of Greek families also the country's southest and largest island is famous worldwide for its Cretan diet, which is based on Mediterranean eating habits. Many studies have shown that the Mediterranean diet is associated with longevity, which can be partly attributed to the traditional Mediterranean foods that the diet itself contains (Trichopoulou et al., 2006). Summarised by Konstantinos (2007), Cretan inhabitants often consume olive oil, whole grain food, legumes, seasonal fruits and vegetables, fish, and in smaller quantities poultry, red meat, processed food and wine made from locally grown grapes.

The EuroFIR AISBL is an international, non-profit and membership-based organisation established under Belgian law. It was founded in 2009 and its primary purpose to provide long-term representation and coordination in the field of food information in Europe. The purpose of the association is to generate, publish and use food composition information and to promote international cooperation and harmonisation of standards to improve the quality, storage and accessibility of data. EuroFIR AISBL integrates the most accurate food information sourced from 26 compiler organisations across Europe, the United States and Canada (FoodEXplorer) as well as validated information on bioactive compounds (eBASIS). Food composition databases provide detailed,

country-specific information on the nutrient composition of food products also a wide range of components, including energy content, macronutrients (e.g. protein, carbohydrate, fat), vitamins and minerals also in some cases specific compounds such as amino acids and bioactive compounds (European Food Information Resource, 2024). In addition, one of the objectives of each national database is to provide data on the nutritional composition of traditional food, so that they are included together with their composition and method of preparation, providing useful information to the food industry for the production of traditional products (Trichopoulou et al., 2006). In Greece, two related databases are available: the Composition tables of foods and Greek dishes (HelTH) also the Medical School of Crete has published a food composition database (Food Composition Tables of Greek Foods), specific to the country and Crete in particular (European Food Information Resource, 2024).

The Food Composition Tables of Greek Foods provide the nutritional composition of some Greek foods according to twelve categories - dairy products, fish, seafood, meat, meat products, vegetables, fruits, olives, seeds and nuts, legumes, grains and traditional food. The Greek database includes typical Cretan products in the following food categories:

- *Dairy products:* Anthotiro cheese (Ανθότυρο Κρήτης), Graviera cheese (Γραβιέρα Κρήτης), Kefalotiri cheese (Κεφαλοτύρι Κρήτης), Mizithra cheese (Μυζήθρα Κρήτης);

- *Meat:* Lamb stew (Αρνί ημιάγριο βραστό Κρήτης), Goat stew (Κατσίκι ημιάγριο βραστό Κρήτης), Homemade pork stew (Χοιρινό σπιτικό βραστό Κρήτης);

- *Vegetables:* Raw/green amaranth (Βλήτα ωμά, Κρήτης), Boiled silver onions (Βολβοί βρασμένοι, Κρήτης), Cretan boiled chard (Γούλες Κρήτης βρασμένες), Boiled chicory from Crete (Ραδίκια βρασμένα Κρήτης), Boiled spiny chicory from Crete (Σταμναγκάθι βρασμένο Κρήτης);

- *Fruits:* Black Cretan Cotsifali grape (Σταφύλι κοτσιφάλι μαύρο Κρήτης), Sultana grapes from Crete (Σταφύλι σουλτανί Κρήτης);

- *Olives:* Cretan black olives (Ελιές μαύρες (σταφιδοελιές) Κρήτης), Cretan green olives (Ελιές πράσινες (τσακιστές) Κρήτης);

- *Grains:* Traditional barley rusk from Crete (Παξιμάδι κριθαρένιο παραδοσιακό Κρήτης), Boiled sour trahanas from Crete (Τραχανάς ξινός Κρήτης (βραστός). (Medical School of Crete, 2024).

Cretan people are really proud of their fresh raw materials also typical and local dishes, such as μουσακάς (moussakas: casserole of aubergines with potatoes and minced meat), τζατζίκι (tzatziki: yoghurt flavoured with grated cucumber and garlic), χοχλιοί μπουμπουριστοί (hohli bourbourbouristi: a traditional dish made from snails), ντάκος (Cretan dakos: a traditional starter, actually a wholemeal rusk) - all of which are popular among tourists who are visiting the island. Traditional food products are essential part of the Cretan dietary patterns and are considered healthy and delicious by the local population.

Materials and methods

I carried out primary research related to the research topic, using descriptive statistical tools. Similar to my previous research conducted in the Northern Great Plain region, the Cretan questionnaire-based study used an identical research design and methodological approach. The same set of hypotheses was also formulated to ensure comparability between the two studies. During the primary research, I applied a quantitative approach utilizing structured questionnaires, which were administered between 5 June 2022 and 12 December 2022. The key objective was to evaluate respondents' willingness to pay more for traditional and regional food products also to draw deductions regarding the fundamental economic circumstances of food production, as well as the distinctive characteristics of the consumption of these products within the region of Crete (Halasi, 2025).

The questionnaire was conducted for the residents of the Cretan region, exclusively online, also it was created using the Google Docs application. The participation was voluntary and the Greek-language survey was attainable on a social networking site, linked to various local communities and regions through user communities/groups (names of the communities/regions: Agios Nikolaos, Chania, Elounda, Gournes, Gouves, Heraklion, Hersonissos, Ierapetra, Kalamaki, Koutouloufari, Lasithi, Malia, Mirtos, Mohos, Pacheia Ammos, Paleochora, Plakias, Platanias, Rethymnon, Sissi, Sougia, Stalis, Stavrochori, Tertsa). The total sample size for the Cretan region is 607 persons, during the research SPSS 25.0 and Excel programs were used to process the questionnaires.

The sample size itself provides a solid basis for statistical inference also it can detect relationships among variables and supports the robustness of quantitative analysis. In survey research, samples exceeding 400–500 cases generally allow for reliable estimation with an acceptable margin of error at a 95% confidence level (Bryman, 2016). The sampling strategy ensured that the survey reached the relevant target population, namely individuals with direct experiences related to the island. In online environments, targeted community groups often function as natural clusters of the population under study, making them effective channels for accessing specific social segments (Kosinski et al., 2015). The Facebook groups used for the survey represent one of the most active and concentrated forms of community engagement related to the island, thereby supporting the appropriateness of the sampling approach.

Also some sources of bias may influence the representativeness of the data and must be acknowledged to fully contextualize them:

- self-selection bias (individuals with stronger interest in Crete may have been more inclined to participate, thereby overrepresenting highly engaged users),

- coverage bias due to platform-specific data collection (individuals who are not active on Facebook were excluded from the sampling frame and certain demographic categories may were underrepresented),

- social desirability bias (even in anonymous online settings, individuals may provide answers they perceive as socially acceptable or favourable),

- algorithmic exposure bias (the visibility of posts within Facebook is partially determined by the platform's algorithms and the algorithmic filtering may systematically favour highly active users (Bakshy et al., 2015).

Overall, the sample's size, targeted distribution, internal heterogeneity and alignment with the study's conceptual population make the 607-respondents dataset methodologically adequate and partially representative for the aims of this research.

Results and Discussions

Social and demographic attributes of the survey population

The demographic attributes of the respondent sample were classified according to gender, age categories, educational attainments and the type of settlement of habitation. In addition, the survey collected information on perceived income status of the responders, as well as the level of per capita household income (Halasi, 2025).

In the Cretan region, women comprised 71.5% of the responders and nearly the one-third (32.1%) of them belong to the '30-39 years' age category. More than a quarter of the respondents (26.2%) belong to the '18-29 years' or the '40-49 years' age categories. Almost two-thirds of respondents (64.9%) have higher education level and a quarter (25.0%) of them have graduated. Nearly three quarters (72.7%) of the surveyed inhabitants live in cities with county status. More than a third of Cretan respondents (35.9%) are active white-collar workers and nearly a fifth of them (17.3%) are dependents. The proportion of people in the categories of homemakers, retired/retired on disability pension and childcare allowance claimants is relatively low. Almost half of the residents (41.7%) have a per capita income of more than 600 EUR and 13.7% of them have an income between 451 and 600 EUR. Nearly two-thirds of respondents (61.8%) spend between 21% and 40% of their income on food and more than one fifth of them (21.4%) spend between 41% and 60%. The share of food purchases above 60% of the total income is 2.5%. The detailed social and demographic characteristics and composition of the survey population is shown in *Table 1*.

Table 1. Social and demographic attributes of the survey population.

Number of survey participants (N=607)		
Demographic categories	**N**	**%**
Gender categories		
Man	173	28.5%
Woman	434	71.5%
Age categories		
From 18 to 29 years old	159	26.2%
From 30 to 39 years old	195	32.1%
From 40 to 49 years old	159	26.2%
From 50 to 59 years old	75	12.4%
Over 60 years old	19	3.1%

Educational attainments		
Elementary school	1	0.2%
Specialized school	60	9.9%
Graduation	152	25.0%
Higher education	394	64.9%
Settlement classification		
County town	441	72.7%
Settlement with more than 10.000 residents	61	10.0%
Settlement from 2.000 to 10.000 residents	53	8.7%
Settlement with under 2.000 residents	52	8.6%
Economic activity categories		
Employed in blue-collar occupations	77	12.7%
Employed in white-collar occupations	218	35.9%
Childcare allowance claimant	12	2.0%
Retired/retired on disability pension	18	3.0%
Student	61	10.0%
Homemaker	19	3.1%
Unemployed	42	6.9%
Dependent	105	17.3%
Other	55	9.1%
Level of per capita household income categories		
Under 150 EUR	46	7.6%
151-250 EUR	45	7.4%
251-350 EUR	35	5.8%
351-450 EUR	46	7.6%
451-600 EUR	83	13.7%
Over 600 EUR	253	41.7%
No answer	99	16.3%
How many percent of the income belongs to food purchasing in the household?		
0-20%	87	14.3%
21-40%	375	61.8%
41-60%	130	21.4%
Over 60%	15	2.5%

Source: Own editing, 2024; Halasi, 2025

Hypothesis tests

A key objective of the study was to analyze the economic significance of traditional and regional food products among local consumers in the Cretan region. The study emphasized regional particularities by gathering the perspectives of local inhabitants regarding their consumption, with the dual aim of supporting the domestic market and enhancing product competitiveness. While local and traditional products primarily serve the interests of local enterprises and the tourism sector – and are therefore not positioned to address the broader structural challenges of the region – they can support the economic development and meet the specific needs of various social categories through their complementary or 'supporting' role (Halasi, 2025).

The first hypothesis

H₁: Local inhabitants who frequently eat traditional and regional meals in their own households often decide to consume them in restaurants as well.

The study examined how frequently local inhabitants consume traditional Greek meals within their own households, as well as the extent to which they select traditional Greek meals when dining in restaurants (Halasi, 2025). A cross-tabulation analysis of these two variables – household consumption frequency and consumption frequency in restaurants – was performed and the results are presented in *Table 2*. below.

Table 2. Household consumption frequency of traditional and regional foods in relation to their consumption in restaurants.

How often do you eat traditional Greek food in your own household?		When you visit a restaurant, how often do you select traditional Greek meals?			
		Mostly I don't select	Sometimes yes, sometimes no	Mostly I select	Total
Less than once a month	N	5	14	14	33
	%	15.2%	42.4%	42.4%	100.0%
No more than once a week	N	4	20	22	46
	%	8.7%	43.5%	47.8%	100.0%
Several times a week	N	5	74	161	240
	%	2.1%	30.8%	67.1%	100.0%
Daily	N	2	72	210	284
	%	0.7%	25.4%	73.9%	100.0%
Total	N	16	180	407	603
	%	2.7%	29.9%	67.5%	100.0%

Source: Own editing, 2024; Halasi, 2025

When examining the relation between the two qualitative variables, Pearson's chi-square (χ^2) test indicated a statistically significant association (p<0.01). The result demonstrates that the frequency with which individuals consume traditional foods at their households is associated with how often they choose traditional foods when dining in restaurants. As both variables form an ordinal scale – meaning that the ranking of numerical values corresponds to an inherent order in the responses – the relation was additionally examined using Spearman's rank correlation (Halasi, 2025). The Spearman correlation has a value of -0.18 and p<0.001. The latter means that individuals who consume traditional foods more frequently at home also tend to choose these foods more often when dining in restaurants, but there is a break in the monotony, and there are two distinct patterns of response. In one pattern, about 70% of consumers (67.1% and 73.9%) mostly and about 30% (25.4% and 30.8%) sometimes choose traditional Greek foods in restaurants, if they eat it several times a week and daily in their own households. The other pattern shows that around 45% (42.4% and 47.8%) of residents choose traditional Greek foods in restaurants most of the time and around 45% (42.4% and 43.5%) sometimes, if they eat it in their households at most once a month or once a week.

The hypothesis H_1 is confirmed.

The second hypothesis

H_2: Local residents who frequently consume traditional and regional foods in their households consider that it is relevant that these food products are produced by using local ingredients.

A cross-tabulation analysis of the variables – the household consumption frequency of traditional and regional foods in relation to the relevance of using local ingredients – is shown in *Table 3.* below.

Table 3. Household consumption frequency of traditional and regional foods in relation to the relevance of using local ingredients.

How often do you eat traditional Greek food in your own household?		How significant is the use of local ingredients to you when evaluating a food product?			
		Very relevant	Relevant	Irrelevant	Total
Less than once a month	N	7	9	15	31
	%	22.6%	29.0%	48.4%	100.0%
No more than once a week	N	8	26	9	43
	%	18.6%	60.5%	20.9%	100.0%
Several times a week	N	84	126	25	235
	%	35.7%	53.6%	10.6%	100.0%
Daily	N	146	127	8	281
	%	52.0%	45.2%	2.8%	100.0%
Total	N	245	288	57	590
	%	41.5%	48.8%	9.7%	100.0%

Source: Own editing, 2024; Halasi, 2025

The association between the two variables was found to be statistically significant ($p<0.01$) based on Pearson's chi-square (χ^2) test, indicating that the frequency with which individuals consume traditional foods at home is related to the degree to which they consider the importance of using local ingredients in food production. Since the two variables form an ordinal scale, their relation was further examined using Spearman's rank correlation. The resulting coefficient was 0.284 and $p<0.001$, demonstrating that higher household consumption frequency of traditional and regional foods is connected to a higher relevance of using locally sourced ingredients (Halasi, 2025). The row percentages (Table 3.) further support this trend: as the frequency of home consumption increases, the proportion of consumers who consider the relevance of using local ingredients shows a monotonous rise (18.6%, 35.7%, 52.0%). Conversely, the share of respondents who regard this aspect as unimportant is monotonically decreasing (48.4%, 20.9%, 10.6%, 2.8%).

The hypothesis H_2 is confirmed.

The third hypothesis

H$_3$: Local inhabitants who frequently select traditional Greek meals in restaurants also demonstrate a greater willingness to pay more for food products prepared with traditional, locally sourced ingredients.

The survey investigated both the frequency with which residents choose traditional Greek foods in restaurants also their willingness to pay more for food products made from traditional, locally sourced ingredients (Halasi, 2025). *Table 4.* below presents the relation between these two variables.

Table 4. The relation between the frequency of selecting traditional Greek meals in restaurants also willingness to pay for food products made from traditional local ingredients.

When you visit a restaurant, how often do you choose traditional Greek dishes?		Would you be willing to pay more for a food product, prepared using traditional, locally sourced ingredients?			
		Yes	Maybe	No	Total
Mostly I don't choose	N	10	3	2	15
	%	66.7%	20.0%	13.3%	100.0%
Sometimes yes, sometimes no	N	85	76	19	180
	%	47.2%	42.2%	10.6%	100.0%
Mostly I choose	N	251	124	31	406
	%	61.8%	30.5%	7.6%	100.0%
Total	N	346	203	52	601
	%	57.6%	33.8%	8.7%	100.0%

Source: Own editing, 2024; Halasi, 2025

The Pearson's chi-square (χ^2) test indicated that the relation between the two variables is statistically significant ($p<0.01$), suggesting that the frequency with which residents select traditional Greek foods in restaurants is associated with their willingness to pay more for products made from traditional, locally sourced ingredients (Halasi, 2025). Interestingly, even consumers who mostly do not choose traditional Greek dishes in restaurants exhibit a notable willingness to pay for these products (66.7%). Conversely, the willingness to pay decreases if a Cretan resident sometimes chooses (47.2%, 42.2%, 10.6%) or mostly chooses (61.8%, 30.5%, 7.6%) these traditional food products in a restaurant.

The hypothesis H$_3$ is confirmed.

The Kruskal-Wallis and Jonckheere-Terpstra tests were applied to examine differences in commitment to traditional and regional foods across groups defined by key background variables, including age, type of settlement, and per capita household income. The commitment was assessed using four survey items:

- The importance of a food product being produced from locally sourced ingredients.

- Willingness to pay more for a food product made from traditional, locally sourced ingredients.

- Frequency of consuming traditional Greek food products within the household.

- Frequency of selecting traditional Greek meals when visiting restaurants (Halasi, 2025).

The fourth hypothesis

H$_4$: The level of commitment to traditional and regional foods among local inhabitants increases with age.

The Jonckheere-Terpstra test is a rank-based nonparametric test that can be used to determine whether there is a statistically significant trend between an ordinal independent variable and a continuous or ordinal dependent variable (Ali et al., 2015). The Jonckheere-Terpstra test was applied to compare the level of commitment to traditional and regional foods across different age categories. In this case, in contrast to the Kruskal-Wallis test, the counterhypothesis is not the inequality of the group medians, but their monotonic variation, which is significant in connection with age categories and four factors: the importance of using local ingredients, willingness to pay more, frequency of consumption in households also frequency of selection in restaurants (p<0.05). The level of commitment to traditional and regional foods by age groups is illustrated in *Figure 1.* below.

Figure 1. Commitment to traditional and regional foods across age categories of local residents
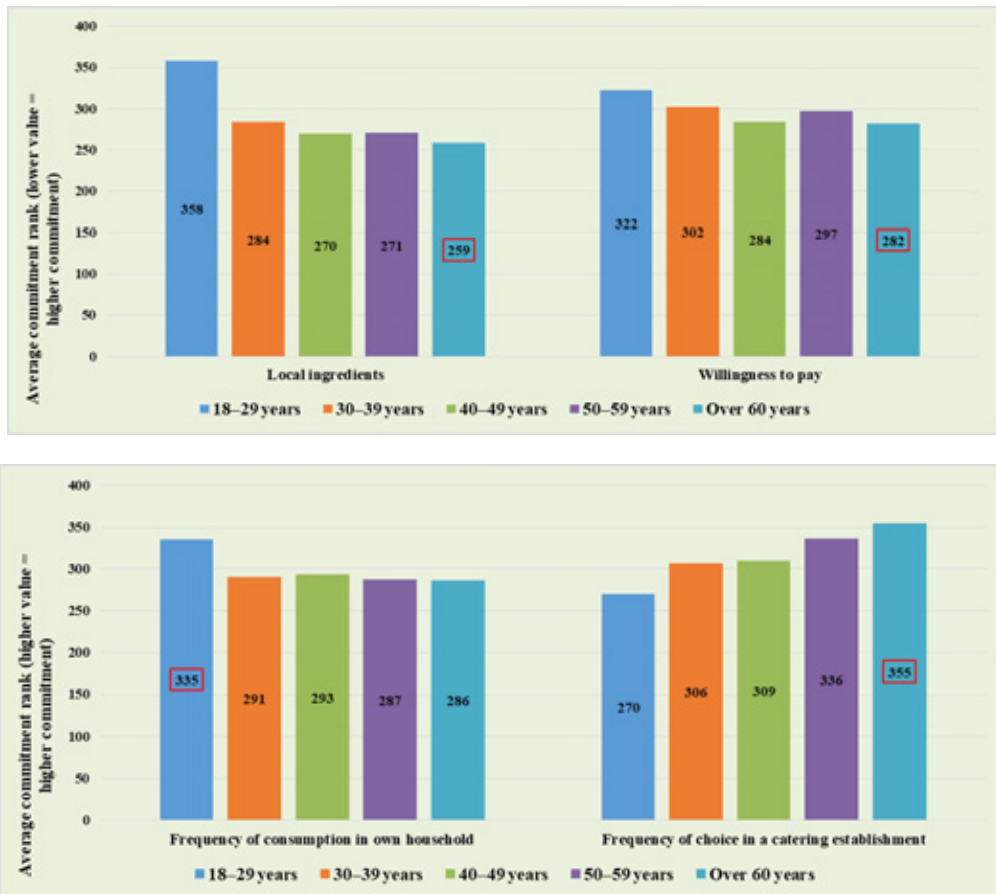
Source: Own editing, 2024; Halasi, 2025

For the variables importance of local ingredients and willingness to pay, lower response values indicate higher commitment to traditional and local foods (Halasi, 2025). Based on the average rank values, the 'over 60 years' age category demonstrates the strongest commitment, with average ranks of 259 for the importance of local ingredients also 282 for willingness to pay more. In contrast, the '18–29 years' age category shows the lowest level of commitment, with average ranks of 358 (importance of local ingredients) and 322 (willingness to pay).

For the variables frequency of consumption in households and frequency of selection in restaurants, higher values correspond to stronger commitment (Halasi, 2025). The '18–29 years' age category consumes traditional Greek foods most frequently at home (average rank: 335), whereas the 'over 60 years' group consumes them less often (average rank: 286). In restaurants, the pattern is reversed: the 'over 60 years' group selects traditional Greek meals most frequently (average rank: 355), while the '18–29 years' group shows the lowest commitment (average rank: 270).

The hypothesis H_4 is confirmed.

The fifth hypothesis

H$_5$: In certain municipalities within the region, commitment to traditional and regional foods appears to increase as the population size decreases.

The Kruskal-Wallis test is a nonparametric statistical test. It evaluates differences between three or more independently sampled categories based on a single, non-normally distributed continuous variable. Non-normally distributed data (e.g., ordinal or ranked data) are suitable for the Kruskal-Wallis test (Kruskal & Wallis, 1952). The Kruskal-Wallis test was applied to compare the commitment to traditional and regional foods among residents across different types of settlements. The analysis revealed no statistically significant differences between settlement types, $p>0.01$.

The hypothesis H_5 is not confirmed.

The sixth hypothesis

H$_6$: Commitment to traditional and local foods increases as the per capita household income decreases.

The Kruskal-Wallis test was applied to compare consumer commitment to traditional and regional foods across different income categories. The results indicated no statistically significant differences between the groups ($p>0.01$).

The hypothesis H_6 is not confirmed.

The results confirm that traditional and regional foods remain vital components of Crete's social and economic life, but with generational differences that reflect changing lifestyles and values. The integration of traditional food production with agritourism offers additional development opportunities. Collaboration between farmers, restaurant owners and tourism operators would further support the island's economy by combining gastronomy with

cultural tourism. Th research quantifies behavioral patterns among Cretan consumers and statistically confirms the socio-economic relevance of traditional food products.

Conclusions

Cretan locals are hospitable and traditional people who really love and respect their homeland also they are always ready to share their tables with a foreign visitor. They usually serve their guests a glass of local wine, raki or ouzo also homemade meals and sweets. Some special and traditional local restaurants, tavernas and cafés offer appetizers and main dishes based on the Cretan diet, which are often served also at regional community events and programs in the towns and villages (Region of Crete, 2013).

In the Cretan region women play a significant role in the society also in the family in connection with food purchasing. They are usually the ones who decide what foods to buy, also they are the decisive majority of respondents in the region. During my research, I formulated six hypotheses and four of them were confirmed also two of them were not confirmed.

As a result of the study, two correlations in particular can be highlighted:

- The frequency with which residents choose traditional Greek meals in restaurants is associated with their willingness to pay more for food products made from traditional, locally sourced components. Even consumers who rarely select traditional dishes in restaurants still demonstrate a willingness to pay for these food products. If the Cretan resident sometimes or mostly chooses these traditional Greek meals in a restaurant, their willingness to pay decreases.

- Among age categories, inhabitants over 60 years old represent the highest level of commitment to traditional and local foods, particularly regarding the significance of using local ingredients and willingness to pay more. In contrast, the '18–29 years' age group shows the lowest level of commitment (Halasi, 2025).

Traditional and regional foods can contribute to economic growth and increased tax revenues in the region:

- they represent product development opportunities for industry, enable the launch of small and medium-sized enterprises, and provide job creation opportunities in underdeveloped areas;

- they offer opportunities for expanding the range of products available in retail and catering, enabling a higher proportion of locally produced food products to be used locally;

- they can be used in rural development programs to promote and boost tourism, for example by organizing food tours and themed events;

- overall, they strengthen the attractiveness and image of the region and the country (Szakály et al., 2010).

It is a relevant objective that consumers in the Cretan region choose traditional and regional food products (Halasi, 2025). The practical implications of the research conclusions can be applied in several areas, including through the development and implementation of specific action plans:

- supporting regional governments in developing local product strategies and tourism identities,

- supporting local chambers of agriculture in planning marketing support for local producers,

- providing inspiration and guidance to tourism businesses in the region in developing their gastronomic tourism offerings based on consumer preferences,

- supporting and encouraging local producers in developing new branding and packaging strategies,

- supporting and encouraging the education of local young people to make conscious decisions about the consumption of traditional and local foods, supporting local communities and values, and increasing local tax revenues.

Conflict of interests

The authors declare no conflict of interest.

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THE IMPACT OF VALUED MACROECONOMIC FACTORS BY TOP MANAGEMENT ON BUSINESS IN MEDIUM-SIZED INDUSTRIAL AND MEDIUM-SIZED AGRIBUSINESS ENTERPRISES

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A B S T R A C T

The aim of the research was to investigate the impact of macroeconomic factors on the operations of medium-sized industrial and medium-sized agribusiness enterprises. The subject of the research was medium-sized industrial and medium-sized agribusiness enterprises. The authors conducted a survey of top management in relation to the impact of 7 macroeconomic factors. The method of comparing the results obtained from both forms of enterprise organization in the research period (2023-2025) was used. The existence of differences in the evaluation of top management in relation to the form of enterprise organization was revealed. Agribusiness enterprises had more confidence in the analyzed macroeconomic factors: exports, subsidies and the impact of banking, while industrial enterprises had more confidence in the impact of gross domestic product, employment, imports and tax breaks.

Introduction

The impact of industrial enterprises' operations is such that it plays a dominant role within the overall economic activities of an economy. Considering industry as a significant factor in economic development is an existential issue for many economies. When considering the importance of the impact of a particular activity on general social development, one of the key issues is the inevitable recognition of macroeconomic influences and factors on making business or valid decisions by those who manage such organizations or enterprises.

Authors such as (Makoye et al., 2022) have focused on the importance of the influence of macroeconomic factors on the business results of the construction industry in a developing country, in a way that recognizes the general goal of development through a business model that can help economic policymakers in their efforts to develop a specific segment of the industry by making valid management and other business decisions in order to improve the overall business results of the economy.

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There is no universality in the development of industrial enterprises. Thus, the author (Wu, 2025) emphasizes that it is primary to observe the influence of macroeconomic factors in relation to the efficiency of real estate companies, taking into account the frontier analysis in their business. This emphasizes the technical component in observing the use of resources in the real estate industry, but with acknowledging the influence of macroeconomic factors in relation to making future business decisions within the aforementioned form of industry.

The influence of macroeconomic factors, for example, in middle-income countries can be focused by emphasizing the importance of accelerated infrastructure development and combining it with foreign direct investment, because in this way the creation of added value in the industry can be accelerated, taking into account the aforementioned as part of efforts to improve the making of valid management decisions by decision-makers (Bernard Azolibe, 2021).

Numerous macroeconomic factors, such as gross capital formation, infrastructure development, household consumption expenditure, bank loans, labour force, foreign direct investment, trade openness, and political stability, can have significant impacts on the operations of industrial companies, or on the making of key business decisions, which has been the focus of research by numerous authors such as (Issah & Antwi, 2017).

Influential macroeconomic factors (Vychytilová, et al., 2019) can be linked to the price of shares in the automotive industry, but also to the listing on the stock exchanges, which leads to a connection between the application of certain macroeconomic factors and the listing on the stock exchanges, with the factor of gross domestic product, unemployment, and others that should be taken into account in the real making of future key business decisions by decision-makers.

However, some authors observe the development of industry, especially in underdeveloped economies, which can be seen in works such as (Yitayaw, 2021) within credit relations, primarily from relations with commercial banks, as they saw a comprehensive connection between the development of industry and the banking sector as a whole, which implies the creation of conditions for the correction of industrial policy in an economy such as Serbia (Savić & Lutovac Đaković, 2019; Lutovac Đaković, 2024).

The development of the industry (Irani, et al., 2021) is increasingly influenced by macroeconomic factors such as share prices, for example, of tourism companies, but it is also necessary to take into account the influence of other factors such as increased political and economic risks, uncertainty of global economic policy and the real exchange rate on making valid management decisions by the top management of the specific industrial activity in question.

The development of the industry can primarily be observed through the essential management of working capital. This is necessary for the development of numerous

companies, which have their own business goals (Wang, et al., 2021; Makoye, 2024; Kotcharin & Jantadej, 2024; Bakmaz et al., 2025; Popović et al., 2025).

Making valid management decisions is not characteristic only for the observation of industry, but it should also be observed within less intensive activities, such as the agricultural organization of business. Thus, authors such as (Bakmaz et al., 2025-a) emphasize the importance of making business decisions in relation to the size category of legal entities (small and medium-sized enterprises), and authors such as (Popović et al., 2025-a) also include the factor of dynamism, that is, the factor of location as an important factor for making valid management decisions in future business.

Literature review

The influence of macroeconomic factors can be observed within the framework of economic practice related to making practical decisions regarding the operations of numerous legal entities in both industry and agribusiness. This was the basis for considering already published research that is based on considering the theoretical approaches of numerous authors.

In this paper, the author has taken into account the assumptions of published research results that come from the most populous country in the world. Specifically, the focus of the authors there on focusing on the influence of macroeconomic variables was taken into account, because they play a significant role in assessing the volatility of commodity futures market prices in India (Sreenu et al., 2021) which currently plays an important role in making management decisions in such an economy, but the same experiences can be largely applied to other economies, as can be seen in the papers (Bojaj & Aharon, 2024; Shahzad et al., 2024; Mohamed et al., 2024).

Focusing on only one macroeconomic factor that can influence economic development would not contribute to rapid and comprehensive economic growth in most economies, and the literature also mentions macroeconomic results of the impact on proper management decision-making in the broad functioning of different economies by using, for example, joint ventures as a factor in the development of heterogeneous legal entities (Colović et al., 2025).

In addition, there is a focus on examining the impact of macroeconomic variables and firm-specific factors on the profitability of enterprises in emerging economies during and after the global financial crisis, which draws important attention to the dynamic consideration of macroeconomic factors in management processes (Cheong & Hoang, 2021). Similar views that focus on business after major events such as accession to economic integration, wars and other in a wide range of effects on the development of certain segments of the economy (especially agriculture) are found in the literature (Berxolli et al., 2023) but also by other authors as an important factor to consider when making important future management decisions in the economy (Thuy Tien, 2022).

Real business should take into account the presence of an analysis of real influencing

factors, especially macroeconomic influences on the economy and the achievement of overall results of the development of an economy, but also specifics such as determining the reality that the announcement of macroeconomic news is transmitted, for example, from the American to the Chinese commodity futures market as reality (Cai et al., 2020).

In addition to the economic impact on macroeconomic factors, the literature also emphasizes the importance of applying macroeconomic factors that take into account the limited reflections of political regimes (Mwinuka & Mwangoka, 2023). Similar views are found in the literature (Hussein Mohamud et al., 2025), which emphasizes the strong impact of constant military conflicts and economic instability, as well as the impact on the economy caused by environmental degradation, especially deforestation, as a general impact on a number of macroeconomic factors. At the same time, the aforementioned study recommends integrated strategies, including regulatory reform initiatives, which would contribute to raising environmental sustainability in a particular economy as part of a broader regional perspective.

The efficiency of numerous macroeconomic factors is the basis for the development of future important business plans in agriculture, which influences the application of macroeconomic factors of investments in agriculture, in agricultural production, and the reduction of gas emissions (Al-mulali et al., 2016), which is a similar observation within the framework of the real economy of other companies, especially industrial ones that have a key impact on overall development (Mkhabela et al., 2022; Bortz & Toftum, 2023; Rahman et al., 2023) which is primarily initially observed within the framework of making valid management decisions.

Business decision makers should assess numerous factors, primarily economic environment factors, as they can have a strong impact on the work and operations of agricultural companies (Epshtein et al., 2018) by focusing on adopting measures that will increase the resilience of domestic agriculture as a whole, but also of individual companies, primarily from agribusiness, thereby reducing the impact of external shocks, which is similarly encountered when clarifying the benefits of governance in the work of heterogeneous legal entities (Ljumovic et al., 2023; Zou & Hu, 2024; Diop et al., 2024).

The interconnectedness of macroeconomic factors in countries developing agribusiness requires the practical implementation of environmentally friendly norms (Adenaeuer et al., 2022), (such as reducing gas emissions) because they have a real impact on the development and performance of the overall economy, especially if the observation is carried out through an integrative approach, for example, accession to the EU and other associations (Gignarta et al., 2024; Deb, 2025).

State authorities, as well as top management of numerous companies, should consider the impact of various economic factors on the overall business operations of the economy, because the general postulate of economic activities is the achievement of the best possible economic results (profits) as an imperative for survival through the application, for example, of factors reducing environmental degradation due to high economic growth (Sadiq et al., 2022), which can enable real economic growth, increase

foreign direct investment, average inflation, and other things that can be seen in the example of strong economies (Kirui et al., 2023; Zhou et al., 2024; Trakem et al., 2024).

However, in the review of the literature used for the preparation of this study, it is noted that there is a gap in the practical application of comparing two categories of legal entities that are important for the economy, such as the economy of the Republic of Serbia. Namely, it was necessary to investigate the operations of industrial companies on the one hand as the leading driving locomotives of the economy that strives for integration, and on the other hand it was necessary to make a comparison with agribusiness legal entities in relation to the application of factors that can determine macroeconomic influences on making valid management decisions.

To fill the perceived gap, the author noticed and approached the analysis of the following factors: gross domestic product, employment, imports, exports, tax benefits, subsidies and the influence of banking, comparing industrial and agricultural enterprises through valuation by top management.

Thus, the goal of the study was achieved through the presentation of the comparison of the evaluated macroeconomic factors of the mentioned two forms of organization of the mentioned legal entities in the economy of the Republic of Serbia.

With this, the author believes and points out that the study can fill the mentioned gap, and the results he reached show the basic guidelines for action and making valid management decisions in relation to the mentioned industrial and agribusiness companies, both in the economy in Serbia and more widely in the economy, especially in the countries that once belonged to the once unified area of the former Yugoslavia.

Materials and methods

The aim of the study authors' research was to determine the possible impact of selected macroeconomic factors on the operations of medium-sized industrial and medium-sized agribusiness enterprises operating in the territory of the Republic of Serbia. The significance of the research subject was reflected in the connection of the theoretical approach and its impact through the analysis of selected macroeconomic factors on practical management decision-making in the two most common forms of enterprises in the Republic of Serbia.

The essential subject of the research was focused on medium-sized industrial and medium-sized agribusiness enterprises. The author of the study basically compared the results obtained from seven selected macroeconomic factors based on the evaluation of top management that makes important management decisions in the two mentioned forms of medium-sized enterprises on a daily basis.

The study included an analysis of the following macroeconomic factors: gross domestic product, employment in the economy, import of products, export of products and tax policy with its impact of subsidies and banking policy on the operations of the analyzed (surveyed) enterprises.

The fact is that the surveyed companies differ from each other in their business orientation and in essence very often operate differently, which is also a consequence of their position on the market, that is, they are very different companies in their orientation, and the point was to carry out a comparative analysis of their impact on business, that is, management, which is reflected in the decisions of their top management.

The author analyzed the assessment of the aforementioned seven factors in the research period, which was from February 1, 2023 to February 20, 2025, which covered the aforementioned two forms of organization of legal entities in the Serbian economy. The survey was completed by top managers who manage the aforementioned two types of surveyed companies on a daily basis, in relation to the seven factors that were defined and presented. The assessment option was in the assessment interval (1-10). The least confidence in the offered factor could be rated with a score of one. The highest confidence could be rated with a score of ten. For the purposes of the study, surveys were collected from 346 medium-sized enterprises, namely 192 industrial enterprises and 154 medium-sized agribusiness enterprises. All surveys were conducted in such a way that the questionnaires were filled out by general directors, financial directors or people authorized by the management body.

Respecting the above propositions, the authors decided to use statistical data processing in order to safely present the obtained differences in the assessment of the developed and analyzed macroeconomic factors by two relatively different forms of legal entities, i.e. industrial enterprises and agribusiness enterprises (Table 1-3). In addition, in the aforementioned tables, the comparison results are strengthened by the application of the t-test as well as by the display of significance, which reflects the real confidence of the top management in the estimated macroeconomic factors. In the following (Table 4-6), a substantive comparison of the estimated macroeconomic factors was performed using Person's correlation analysis in order to strengthen the authors' confidence in the obtained results and to show the real connection of the selected macroeconomic factors in the real business of two extremely important forms of enterprise organization in the Serbian economy.

Hypotheses

The hypotheses were formulated in order to achieve a realistic comparison of the obtained research results. For this purpose, valuation was used, which resulted in the evaluation of top management in relation to the analysed macroeconomic factors: gross domestic product, employment, import, export, tax breaks, subsidies and the influence of banking in relation to the operations of the two most common forms of medium-sized enterprises in the Republic of Serbia.

In order to determine the hypotheses with certainty, the authors' views were used, which focused on the importance of applying control mechanisms in the case of making valid management decisions (Bakmaz et al., 2024), which was the basis for formulating the first hypothesis.

Recognizing the basic motives for focusing on the application of selected macroeconomic factors in the operations of the two most common forms of organizing enterprises operating in the Republic of Serbia, the author decided to set the following hypotheses.

H1: There are no significant deviations based on the evaluation of top management of medium-sized industrial enterprises and medium-sized industrial agribusiness enterprises operating in the Republic of Serbia based on the evaluated analysed macroeconomic factors that are the basis for future business decision-making, for each individually observed year of the research.

Furthermore, in order to strengthen the views presented in the study and compare them with the views already presented by other authors (Katzv & Jung, 2024; Liu et al., 2025), i.e. that there is a significance of applying a comparative analysis of macroeconomic factors in the assessment of factors in the real operations of the two forms of enterprises, the author formulated another hypothesis.

H2: There is no strong relationship (linear dependence) between each individually evaluated analysed macroeconomic factor (GDP, employment, imports, exports, tax incentives, subsidies and banking influence) that can influence future business decisions made in the operations of medium-sized industrial and medium-sized agribusiness enterprises by the years of the research.

Data processing

After obtaining the data from the survey, a classical statistical analysis of the obtained data from the survey was performed. IBM SPSS software, version 25, was used in the work.

In the study, the author conducted a t-test, with the aim of showing possible differences in the evaluation of the analysed macroeconomic factors. In this way, the existence of real differences between medium-sized industrial enterprises and medium-sized agricultural enterprises would be seen.

In addition, the author applied Pearson correlation analysis, which strengthened the obtained results of the evaluation of the surveyed participants based on the data collected from the survey, with the note that the significance was done with 0.05.

Results

The results of the evaluation of macroeconomic factors that affect the operations of the aforementioned companies are presented by the author through the following sections that form a logical whole.

Presentation of evaluated macroeconomic factors in the work of the analysed companies

The results obtained in the study in the first year of observation, which related to the evaluated factors, are presented after their testing.

Table 1. The resulting differences in macroeconomic factors for 2023

	Industrial companies	Agricultural enterprises	t	p
	Average value			
Gross domestic product	3.66 ± 0.47	2.59 ± 0.49	20.538	<0.0005*
Employment	5.16 ± 0.68	3.77 ± 0.42	23.167	<0.0005*
Import of products	5.16 ± 0.68	2.36 ± 0.48	44.404	<0.0005*
Export	5.33 ± 0.47	5.36 ± 0.48	-10.511	<0.0005*
Tax incentives	6.83 ± 0.37	5.18 ± 0.38	40.216	<0.0005*
Subsidies	4.83 ± 0.37	6.18 ± 0.38	-32.837	<0.0005*
Banking	5.00 ± 0.81	5.36 ± 0.48	-5.141	<0.0005*
Total score	5.14 ± 0.39	3.97 ± 0.36	28.119	<0.0005*

Source: Author (2025).

A summary of the results of the seven analysed macroeconomic factors and their scores for 2024.

Table 2. Differences in macroeconomic factors for the year 2024

	Industrial companies	Agricultural enterprises	t	p
	Average value			
Gross domestic product	4.66 ± 0.47	3.77 ± 0.42	18.594	<0.0005*
Employment	5.50 ± 0.50	5.00 ± 0.00	13.820	<0.0005*
Import of products	5.66 ± 0.47	3.59 ± 0.49	39.630	<0.0005*
Export	5.33 ± 0.74	7.40 ± 0.49	-30.983	<0.0005*
Tax incentives	7.00 ± 0.57	6.40 ± 0.49	10.247	<0.0005*
Subsidies	4.66 ± 0.47	7.18 ± 0.38	-54.424	<0.0005*
Banking	5.66 ± 0.47	6.18 ± 0.38	-11.147	<0.0005*
Total score	5.50 ± 0.27	5.64 ± 0.25	-5.267	<0.0005*

Source: Author (2025).

The results that give an overview of each macroeconomic analysed factor and their score in the third year of research are shown in the following table with reinforcement through the performed test (column four).

Table 3. Differences in macroeconomic factors for the year 2025

	Industrial companies	Agricultural enterprises	t	p
	Average value			
Gross domestic product	6.50 ± 0.50	3.77 ± 0.42	55.024	<0.0005*
Employment	7.33 ± 0.47	5.00 ± 0.60	39.216	<0.0005*
Import of products	7.66 ± 0.47	3.36 ± 0.48	83.375	<0.0005*

	Industrial companies	Agricultural enterprises	t	p
	Average value			
Export	7.50 ± 0.50	8.00 ± 0.60	-8.236	<0.0005*
Tax incentives	7.66 ± 0.47	6.63 ± 1.02	12.359	<0.0005*
Subsidies	6.66 ± 1.10	8.22 ± 0.73	-15.666	<0.0005*
Banking	6.00 ± 0.81	7.22 ± 0.73	-14.485	<0.0005*
Total score	7.04 ± 0.48	6.03 ± 0.53	18.158	<0.0005*

Source: Author (2025).

In the third tabular representation of the results as well as the performed testing, the author gave the results, where you can see the existence of important differences for all factors as well as for their score.

Presentation of connection between macroeconomic factors 2023-2025

The obtained results that show the connection of macro-economic factors for the period from 2023 to 2025

The results obtained after applying Pearson's correlation analysis, i.e. the concretization of the results of macroeconomic influences, are given in the fourth presentation.

Table 4. Correlation of macroeconomic factors for 2023

	Gross domestic product	Employment	Import	Export	Tax incentives	Subsidies	Banking
Gross domestic product	1						
Employment	0.708**	1					
Import	0.771**	0.852**	1				
Export	0.823**	0.798**	0.904**	1			
Tax incentives	0.821**	0.849**	0.949**	0.923**	1		
Subsidies	-0.476**	-0.485**	-0.662**	-0.760**	-0.585**	1	
Banking	-0.059	0.150	-0.052	-0.148	-0.007	0.484**	1

Source: Author (2025).

The results obtained from the previous table indicate that there is a significant correlation of macroeconomic factors for 2023.

The presentation of the results in the second year of the research is given in Table 5.

Table 5. Correlation of macroeconomic factors for the year 2024

	Gross domestic product	Employment	Import	Export	Tax incentives	Subsidies	Banking
Gross domestic product	1						
Employment	0.717**	1					
Import	0.764**	0.685**	1				
Export	-0.583**	-0.640**	-0.796**	1			
Tax incentives	0.442**	-0.071	0.291**	0.014	1		
Subsidies	-0.605**	-0.524**	-0.929**	0.869**	-0.278**	1	
Banking	-0.202	0.281**	-0.650**	0.608**	-0.209	0.762**	1

Source: Author (2025).

The results shown in the fifth part of the tables indicate that there is a significant correlation of macroeconomic factors for 2024.

The presentation of the results in the third year of the research is given in Table 6.

Table 6. Correlation of macroeconomic factors for the year 2025

	Gross domestic product	Employment	Import	Export	Tax incentives	Subsidies	Banking
Gross domestic product	1						
Employment	0.910**	1					
Import	0.935**	0.905**	1				
Export	-0.337**	-0.164	-0.271**	1			
Tax incentives	0.643**	0.693**	0.568**	0.062	1		
Subsidies	-0.477**	-0.429**	-0.518**	0.727**	0.104	1	
Banking	-0.436**	-0.358**	-0.538**	0.680**	0.188	0.962**	1

Source: Author (2025).

The sixth tabular presentation of the results indicates the existence of a significant correlation between macroeconomic factors for the third year, i.e. 2025.

Graphic presentation of the three-year valuation of macro-economic factors

Presentation is given in the form of Figures 1-3, by years for which the research was done.

Figure 1. Comparison of macroeconomic factors for 2023
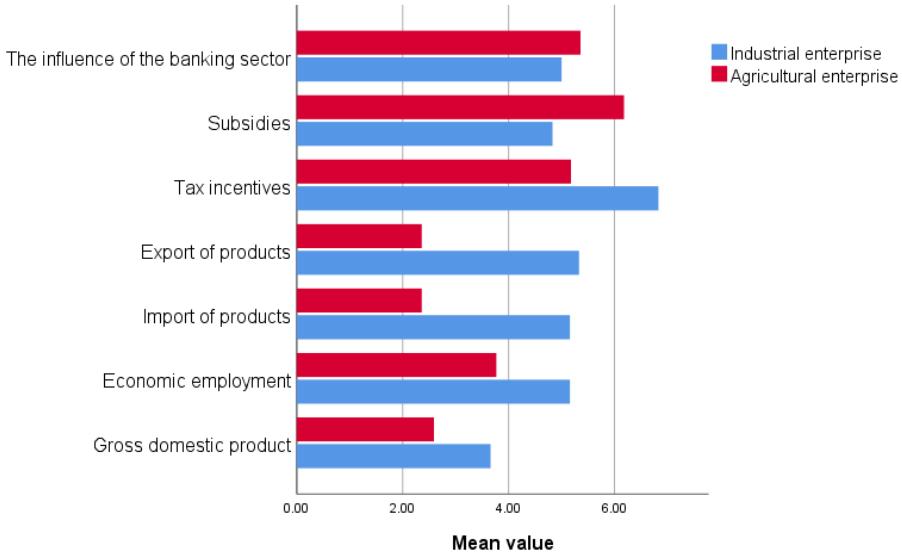
Source: Author (2025).

Figure 2. Comparison of macroeconomic factors for 2024
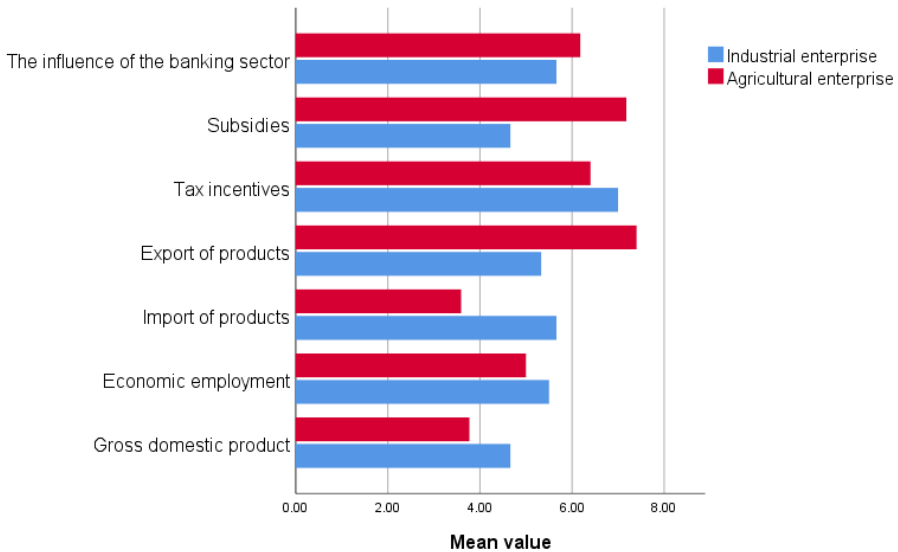
Source: Author (2025).

Figure 3. Comparison of macroeconomic factors for 2025
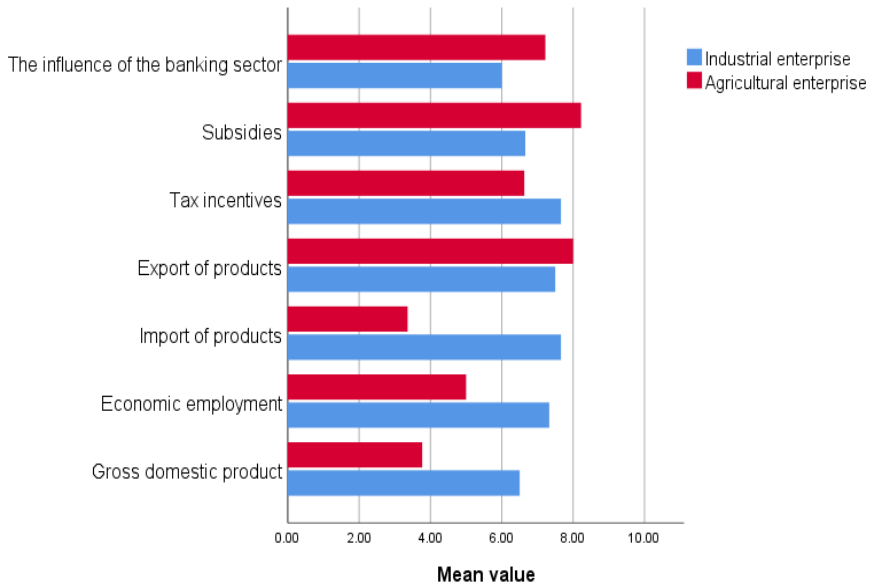
Source: Author (2025).

Discussion

The results in the first year of observation indicate that there is a significant difference in the valuation of macroeconomic factors for each individual macroeconomic factor, as well as for their overall result. At the same time, it can be seen that the macroeconomic factors: gross domestic product, employment in the economy, import of products, tax breaks and overall result have a higher value for medium-sized industrial enterprises, i.e. the results indicate that the top management of the enterprises mentioned has greater trust in them. At the same time, the macroeconomic factors: exports, subsidies and the influence of the banking system have a higher value for medium-sized agribusiness enterprises for 2023.

The results in the second year of observation indicate a continuation of the trend from the previous year of research, where macroeconomic factors: gross domestic product, employment, product imports and tax breaks are higher in medium-sized industrial enterprises, and the value of product exports, subsidies, the influence of the banking system and the overall score are higher in medium-sized agribusiness enterprises (Table 2).

The results in the third year are such that it can be seen that there are differences in macroeconomic factors, namely: gross domestic product, employment in the economy, product imports, tax breaks and the overall score, which are clearly higher in medium-sized industrial companies, while at the same time the macroeconomic factors: product exports, subsidies and the influence of the banking system are higher in medium-sized agribusiness enterprises (Table 3).

The previously presented results indicate that hypothesis H1 can be rejected, i.e. that there are significant deviations in the analyzed macroeconomic factors in all three years. This shows similarities with published works (Barbero et al., 2024) because they essentially presented the importance of spatial macroeconomic analysis. However, there are slightly different interpretations of the importance of macroeconomic factors in these works, which is evident from the fact that they still emphasized the application of the trade-off between fairness and efficiency in the management of European cohesion policy, unlike the study where the focus was on the analysis of business in Serbia.

The results of the comparative analysis of macroeconomic factors during the first year (Table 4) indicate that there is a significant relationship between gross domestic product and employment in the economy, imports and exports of products, tax breaks (positive and high correlation) and subsidies (medium and negative correlation). With the growth of gross domestic product, employment in the economy, imports and exports of products and tax breaks increase, while subsidies decrease. There is a significant relationship (positive) between employment in the economy, imports and exports of products, tax breaks and subsidies (medium and negative). As employment in the economy increases, imports and exports of products and tax breaks increase (high correlation), while subsidies decrease (negative). There is a significant relationship between exports of products with tax breaks (high and positive) and subsidies (high and negative). As exports of goods increase, tax breaks increase, while subsidies decrease. It can be seen that there is a significant relationship between tax breaks and subsidies, with subsidies decreasing as tax breaks increase. It can be seen that there is a significant relationship between subsidies and the influence of the banking sector (the relationship is positive and medium), with the influence of the banking sector (especially interest) increasing with the increase in subsidies.

The results of the comparative analysis in the second year (Table 5) show that with the growth of gross domestic product, employment in the economy, imports of goods, and tax breaks increase, while exports of goods, and subsidies decrease. As employment in the economy increases, imports increase, while exports, subsidies, and the influence of the banking sector decrease. With an increase in product imports, tax breaks increase, while exports, subsidies, and the influence of the banking sector decrease. It is also seen that there is a significant relationship between the export of products with subsidies and the influence of the banking sector. It is emphasized that there is a significant relationship between tax breaks and subsidies (the relationship is negative and small, where subsidies decrease with an increase in tax breaks).

The results of the comparative analysis of macroeconomic indicators in the third year (Table 6) show that there is a significant relationship between gross domestic product and employment, imports and exports of products, tax breaks, subsidies, and the influence of the banking sector. With an increase in gross domestic product, employment in the economy, imports of products, and tax breaks increase, while exports of products, subsidies, and the influence of the banking sector decrease. With an increase in employment in the economy, imports and tax breaks increase, while subsidies and the

influence of the banking sector decrease, and there is a significant relationship between imports of products and exports of products, tax breaks, subsidies and the influence of the banking sector. With an increase in imports of products, tax breaks increase, while exports, subsidies and the influence of the banking sector decrease. Furthermore, it can be seen that the relationship is positive and large for subsidies and the influence of the banking sector, where with an increase in exports, subsidies and the influence of the banking sector increase.

By reviewing the comparison in all three years individually, it can be seen that there is a strong relationship between each individually analyzed macroeconomic factor in the operations of medium-sized industrial and medium-sized agribusiness enterprises for all three years of observation, i.e. H:2 can be safely rejected because it can be seen that there is a strong relationship between each individually analyzed macroeconomic factor in the operations of medium-sized industrial and medium-sized agribusiness enterprises in all years of research.

The obtained results of the study coincide in the domain of focusing on two groups of extremely important companies, that is, they coincide with works such as (Kumar et al., 2024; Yex & Liou, 2024; Solarin et al., 2025) in which they emphasized the importance of the existence of the specificity of heterogeneous companies that strive for development within the industrial national complex. Similar views exist in works such as (Bardazzi et al., 2024; Boussetta et al.) al., 2025) where identical views are clearly seen but within the focus on companies that are predominantly from agribusiness. Thus, the basic determination of the authors of this study coincides with the framework for defining the forms of legal entities in the already cited literature, emphasizing that the study is nevertheless specific because the analysis was carried out for the most important macroeconomic factors for the operations of the economy of Republic of Serbia.

A graphical visualization of the results obtained is made in the display in Figure 1-3 in order to see the overall trend of the evaluation of all seven analyzed factors, which essentially provide an overview of the comparison of medium-sized industrial enterprises with medium-sized agribusiness enterprises in the economy. The author emphasizes that this study can be expanded to include more macroeconomic factors in the following years or observation periods, thus fulfilling expectations, and that similar research can be applied to a number of other middle-income countries.

Conclusions

The study shows that macroeconomic factors in the leading economy of the so-called Western Balkans (conceptually created as a "neologism" in the 1990s, as a feature of the former Yugoslavia (except Slovenia) and Albania, which did not want to be identified with the negative image of the "Balkans") are of exceptional importance, which is followed by research on the two most commonly used forms of business, namely medium-sized industrial and medium-sized agribusiness enterprises in the Republic of Serbia. The first conclusion would be that in the aforementioned observation period

(2023 to 2025), based on the evaluation of the top management of medium-sized industrial and medium-sized agribusiness enterprises, there is a strong deviation based on all analyzed macroeconomic factors, which means that the first hypothesis can be safely rejected. However, it should be noted that the study showed that top management of industrial companies has more confidence in the application of macroeconomic factors: gross domestic product, employment, imports, tax policy, or overall, observed through the total score of all analyzed macroeconomic factors, while top management of agribusiness companies has more confidence in the application of macroeconomic factors: exports, subsidies and the influence of banking on making valid management decisions. Another conclusion would be that through the application of Pearson's correlation analysis, it was shown that there is a strong connection between all analyzed macroeconomic factors in relation to the aforementioned two forms of companies based on the evaluation of top managers who manage them, which allows hypothesis 2 to be safely rejected. Namely, the results obtained confirmed the existence of these differences based on all analyzed macroeconomic factors and the existence of a specific connection for all macroeconomic factors for the mentioned period that exists in the evaluation of top management between medium-sized industrial and medium-sized agribusiness companies. Everything stated is also reinforced within the framework of a graphic display, i.e. a visualization of a comparative review of the evaluation of all seven macroeconomic factors that can influence the business management of the analyzed medium-sized enterprises in the economy of the Republic of Serbia, with the focus of the study being on business decision-making of medium-sized industrial and medium-sized enterprises operating in the field of agribusiness.

Conflict of Interests

The authors declare no conflicts of interest.

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CAN RURAL AREAS BENEFIT FROM ONLINE REVIEWS? MANAGING TOURIST SENTIMENTS IN RURAL ACCOMMODATION IN OHRID (NORTH MACEDONIA)

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A B S T R A C T

This paper investigates factors influencing tourist satisfaction with rural accommodation, crucial for the sustainable development of rural areas. Recognizing that accommodations are important for rural economies, this study performs a sentiment analysis. It analyzes 4,557 online reviews from tourists visiting the rural areas of the east coast of Lake Ohrid (North Macedonia). Results reveal 15 factors grouped into four clusters: 'Facility', 'Surrounding', 'Service', and 'Site'. The 'Surrounding' cluster has the most profound impacts on tourist satisfaction, consistently generating strong positive sentiments due to the excellent natural landscape in which rural accommodations are located. The 'Facility' cluster generally impacts negative sentiments, while 'Service' displays mixed sentiments. The 'Site' cluster reveals partially positive and mixed but negative sentiments. Such variability suggests a need for further managerial analysis and targeted improvements. This research provides practical suggestions for managers of rural accommodation to understand tourist emotions, optimize service quality, and foster sustainable rural tourism development.

Introduction

In the contemporary digital landscape, planning travel often begins with seeking information on Online Travel Agencies (OTAs) such as Booking, Expedia, Airbnb, TripAdvisor, etc. These platforms offer a vast range of travel options, from

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accommodation to various tourism activities, becoming essential tools for modern travelers who can easily book services within a single, user-friendly interface.

On the other hand, tourists post text reviews on these platforms explaining everything about their experiences, from the comfort of the beds to the friendliness of the staff. These narratives go beyond simple scores and provide valuable context shaping the decisions of future travelers. Highlighting both positive and negative memorable moments plays a significant role in creating electronic word-of-mouth (e-WOM). Online recommendations and first-hand stories often carry more weight than traditional marketing, by shaping perceptions and inspiring visits (Chevalier & Mayzlin, 2006; Duan et al., 2008; Floh et al., 2013; Song et al., 2016; Zakarija et al., 2024).

The digital revolution, led by OTAs and the widespread influence of e-WOM, has significantly transformed global tourism patterns, particularly in booking, even reaching the most remote areas. This enabled change in the landscape of rural areas which became easily accessible, empowered with trust and worthiness for visiting unique rural destinations. The authentic experiences that the rural locations offer create a dynamic relationship where OTAs and traveler narratives are essential for understanding the dynamics of modern rural tourism (Chen et al., 2013; Lee et al., 2003; Zhai & Chen, 2020).

When coping with numerous unfavorable socio-economic trends such as aging, depopulation, and abandonment, rural areas are seeking new opportunities for resilience. Often an effective solution is detected in the increasing demand for leisure and tourism (Ruiz-Real et al., 2020), serving as an effective way to revitalize from economic and socio-cultural difficulties (Tseng & Yang, 2010). Consequently, rural areas and villages are transformed into second-home tourism destinations (Terzić et al., 2024) or offer rural establishments where tourists can experience adventures while enjoying rurality (Perić et al., 2020). Tourism related activities significantly contribute to sustainable rural livelihoods, making important the maintenance and evaluation of sustainable rural tourism development (Terzić et al., 2019).

Rural tourism is a vital driver of socio-economic development (Cvijanović & Ružić, 2017) and is urged to develop through the powerfulness of e-WOM. When sharing online reviews on rural sightseeing spots and accommodation establishments, they contribute to sustainable growth. Particularly positive online narratives play a crucial role in attracting new visitors and fostering the development of rural areas. This "spill-over effect" (OECD, 2017) of tourism activities includes job creation, increased incomes, infrastructure development, knowledge diffusion, and tourism promotion (Terzić et al., 2020).

In North Macedonia, rural areas have been a focus of various initiatives for introducing new innovative tourism products for their reanimation and improvement (Petrevska et al., 2021). The importance of their rural capital has been elaborated as an important precondition for developing rural tourism (Dimitrov et al., 2020). Researchers have also identified various activities to support tourism in depopulated rural areas in North Macedonia (Dimitrov & Petrevska, 2020), acknowledging numerous challenges

(Dimitrov & Petrevska, 2019) along with the importance of planning for tourism development (Petrevska & Dimitrov, 2013). Furthermore, discussions have explored rural tourism development zones in North Macedonia (Dimitrov and Petrevska, 2012).

While the importance of developing rural tourism in North Macedonia has been previously discussed (Dimitrov & Petrevska, 2012, 2019, 2020; Petrevska et al., 2021), there has been no specific research on the sentiments of tourists that visit rural areas. Online reviews contain far more reliable information than only rating on OTA websites, which cannot reflect specific characteristic dimensions that may interest potential tourists. This research aims to identify tourists' sentiments and to determine factors that affect their satisfaction with accommodation in rural areas. It carries out opinion mining on online text reviews from Booking.com from tourists who visited rural accommodation in the east coast of Lake Ohrid, a top summer tourist destination in North Macedonia. This platform was selected due to its widespread use among accommodation providers in North Macedonia, which translates to a larger volume of reviews available for analysis and a higher level of trust compared to OTAs.

Following this introduction, the paper presents an overview of relevant literature, followed by the methodology section. The next section details the results, along with a discussion of the findings. Finally, the paper concludes with the main conclusions.

Literature review

Electronic word of mouth (e-WOM) has fundamentally reshaped the way everything is promoted, allowing consumers to communicate directly and easily interact with review content. Researchers extensively acknowledge the benefits of online reviews from various platforms as an information source for both consumers and service providers (Chevalier & Mayzlin, 2006; Duan et al., 2008; Floh et al., 2013; Song et al., 2016). Generally, they all agree that online reviews represent the most intuitive, specific, and authentic consumer experience with online platforms which serve as an important distribution channel.

Chevalier and Mayzlin (2006) examine the effect of consumer reviews on relative sales of books on online platforms and confirm that this form of communication has an important impact on customer behavior. Their study evidence that e-WOM directly impacts consumer purchasing behavior and decision. Duan et al., (2008) further argue that online reviews enable potential consumers to make informed purchasing decisions and assist managers to improve the quality of products and services. They argue that the underlying e-WOM effect plays a dominant role rather than the user ratings. According to their study, while the online review sites facilitate the revelation of e-WOM, they may not play a significant role in influencing sales as commonly expected. Floh et al., (2013) investigate the effect of online reviews on shopping behavior revealing the content that most concern consumers and uses them to study the factors affecting consumer satisfaction. Their findings indicate a significant change in online shopping behavior in response to positive medium and strong reviews, but not to negative ones. Upon these findings, they suggest that managers should

encourage customers to share positive consumption-related experiences by offering strong arguments that will convince other customers. Similarly, Song et al. (2016) recognize the importance and potential benefits of customer reviews as a source of the 'voice of customers'. They propose a framework and procedures for analyzing customer reviews, specifically tailored to diagnosing service quality. By capturing customers' perception, they provide a diagnostic tool capable of examining service quality.

Scholars also extensively investigate tourist satisfaction based on tourists reviews since online tourism platforms have been strongly used for tourism purposes (Chen et al., 2013; Lee et al., 2003; Zakarija et al., 2024; Zhai and Chen, 2020; Wu & Yang, 2023). Zakarija et al., (2024) investigate attractions as an important aspect of destinations often requiring careful attention and investments. They develop a sentiment analysis model, demonstrating its effectiveness and applicability to other destinations to increase visitor engagement. Zhai & Chen (2020) delve into the factors affecting tourist satisfaction with rural homestay inns. They employ a sentiment analysis and construct an econometric model to interpret the relationship between rural homestay inns and tourist satisfaction. Chen et al., (2013) discuss resource allocation in developing marketing strategies for bed and breakfast capacities in rural tourism. Surprisingly, their research detects WoM publicity as the most effective promotion channel over the OTA websites and travel guidebooks. Lee et al., (2003) similarly discuss that the WoM publicity is considered the most successful marketing strategy for rural accommodation, primarily due to limited financial resources and room capacity. Yet, they note that a limitation of this type of promotion is its inability to reach a specific target market. Wu & Yang (2023) investigate insights from tourist online comments regarding rural destinations. They uncover full details on five service attributes (Nature, Price, Food, Hospitality, and Culture), and propose a methodology for developing specific sustainable strategies for understanding rural tourism.

In summary, researchers widely use analysis of online reviews to create models that extract factors that enable interpretation of the relationship between service and satisfaction. This research aligns with this state-of-the-art approach, contributing to a better understanding of rural areas and their potential for resilience and development.

Methodology

The research analyzes online reviews from Booking.com for accommodation in rural areas located on the east coast of Lake Ohrid. It aims to identify the factors that affect tourists' satisfaction, quantity their impact and, provide a theoretical foundation and practical framework for rural accommodation to improve tourists' satisfaction.

More precisely, the study addresses the following research questions (RQs):

RQ_1: Which factors affect tourist satisfaction with accommodation in rural areas?

RQ_2: Which emotions reveal the relationship between accommodation feature evaluation and tourist satisfaction in rural areas?

To meet these questions, a combined multi-stage methodological approach is employed.

Stage 1 involves desk research, a scholarly approach (Van de Ven, 2007), which includes literature review.

Stage 2 involves collecting data from Booking.com, one of the world's leading OTAs. The sample comprises five villages (Dolno Konjsko, Elshani, Peshtani, Trpejca, Ljubanishta) and two tourist settlements (Eleshec, St. Naum), all located on the east coast of Lake Ohrid (Fig 1). These locations are selected for their specific geographic location within this significant region. They represent a diverse range of tourism activities and accommodation options typical of the area's rural tourism sector, enabling an examination of the various factors influencing their development.

Figure 1. Locaton of sampled rural areas, east coast of Lake Ohrid (North Macedonia)

Description: 1- Dolno Konjsko, 2- Eleshec, 3-Elshani, 4-Peshtani, 5-Trpejca,
6-Ljubanishta, 7-St. Naum

Source: Authors

The sampled locations include 79 accommodation facilities, such as private apartments and villas. These are registered on Booking.com and have 4,557 text reviews written between January 1, 2023, and December 31, 2024 (Table 1).

Table 1. Sampling details

Village / Tourist settlement	Number of accommodations	Number of reviews	Average grade	Standard deviation
Dolno Konjsko	13	992	8.8	0.70
Eleshec	4	83	9.5	0.49
Elshani	8	1,122	9.5	0.37
Peshtani	21	622	9.1	0.72
Trpejca	22	1216	9.2	0.88
Ljubanishta	9	126	9.7	0.50
St. Naum	2	396	8.7	0.21
Total	79	4,557	9.2	0.74

Source: Booking.com and authors' calculations

Stage 3 involves data preprocessing and filtering. The raw review text is organized before the analysis (Haddi et al., 2013) and transformed into meaningful features that the model can understand. This enables the model to perform accurate sentiment classification (Kosala & Nirmalrani, 2025). Specifically, a Support Vector Machine (SVM) algorithm is employed. Out of 4,557 total reviews, only 3,460 are analyzed. The remaining text is removed as noise – elements such as emoticons, special characters, symbols, repetitive punctuation (e.g. three dots in a series), HTML tags, URLs, excessive whitespace, and similar. These noisy elements are removed since they can confuse the model. Also, all numbers were removed and, if relevant, were replaced by appropriate words. Non-English reviews were translated in English. The reviews were already bi-polarly classified (79% positive and 21% negative), because guests were first prompted to write about positive aspects, followed by negative ones. Yet, in many instances, in the section for negative aspects guests wrote phrases like "Nothing to dislike" or "Everything was good". These sentences were not included into consideration for further analysis.

Stage 4 is data processing. To identify different factors, aspects of the classified factors, and key notes about tourist satisfaction with accommodation, factor sentiment analysis (FSA) is applied with Google Colab. This process includes several iterations of text analysis, combining with Natural Language Processing (NLP), Lexicon-based sentiment analysis, pattern recognition, contextual and human understanding. The results are presented as a dendogram of review clusters (Fig 2) and a factor sentiment heatmap (Fig 3). Summarized sentiments are presented in Table 2.

Stage 5 is calculating evaluation metrics. Precision (P), Recall (R) and F-value (F) as standard parameters are calculated using both the SVM algorithm and the overall NLP process (Table 3). P measures the number of positive class predictions that belong to the positive class, R calculates the number of positive reviews out of all positive examples in the dataset, while the F balances the concerns of both P and R into a single metric.

Stage 6 involves reporting, which includes a qualitative data evaluation (Hora, 2014).

Results

The sentiment analysis covers all sampled locations, not individual sites like villages or tourist settlements in rural areas. Table 1 (sampling details) shows a high average rating (9.2) and standard deviation (0.74) for the analyzed facilities. This is likely because most accommodations are private apartments and villas that offer quality service at low prices. The lowest rating (8.7) stands for the tourist settlement St. Naum. Yet, since one out of two accommodation units there is a hotel, this rating may not accurately reflect the overall quality of accommodation. The second-lowest rating (8.8) is for the accommodation in the village of Dolno Konjsko offering higher prices and lower quality service. Regarding consistency of the ratings, the smallest standard deviation (0.21) is for St. Naum, followed closely by Elshani (0.37). The highest standard deviation (0.88) is observed for the village of Trpejca, followed by the villages of Dolno Konjsko (0.7) and Peshtani (0.72).

Out of 3,460 applicable reviews, 79% are positive and 21% are negative. There is a significant difference in the average sentiment values for positive reviews (0.994) and negative (0.0188). This notable difference is due to the review system of Booking.com which has separate sections for positive and negative sentiments.

Figure 2. Dendogram of review sentiment clusters
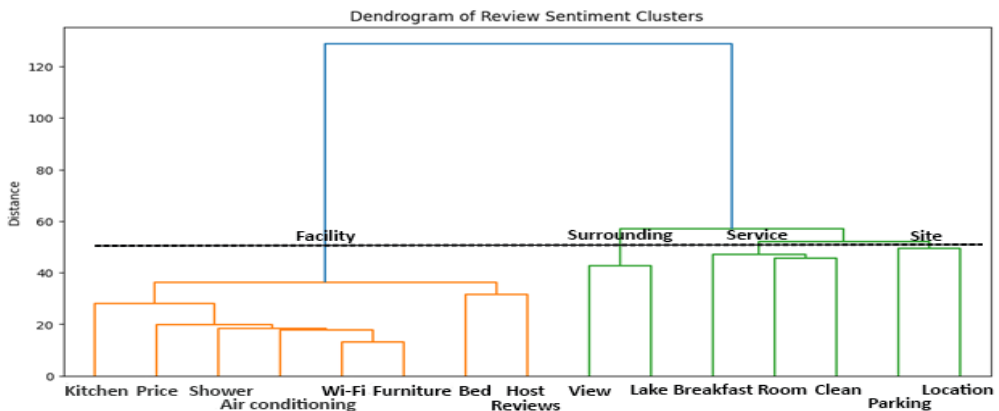
Source: Authors

Figure 2 displays a dendrogram of clusters derived from 104,253 words within reviews. These words were vectorized as nouns and grouped using K-means clustering, identifying 15 key factors. Following hierarchical clustering, these factors were further organized into four broader categories:

o   Factor 1: 'Facility' – This is a broader category encompassing 'Kitchen', 'Price', 'Shower', 'Air conditioning', 'Wi-Fi', 'Furniture', 'Bed', and 'Host reviews'.

o   Factor 2: 'Surrounding' – This includes 'View' and 'Lake'.

o   Factor 3: 'Service' – This category includes 'Breakfast', 'Room', and 'Clean'.

o   Factor 4: 'Site' – This consists of 'Parking' and 'Location'.

Figure 3. Factor sentiment heatmap
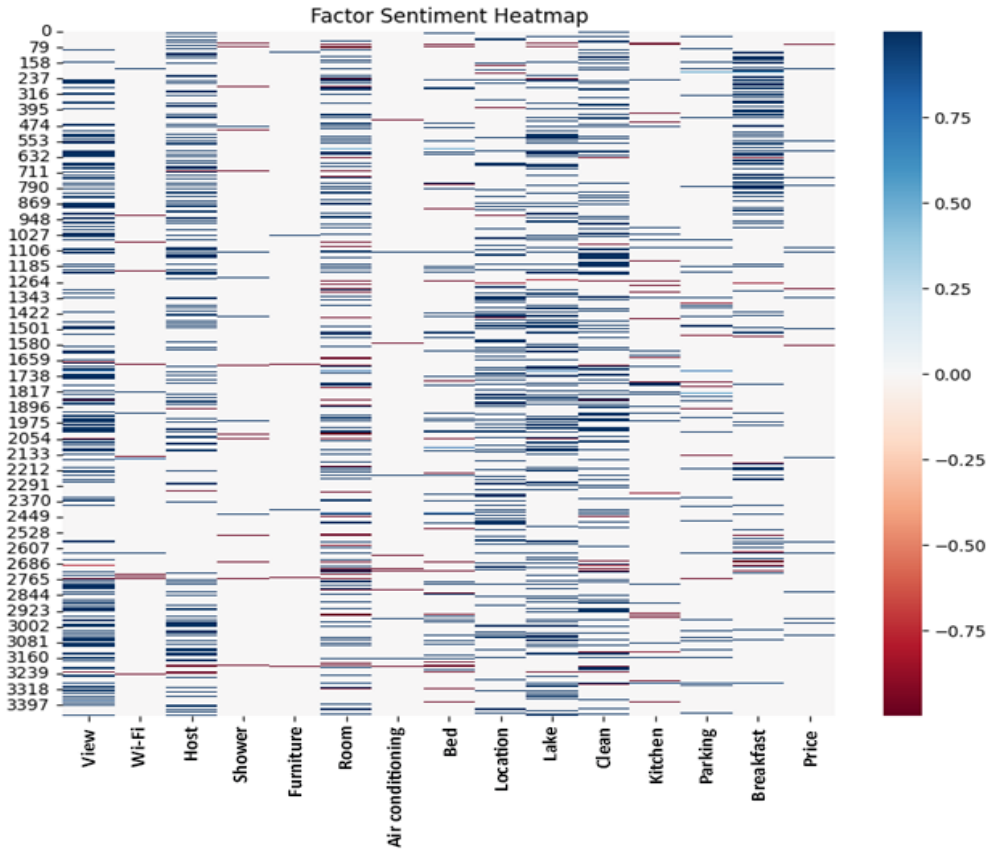
Source: Authors

Further, the clustering quality is determined by the closeness of clusters with 128 levels in distance axis presented in Figure 3 as a factor sentiment heatmap. This map visually represents the scores, and distribution of both positive and negative sentiments associated with the key factors identified from tourist reviews. Moreover, the heat map enables discussion of the granular understanding of how tourists perceive specific aspects of the service of rural accommodation, allowing for targeted improvements. Sentiments for each identified factor range from deep red (representing strong negative sentiment) to deep blue (representing strong positive sentiment). The more prevalent a sentiment, the greater the influence of that factor. This visualization is particularly important for addressing negative factors enabling targeted improvements to enhance overall tourist satisfaction.

Table 2 summarizes the most significant factors influencing overall customer satisfaction and dissatisfaction. Sentiments are categorized as positive (from generally positive (+) to strongly positive (+++)), negative (from generally negative (-) to strongly negative (---)), and mixed (indicating different variations).

Table 2. Summarized sentiments

Factor class	Positive sentiment	Negative sentiment	Mixed sentiment
Facility	'Host reviews' (+) 'Kitchen' (+)	'Shower' (-) 'Air conditioning' (---) 'Wi-Fi' (-) 'Furniture' (-)	'Price' (+) 'Bed' (-)
Surrounding	'View' (+++) 'Lake' (+++)		
Service			'Breakfast' (+) 'Room' (+-) 'Clean' (+)
Site	'Location' (++)		'Parking' (-)

Source: Authors

The model's performance is evaluated using standard parameters. As shown in Table 3, the model achieves high Precision of 91.2%, a high Recall of 92.7%, and a desirable F-value of 0.919. These metrics collectively indicate a good fit for the algorithm.

Table 3. Evaluation metrics

Precision (%)	Recall (%)	F-value
91.2	92.7	0.919

Source: Authors

Discussions and findings

This section discusses the factors and effects (positive, negative and mixed) of online reviews on tourist satisfaction with accommodation in rural areas. It is important to understand that numerical ratings of online reviews alone are insufficient for a comprehensive evaluation. They cannot lead to thorough and accurate evaluation of the tourist product due to its multi-dimensional attributes. Besides rating, writing comments on the experience on the OTA website immediately after leaving the accommodation provides valuable insights that determines the reputation of the accommodation unit and affects the choices of other consumers.

The research identified 15 factors, clustered into four main categories: 'Facility', 'Surrounding', 'Service', and 'Site'.

The 'Surrounding' category elicited the strongest positive emotions, with the natural environment being the most significant trigger for satisfaction. This finding aligns with the research by Wu and Yang (2023) and Zhou (2014), which highlights nature as a powerful source of experiencing authentic satisfaction and aesthetic pleasure.

'Facility' emerged as the second strongest emotion, consistent with the findings of Zhai & Chen (2020). However, the results revealed negative sentiments and frustrations, echoing discussions by Xu & Li (2016). Specific facility elements such as shower, air conditioning, wi-fi connectivity, and furniture equipment were identified as sources of dissatisfaction, despite their recognized importance in influencing overall tourist satisfaction (Gu & Ryan, 2008).

Opposite to Zhai & Chen (2020), who identified the strongest emotion in the 'Service' dimension, this research ranked this factor to be the third most impactful. The elements that determine this clustered factor displayed mixed sentiments, ranging from positive to neutral and negative. Such variability in emotions suggests a need for improvements and more consistent standards in providing service.

Finally, the 'Site' factor revealed positive sentiments in 'Location' consistent with other studies that confirm that a favorable location contributes to positive sentiment (Gu & Ryan, 2008). Conversely, 'Parking' was perceived with mixed but generally negative connotations, a finding also supported by research indicating parking as a determinant of customer dissatisfaction (Xu & Li, 2016).

Besides general factors, the research further examined how online reviews of rural accommodations affect tourist satisfaction.

Tourists generally express positive sentiments towards 'Host reviews' and the 'Kitchen' ('Facility') factors. Rural accommodations are usually family-run, offering a friendly atmosphere where owners put significant effort into enabling pleasant stays and helping tourists connect with the local environment (Nuntsu et al., 2004). The positive sentiment on host interactions significantly contributes to overall satisfaction, highlighting the importance of hospitality (Wu & Yang, 2023). This welcoming approach, combined with local culture, ecology, and natural beauty, creates a unique leisure experience (Wu & Jang, 2010). Similarly, the 'Kitchen' factor appeared in 61 reviews, with 37 expressing positive sentiment, indicating that guests are provided with functional and operational kitchenettes. Yet, the presence of variability in these elements suggests inconsistencies in facility services which may be a starting point for further improvement. On the other hand, the 'View' ('Surrounding') factor consistently received strong positive sentiment across all reviews, confirming its importance to tourist satisfaction. In this line are also the reviews for the 'Lake' factor that showed overwhelmingly positive sentiment. All sampled rural accommodation units have views of Lake Ohrid, so it is expected to have such strong sentiment. To this, the 'Location' ('Site') factor was noted in many reviews with strictly positive sentiment which is also anticipated since all sampled accommodations are located on the aesthetically pleasant east coast of Lake Ohrid. Good and favorable geographical location is critical for a positive sentiment (Gu & Ryan, 2008). Only seven reviews rated location negatively, mostly due to infrastructure concerns. This finding suggests that the natural landscape of rural areas provokes overwhelming positive emotions. So, Lake Ohrid, along with the panoramic view that rural establishments provide, are the most powerful and attractive elements of rural

tourism product that managers should have in mind when creating marketing strategies. The natural environmental surrounding of rural areas is frequently packaged to attract tourists, allowing them to experience the nature (Wu & Yang, 2023; Zhou, 2014).

Negative sentiment is detected only within the 'Facility' factor, specifically concerning 'Shower', 'Wi-Fi', 'Furniture' and 'Air conditioning'. It is very important for tourists to have a comfortable and cozy stay, so they pay great attention to many aspects of an accommodation facility (Zhai & Chen, 2020). Yet, findings suggest that tourists exhibit predominantly dissatisfaction and negative sentiment with insufficient hot water for showering, poor wi-fi connectivity, outdated furniture inadequate to meet room-star typology and categorization standards. The 'Shower' factor appeared in 32 reviews, and in most cases (22) guests highlighted issues related to water difficulties. Dissatisfaction with the water heating system, water flow and the absence of shower cabins, is often mentioned as a negative sentiment (Foris et al., 2020). Similarly, slow internet connection and weak wi-fi signal often provokes frustrations and negative feedback (Xu & Li, 2016). The need for urgent improvements in this area is further emphasized by the strong negative sentiment detected at 'Air conditioning'. Tourists noted the absence of AC devices in some accommodations. Having in mind that Ohrid is a popular summer destination with high temperatures, tourists expect to be accommodated in air-conditioned rooms. Generally, the air conditioning systems in rooms are highly valued by tourists (Foris et al., 2020).

Tourist satisfaction shows mixed sentiments across several key areas. These include 'Breakfast,' 'Room,' and 'Cleanliness' under the 'Service' factor; 'Parking' as a 'Site' factor; and 'Price' and 'Bed' as 'Facility' factors. Finding positive, neutral and negative feedback in three out of four main clustered factors provides a good starting point for deeper managerial analysis. 'Breakfast' ('Service') factor is identified as very important since it appears in 146 reviews with 124 of those expressing positive sentiments. Generally, when guests are accommodated in urban areas (like Ohrid for example) they have many options for breakfast and other meals. This is not usually the case in rural areas, where guests often must search for restaurants or small grocery shops that might be far from their accommodation. In most of the sampled units, hosts live alongside tourists and offer a homemade breakfast from local ingredients, which is included in the accommodation price. For other elements comprising the 'Service' factor, tourists also show mixed sentiments. ''Room' comfort is perceived with both positive and negative emotions, while generally positive, variations in the 'Clean' factor indicate a need for improvements and more consistent standards for service in rural accommodations. The mixed sentiment on the 'Parking' ('Site) factor may be attributed to limited parking capacity at specific facilities and the need for coordination among guests. Generally, issues like room cleanliness and parking are known to cause customer dissatisfaction (Xu & Li, 2016). Similar stands for the 'Bed' ('Facility') factor which appears in 104, with 32 expressing negative feedback. Bed conditions, particularly size, comfort and linens, are important attributes for customer satisfaction (Gu & Ryan, 2008; Jang et al., 2018). The 'Price' ('Facility') factor also has mixed sentiment, though it is generally

positive given the specific location and accommodation. It appears in 36 reviews, with only six guests expressing dissatisfaction. Generally, prices for accommodation in rural areas are typically lower compared to the urban Ohrid area. Price is often a key driver that guides tourists when choosing rural accommodation affecting their satisfaction (Fanelli, 2020; Wu & Yang, 2023).

Such varied findings of positive, negative, and mixed sentiments regarding tourist satisfaction offer valuable insights for focused managerial efforts to enhance overall guest satisfaction.

Conclusion

Accommodation units in rural areas are important for stimulating local economic dynamics, especially in smaller communities where hotels are limited and smaller facilities are often key to handling tourism activities. A leisure-based economy is particularly important for managing sustainable and resilient development in rural areas, offering an opportunity for regeneration and extending their lifecycle. Yet, rural areas frequently face resource-based marketing and management obstacles, like lack of essential skills and knowledge, as well as delay in seeing immediate financial returns. Therefore, identifying and implementing effective management practices is crucial for supporting tourism development in these areas.

To address these challenges, research was conducted involving an in-depth analysis of text data from online tourist reviews. The reviews focused on accommodations in rural areas along the east coast of Lake Ohrid (North Macedonia). Using sentiment analysis, the study identified four clustered factors: 'Facility', 'Surrounding', 'Service', and 'Site'. Each of these groups comprised various factors that were evaluated as having either a positive, negative, or mixed sentiment based on the tourists' feedback.

Research shows the 'Surrounding' factor most significantly impacts tourist satisfaction. Tourists consistently express strong positive sentiments, indicating that the environment greatly enhances their stay. This means the setting where rural accommodations are located profoundly influences a tourist's overall satisfaction. The uniqueness of the view on Lake Ohrid creates memorable experiences that rural destinations may offer as part of value-added packages. By combining this esthetic appeal with cultural activities, it can significantly boost tourism in rural areas. As such, managers of rural accommodations should use this factor as a base when creating their marketing campaigns and developing sustainable management practices. Regarding the 'Facility' factor, tourists generally expressed negative sentiments along with slightly positive, and mixed sentiments. This suggests that managers should conduct a more profound analysis on the poor logging experience as a critical point for improvement since the comfort and coziness of a stay is highly important for guests' satisfaction and positive reviews. Similarly, the 'Service' factor constantly revealed only mixed sentiments, pointing to an urgent need for rural accommodations to elevate service standards. Finally, the 'Site' factor received strong positive reviews for its location element, which acts as a trigger for attracting visitors

and adds value to the beautiful natural environment in which rural establishments are embedded. However, the mixed sentiments with negative connotations with regards to the 'Parking', indicates an issue which requires further discussion and improvement.

This research contributes to raising awareness about the importance of online reviews in identifying tourists' sentiments regarding their satisfaction and dissatisfaction after their stay in rural areas. Rural areas can benefit significantly from online reviews, as sentiment analysis of these reviews provides valuable insights beyond positive feedback. It highlights specific challenges commonly faced in rural destinations, such as transportation difficulties, maintenance issues, limited parking, poor connectivity, and infrastructure gaps. By identifying these problems through the analysis of visitor sentiments, stakeholders in rural areas can develop targeted strategies to address and mitigate these issues. This not only enhances the overall visitor experience but also supports the sustainable development and management of rural tourism destinations.

By analyzing these reviews, managers of rural accommodations can identify key areas for improvement, ultimately optimizing their service quality and contributing to sustainable rural tourism development. Understanding the reputation gained from factors influencing tourist satisfaction empowers managers and owners to develop effective marketing strategies and management practices. Providing friendly, personalized service can generate both new and repeat business. By acknowledging the findings of this study, managers of rural accommodations may improve their services and help create resilient rural tourist destinations.

The research had several shortages that may be overcome in future research. These include using a single review platform, small sample size, limited timeframe for displaying reviews according to Booking.com's policy, reviews referring only to the rural areas on the east coast of Lake Ohrid and identifying somewhat narrow interests of tourists. Despite these limitations, the study offers valuable insights for managing future rural tourism development.

Conflict of interests

The authors declare no conflict of interest.

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MARKET INCLUSION AND SUSTAINABLE PRACTICE IN SERBIAN AGRITOURISM

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A B S T R A C T

This study examines how market integration affects the adoption of sustainable production practices among agritourist households in Serbia. Using a Propensity Score Matching approach supported by endogeneity tests, mediation analysis, and Double Machine Learning, data from 148 households were analyzed. Results show that participation in modern market channels significantly increases the use of green technologies, particularly drip irrigation, biological pest control, and crop residue management. The mediation model confirms that market integration fosters adoption partly by enhancing producers' cognitive awareness of sustainability. Findings remain robust across different estimation methods. The study offers policy insights into promoting sustainable agritourism through support for market access and digital competencies.

Introduction

Agricultural production is undergoing major shifts under the combined pressure of climate change, stricter environmental regulations, and rising market expectations, positioning sustainability as a key principle for future systems (Datta & Behera, 2022; Elnahal et al., 2022). Traditional intensive models are increasingly inadequate for protecting resources, adapting to climate risks, and ensuring household viability. Farmers'

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perceptions play a central role in this transition. Jha et al. (2020) emphasize that attitudes and willingness to adopt innovations are crucial, especially in developing countries with limited adaptive capacity. Zhang et al. (2025) further highlight the importance of market incentives and cognitive mechanisms in shaping sustainable behavior. Broader climate perceptions also matter, Torres et al. (2020) stress that recognizing climate risks is vital for adopting mitigation technologies. In Serbia, financial constraints remain a barrier (Petrović et al., 2021), yet education and market integration, especially through tourism and gastronomy, can improve household sustainability (Vuksanović et al., 2024). Despite the considerable body of research analyzing perceptions, adaptation, and market positioning in the context of sustainable agriculture, there remains a lack of integrated studies examining how market engagement and opportunities directly influence farmers' decisions to adopt sustainable production practices, particularly through the mediating role of cognitive awareness regarding ecological benefits (Datta & Behera, 2022; Zhang et al., 2025). Building on these findings, this study aims to investigate the effects of market engagement on the adoption of sustainable production technologies among agricultural households involved in agritourism in Serbia, with a specific focus on the role of farmers' perceptions and knowledge as mediating mechanisms in decision-making processes. In doing so, the study contributes to filling identified theoretical gaps and offers a comprehensive analytical framework for understanding the transition toward sustainable production practices under conditions of market diversification.

Conceptual background and hypotheses formulation

The link between sustainability and rural diversification through agritourism has gained prominence, yet many studies remain conceptually limited. Brandano et al. (2018) discuss supply-demand balance in agritourism but offer little on household-level adoption. Shen et al. (2020) focus on sustainability indicators at the macro level, while Cavalleri (2021) reveals regional disparities that hinder broader generalizations. More recent research shifts toward household decisions. Pehin Dato Musa and Chin (2022) confirm the role of farm-to-table models but narrowly frame sustainability through gastronomic practices. Cavalleri, Tanwattana, and Grünbühel (2022) highlight market knowledge as vital, though evidence on how integration drives ecological investments is lacking. Stankulova et al. (2024) critique conventional metrics for ignoring ecological dimensions. In Serbia, Gajić et al. (2024) and Ristić et al. (2019) show agritourism's sustainability potential, yet causal pathways between market engagement and technology adoption remain unclear. Bibliometric reviews (Yasin & Bacsi, 2025; Yuan, 2025) confirm this gap, calling for empirically grounded, mechanism-focused studies. The role of agritourism in sustainable rural development has drawn increasing scholarly interest, particularly regarding its potential to strengthen rural economies and living standards. Ciolac et al. (2019) show how activity diversification revitalizes Romanian villages, yet without addressing market participation or production technologies. Ammirato et al. (2020) emphasize the strategic role of market positioning for agritourism sustainability, though they note a lack of focus on household-level decision-making.

Similarly, Paniccia and Baiocco (2020) underline how market, institutional, and social co-evolution fosters modernization, but evidence on technology uptake remains limited. Wang et al. (2025) find that stronger market structures in China boost ecological innovation, though regional disparities mediate the effect. Baipai et al. (2023) argue that market access enables reinvestment in green practices, but institutional and educational gaps weaken outcomes. Studies from Slovenia (Cigale & Lampič, 2023), Indonesia (Riady et al., 2024), and Serbia (Popović et al., 2025) affirm that market control and visibility support adoption, but effects vary across contexts. Despite growing literature, most studies lack causal insight into how market engagement concretely drives green technology adoption in agritourism. Hence, this study tests:

H1: A higher degree of market engagement by agritourism households positively influences the adoption of sustainable production practices.

While institutional incentives matter, they fall short without producer awareness. Kiełbasa et al. (2018) and Petway et al. (2019) note barriers like poor nutrient practices, yet offer little on structural solutions. Ramborun et al. (2020) and Li et al. (2020) highlight ecological awareness but don't clarify whether it stems from learning or market forces. Muhamadi and Boz (2022) and Sulaj et al. (2022) link education to sustainability openness, ignoring wider socio-institutional factors. Baipai et al. (2023) and Cigale & Lampič (2023) stress the role of cognitive readiness but remain case-bound. Riady et al. (2024) show that direct sales aid green adoption only when market complexities are understood, without broader generalization. Others (Nistoreanu et al., 2024; Bednář et al., 2025; Kanazoe et al., 2025; Kule et al., 2025; Batas et al., 2025; Stankulova et al., 2024) confirm awareness as key but often treat it passively. Based on these insights, the second research hypothesis is formulated to test whether market engagement indirectly influences the adoption of sustainable technologies through the development of cognitive awareness among farm households:

H2: The effect of market engagement on the adoption of sustainable production practices is partially mediated by the cognitive awareness of farm households regarding sustainable production.

Methodology

The research was conducted in Serbia on 148 registered agritourism households combining farming, tourism, and direct food sales. Data were collected from August 2024 to May 2025 across Vojvodina, Šumadija, Western, and Eastern Serbia, ensuring regional diversity. The sample included both households using digital sales channels (websites, social media, apps) and those relying on traditional on-site sales, enabling a direct comparison of their impact on sustainable production adoption.

Figure 1. Research area

Area of research (Municipalities where the research was conducted with the number of agrotourism farms):

Republic of Serbia
1. Vrbas (3)
2. Temerin (4)
3. Titel (4)
4. Šid (5)
5. Sremska Mitrovica (8)
6. Irig (5)
7. Bogatić (6)
8. Šabac (7)
9. Loznica (7)
10. Vladimirci (5)
11. Krupanj (5)
12. Mali Zvornik (3)
13. Koceljeva (3)
14. Ljubovija (5)
15. Požarevac (4)
16. Veliko Gradište (4)
17. Užice (6)
18. Lučani (4)
19. Ivanjica (7)
20. Prijepolje (6)
21. Sjenica (4)
22. Novi Pazar (4)
23. Kuršumlija (7)
24. Blace (5)
25. Prokuplje (6)
26. Žitoradja (3)
27. Vlasotince (6)
28. Majdanpek (6)
29. Negotin (2)

Source: Authors' calculations

Prior to the main survey, a pilot study was conducted to test the clarity, comprehensibility, and functionality of the questionnaire. The pilot sample included 20 agritourism households, structurally representative of the target population but not included in the final analysis. Based on pilot results, minor adjustments were made to improve the precision, terminology, and interpretability of measurement scales. The questionnaire design involved consultations with experts in rural development, agritourism, and sustainable agriculture, ensuring content validity and methodological consistency. These consultations helped identify ambiguous formulations and enhanced instrument reliability. The questionnaire was based on validated instruments related to digital sales, agritourism, and sustainable agriculture (Jha et al., 2020; Torres et al., 2020; Ammirato et al., 2020; Datta & Behera, 2022; Gajić et al., 2024; Zhang et al., 2025), adapted to the Serbian context (Petrović et al., 2021; Vuksanović et al., 2024). It covered household characteristics, market engagement, and sustainability perceptions, with emphasis on cognitive awareness of green production—measured through knowledge,

responsibility, and perceived benefits (Ramborun et al., 2020; Li et al., 2020; Muhamadi & Boz, 2022; Sulaj et al., 2022; Kanazoe et al., 2025)—using five-point Likert scales. An entropy-weighted composite index captured awareness multidimensionality (Cigale & Lampič, 2023; Baipai et al., 2023; Bednář et al., 2025; Kule et al., 2025). Among 148 valid responses (41.9% digital, 58.1% traditional), most were farm owners or managers. The average respondent was 49.7 years old, with secondary education, 12.3 years of agritourism experience, and 4.7 hectares of land. Net income averaged €5,200 per household member. Local product specialization (64%) and participation in sustainability training (47%) indicate moderate but improvable market orientation and formal knowledge (Table 1).

Table 1. Overview of basic descriptive statistics for agritourism household sample variables

Variables	Variable definition	M (SD)
Age of household head	Chronological age in years	49.7 (8.4)
Education level	1 = primary or lower; 2 = secondary; 3 = higher education	2.31 (0.68)
Number of active family Members	Total number of family members engaged in farm activities	2.44 (0.93)
Years in agritourism	Number of years engaged in agritourism activities	12.3 (5.9)
Cultivated land area (ha)	Total area of cultivated land (hectares)	4.7 (3.2)
Net income per household member	Annual net income per household member (in thousand EUR)	5.2 (2.1)
Specialized production	1 = household produces specific local products; 0 = no	0.64 (0.48)
Partial off-farm employment	1 = household member has additional non-farm income; 0 = no	0.22 (0.42)
Participation in training	1 = participated in sustainable production training; 0 = no	0.47 (0.50)
Digital sales participation	1 = uses digital sales channels; 0 = traditional sales only	0.42 (0.49)
Number of sustainable practices adopted	Total number of sustainable technologies adopted (0 to 5)	2.36 (1.14)

Source: author's research

The study followed strict ethical standards. Participants were fully informed about the research purpose, ensured anonymity, and participated voluntarily with the right to withdraw at any time. All data were used exclusively for research, with personal information kept confidential. Measures were taken to minimize moral hazard through transparent communication and the prevention of any undue influence during data collection.

Model design and estimation strategy

Addressing selection bias using propensity score matching

In this study, the adoption of digital sales channels by agritourism households is treated as a non-random decision influenced by education, income, production specialization, and market orientation. As these same factors may also affect the adoption of sustainable

practices, the risk of selection bias arises. To address this, the analysis applies the Propensity Score Matching (PSM) method, which compares households with similar characteristics but differing digital sales engagement (Angrist & Pischke, 2009). This quasi-experimental approach estimates how digital households would behave in the absence of digital sales. Propensity scores were calculated using a logit model based on relevant socio-economic and production variables. The probability of household participation in digital sales channels (i.e., the propensity score) was estimated using a logit model, specified as follows:

$$Pi = P(Di = 1 \mid Xi) = \frac{e^{\beta 0 + \beta 1 Xi1 + \beta 2 Xi2 + \cdots + \beta k Xik}}{1 + e^{\beta 0 + \beta 1 Xi1 + \beta 2 Xi2 + \cdots + \beta k Xik}}$$

The probability that a household adopts digital sales channels (Pi) was estimated using a logit model, where Xi_includes socio-demographic, economic, and production characteristics, and β represents model coefficients. The procedure involved three stages. First, households were classified into treatment (digital sales users) and control groups. Covariates included age, education, income, farm size, agritourism experience, specialization, and prior training. Second, households were matched using various PSM algorithms (nearest neighbor, radius, caliper, kernel) to ensure comparability. Finally, the Average Treatment Effect on the Treated (ATT) was calculated to measure the difference in the number of sustainable practices adopted, defined as ATT=*E(Y1−Y0□D=1)* where Y1 is the observed outcome with digital sales and Y0 the counterfactual without it (Hayes, 2018).

Causal pathways: the mediation analysis framework

To clarify how digital sales influence the adoption of sustainable practices, the study applies mediation analysis, aiming to uncover not just whether an effect exists, but how it operates. Guided by the Theory of Planned Behavior (Ajzen, 1991), the model assumes that digital participation affects green production both directly and indirectly, by shaping farmers' knowledge, attitudes, and perceptions. The cognitive awareness index reflects key TPB components: behavioral attitudes and perceived control. Engagement in digital platforms increases exposure to sustainability-oriented market demands, encouraging producers to learn about ecological techniques and standards. This acquired awareness is posited as the mediating factor linking market integration to adoption decisions. The mediation was tested via a two-step model: first estimating the effect of digital sales on the awareness index, and then analyzing the index's influence on the adoption of sustainable technologies (Zou et al., 2021). Formally, the basic regression specification of the mediation model was defined as follows:

$$M_i = \alpha + \beta D_i + \gamma Xi + \varepsilon_i$$

In the mediation model, the mediating variable M_i represents the level of sustainable production awareness for household *i*, D_i indicates digital sales participation, X_i includes control variables, and ε_i is the error term. A significant β\betaβ coefficient confirms the mediation effect. Constructing the awareness index posed a challenge in

weighting its components objectively. To address this, the entropy weighting method was used, assigning weights based on response variability. The results showed that perceived personal responsibility had the highest weight, followed by technical knowledge, awareness of resource depletion, and understanding of pollution effects, together forming a multidimensional profile of ecological cognition (Table 2).

Table 2. Weighted results of sustainable practices knowledge dimensions (entropy weighting method)

Dimension of Sustainable Practices Knowledge	Indicator Description	Assessment scale	Weight
Technical Knowledge	Familiarity with specific sustainable technologies applicable on the farm (e.g., composting, solar panels, biological pest control, irrigation optimization)	Uninformed (1) – Fully informed (5)	0.378
Awareness of Economic Benefits of Sustainable Production	Understanding long-term economic benefits and cost reductions through green technology adoption	Strongly disagree (1) – Strongly agree (5)	0.264
Perception of Personal Responsibility	Degree of personal responsibility for preserving natural resources and food quality on the farm	Strongly disagree (1) – Strongly agree (5)	0.198
Awareness of Pollution Risk and Ecological Consequences	Understanding potential negative impacts of chemical use on soil, water, biodiversity, and health	Strongly disagree (1) – Strongly agree (5)	0.113
Residual Variations	Other non-systematized components	–	0.047

Source: author's research

The results presented in Table 3 indicate significant differences between households using digital sales channels and those relying solely on traditional sales models. The average number of sustainable practices adopted is significantly higher among digitally active households (M = 2.63) compared to those without digital sales (M = 1.91), confirming the positive association between digital presence and ecological engagement (t = 0.72; ***p < 0.01). Regarding individual technologies, particularly large differences were observed in drip irrigation (0.58 vs. 0.33), biological pest control (0.39 vs. 0.17), and mulching with crop residue return (0.65 vs. 0.38), with all differences being statistically significant at p < 0.01. In contrast, differences in the use of organic fertilizers and waste recycling were not statistically significant, suggesting that these practices may be more influenced by local policies and technical capacities than by market engagement alone. The largest difference between the groups was found in the sustainable practices knowledge index, where digitally active households demonstrated substantially higher levels of awareness (M = 0.622) compared to traditional producers (M = 0.431), further confirming the cognitive gap in perception and understanding of sustainable production (t = 0.19; ***p < 0.01).

Table 3. Descriptive statistics of key variables and group differences

Variable	Total sample (n=148)	Digitally active (n=62)	Non-digital sales (n=86)	Difference (t-test)
Adoption of Sustainable Practices (0–5)	2.21 (1.08)	2.63 (0.91)	1.91 (0.99)	0.72***
Use of Organic Fertilizer (0/1)	0.51 (0.50)	0.55 (0.50)	0.48 (0.50)	0.07
Drip Irrigation (0/1)	0.43 (0.50)	0.58 (0.50)	0.33 (0.47)	0.25***
Biological Pest Control (0/1)	0.26 (0.44)	0.39 (0.49)	0.17 (0.38)	0.22***
Mulching and Crop Residue Return (0/1)	0.49 (0.50)	0.65 (0.48)	0.38 (0.49)	0.27***
Waste Recycling (0/1)	0.46 (0.50)	0.50 (0.50)	0.44 (0.50)	0.06
Sustainable Practices Knowledge Index	0.519 (0.22)	0.622 (0.19)	0.431 (0.17)	0.19***

Source: author's research

Analysis and results

The analysis employed a comprehensive set of statistical and econometric methods to test the hypotheses and examine the relationship between market engagement and the adoption of sustainable practices among Serbian agritourism households. Data processing was conducted using STATA 17 and SPSS 27. Descriptive statistics were first used to profile the sample and assess variability in key socio-economic variables. To address selection bias stemming from non-random adoption of digital sales, Propensity Score Matching (PSM) was applied (Rosenbaum & Rubin, 1983), with matching performed via nearest neighbor, radius, caliper, and kernel algorithms. Covariate balance was assessed using pseudo R^2, chi-square, standardized biases, and B/R indicators. To validate causality, an instrumental variable (2SLS) approach was used, leveraging the average digital engagement within villages (Caliendo & Kopeinig). Mediation analysis tested indirect effects via cognitive awareness, with a composite index constructed through entropy weighting (Wager & Athey, 2018). Robustness was confirmed using Double Machine Learning (Chernozhukov et al., 2018), applying LASSO and Random Forest to capture nonlinearities and complex interactions.

Logit model estimation results for the decision to participate in digital sales

The logit model revealed that higher education, greater income, and specialized local production significantly increase the likelihood of digital sales adoption, reflecting the role of financial and cognitive assets. More active household members also support adoption, while older household heads and larger landholdings reduce it, pointing to generational and structural barriers. Non-significant factors included agritourism experience and land quality. These patterns confirm that digital adoption is influenced by diverse household characteristics, justifying the use of PSM for unbiased comparison of sustainability outcomes (Table 4).

Table 4. Logit model results for estimating the probability of participation in digital sales

Variable	Coefficient	Z-value	Standard Error
Age	-0.063***	-3.02	0.021
Education Level	0.872***	3.79	0.230
Number of Active Family Members	0.354*	1.82	0.195
Years in Agritourism	-0.011	-0.57	0.020
Land Area	-0.006*	-1.69	0.004
Net Income per Household Member	0.298***	3.61	0.082
Specialized Production	1.093***	3.42	0.320
Partial Off-Farm Employment	-0.076	-0.19	0.394
Participation in Training	0.617***	3.00	0.206
Constant	-0.985	-0.65	1.517
Log-likelihood	-147.295		
LR chi2(10)	128.73		
Pseudo R²	0.303		
Number of Observations	148		

Source: author's research

Notes: * and *** indicate significance at the 10% and 1% levels, respectively.

To verify the reliability of the matching process, a common support test was performed to examine the overlap in propensity scores between treatment and control groups. Before matching, density curves showed clear separation, digital sales households had higher propensity scores, while non-users clustered at lower values, indicating initial imbalance. After matching, the distributions converged significantly, with both groups falling within a shared support region. This improved overlap confirms that the matching procedure effectively corrected structural differences, validating the use of PSM and enabling unbiased estimation of digital sales effects on sustainability adoption (Figure 2).

Figure 2. Propensity score distribution before and after matching.
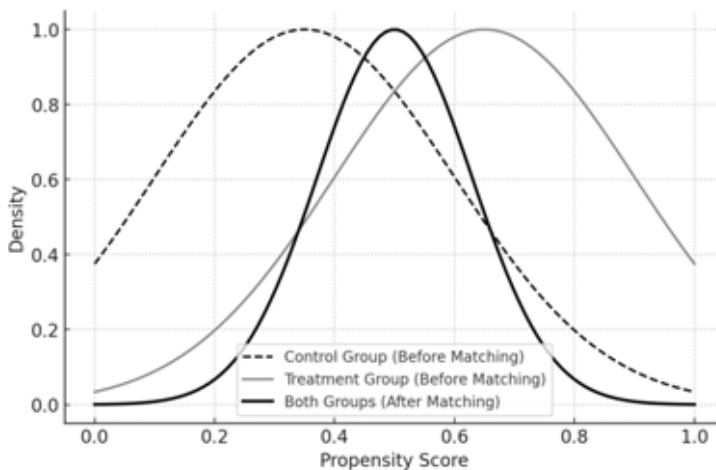
Source: Authors' calculations

Covariate balance test between treatment and control groups

To confirm that observed differences stem from digital sales participation and not from structural disparities, covariate balance was assessed before and after matching. Multiple algorithms were used, nearest neighbor (1:2, 1:4), radius, caliper, and kernel matching, with standard diagnostics applied: pseudo R^2, LR chi², mean/median bias, and B/R indicators. Before matching, the pseudo R^2 was 0.278, LR chi² = 125.11, mean bias 49.4%, and median bias 47.1%, showing substantial imbalance. After nearest neighbor matching (1:2), pseudo R^2 fell to 0.018, mean bias to 7.3%, and median bias to 5.9%. Across all algorithms, mean bias ranged from 3.3% to 6.1%, while B and R indicators remained within acceptable limits. These results confirm the success of the PSM procedure in minimizing selection bias and ensuring valid estimation of digital sales effects on sustainable production (Table 5).

Table 5. Covariate balance test results after different PSM matching methods

Matching method	Pseudo R^2	LR chi²	Mean bias (%)	Median bias (%)	B-value	R-value
Before matching	0.278	125.11	49.4	47.1	132.6*	1.22
Nearest neighbor (1:2)	0.018	4.58	7.3	5.9	30.4*	1.46
Nearest neighbor (1:4)	0.007	1.72	5.0	4.6	18.5	1.41
Radius matching	0.009	1.89	3.9	2.1	19.8	1.50
Caliper matching	0.010	2.42	6.1	5.4	22.7	1.33
Kernel matching	0.007	1.76	3.3	2.5	18.6	1.38

Source: author's research

Notes: * indicates significance at the 10% level.

Estimation of average treatment effects (ATT) and heterogeneity analysis

Using various PSM algorithms (nearest neighbor 1:2 and 1:4, radius, caliper, kernel), the analysis confirmed a stable, significant effect of digital sales participation on sustainable technology adoption. Households using digital channels adopted on average 2.84 sustainable technologies, compared to 1.92 among non-users, a statistically significant difference of 0.92 across all models. These results support the hypothesis that digital engagement enhances sustainable practices. In Serbia, digital sales connect farms with ecologically conscious consumers, creating pressure to meet green standards. They also improve access to educational content, advisory platforms, and peer support, fostering a "see–learn–apply" mechanism for technology diffusion. Digitally active households respond more effectively to market incentives for eco-labeled, local products and often gain price premiums that offset the costs of adopting sustainable practices. Additionally, digitalization reduces transaction costs and improves access to inputs, further easing the transition toward environmentally responsible production (Table 6).

Table 6. Estimated average treatment effects (ATT) of digital sales on the adoption of sustainable production practices

Matching method	Treatment group mean (digital sales)	Control group mean (traditional sales)	ATT	T-value
Nearest neighbor (1:2)	2.84	1.93	0.91***	4.15
Nearest neighbor (1:4)	2.84	1.92	0.92***	4.32
Radius matching	2.84	1.89	0.95***	4.58
Caliper matching	2.84	1.90	0.94***	4.42
Kernel matching	2.84	1.91	0.93***	4.48

Source: author's research

. Notes: *** indicates significance at the 1% level.

Differential analysis of effects by types of green technologies

Additional analysis explored how digital sales affect the adoption of specific sustainable technologies. The strongest effect was observed for drip irrigation, with a 23.4% higher adoption probability among digital households. Biological pest control also showed a significant 12.7% increase, reflecting alignment with consumer demand for transparency and minimal input use. Mulching and crop residue return showed marginal effects (significant at the 10% level), while no significant differences were found for organic fertilizer use or systematic waste recycling. These results suggest that such practices remain more dependent on institutional incentives than on market-driven digital engagement (Table 7).

Table 7. Estimated ATT effects of digital sales by types of green technologies (nearest neighbor 1:4)

Technology	Treatment group	Control group	ATT	Significance level
Organic Fertilizer	0.53	0.48	0.05	ns
Drip Irrigation	0.64	0.40	0.24***	1%
Biological Pest Control	0.38	0.25	0.13***	1%
Mulching	0.59	0.47	0.12*	10%
Waste Recycling	0.50	0.47	0.03	ns

Source: author's research

Notes: ns – not significant; * and *** indicate significance at 10% and 1% levels, respectively.

Heterogeneity of effects by type of digital sales model

The analysis confirmed that while both direct and third-party digital sales models enhance green technology adoption, direct sales yield stronger effects. Households using direct channels adopted 1.02 additional technologies, compared to 0.53 for those using intermediaries, a statistically significant difference of 0.49. The greater impact of direct sales likely stems from enhanced control over marketing, pricing, and consumer interaction, which reinforces sustainability incentives. In contrast, third-party platforms may dilute these signals. Thus, the structure of e-commerce channels shapes not only

economic but also environmental outcomes for agritourism households.

Figure 3. Comparative ATT estimates and confidence intervals across e-commerce participation modes.
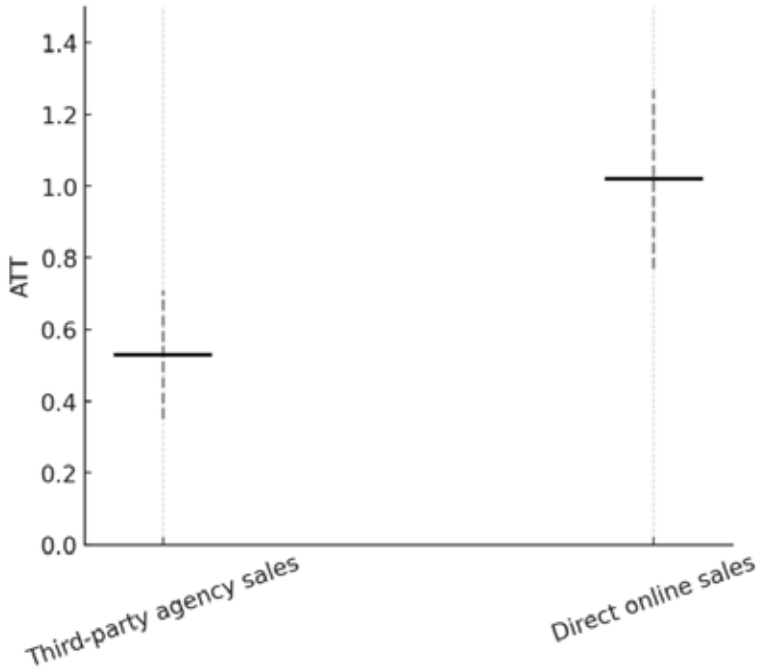
Source: Authors' calculations

Endogeneity and robustness test

To address possible endogeneity, where prior adoption of green technologies may influence entry into digital sales or vice versa, a two-stage least squares (2SLS) method was applied. As an instrument, the average digital sales participation rate among other village households (excluding the observed one) was used. This variable meets both relevance (via social influence) and exogeneity (no direct effect on green adoption) criteria. The first-stage regression confirmed the instrument's strength (F = 42.18), avoiding weak instrument concerns. In the second stage, digital sales remained a significant and positive predictor of sustainable technology adoption, even after controlling for potential bidirectional causality. These results confirm the robustness of the original findings and further validate the causal interpretation of the digital–sustainability relationship (Table 8).

Table 8. Endogeneity test results (2SLS analysis)

Stage	Variable	Coefficient	Standard Error
First Stage	Instrumental Variable (Village Average)	0.671***	(0.152)
	Constant	5.104***	(0.298)
	Control Variables	included	–
	Instrument F-statistic	42.18	–
Second Stage	Digital Sales	1.489***	(0.077)
	Adjusted R²	0.0691	
	Number of Observations	148	

Source: author's research. Notes: *** indicates significance at the 1% level.

As an additional robustness test, the binary variable for digital sales was replaced with a continuous measure, the share of household income generated through e-commerce. Results confirm that a higher degree of digital sales engagement significantly increases the adoption of sustainable technologies, even when controlling for household characteristics. Farms that rely more heavily on e-commerce income are also more likely to adopt complex green innovations, indicating a stronger orientation toward long-term ecological competitiveness (Table 9).

Table 9. Robustness – substitution of the independent variable

Variables	Model 1 (without controls)	Model 2 (with controls)
E-commerce engagement level	3.042*** (0.531)	1.312** (0.623)
Constant	1.488*** (0.062)	1.012* (0.589)
Adjusted R²	0.094	0.176
Number of observations	148	148

Source: author's research

Notes: *, *, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

To reinforce causal inference, a Double Machine Learning (DML) approach was used, combining Lasso regression and Random Forest algorithms via K-fold cross-fitting (K = 3, 5, 8). This method reduces bias from model assumptions and enhances estimate stability. Across all specifications, results consistently confirmed a significant positive effect of digital sales on the adoption of sustainable technologies, with Random Forest models indicating slightly stronger effects due to their ability to account for household heterogeneity (Table 10).

Table 10. DML test results

Model	K-fold=3	K-fold=5	K-fold=8
Lasso	0.582*** (0.131)	0.439*** (0.127)	0.418*** (0.124)
Random forest	0.788*** (0.126)	0.691*** (0.118)	0.642*** (0.113)

Source: author's research

Notes: *** p<0.01

Mediation effect of sustainable production cognition

Grounded in the Theory of Planned Behavior, farmers' perceptions and knowledge of sustainable practices mediate the relationship between e-commerce participation and the adoption of green technologies. Households with higher ecological awareness are more inclined to accept the costs and risks of implementing sustainable innovations. Mediation analysis confirms that digital sales positively influence cognitive awareness, which subsequently increases the adoption rate of green technologies (Table 11).

Table 11. Mediation effects (sustainable production cognition)

Variable	Coefficient	SE
Digital sales → cognition	0.158***	0.027
Constant	0.321**	0.117
Control variables	included	
Number of observations	148	

Source: author's research

Notes: ** indicates p<0.05; *** indicates p<0.01.

Discussion

The results confirm that market integration, particularly through digital sales, significantly promotes the adoption of sustainable practices among Serbian agritourism households, supporting the first hypothesis. Farms using digital channels adopt more green technologies than those relying on traditional sales, consistent with Pehin Dato Musa and Chin (2022), who emphasized the sustainability benefits of shorter supply chains. This aligns with Cavalleri et al. (2022) and Baipai et al. (2023), who noted that stronger market competencies and income generation from digital engagement foster reinvestment in ecological technologies. However, the effects are not uniform across all practices. Technologies closely tied to food safety and transparency, such as drip irrigation, biological pest control, and residue treatment, showed the strongest association with digital market participation. This is in line with Wang et al. (2025), who highlighted the role of consumer-driven standards in shaping adoption patterns. In contrast, practices like organic fertilization and waste recycling showed no significant association, reinforcing Petrović et al. (2021), who pointed to producers' reliance on regulatory support due to limited financial capacity. The second hypothesis, regarding the mediating role of cognitive awareness, was also confirmed. Mediation analysis showed that participation in digital markets enhances farmers' knowledge and attitudes, which indirectly drive sustainable adoption. This supports Kule et al. (2025) and aligns with Muhamadi and Boz (2022), Sulaj et al. (2022), and Cigale and Lampič (2023), who emphasized that internalized ecological values and perceived long-term benefits increase adoption readiness. Moreover, households engaged in direct online sales demonstrated a greater intensity of green technology use than those using intermediaries. This reflects the findings of Riady et al. (2024) and Cigale and Lampič (2023), who noted that direct market feedback fosters adaptive learning and ecological innovation. The present study

thus empirically affirms that sustainable agritourism transformation relies not only on market access but also on the cognitive readiness of producers, an insight consistent with Shen et al. (2020), Zhang et al. (2025), and Nistoreanu et al. (2024). Together, market incentives and cognitive capacities emerge as mutually reinforcing conditions for sustainable agritourism development.

However, not all practices demonstrated equally strong effects, which requires further reflection. The limited effects of certain sustainable practices can be explained by a combination of structural, behavioral, and institutional barriers. Many agritourism households operate with restricted financial resources, which constrains their ability to invest in environmentally friendly technologies or advanced digital tools. In addition, knowledge gaps and limited access to specialized advisory services reduce the effectiveness of training and capacity-building programs. From the demand side, consumer preferences in Serbia still show a strong orientation toward traditional products, which lowers the immediate market incentives for innovation. Finally, policy support is often fragmented and short-term, leading to inconsistencies in implementation and difficulties in scaling up successful practices. These factors jointly explain why some initiatives demonstrate weaker impacts, despite their potential to contribute to sustainability.

Conclusions

This study offered empirically grounded insights into how market integration, particularly through digital channels, influences the adoption of sustainable practices among agritourism households in Serbia. Findings confirmed that digital engagement not only improves market visibility and access to financial and educational resources but also strengthens cognitive awareness of sustainability, which in turn drives green technology adoption. These results support the research hypotheses and highlight the interplay of economic and psychological mechanisms in fostering sustainable transitions in rural contexts.

Theoretically, this study enriches understanding of sustainability transitions in transitional economies by demonstrating that digital market engagement acts as both an economic and cognitive driver. It builds on behavioral economic theory by showing how market exposure shapes producer awareness. The stronger effects of direct digital sales versus intermediary platforms add nuance to debates on e-commerce and rural sustainability. Moreover, the multifunctional nature of Serbian agritourism households, as production, tourism, and consumption units, suggests the need for more integrative models of rural development. Importantly, a stronger emphasis on the tourism dimension and a tighter link between empirical results and policy implications would further enhance the explanatory and practical value of the study.

Practically, the findings point to clear policy directions. Capacity-building programs in digital marketing and e-commerce logistics are essential. Supporting local platforms that enable direct producer–consumer interaction can reduce reliance on intermediaries and boost returns for sustainable products. Advisory services should integrate agronomic and

digital skills, while incentives should promote environmentally friendly technologies aligned with market demand. These measures can enhance competitiveness, income diversification, and resilience among rural producers.

From a political perspective, the study highlights the importance of integrating agritourism into broader strategies for rural development and food security. Policymakers should ensure that sustainable agritourism is embedded in national agricultural and tourism policies, supported by regulatory frameworks that encourage innovation, transparency, and equitable market access. Strengthening cross-sectoral governance, particularly cooperation between ministries of agriculture, tourism, and environment, can provide institutional backing for local initiatives. Furthermore, aligning these measures with EU accession processes and international sustainability commitments would not only reinforce Serbia's strategic positioning but also create transferable lessons for other emerging economies.

However, several limitations must be acknowledged. The focus on registered agritourism farms may limit broader applicability. Although Propensity Score Matching mitigated selection bias, unobserved factors such as entrepreneurial capacity remain potential sources of endogeneity. The reliance on self-reported data to measure awareness may introduce social desirability bias. Future studies should adopt objective measures and expand analytical models to include psychological, institutional, and sociocultural variables. Regional disparities in Serbia also warrant attention, as do cross-country comparisons in the Western Balkans. Finally, longitudinal research is needed to track how emerging technologies, such as blockchain and digital export models, continue to shape sustainability adoption in agritourism.

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Conflict of interests

The authors declare no conflict of interest.

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PANEL DATA ANALYSIS OF THE IMPACT OF AGRICULTURAL INDICATORS ON ECONOMIC DEVELOPMENT ASPECTS: THE EXPERIENCE FROM THE BRICS COUNTRIES

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A B S T R A C T

The aim of this paper is to empirically assess the influence of the most significant agricultural measures on basic economic indicators in original BRICS countries (Brazil, Russia, India, China and South Africa), as well as to offer reasonable explanations for the nature of the established relations. For this purpose, two models were built: a) The Period Random Effects Model that traces their influence on GDP growth rate, and b) Two-way Random Effects Model that assesses their influence on Average income in BRICS nations. The paper determined mostly negative and statistically significant relations between mere agricultural measures and economic indicators, pointing to the conclusion that these countries are burdened by problems of law agricultural productivity, poor technological progress and low value added in their agriculture, as well as to the need for the implementation of more serious institutional, land, production, education, infrastructural and other fields of reforms in BRICS.

Introduction

Agriculture is one of the key factors of economic development that significantly contributes to the GDP growth rate, income generation, employment, export incomes, human feed, production of industrial raw materials, improvement of infrastructure and related industries' development. It is one of the essential economic branches of exceptional importance for the national economy itself since it highly influences

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macroeconomic indicators and development trends (Grujić Vučkovski et al., 2022). Developed countries have long since confirmed the role of agriculture, which determines their overall growth and development. On the other hand, developing countries still face numerous limitations in this area, and especially the need for greater agricultural investments and more balanced rural development (Ilić et al., 2017). Agriculture has a special importance for developing countries since it provides them with nutrients, income and employment in rural areas (Prasanth & Sivanantha, 2021). It serves as a major source of poverty reduction, food security and livelihood, especially for poor rural households in developing farmland. However, the contemporary agricultural systems of these countries are increasingly threatened by changing climatic circumstances, their general vulnerability and inadaptability, which threaten their productivity and resistance to climate change (Trentinaglia et al., 2023).

Agriculture is also of key importance in the BRICS countries (Brazil, Russia, India, China and South Africa) since they make a large share in the global population, world agricultural land, food production and global exports of agricultural products. They are key actors in global food production, playing a pivotal role in boosting agricultural productivity, sustainability and ensuring global food security. The original BRICS countries account for 59% of the global population, 33% of the world's agricultural land, 42% of the world's agricultural production and 35.4% of the global economy (BRICS Agriculture Working Group, 2025). These nations belong to the group of major players in the agri-food products' international markets, especially when it comes to the trade of primary foodstuffs with other members of the Global South that face food shortages, poverty and malnutrition (Glauben & Duric, 2024). However, the BRICS members also face their own numerous challenges such as global warming, climate change, land devastation, scarcity of water resources and reduction of biodiversity, limited arable land, agricultural pollution, and lowering of yields (Magazzino et al., 2024). In addition, their agricultural activities indirectly, through their impact on the emissions of carbon dioxide (CO_2) and environmental degradation, can represent a significant obstacle to their sustainable economic growth (Balsalobre-Lorente et al., 2019).

Considering all the above, the purpose of this article is to empirically examine the impact of the most important mere agricultural measures on the basic economic indicators of the BRICS countries in the period from 2002 to 2023, bridging the visible vacuum in the knowledge on these important issues. Its aim is also to provide reasonable explanations for the established negative relationships between their agriculture and basic economic indicators. The article starts from the assumption that agriculture significantly affects the economic activities of these countries measured by the GDP growth rate and the average income expressed in GDP per capita, representing a topic that was largely neglected in previously published studies. The next section gives the review of selected literature, while the third one is devoted to the description of the data used and the selected research methodology. The fourth and fifth sections present the findings and discuss the obtained results, while the last one concludes the paper.

Literature review

Agriculture is one of the most important sectors in any developing nation since it ensures the stability of economic structural changes by generating the necessary income, ensuring modernization and diversifying economic output (Alijonovna Inomjonova, 2024). Investments in agriculture and the agricultural sector development in many cases represent a prerequisite for economic growth, generating income and livelihoods, industrialization, food security and many other related activities (Chandrasekaran, 2024). The growth of its efficiency and agricultural investments are of great importance not only for the country's economic growth and agricultural GDP (Laurentiu & Ion, 2019), but also for wider social development since agriculture contributes to the rise of social well-being and the development of rural areas (Oluwabukade et al., 2024).

However, although it is traditionally considered a pillar of economic growth and development, agriculture can also have a negative impact on economic development, primarily due to low productivity and technological stagnation, weak production diversification, sensitivity to climatic conditions and world prices of agricultural products, ecological costs and environmental degradation, and accelerated industrialization accompanied by marked deagriculturalization. There is a significant negative relationship between deagriculturalization and economic growth, especially in the long term (Ullah et al., 2021), while the low total factor productivity in agriculture itself can have an unfavorable impact on economic growth (Tahamipour & Mahmoudi, 2018), hindering sustainable development.

Given the noticeable gap in the literature on these important issues, the authors of this article have found only a few studies that include the impact of some of the agricultural measures on the economic growth and development in the BRICS countries. Fakher et al. (2024) study the relation between financial development and environmental degradation in BRICS from 2005 to 2019 by constructing composite indicators of environmental quality (CEQP) and financial development (CFDP). The authors in this paper prove the indirect negative impact of agricultural activities measured by the agricultural share in GDP, through environmental degradation, on sustainable economic growth, given the established U-shaped relationship between the CEQP and economic growth.

Guo and Li (2024) examine the impact of industry and agriculture on the GDP of the BRICS countries in the period from 1970 to 2020 using static and dynamic methods. By constructing a multivariate nonlinear regression model, the authors conclude that the growth of agricultural value added as a percentage of GDP slows down their GDP growth, indicating that in these nations the share of agriculture in their economic structure can negatively affect their total GDP. Basu et al. (2013) considered the way in which changes in employment, especially those in industry, services and agriculture, affected the growth of GDP per capita in the BRICS countries in the period from 1991 to 2009. The authors concluded that the GDP per capita growth rate in the BRICS countries was largely determined by the faster growth of labor productivity in industry and the service sector, which was not the case with agriculture, where productivity

was almost twice as low, indicating that economic growth in the BRICS is mainly conditioned by demographic, as well as sectorial factors. They also noted a visible sectorial shift in employment from the agricultural sector to industry and services.

However, there are also authors who have found a positive relation between agricultural production and economic growth in the BRICS countries. Tsaurai (2021) used a dynamic GMM model to study the joint effect of agricultural production, personal remittances, inflation, infrastructure development, trade openness, and financial development, as a transmission channel of agricultural activity, on the BRICS nations' economic growth from 1996 to 2018, concluding that agriculture had a significant positive impact. Similarly, Garidzirai (2020) used data for the period from 1995 to 2018 and applied the Pooled Mean Group model to find that agricultural production contributes to economic growth and the decrease of income inequality in BRICS, suggesting that short-term imbalances can be corrected in the long run. There are also articles such as Sergeevich Streltsov et al. (2021) that, by studying the BRICS countries individually, emphasize that agriculture and the vast mineral reserves have made a major contribution to the rapid development of the Russian economy. Nevertheless, so far there have been few published studies that take these perspectives into account in all BRICS members considered together.

Data and research methods

The paper examines the impact of agricultural indicators on the economic growth rate and average income in BRICS countries measured by GDP per capita from 2002 to 2023 within the framework of two compalementary models, both of which belong to the group of Random Effects (RE) models: a) the first one is the Period RE Model that traces the influence of agricultural indicators on the GDP growth rate, while b) the other one is the Two-way RE Model that monitors the influence of agricultural predictors on the GDP per capita. The advantage of RE models is that they include time-invariant variables, generate more efficient regression coefficients' estimates, and are characterized by less loss of information compared to Fixed Effects (FE) models that can be expensive in terms of degrees of freedom (Gujarati, 2003). Data for analysis are derived from the World Bank Group, FAOSTAT and U.S. Department of Agriculture (USDA) databases, as evidenced by the following Table 1. These models can be represented by the following system of equations (Fitrianto et al., 2016):

Model 1:

$$GROWTH_{it} = \alpha + \beta_1 AGRITFP_{it} + \beta_2 PUBEXP_{it} + \beta_3 AVA_{it} + \lambda_t + v_{it}$$

Model 2:

$$INC_{it} = \alpha + \beta_1 AGRITFP_{it} + \beta_2 AGRIEXP_{it} + \beta_3 RURPOP_{it} + u_i + \lambda_t + v_{it}$$

where β are model coefficients, $GROWTH_{it}$ and INC_{it} are dependent variables, x_{it} are

predictors, v_{it} is zero mean random disturbance with variance σ_v^2, u_i are unobserved individual specific effects and λ_t are unobserved time specific effects.

Below is a fitted graph of scatter plots (Figure 1) of the observed independent variables (GDP growth rate and GDP per capita) with the predictors that most affect them in both constructed models (Agricultural value added and Agri exports), indicating a clear negative relationship between the considered variables.

Figure 1. Negative fitted relationships between observed variables in the considered models
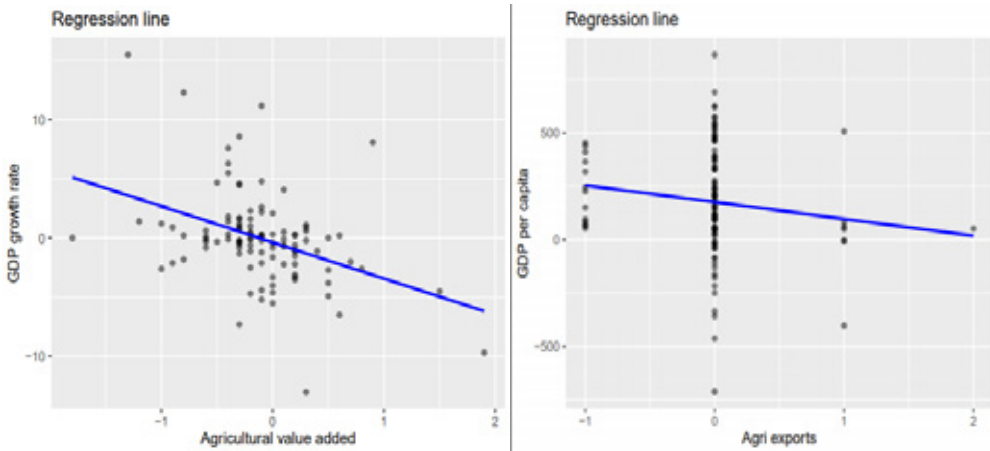
Source: Authors' contribution

The following Table 1 provides a detailed overview, description and sources of data used in the study.

Table 1. Overview and description of the data used in the analysis

Variables	Description	Label	Data sources
Growth rate	Annual GDP growth rate (in %)	GROWTH	World Bank Data
Average income	Real GDP per capita (in constant 2015 US$)	INC	World Bank Data
Agri TFP index	Agricultural total factor production index (100=2015)	AGRITFP	U.S. Department of Agriculture (USDA)
Total agri expenditures	Total government expenditure on agriculture, forestry and fisheries (in millions of constant 2015 US$)	PUBEXP	FAOSTAT
Agricultural value added	Agriculture, forestry, forestry and fishing value added (as a % of GDP)	AVA	World Bank Data
Agricultural exports	Agricultural raw materials exports (in % of merchandise exports)	AGRIEXP	World Bank Data
Rural population	Rural population (as a % of total population)	RURPOP	World Bank Data

Source: Authors' analysis

Research findings

The following Table 2 presents the results of descriptive statistics of the variables used in the constructed models.

Table 2. Results of descriptive statistics

Variables	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
Growth rate	4.4464	4.6500	14.1000	-7.8000	3.9882	-0.4810	3.4247
Average income	6300.775	6270.700	12175.20	793.6000	3071.668	-0.4019	2.0230
Agri TFP index	94.0951	95.8102	120.6565	66.2095	12.5091	-0.2778	2.4564
Total agri expenditures	52897.71	8331.430	401182.2	1015.120	96631.00	2.2251	6.5959
Agricultural value added	7.4618	4.8000	19.6000	1.9000	5.4681	0.9354	2.3852
Agricultural exports	2.1909	2.0000	6.0000	0.0000	1.4992	0.4265	2.6468
Rural population	38.6636	36.0000	72.0000	12.0000	18.8292	0.3846	1.8967

Source: Authors' calculations

In the paper, a panel data regression analysis was carried out on the example of two selected models. The panel consisted of 5 countries (Brazil, Russia, India, China and South Africa) within which the influence of agricultural predictors was traced in the period from 2002 to 2023, making a total of 110 observations. Analyses were conducted in statistical packages Eviews and R programming language.

At the beginning of the analysis, a correlation analysis was conducted to determine whether the proposed models were subject to the risk of multicollinearity. The conducted correlation analysis indicated that there was no multicollinearity between the predictors, given that none of the correlation coefficients between the observed variables exceeded the value of 0.70 (Tabachnick & Fidell, 2019), which allowed the continuation of this analysis. The results of the conducted VIF test also indicated the safety of further analysis, given that their values were far lower than 5 (Siddamsetty et al., 2023). Due to the limitations in the length of this article, the results of these analyses are available upon reasonable request from the authors.

In the next step, the article proceeded to calculation of the Pesaran CD test with the aim of detecting cross-sectional dependence in individual variables (*Table 3*).

Table 3. Pesaran CD test results

Variables	Statistic	p-value
GDP growth rate	8.6328*	0.0000
Agri TFP index	12.6877*	0.0000
Total agri expenditures	2.9603*	0.0031
Agricultural value added	7.6281*	0.0000
GDP per capita	11.5384*	0.0000
Agricultural exports	0.0952	0.9241
Rural population	13.9073*	0.0000

Note: * indicates statistical significance at the level of α=0.01

Source: Authors' calculations

The results of the conducted Pesaran CD test indicated cross-sectional dependence in almost all observed variables with the exception of Agricultural exports, which is why the second generation of unit root tests was used embodied in the Pesaran CIPS test (*Table 4*). In addition, the advantage of this test is reflected in the fact that, unlike the first-generation tests, it corrects for the presence of common factors that cause interdependence among panel units, ensuring consistency even in the presence of a common factor with heterogeneous effects, while simultaneously taking into account cross-sectional dependence and correlation of serial residuals (Barbieri, 2009).

Table 4. Pesaran CIPS test results

Variables	Variables at the level		Differentiated variables	
	t-statistics	p-value	t-statistics	p-value
GDP growth rate	-3.2820*	<0.01	-5.6859*	<0.01
Agri TFP index	-1.4930	>=0.10	-3.4589*	<0.01
Total agri expenditures	-2.0952	>=0.10	-3.6006*	<0.01
Agricultural value added	-1.4442	>=0.10	-2.2767*	<0.01
GDP per capita	-1.5283	>=0.10	-3.4053*	<0.01
Agricultural exports	-3.2255*	<0.01	-4.6951*	<0.01
Rural population	-1.9947	>=0.10	-2.7742*	<0.01

Note: * indicates statistical significance at the level of α=0.01

Source: Authors' calculations

The results of the Pesaran CIPS test indicated the stationarity of all variables at their first differences, which is why the panel regression analysis in its further research steps was conducted on differentiated data, reducing the number of observations from 110 to 105. Table 5 represents the results of regression analysis for both models.

Table 5. Results of the regression analysis

Variables	Model 1	Variables	Model 2
C	0.0333 (0.9601)	C	155.1669 (0.0889)
Agri TFP	-0.1933* (0.0067)	Agri TFP	-7.4073 (0.0743)
Total agri expenditure	6.42e-06 (0.6770)	Agricultural exports	-76.7055* (0.0005)
Agri value added	-2.3358* (0.0001)	Rural population	-63.5432** (0.0162)
R-squared	0.1999	R-squared	0.0916
Adjusted R-squared	0.1761	Adjusted R-squared	0.0646
S.E. of regerssion	2.2773	S.E. of regerssion	162.9916
Total sum of squares	654.69	Total sum of squares	2953700
Residual sum of squares	523.82	Residual sum of squares	2683200
F-statistic	8.4111*	F-statistic	3.3946**
Prob.(F-statistic)	0.0000	Prob.(F-statistic)	0.0208
Durbin-Watson stat.	2.6106	Durbin-Watson stat.	1.4537*
Prob.(DW stat.)	0.9993	Prob.(DW stat.)	0.0032

Note: * indicates statistical significance at the level of α=0.01, while ** indicates statistical significance at the level of α=0.05

Source: Authors' calculations

Model 1: Tests conducted with the aim to select the appropriate panel data model favoured the selection of the Period RE model (*Table 6*). From the results, it was clearly concluded that the proposed Model 1 explained 17.61% of the variability of the dependent variable (GDP growth rate), as well as that all predictors taken together affected the dependent variable. Also, the effect of the considered agricultural indicators (Agri TFP and Agri value added) on the growth rate of BRICS countries was predominantly negative and statistically significant at the level of α=0.01. Conducted post hoc tests also suggested the absence of cross-sectional dependence, serial correlation in residuals and heteroskedasticity in error variances.

Model 2: In this case, tests conducted in order to select the appropriate panel data model were also in favour of choosing the RE model (*Table 6*). From the obtained results, it followed that the selected Model 2 explained 6.46% of the variation of the dependent variable (GDP per capita), that all predictors taken together influenced the dependent variable, and that the proposed model also did not suffer from significant serial correlations in the residuals. The impact of the considered agricultural indicators (Agri TFP, Agricultural exports and Rural population) on the standard of living in the BRICS countries measured by GDP per capita was negative, with a statistically significant effect of the second and third predictor at the level of α=0.05. Conducted post hoc tests indicated the absence of heteroscedasticity and serial correlation in the residuals, but also the presence of cross-sectional dependence, which is why the correction of the standard error was performed using the Driscoll-Kraay method, thus ensuring the consistency and robustness of the estimated standard errors.

The following Table 6 provides an overview of the conducted tests for selecting the appropriate panel data model and the post hoc tests for both generated models.

Table 6. Results of panel model selection tests and post hoc tests

Test type	Model 1			Model 2		
	Statistic	d.f.	Prob.	Statistic	d.f.	Prob.
Redundant Fixed Effects	8.2849*	(20,81)	0.0000	5.7952*	(20,77)	0.0000
Hausman	3.8584	3	0.2772	0.9368	3	0.8165
Breusch-Pagan LM	66.1764*	1	0.0000	33.0597*	1	0.0000
Pesaran CD test	0.0092		0.9927	7.0353*		0.0000
Breusch-Godfrey/Wooldridge	31.632	21	0.0638	28.197	21	0.1346
Studentized Breusch-Pagan	4.273	3	0.2335	1.2184	3	0.7486

Note: * indicates statistical significance at the level of $\alpha=0.01$

Source: Authors' calculations

Discussions of the results

The results of published studies on the relation between agriculture and economic growth are very mixed, as can be seen from the Literature review section. The findings of this study on the negative link between agriculture and economic indicators in BRICS countries fit well with the reviewed articles such as Basu et al. (2013), Ullah et al. (2021), Fakher et al. (2024) and Guo and Li (2024) that confirm an indirect or direct negative effect of agricultural production on economic growth in these countries. However, compared to some other studies that combined agricultural with other types of predominantly economic indicators, this study did not provide consistent results. More specifically, these are the studies by Garidzirai (2020) and Tsaurai (2021) that indicate a positive contribution of agricultural production to economic development, although they use multiple economic, financial, and trade control variables in their built models.

As can be seen from the constructed models, most of the considered agricultural indicators generally have a negative and significant impact on economic growth and living standards in the BRICS countries. The explanation of this phenomenon can be found in their developmental, economic, structural and institutional problems. Although BRICS members are among the leading top agricultural producers in the world, they are still characterized by lower agricultural productivity and pronounced environmental vulnerability compared to the rest of the developed world. Most of the countries of the Group, and especially India, lag significantly behind and have lower productivity compared to the global average. Farmers from these countries are still not ready to adopt modern technologies and imported seeds, as well as to use foreign funds to improve their agricultural productivity. The BRICS countries also suffer from outdated production techniques, accelerated urbanization and inefficient use of resources, which collectively threaten their agricultural productivity, while leaving their agricultural sector in a critical position, as evidenced by researches of many authors such as Shah et al. (2023), Patel and Joshi (2023) and Inkaya and Masca (2025).

Although the developing BRICS nations are experiencing visible technological improvements in many spheres of their economic activities, they have not yet sufficiently introduced technological innovations in their agricultural sector, pointing to the fact that their transition to high-tech agriculture is still ongoing. Thus, for example, China lags behind developed countries in the use of precision agriculture, primarily because of its agricultural system that relies on small family farms, which show resistance to change. Moreover, small farmers consider it unnecessary for the development of their family farms. The exception in this sense is only Brazil, which since the 1990s has made great progress in the production and export of agricultural products, focusing on the abundant use of information technologies and the computerization of fundamental research in its agro-industrial sector. Brazil has widely adopted Agriculture 4.0 practices, cloud computing and big data analytics, as well as artificial neural networks to estimate crop harvests and determine the ideal size of planting area, paving the way for the successful digitization of its agricultural production. However, insufficient availability of technological innovations in other BRICS nations directly threatens productivity, income generation, sustainable food production and food security, leading to low returns per worker and affecting the relatively small contribution of a large part of the workforce to GDP creation. These findings have been confirmed by numerous published studies such as Kendall et al. (2017), Salnikova and Rozhakova (2021) and Inkaya and Masca (2025).

The BRICS countries are also facing key structural changes in their economies, primarily with intensive urbanization and industrialization that relativized the role and importance of agriculture itself in generating their GDP. Although constant technological improvements in their many economic sectors have fuelled their economic rise, it is still largely based on extensive agricultural activities. These countries, especially Brazil and Russia, have a dominant role in the export of low and medium-low technological goods, remaining at the lower levels of global value chains. In contrast to the industrial and service sectors as drivers of economic development, the agriculture of BRICS countries still produces raw agricultural products with low added value, endangering its very contribution to their economic growth and development. They witness a decrease in the share of agriculture in their GDP, which is in line with the structural transformation of their economies, by anchoring the levers of their future growth and development towards an economy based on services and knowledge. Unlike Brazil and Russia where the share of the primary sector remained relatively stable, China and India experienced a dramatic decline in the share of agriculture in their GDP, while industry and services grew consistently (Magacho et al., 2018; Jiaduo et al., 2023; de Sousa Filho et al., 2024). Finally, as evidenced by the data used in this research, in addition to accelerated industrialization, BRICS members also face a constant decline in their rural population that moves to cities and other industries, naturally causing a negative impact of agriculture on the considered economic indicators.

Conclusions

The purpose of this article was to examine the impact of the most important mere agricultural indicators on the economic growth rate and the average income of the BRICS nations from 2002 to 2023 through the construction of two panel data models. For this purpose, two complementary models were constructed, namely: a) Model 1 which examined the effect of Total Factor Productivity, Total Agricultural Expenditure and Agricultural Added Value on GDP growth rate, and b) Model 2 which considered the effect of Total Factor Productivity, Agricultural Export and Rural Population on GDP per capita of these countries. Both generated models belonged to the group of RE panel data models, the first of which was the Period RE Model, while the second one was the Two-way RE Model. The results of the analysis unequivocally indicated a predominantly negative and statistically significant effect of most of the considered variables on the growth rate and average income in BRICS, confirming the initial hypotheses of this analysis.

These countries are primarily characterized by low agricultural productivity, insufficiently developed agricultural innovations and limited access to modern technologies, all of which result in a limited contribution of agriculture to GDP growth. In addition, the BRICS countries are also burdened by the export of large quantities of primary products to world markets, as well as their low added value, all of which limit their further growth and lead these countries into the trap of an economy based on raw materials. In addition to the structural changes in their economies, in which rapid industrialization, the service sector and the knowledge economy are taking precedence, their certain infrastructural weaknesses can also be observed, which all point to the need for the conduction of more effective land policies, better subsidy policies, as well as for strengthening the protection of the small farmers' rights. The agricultural base of most BRICS countries is still technologically back warded and inefficiently organized, pointing to the urgent need for its further modernization and technological development, diversification of agricultural products, implementation of appropriate institutional and land reforms, development of rural infrastructure, but also for conducting a better investment policy in education and training of farmers.

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Conflict of interests

The authors declare no conflict of interest.

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THE USE OF INFORMATION TECHNOLOGIES AND IMPLEMENTING BIG DATA CONCEPT, DRONES, AND ARTIFICIAL INTELLIGENCE IN THE AGRICULTURE - PERCEPTION OF SMALL FARMERS IN SERBIA

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A R T I C L E   I N F O

A B S T R A C T

This study explores the attitudes and readiness of small farmers in the Republic of Serbia toward digital transformation in agricultural production, with emphasis on the application of Big Data, drone technology, and artificial intelligence. The research implemented a quantitative survey, collecting data from 437 participants across three regions of Serbia. Descriptive statistics and Spearman's rank correlation analysis were used to examine the correlation of demographic factors, including age, gender, education level, and geographic location, with the perceptions on using information technologies in agriculture. Results present significant interest in digital tools that support productivity and sustainability, despite limited practical experience and low levels of digital literacy. Statistically significant correlations were identified between age, education level, and geography in shaping openness toward technological adoption, while gender showed no significant correlation. Younger and more educated respondents consistently expressed stronger support for using advanced technologies, underscoring the importance of strategic government awareness programs and training initiatives.

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Introduction

With the rapid growth of global population, the demand for food is rising rapidly, too. To meet this increasing need, 21st century agriculture must adopt innovative technologies and approaches that enhance productivity, sustainability, and resilience (Zhang, Guo, Ullah, Melagraki, Afantitis, & Lynch, 2021; Rejeb, Abdollahi, Rejeb, & Treiblmaier, 2022; Uzhinskiy, 2023; Gebresenbet, Bosona, Patterson, Persson, Fischer, Mandaluniz, … Nasirahmadi, 2023; Guebsi, Mami, & Chokmani, 2024; Boros, Szólik, Desalegn, & Tőzsér, 2025).

In the Republic of Serbia, agriculture is one of the most important sectors of economy. However, it faces challenges such as outdated practices, dominance of small farms with limited access to modern technologies (Đurić, Cvijanović, Prodanović, Čavlin, Kuzman, & Lukač Bulatović, 2019). Most of the current research on Serbia focuses on the possibilities of satisfying growing demands for quality food while aligning with EU agricultural standards (Stojiljković, Raičević, & Djurković, 2025). New topics emerging from both academic research and practice, concentrate on implementation of and investments in innovative, advanced technological solutions that would improve agricultural production efficiency and minimize potential negative impact on the environment (Bešić, Ćoćaklo, Bakator, Vidas-Bubanja, & Stanisavljev, 2025). This is particularly important for small producers, who often lack access to new technologies and necessary trainings for their importance and use. In this process emerges the crucial role of the state in creating conditions for the use of new technologies and systemic organization of trainings for small producers.

Literature review

Over the past decade, a growing body of research has focused on the application of emerging technologies in agriculture, with particular emphasis on information technology, Big Data, Internet of Things (IoT), artificial intelligence (AI), machine learning, deep learning, and the use of Unmanned Aircraft Systems (UAS) or drones (Bu, & Wang, 2019; Rađenović, Krstić, & Marković, 2020; Boursianis, Papadopoulou, Diamantoulakis, Liopa-Tsakalidi, Barouchas, Salahas, G., … Goudos, 2022; Schaefer, 2023; Fuentes-Peñailillo, Gutter, Vega, & Silva, 2024). Widely researched concept of Industry 4.0 (Javaid, Haleem, Singh, & Suman, 2022) can also be implemented in agriculture. Current body of research focuses not only on developed countries (Mohr, & Kühl, 2021), but on developing countries, too, where new technological solutions can assist in improvement of agricultural practices (Ilic-Kosanovic, Pazun, Langovic, & Tomic, 2019).

Rising global temperatures and the increasing frequency of extreme weather events, such as severe droughts and torrential rains pose mounting challenges to agricultural productivity. To address these issues, innovative solutions including AI, Big Data analytics, and IoT, are becoming essential tools in optimizing crop yields and ensuring sustainable agricultural practices (Petkovic, Petkovic, & Petkovic, 2017; Linaza, Posada, Bund, Eisert, Quartulli, Döllner, Pagani, Olaizola, Barriguinha, Moysiadis, & Lucat, 2021; Pantović et al., 2022; Ahmed, & Shakoor, 2025).

Some researchers are focused on the use of AI, especially smart sensing systems, in crops' spraying control in order to avoid contamination, (Partel, Costa, & Ampatzidis, 2021). Those systems are also used for identification of weed, assessing crops, fruit, and vegetables quality, for timely detection of diseases, and for minimizing waste (Costa, Nunes, & Ampatzidis, 2020). AI can also support crop monitoring (in terms of quality, soil evaluation, yield, etc.) (Roslim, Juraimi, Che'Ya, Sulaiman, Manaf, Ramli, & Motmainna, 2021; Talaviya, Shah, Patel, Yagnik, & Shah, 2020; Arza-García, & Burgess, 2023; Näsi, Mikkola, Honkavaara, Koivumäki, Oliveira, Peltonen-Sainio,... & Alakukku, 2023). Since the use of fertilizers and pesticides endangers the environment, the need for the use of new technologies to minimize the negative effect of excess chemicals is one of the essential topics for researchers and practicioners alike (Talaviya, Shah, Patel, Yagnik, & Shah, 2020; Rejeb, Abdollahi, Rejeb, & Treiblmaier, 2022). In response to these concerns, many scholars and experts are now exploring data-driven methods such as precision farming and remote sensing to enhance crop management while safeguarding soil health and biodiversity (Talaviya, Shah, Patel, Yagnik, & Shah, 2020; Bešić et al., 2024).

Drone technology is used for crop monitoring, precision weed and pest control and mapping, and evaluation of possibilities for development of various diseases (Drăgoi et al., 2018; Michels, von Hobe, Weller von Ahlefeld, et al. 2021; Rejeb, Abdollahi, Rejeb, & Treiblmaier, 2022; Spanaki, Karafili, Sivarajah, Despoudi, & Irani, 2022; Erokhin et al., 2022; Uzhinskiy, 2023). In the agricultural sector, drone manufacturers are designing customized, application-oriented solutions tailored to the specific needs of farmers and agronomists. Technological developments have led to the development of a wide range of UAV models in various sizes, weights, and configurations, each capable of carrying specialized sensor payloads (Merz, Pedro, Skliros, Bergenhem, Himanka, Houge, Matos-Carvalho, Lundkvist, Cürüklü, Hamrén, Ameri, Ahlberg, & Johansen, 2022; Radic, Radić, & Cogoljević, 2022; Guebsi, Mami, & Chokmani, 2024). These innovations enable precision farming applications such as crop health monitoring, soil analysis, irrigation management, and yield forecasting, making agriculture more efficient and data driven (van der Merwe, Burchfield, Witt, Price, & Sharda, 2020; del Cerro, Cruz Ulloa, Barrientos, & de León Rivas, 2021; Abbas, Zhang, Zheng, Alami, Alrefaei, Abbas,... & Zhou, 2023; Uzhinskiy, 2023; Phang, Chiang, Happonen, & Chang, 2023).

One of the significant topics for researchers is the use of AI in land irrigation. IoT, for example, enables solar power based irrigation systems (Ahmed, & Shakoor, 2025). One of the new, technology based, methods is drip irrigation, with minimum of water used for maximum gains (Talaviya, Shah, Patel, Yagnik, & Shah, 2020). AI can also be used for enabling the preservation of environment during the process of agricultural production (Oliveira, & Silva, 2023). In addition, the new technologies, namely AI, measure rainfall and predict extreme weather conditions (severe rain, floods, or draughts) (Aijaz, Lan, Raza, Yaqub, Iqbal, & Pathan, 2025; Ahmed, & Shakoor, 2025).

One of the significant roles of AI lays in its application in decision-making process of farmers (Alaoui, Amraoui, Masmoudi, Ettouhami, & Rouchdi, 2024; Backman, Koistinen, & Ronkainen, 2023; Gebresenbet, Bosona, Patterson, Persson, Fischer, Mandaluniz, Nasirahmadi, 2023; Milačić, 2024; Javaid, Haleem, Haleem Khan, & Suman, 2023). Big data enables precision agriculture by integrating real-time sensor data, satellite imagery, and environmental variables to optimize irrigation, fertilization, and crop protection decisions and assists in statistical analysis of available data (Delgado, Short Jr, Roberts, & Vandenberg, 2019; Ahmed, & Shakoor, 2025). AI also has key role in product storing, marketing, product placing, demand forecasting, and prices projecting (Javaid, Haleem, Haleem Khan, & Suman, 2023). Furthermore, Big Data supports predictive modeling and supply chain optimization, allowing farmers to anticipate risks, manage resources more efficiently, and align production with market demands (Delgado, Short Jr, Roberts, & Vandenberg, 2019)

Some of the other key topics include ecological issues and the impact on society and ethical behavior in production and consumption (Klerkx, Rose, 2020). Some authors focus on the risks of the cost and attainability of modern technologies for small farmers, not only in developing countries, but in developed countries as well. The trend of introducing and implementing new technologies can lead to destruction of small farmers and the further rise of corporate landholdings (Klerkx, & Rose, 2020). Some of the prerequisites for implementing information technologies are stable Internet connection, and data processing capability, which is not always available in rural areas (Aijaz, Lan, Raza, Yaqub, Iqbal, & Pathan, 2025).

Finally, one of the most important issues in introducing new technologies, especially to the small farmers is resistance from farmers, lack of understanding of the possible gains, inadequate education, and training for using various new technological solutions (Meshram, Patil, Meshram, Hanchate, & Ramkteke, 2021). Some of the skills needed are highly specialized and technical (Aijaz, Lan, Raza, Yaqub, Iqbal, & Pathan, 2025), for example for drone operating, and other, traditional, are becoming obsolete. Governments' initiatives are needed for developing awareness and training programs (Aijaz, Lan, Raza, Yaqub, Iqbal, & Pathan, 2025), and providing accessible and inexpensive solutions, that can be shared through communities.

In the Republic of Serbia, implementation of digital technologies in agricultural practices is not a new process, it is particularly evident in the northern Serbian region of Vojvodina, where their application has led to significant advances in productivity. Agricultural producers in Vojvodina benefit from fertile land and more advanced infrastructure, resulting in higher productivity compared to those in central and southern Serbia. In contrast, producers in southern Serbia face various disadvantages, including mountainous terrain, limited access to technology, and lower education levels (Jurjević, Zekić, Đokić, & Matkovski, 2019; Dimitrijević, Ristić, & Despotović, 2021). However, despite increasing understanding of the strategic importance of using IT for achieving sustainable agricultural production, Serbia continues to face many barriers

for broader information technologies adoption in agricultural practices. These include limited financial resources and, especially, a generally low level of digital literacy and capacity for innovations among agricultural producers (Jurjević, Bogićević, Đokić, & Matkovski 2019; Kljajić, Paraušić, & Stanković, 2024; Paunović, Štrbac, & Živković, 2024). Despite these obstacles, integrating IT into Serbian agriculture is seen as a strategic pathway toward long-term sustainability, economic competitiveness, and alignment with European Union standards (Vukadinovic, Jesic, Okanovic, & Lovre, 2022; Stojiljković, Raičević, & Djurković, 2025), and this process requires state strategic support.

Materials and methods

The purpose of the empirical research is to analyze the perceptions of agricultural producers of three distinct areas: in central Serbia - Raška district, municipality Kraljevo, villages Lazac and Samaila; in northern, Autonomous Province of Vojvodina - Suthern Bačka district, municipality Vrbas, villages Savino selo and Ravno selo; and in the furthermost south of the country in Pčinjski district - municipality Vranje, villages Ćukovac and Tibudže, on the use of information technologies and implementing Big Data, drones, and artificial intelligence in the agriculture.

The neighbouring villages Samaila and Lazac are located between towns Kraljevo and Čačak in central Serbia and they belong to the municipality of Kraljevo. While Samaila is positioned mostly in the flat land, Lazac is spreading across mainly hilly area. Samaila covers 23.33 km^2, and Lazac 21.75 km$^{2.}$ (Municipality of Kraljevo, 2017). As of population survey from 2011, Samaila consists of 485 households and 1466 inhabitants and Lazac consists of 249 households and 695 inhabitants (Municipality of Kraljevo, 2017; Republički zavod za statistiku, 2011). Villages Savino selo and Ravno selo are located on the west from town of Vrbas in a flat land and they belong to the municipality of Vrbas. Savino selo consists of 939 households and 2957 total inhabitants, and Ravno selo consists of 1014 households, 3107 total inhabitants as of survey from 2011 (Vrbas, 2020; Republički zavod za statistiku, 2011). Villages Ćukovac and Tibudže are located south-east of the town of Vranje, and they belong to the municipality of Vranje. Ćukovac consists of 285 households and 1030 inhabitants and Tibudže consists of 368 households and 1295 inhabitants (Republički zavod za statistiku, 2011).

The study included 437 adult respondents over age of eighteen that have been fully or partially involved in agricultural production. The survey in Raška regions villages has been conducted in July/August 2024, in Vojvodina villages in October/November 2024, and in the Pčinjska region villages in January 2024, through Google forms platform, that the respondents could fill themselves or the volunteers could have helped the older ones to fill in the forms on the tablets.

In the first part of the structured survey, the participants have had the opportunity to state their knowledge of the term e-agriculture, strategy of agricultural development

in the EU, of using apps for marketing and sales for maximizing the profit, and the acquaintance with the usage of Cloud, drones, sensors and IoT systems for crops monitoring. In the second part of the survey, four main research questions have been devised in regard to their perception on the use of information technologies and implementing Big Data, drones, and artificial intelligence in the agriculture.

According to the literature review, four main research questions (statements) were developed:

- It is necessary that the state, faculties, and other certified educational institutions provide online or live courses for the agricultural producers on the benefits and the importance of new information technologies usage in agricultural production.
- If the state enables usage of Big Data concept for the purpose of production risk minimizing, I would participate in its implementation (courses, execution, etc.).
- I would use drones as agricultural tool (terrain surveying, crop dusting, soil monitoring, etc.).
- Robotization and artificial intelligence has the potential for agriculture in the Republic of Serbia in the near future.

Five-point Likert scale was used to assess the statements (1 – I disagree completely; 2 – I somewhat disagree; 3 – I am neutral; 4 – I somewhat agree; 5 – I agree completely). The constructed scale was subjected to the test of reliability and it had strong (0.875) Cronbach's Alpha value, which indicated an adequate level of internal consistency for the scale with the specific sample used for the study (Cohen, 1988) as it can be seen at Table 1.

Table 1. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.875	.877	4

Source: Authors

Furthermore, it was assessed weather the Cronbach's Alpha would suffer from the removal of some items and the results are presented at Table 2.

Table 2. Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
RQ 1	9.23	8.013	.723	.537	.844
RQ 2	9.59	7.824	.765	.592	.828
RQ 3	9.25	7.737	.741	.551	.836
RQ 4	9.31	7.360	.706	.502	.853

Source: Authors

Collected data have been analyzed by using statistical package SPSS v. 18.

Results and discussion

The total sample size has been 497 and 17.6% of the participants have been from Lazac (n=77), 15.1% (n=66) from Samaila, 18.3% from Savino selo (n=80), 14.4% from Ravno selo (n=63), 19.7% from Ćukovac (n=65), and 14.9% from Tibudže (n=65). Among the participants, 49% have been female (n=214), and 51% male (n=223) as seen at Table 3.

Table 3. The respondents' village and gender

Village	Frequency	%	Gender	Frequency	%
Samaila	66	15.1	Male	223	51.0
Lazac	77	17.6	Female	214	49.0
Savino selo	80	18.3	Total	437	100.0
Ravno selo	63	14.4			
Čukovac	86	19.7			
Tibudže	65	14.9			
Total	437	100.0			

Source: Authors

The participants belonged into different age groups, as well as five levels of education, going from unfinished elementary education to higher education (college or university), as it can be seen at Table 4.

Table 4. The respondents' age and level of education

Respondents age (years)	Frequency	%	Highest educational level achieved	Frequency	%
From 18 to 25	23	5.3	Unfinished Elementary school	10	2.3
From 26 to 35	72	16.5	Elementary school	81	18.5
From 36 to 45	93	21.3	Vocational high school (three years)	172	39.4
From 46 to 55	90	20.6	High school	168	38.4
From 56 to 65	99	22.7	Higher education	6	1.4
Over 65	60	13.7	Total	437	
Total	437	100.0			

Source: Authors

The participants belonged in the households with various number of members and various number of members involved in the agriculture as seen at Table 5.

Table 5. Total number of household members and household members involved in agriculture

Total household members	Frequency	%	Household members involved in agriculture	Frequency	%
One	40	9.2	One	198	45.3
From 2 to 3	241	55.1	Two	181	41.4
From 4 to 5	122	27.9	Three	36	8.2
More than 5	34	7.8	Four	22	5.0
Total	437	100.0	Total	437	100.0

Source: Authors

Research results indicate that half of the surveyed participants (50.3%) are familiar with the concept of e-agriculture, suggesting a basic understanding and a genuine interest in the digital transformation of agricultural practices. On the other hand, a significant majority (86.3%) are unfamiliar with agricultural development strategies implemented across European countries, which points to a lack of knowledge and experience with international standards and innovations.

Similarly, most participants (68.2%) believe that mobile applications for marketing and sales have the potential to maximize profits in agriculture, emphasizing enthusiasm and openness toward using digital tools in the business dimension of farming. However, the vast majority have never used cloud-based services (91.5%) and lack familiarity with sensor technology and IoT systems for crop monitoring (82.4%), revealing a significant gap in practical knowledge and technological skills necessary for implementation of new technologies.

Considering everything, these findings suggest that agricultural producers in Serbia possess an initial awareness and motivation to engage with digital technologies, but are held back by insufficient knowledge, training, and learning opportunities. There is a clear need for systemic education and learning for enabling effective integration of digital innovations and ensuring sustainable agricultural development.

Finally, correlation analysis was conducted in order to determine correlation of demographic variables (age, gender, education and geographical position) to the attitudes on our research questions using Spearman rank order correlation coefficient.

As presented at Table 6, a statistically significant negative correlation was observed between age and the perceived necessity for institutional education on digital technologies in agriculture (*Spearman's ρ = -0.493, p < .01*), indicating that younger participants are more likely to recognize the importance of such training. Conversely, education level showed a significant positive correlation (*Spearman's ρ = 0.490, p < .01*), suggesting that individuals with higher educational level are more inclined to support initiatives for agricultural digital training.

In contrast, no statistically significant correlations were found for gender (*Spearman's ρ = 0.017, p = .726*) or geographic location (*Spearman's ρ = 0.056, p = .244*), implying that these factors do not substantially influence perceptions regarding the need for systemic education on information technology in agriculture.

Table 6. Correlations - The correlation of demographic variables to RQ1

			Age	Gender	Education	Village
Spearman's rho	It is necessary that the state, faculties, and other certified educational institutions provide online or live courses for the agricultural producers on the benefits and the importance of new information technologies usage in agricultural production.	Correlation Coefficient	-.493**	.017	.490**	.056
		Sig. (2-tailed)	.000	.726	.000	.244
		N	437	437	437	437

**. Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 7, a significant negative correlation was found between age and willingness to participate in the implementation of Big Data technologies in agriculture (*Spearman's ρ = -0.521, p < .01*), suggesting that younger participants are more inclined to engage with state-supported initiatives involving advanced digital tools for risk management. Conversely, education level exhibited a strong positive correlation (*Spearman's ρ = 0.600, p < .01*), indicating that participants with higher educational attainment are more likely to support and get involved in such programs.

Geographic location (village) revealed a small but significant negative correlation (*Spearman's ρ = -0.247, p < .01*), which may reflect regional differences in access, infrastructure, or exposure to digital agriculture practices. Meanwhile, no significant correlation was observed for gender (*Spearman's ρ = -0.005, p = .918*), implying that gender does not substantially influence attitudes toward participating in Big Data implementation in agriculture.

Table 7. Correlations - The correlation of demographic variables to RQ2

			Age	Gender	Education	Village
Spearman's rho	If the state enables usage of Big Data concept for the purpose of production risk minimizing, I would participate in its implementation (courses, execution, etc.).	Correlation Coefficient	-.521**	-.005	.600**	-.247**
		Sig. (2-tailed)	.000	.918	.000	.000
		N	437	437	437	437
**. Correlation is significant at the 0.01 level (2-tailed).						

As presented in Table 8, a significant negative correlation was observed between age and the willingness to use drones in agricultural applications such as terrain surveying, crop

dusting, and soil monitoring (*Spearman's ρ = -0.506, p < .01*), indicating that younger participants are more inclined to adopt drone technologies in farming. Furthermore, education level demonstrated a strong positive correlation (*Spearman's ρ = 0.538, p < .01*), suggesting that individuals with higher educational attainment are more likely to engage with drone-based agricultural tools.

A small but significant negative correlation with geographic location (*Spearman's ρ = -0.155, p = .001*) implies that participants from more remote or rural areas may exhibit lower levels of enthusiasm or readiness to implement drone technology, possibly due to limited access or exposure. No statistically significant correlation was found for gender (*Spearman's ρ = -0.033, p = .488*), indicating that gender does not play a notable role in shaping attitudes toward the adoption of drone tools in agriculture.

Table 8. Correlations - The correlation of demographic variables to RQ3

			Age	Gender	Education	Village
Spearman's rho	I would use drones as agricultural tool (terrain surveying, crop dusting, soil monitoring, etc.).	Correlation Coefficient	-.506**	-.033	.538**	-.155**
		Sig. (2-tailed)	.000	.488	.000	.001
		N	437	437	437	437

**. Correlation is significant at the 0.01 level (2-tailed).

As indicated in Table 9, a moderate negative correlation was found between age and the belief in the potential of robotization and artificial intelligence (AI) in Serbian agriculture (*Spearman's ρ = -0.477, p < .01*), suggesting that younger participants are more optimistic about the adoption of these technologies in the near future. In parallel, a moderate positive correlation was observed with education level (*Spearman's ρ = 0.478, p < .01*), which implies that higher levels of formal education are associated with stronger support for integrating AI and robotics in agricultural practices.

Additionally, a small but statistically significant negative correlation with geographic location (village) was noted (*Spearman's ρ = -0.153, p = .001*), indicating that individuals from more remote or rural areas may be less convinced of the immediate significance or feasibility of such advanced technologies. No significant correlation with gender was detected (*Spearman's ρ = -0.020, p = .681*), suggesting that perceptions regarding AI and robotization are consistent across genders.

Table 9. Correlations - The correlation of demographic variables to RQ4

			Age	Gender	Education	Village
Spearman's rho	Robotization and artificial intelligence has the potential for agriculture in the Republic of Serbia in the near future.	Correlation Coefficient	-.477**	-.020	.478**	-.153**
		Sig. (2-tailed)	.000	.681	.000	.001
		N	437	437	437	437

**. Correlation is significant at the 0.01 level (2-tailed).

Findings from this study suggest that while many agricultural producers demonstrate genuine interest in innovative tools such as marketing apps, Big Data systems, drones, and AI, there is a significant gap between interest and abilities. Factors such as age, education level, and geographic location consistently correlate with the perceptions and willingness to adopt digital solutions, on the other hand gender appears largely neutral in its effect.

Significantly, the data indicates that younger and more educated farmers show evident openness toward digital transformation. Despite limited practical experience with advanced technologies like cloud services and IoT systems, a clear enthusiasm for learning is existing. Younger, educated farmers want to learn, but they need support through strategic policies and programs.

Discussion

As it is stated, the findings of this study present foundation for digital transformation in Serbian agriculture, especially when it comes to small farmers. While many small farmers, especially older ones, lack understanding and experience with advanced technologies such as cloud computing, IoT systems, and drones, many, especially younger and more educated ones, express a strong interest and willingness to learn and engage with digital innovations. Studies show that in other sectors, such as tourism, the use of information and communication technologies is largely determined by age and level of education (Langović, Pažun, Grujčić, Nikolić, Langović-Milićević & Ugrinov, 2025). Similarly, the use of ICT in agriculture has wider implications, as it has a positive impact on the economy, i.e. on the economic development and competitiveness of the sector (Pažun, Langović, Stojanović, Langović-Milićević & Božović, 2025). Previous research also emphasized the gap between motivation and capability of older farmers, farmers with lower levels of formal education, and the ones in more remote or financially disadvantaged regions (Rađenović, Krstić, & Marković, 2020; Vapa Tankosić, Mirjanić, Prodanović, Lekić, & Carić, 2024).

Younger and educated participants in various studies consistently show higher level of willingness to adopting tools like Big Data analytics, AI, and drone-based monitoring (Jurjević, Zekić, Đokić, & Matkovski, 2019; Dimitrijević, Ristić, & Despotović, 2021) which is supported with the results of this study. Geographic differences, particularly between Vojvodina and southern Serbia, emphasize the need to address the issue through strenghtening the infrastructure, introducing training opportunities, and establishing stronger institutional support (Jurjević, Zekić, Đokić, & Matkovski, 2019; Dimitrijević, Ristić, & Despotović, 2021; Grujić Vučkovski, & Subić, 2024). The absence of significant gender differences may indicate that women and men in Serbian agriculture share similar attitudes toward digitalization.

Conclusion

Serbia's agricultural sector stands at a decisive moment, especially in terms of empowering small farmers to understand and implement innovative solutions. Many of the small farmers, especially younger and more educated ones, already recognize the importance of implementing various digital tools in improving agricultural productivity. This calls for systemic effort to share basic knowledge and awareness between older farmers and to provide education and training for younger ones.

By developing committed strategies and policies, investing in digital infrastructure, and raising awareness among producers, the Serbian state can help ensure that agricultural transformation is both inclusive and resilient. Special attention should be given to practical training programs and the promotion of user-friendly digital tools, such as IoT systems, Big Data applications, and drones, which can be easily adopted and shared within farming communities. With the creation and implementation of these programs, especially if aligned with EU agricultural policies, even small farmers can be effectively integrated into modern agricultural systems, leading to significant improvements in productivity and sustainability.

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Conflict of interest

The authors declare no conflict of interest.

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INTERDISCIPLINARY SYNERGY OF CULTURAL HERITAGE, AGRICULTURE, AND FINANCIAL STRUCTURES IN URBAN DEVELOPMENT STRATEGY: SPLIT SUMMER FESTIVAL AS A MODEL OF INTEGRATION

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A R T I C L E   I N F O

A B S T R A C T

This paper examines the role of cultural festivals in sustainable urban development, focusing on the Split Summer Festival as a model of integration between cultural heritage, and tourism. The purpose is to analyze how festivals influence tourist flows, valorize local agri-food production, and contribute to economic resilience. The methodology combines quantitative analysis of overnight stay statistics (2013–2024) with qualitative secondary literature review, supported by a two-way ANOVA to test differences between festival and non-festival regions. Results confirm that festival locations achieve significantly higher growth in overnight stays and stronger links between cultural events and accommodation demand. Conclusions highlight the importance of festival-driven synergies in shaping cultural capital, economic benefits, and sustainable tourism. Recommendations include integrating small agricultural producers, diversifying accommodation, and strengthening collaborative policy frameworks. Additional data underline the growing role of rural households and agri-food products in enriching the cultural tourism experience.

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Introduction

In the context of intensifying challenges related to climate change, economic transformations, and cultural sustainability, cultural heritage is increasingly recognized not merely as a symbolic asset but as a tangible resource for urban development. The city of Split, as a cultural hub of Dalmatia with a layered historical and intangible heritage, represents a paradigmatic space where local identities, global tourist flows, and rural economic potentials converge. Within this framework, the Split Summer Festival emerges as more than a cultural manifestation; it functions as a platform for the integration of cultural production, sustainable tourism, and local economic development.

This paper departs from the premise that sustainable urban growth requires interdisciplinary synergies between cultural policies, agriculture, and tourism, accompanied by a reconfiguration of governance models, participatory practices, and valorization of local resources.

The research seeks to answer critical questions regarding the role of cultural events in strengthening cultural capital, generating economic benefits for local producers, and optimizing infrastructural capacities within Split and its wider region. The methodological framework rests on quantitative analysis of data drawn from the eVisitor system, the Croatian Bureau of Statistics, and the Tourist Board of Split-Dalmatia County, covering the period 2013–2023.

Festival experiences are increasingly perceived as multidimensional phenomena that shape tourism, cultural identity, and local economies. They are particularly attractive to younger generations, for whom music and cultural events represent a form of lifestyle expression and tourist engagement (Iványi & Bíró-Szigeti, 2020). Beyond their economic contributions, festivals foster social cohesion and influence the long-term perception of destinations through shared experiences, amplified in digital environments.

Contemporary strategies of urban development demand the integration of cultural policy with economic and spatial planning, particularly in a context where globalization profoundly reshapes value systems and local traditions (Dragićević Šešić, 2009). As urban economies shift from industrial to service-oriented logics, cultural policy assumes a central role in creating participatory public spaces and generating sustainable value. Cultural capital is thereby positioned as both a driver of development and a medium for reinforcing collective identity.

Theoretical and Cultural Dimensions of Festivals: From Heritage to the Experience Economy

Festivals in continental Croatia represent a powerful instrument for creating a competitive and recognizable tourism offer that integrates economic objectives with the cultural values of local communities. Although today they are primarily perceived as entertainment, their historical genesis is rooted in ritual and religious celebrations.

During the Middle Ages, festivals served as platforms of collective memory and cultural values, while in contemporary urban contexts—particularly music festivals—they have become generators of cultural identity and local development (Richards & Palmer, 2013; Campbell, 2007). From this perspective, festivals in continental Croatia can be reinterpreted not only as tourist attractions but as continuations of cultural heritage and tools of spatial revitalization.

As a form of cultural capital, festivals may be understood through Bourdieu's (1986) tripartite framework of embodied practices, objectified cultural products, and institutionalized forms of knowledge. They function as platforms for active participation, where audiences reinterpret cultural content, thereby developing cultural competence while also reproducing symbolic hierarchies and mechanisms of social stratification (Lee, 2017). Such an approach frames festivals simultaneously as emancipatory and educational spaces and as arenas of power and inequality.

The lens of the experience economy adds another analytical dimension. Festivals encompass experiential, emotional, and cognitive aspects that allow visitors to temporarily escape everyday routines. Emotional engagement fosters loyalty and encourages recommendation practices in digital contexts (Arnould & Price, 1993; Mitrović, 2022). For continental Croatia—where tourism still predominantly relies on traditional models—the ability to create distinctive and memorable experiences is critical for differentiation and sustainable development.

Agriculture, Gastronomy, and Rural Development in the Context of Cultural Policies and Urban Creativity

A significant dimension of the interdisciplinary approach to festivals is gastronomy and rural development. Gastro-tourism, as a subtype of cultural tourism, enables synergy between local food production and tourist demand. It contributes not only to the economic resilience of rural areas but also to the preservation of local identity (Hall & Gössling, 2016). Nevertheless, planning rural development in Croatia remains challenging due to the involvement of numerous stakeholders with divergent interests (Paparić, Glavaš, & Ravlić, 2024). Linking festivals with local food supply chains enhances integration of agricultural and cultural heritage, strengthening local economies and establishing sustainable practices.

Modern agriculture extends beyond primary production, encompassing processing, distribution, and commercialization within broader socio-economic and cultural systems (Kelić, Turjak, & Unukić, 2018). Thematic and gastronomic festivals, particularly in rural and semi-urban areas, valorize agriculture as a source of identity and authenticity. Through these events, agricultural products become markers of regional capital and cultural representation, while short supply chains and direct producer–consumer interactions promote awareness of sustainable practices.

Tourist motives further reinforce this connection, as visitors increasingly seek authentic encounters with heritage and local products, shaping demand and supply alike (Ujko,

Cvijanović, El Bilali, & Berjan, 2025). In this sense, festivals influence not only cultural offerings but also agricultural practices and accommodation capacities, thereby contributing to rural revitalization, strengthening community self-confidence, and affirming agriculture as both an economic and cultural resource.

From a broader perspective, cultural policies and the "creative city" framework underline the role of festivals in urban regeneration. Creativity is understood as multidimensional, encompassing artistic, economic, and spatial dimensions that intertwine in the urban context (Simonton in Florida, 2002). Festivals stimulate not only tourism but also local economic cycles, provide platforms for business visibility, and act as instruments of political legitimization (Zelić, 2023). Food markets, once primarily spaces of economic exchange, today function as social and cultural symbols, reinforcing destination images and experiential consumption (Crespi-Vallbona & Dimitrovski, 2025).

The processes of shaping destination image depend on the interplay of cultural content, heritage, and local products (Kim & Chen, 2016; Milman, 2011). Accordingly, festivals and food markets contribute to building multicultural identities and creating cultural capital. Theories of the creative city emphasize the role of culture and creative industries as drivers of urban regeneration (Landry & Bianchini, 1995; Landry, 2000), while the creative class (Florida, 2002, 2017) and cultural policies (Neiva Ganga et al., 2021; Borén et al., 2020; Pintossi et al., 2021) are increasingly recognized as mechanisms of symbolic and economic transformation.

Within this framework, the Split Summer Festival can be positioned as a model of integration that connects heritage, cultural production, and agricultural practices. At the global level, UNESCO (2016) emphasizes that culture in urban contexts is a key driver of sustainable development, revitalization, and inclusive communities. Regionally, Mirkov (2019) demonstrates how cultural policies influence tourism competitiveness in Zadar County, highlighting the economic and symbolic role of cultural content. This interplay illustrates how culture functions as a strategic resource for planning and sustainable development in Croatian destinations.

Split Summer Festival as a Model of Cultural Branding, Financial Structures, and Integrated Management

The Split Summer Festival, alongside the Dubrovnik Summer Festival, represents the longest-standing and most recognizable national cultural manifestation. Founded in 1954 with Jakov Gotovac's opera *Ero s onoga svijeta*, and initially titled "Split Summer Performances" until 1968, the event has since evolved into a key institution of Croatian cultural identity (Miroslav Krleža Lexicographical Institute, 2025; Dorić, 2023). Over the decades, it transitioned through various organizational models—from the Croatian National Theatre Split to Dalmacija Concert (1970–1978)—and today operates under the City of Split. Its venues include the Peristyle, Diocletian's Palace, Meštrović's Kaštelet, and nearby towns such as Trogir and Stari Grad (Dorić, 2023).

The program has consistently emphasized collaboration with local institutions, centering on opera, drama, ballet, and dance, while also incorporating visual arts, literary evenings, and poetry recitals (Selem, 2004). Institutional awards such as Judita and Peristil further confirm the festival's status within the system of cultural valorization. Deeply rooted in the city's Renaissance and Baroque heritage—from Juraj Dalmatinac to Ivan Meštrović—the festival today embodies both historical continuity and contemporary cultural management goals, including heritage preservation, multicultural dialogue, and international cooperation (Dorić, 2023).

Analytically, the Split Summer Festival represents a model for studying visitor motivation, loyalty, and satisfaction (Pencinger, 2014; Oliver, 1999), key factors for the sustainability of cultural events. It demonstrates how a cultural brand can integrate symbolic capital with measurable economic effects such as overnight stays, visitor arrivals, and increased consumption of local resources. As such, it enables the application of interdisciplinary research approaches to understanding cultural capital, the experience economy, and urban development. Split Summer, as the most important national theatrical and musical event alongside the Dubrovnik Summer Festival, occupies a central place in the cultural and tourist life of the Republic of Croatia. Its institutional tradition, on-going since 1954, confirms the festival's status as a cultural brand of Split and the wider region.

Ivanov (2020) highlights that digitalization and automation in the tourism and hospitality sector bring substantial changes to the labor market, requiring employees to adapt their skills and prompting the need for more flexible management models. Meanwhile, Ivanov (2017) emphasizes that mass tourism, although often criticized, ensures the sustainability of services dependent on high visitor volumes and generates significant backward and forward linkages with other industries. However, he also notes negative consequences, such as the presence of the "grey economy" in private accommodation, which results in lost fiscal revenue.

In the context of Split, these insights indicate that the Split Summer Festival, while not the primary motivation for all visitors, occurs during the peak season of mass tourism. This timing allows the festival to stimulate increased overnight stays, promote the consumption of cultural content, and enhance the valorization of local products and resources.

From a financial perspective, management of cultural organizations requires adaptability to macroeconomic trends and local risks. Enterprises focus simultaneously on micro-level profitability and macro-level conditions, aiming for flexible investment strategies (Vojinović, Milutinović, Sertić, & Leković, 2022). The COVID-19 pandemic highlighted the vulnerability of tourism-dependent economies, exposing the need for resilient models of cultural and urban development (Mavrin, Šebo, & Glavaš, 2022). The Split Summer Festival thus provides a case for analyzing how cultural heritage, tourism flows, and financial structures intersect in urban strategies.

Its significance extends beyond culture: the festival stimulates demand for authentic Dalmatian products such as wine, olive oil, and prosciutto, reinforcing synergies between

agriculture, gastronomy, and tourism. In doing so, it embodies an interdisciplinary model that connects cultural heritage with economic sustainability and community development.

Finally, management evolution—from classical bureaucratic approaches to contemporary flexible models—illustrates how cultural events adapt to changing social and technological conditions (Zelić, 2025). Effective integration of festival management, hospitality, and tourism accommodation enables strategic planning that balances cultural, social, and economic objectives. This tripartite synergy positions the Split Summer Festival not only as a cultural highlight but also as a driver of sustainable urban development and a reference point for the integration of cultural, agricultural, and financial structures.

Materials and methods

The research employed quantitative methods based on statistical data on tourist overnight stays across Croatian counties, comparing festival and non-festival regions to assess the impact of cultural events on tourism intensity. Descriptive statistics were used to illustrate seasonality and regional distribution, while trend analysis identified patterns and potential festival effects. To ensure interdisciplinarity, qualitative secondary analysis of literature and sources (UNESCO, Florida, Mirkov, Selem, Dorić) was included, linking statistical indicators with concepts of cultural policy, cultural capital, and sustainable tourism. The dataset comprised monthly, regional, and accommodation-type statistics for 2020–2024, systematically reviewed to capture temporal and spatial patterns with emphasis on seasonality, disparities, and the role of accommodation. By integrating descriptive and inferential statistics, the analysis provided insights that extend beyond raw figures, enabling a deeper understanding of the relationship between festivals and tourism dynamics.

To assess the influence of festivals on tourism performance, the study applied a two-way ANOVA without replication, testing the effects of two independent variables – location type (festival vs. non-festival destinations) and year (2020–2024) – on the dependent variable of overnight stays. This model identified both main and interaction effects, showing how festival presence and time shape tourism trends. Statistical significance was evaluated through p-values and F-critical values, ensuring robust conclusions. The analysis focuses on Split-Dalmatia County as a case study, given that Split Summer represents an event of long historical continuity, institutional support, and international importance. A comparative approach between festival and non-festival destinations highlighted dynamic growth trajectories. By integrating descriptive statistics with inferential testing, the framework provides insights into seasonal and structural patterns while empirically examining the hypothesized relationship between festivals and tourism outcomes. The research aims to determine whether cultural events, with a focus on Split Summer, are linked to levels of tourist activity and accommodation occupancy. The hypothesis states that festivals significantly increase tourist overnight stays while fostering cultural heritage integration. In this sense, Split Summer serves as a model of cultural continuity and urban integration, illustrating how cultural production generates

broader impacts on tourism, the economy, and social cohesion.

H1: The number and occupancy of accommodation facilities correlate with the scope of the festival program.

H2: Dynamic growth through years is higher in festival locations compared to non-festival locations

Data sources include eVisitor database: number of tourists, overnight stays, visitor nationality (2013–2023), Statistical data from the Tourist Board of Split-Dalmatia County (monthly distribution of tourists, capacities, traffic), Croatian Bureau of Statistics: data on tourism, agriculture, and consumption, Split Summer: program, number of events, number of visitors (if available).

The data in Table 1 offers overview of the monthly distribution of tourist overnight stays in Croatia. Spanning from January to December, it captures a clear seasonal pattern that dominates the country's tourism industry.

Table 1. Overview of overnight stays

Year 2024	Domestic	Foreign	Total
January	273	431	704
February	311	515	826
March	375	1,101	1,476
April	512	2,596	3,108
May	712	6,925	7,637
June	1,381	12,886	14,267
July	3,308	26,145	29,453
August	3,906	27,727	31,632
September	1,264	11,895	13,159
October	518	3,442	3,960
November	414	721	1,134
December	337	655	992

Source: https://htz.hr – "Information on touristic statistical indicators"

In the first quarter (January–March) Croatia records relatively low tourist activity, with overnight stays remaining under 1.5 million, confirming the marginal role of winter tourism. The trend shifts in April and accelerates in May, when over 7.6 million stays are recorded. A sharp increase follows in June with more than 14 million, setting the stage for the summer peak. July exceeds 29 million overnight stays, and August surpasses 31 million, together representing nearly half of the country's annual tourism volume. This concentration highlights Croatia's strong appeal as a summer seaside destination. After August, the numbers decline, producing a bell-shaped seasonal curve dominated by the summer months.

Figure 1. Number of overnight stays by foreign and domestic turists
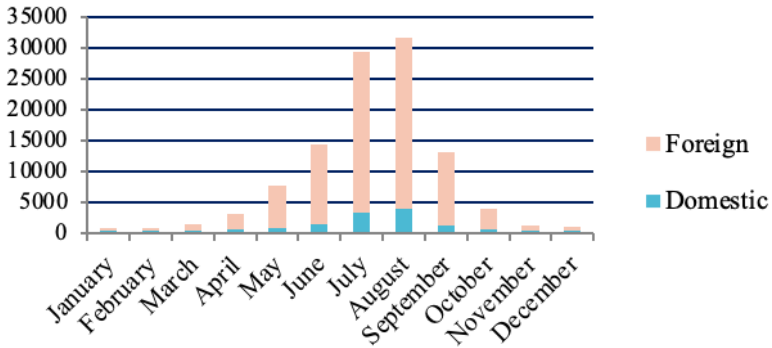
Table 1 and Figure 1 illustrate the 2024 distribution of overnight stays between domestic and foreign tourists in Croatia. Foreign visitors dominate almost every month, with their share most pronounced during the summer peak. The Adriatic coast, warm climate, and beach tourism drive this seasonal concentration, while spring and early autumn show moderate activity and the off-season remains subdued. Domestic tourism maintains a steady presence year-round but is clearly overshadowed by the scale of international arrivals, particularly in the high season.

Figure 2. Number of overnight stays by county
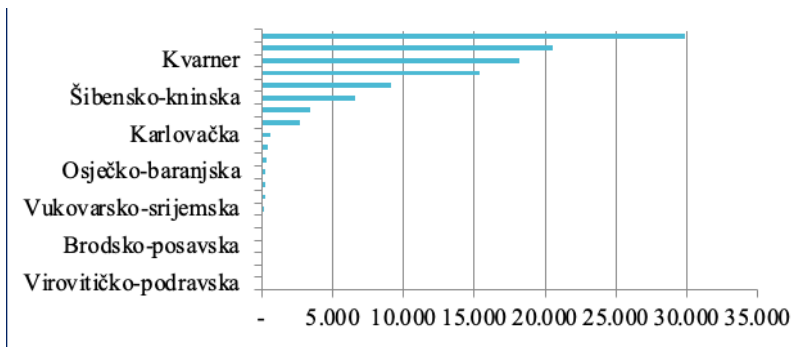
The data show that Istria, Split-Dalmatia, and Kvarner dominate Croatian tourism, each recording tens of millions of overnight stays, driven by beaches, islands, festivals, and developed infrastructure. In contrast, continental counties such as Virovitica-Podravina, Koprivnica-Križevci, and Požega-Slavonia register far fewer visits, in some cases under 100,000. Monthly data for Split-Dalmatia in 2024 reveal a strong seasonal pattern that mirrors national trends on a larger scale: from just over 71,000 stays in January, numbers steadily rise through the first quarter, more than doubling by March to 172,816, marking the onset of the tourist season.

Figure 3. Split – Dalmatia Country
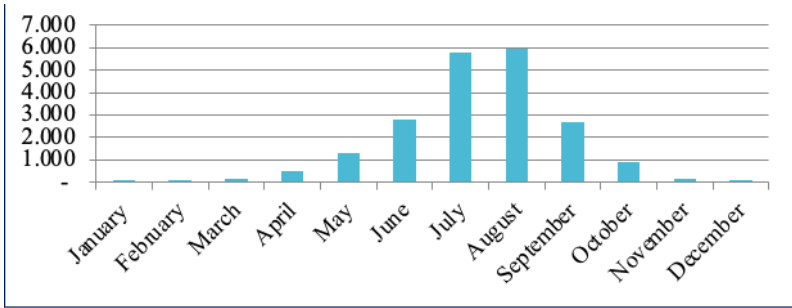
Source: https://htz.hr – "Information on touristic statistical indicators"

Tourist activity rises markedly in spring, surpassing 500,000 overnight stays in April and exceeding 1.3 million in May. The peak occurs in July and August, with nearly 5.8 and 6 million stays, coinciding with the Split Summer Festival, Croatia's leading cultural event. By combining theatre, music, dance, and visual arts, the festival attracts domestic and international audiences and reinforces the seasonal tourism boom. Together, July and August generate more than half of the county's annual overnight stays, highlighting the synergy of coastal tourism and cultural programming.The data for Split-Dalmatia County from 2020 to 2024 reveals a strong and consistent recovery and growth in overnight stays after the initial pandemic-hit year (Figure 4).

Figure 4. Split -Dalmatia County – Overnight stays per year (in 000)
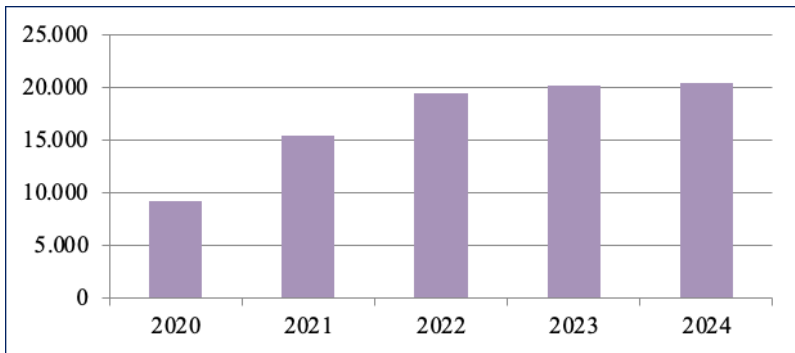
Source: https://htz.hr – "Information on touristic statistical indicators"

In 2020 Split-Dalmatia recorded 9.27 million overnight stays, a sharp decline due to COVID-19 restrictions. Recovery followed quickly: 15.5 million in 2021 (over 67% growth), 19.5 million in 2022, 20.2 million in 2023, and a peak of 20.53 million in 2024, surpassing pre-pandemic levels and reaffirming the region as one of Croatia's top destinations. The Split Summer Festival has been central to this resurgence, attracting culturally motivated tourists and revitalizing urban tourism while stimulating the local economy. Its impact extends to local agri-food products, as visitors increasingly consume

Dalmatian cuisine, wines, olive oil, and produce from nearby rural areas during the high season. This synergy between cultural events and local agriculture highlights the potential of festival-driven tourism as a model for sustainable regional development.

On the Figure 5 is presented data about share of different accommodation types, while table to presents more detailed overview of overnight stays, comparing 2023 and 2024.

Figure 5. Most relevant accommodation types by overnight stays
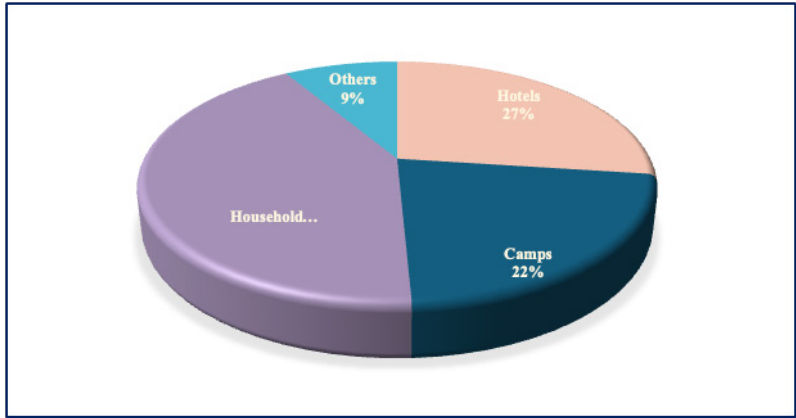
Source: https://htz.hr – "Information on touristic statistical indicators"

Data for 2024 show that household facilities, mainly private apartments and homes, dominate Croatian tourism with 39.6 million overnight stays, well ahead of hotels (25.4 million) and camps (20.8 million). This highlights Croatia's strong orientation toward personalized, informal tourism along the Adriatic coast. Hotels, despite slight growth from 2023, remain the second most used form of accommodation, attracting visitors seeking comfort and full-service options. Camps recorded a minor decline but continue to be popular among Central European tourists. The "other hospitality facilities" category grew modestly, indicating diversification, though it still accounts for only a small share of the total.

Table 2. Overnight stays (in 000) by accommodation type from 2020-2024

Year	Hotels	Camps	Rural Households	Household facilities	Other accommodation facilities	Other	Restaurants
2020	6.996	9.051	61	22.159	3.273	8	3
2021	15.687	17.380	95	32.147	5.523	30	3
2022	22.910	20.798	172	39.405	7.408	52	5
2023	24.613	21.042	184	39.543	7.676	53	5
2024	25.445	20.831	191	39.808	8.091	46	4

Source: https://htz.hr – "Information on touristic statistical indicators"

Table 2 highlights the steady growth of rural households within Croatia's accommodation sector, rising from 61,000 overnight stays in 2020 to 191,000 in 2024, more than tripling in five years. Although modest compared to hotels or private apartments, this increase is highly relevant for sustainable tourism and rural revitalization. Rural households, often linked to small-scale agriculture, provide authentic gastronomic and cultural experiences, support local food systems, and distribute tourism benefits beyond coastal hotspots. In Split-Dalmatia, family farms (OPGs) are increasingly active in the tourism economy, offering farm-to-table dining, accommodation, and experiences tied to festivals and seasonal events.

The growing popularity of festivals as tourism drivers has intensified interest in their impact on overnight stays and local agri-food sales. To test this, a two-way ANOVA without replication was conducted, examining the effects of location type (festival vs. non-festival counties) and year (2020–2024) on overnight stays. Festival counties—including Dubrovnik-Neretva, Zagreb, Osijek-Baranja, Požega-Slavonia, Šibenik-Knin, Split-Dalmatia, Varaždin, and Zagreb County—were contrasted with non-festival counties, where tourism relies less on cultural capital. This design enabled analysis of both spatial and temporal effects of festivals on tourism behaviour.

Two hypothesis will be tested:

H1: The number and occupancy of accommodation facilities correlate with the scope of the festival program.

H2: Dynamic growth through years is higher in festival locations compared to non-festival locations

The two-way ANOVA revealed significant results regarding the main effects of both Location (location type) and Year on overnight stays. The Location factor, which distinguishes between festival and non-festival destinations, had a significant effect on overnight stays. This suggests that the type of location plays a crucial role in attracting tourists, with festival-driven destinations likely seeing spikes in overnight stays during peak seasons. Additionally, the Year factor also showed a significant effect, indicating that overnight stays varied across the years.

Source of Variation	P-value	F crit
Location	< .001	1,70
Years	< .001	2,49

The interaction effect between Type and Year revealed that the influence of festivals on tourism varies over time. The significant interaction term indicated that changes in overnight stays differed between festival and non-festival destinations. Festival locations showed sharper increases in certain years, especially when major events were held, while non-festival destinations displayed steadier, more gradual growth linked to general demand and year-round attractions.

Overall, the two-way ANOVA results confirm that festivals significantly affect tourism, with their impact shaped by both location type and year. This highlights the dynamic relationship between cultural events and tourism trends and provides valuable insights for evidence-based decision-making in the sector.

Conclusion

This analysis demonstrates that festivals—particularly the Split Summer Festival—have a strong impact on the dynamics of tourist overnight stays and the structure of demand in Croatia.

Hypothesis H1, which assumes a correlation between the scope of the festival program and the number and occupancy rate of accommodation capacities, is supported by statistically significant differences between festival and non-festival destinations.

Hypothesis H2, which posits that dynamic growth over the years is more pronounced in festival-hosting counties, is also substantiated by empirical findings. In addition to quantitative indicators, the qualitative analysis emphasizes the importance of the triple synergy between festival management, the hotel sector, and private accommodation. Only through integrated strategic planning is it possible to balance the cultural, economic, and social goals of the season. Such collaboration enables an increase in tourist accommodation capacity, better integration of cultural offerings with hotel and hospitality services, and the promotion of local agricultural product consumption.

In conclusion, festivals should not be viewed merely as cultural events, but rather as strategic instruments of urban and regional development—linking cultural heritage, tourism, and the local economy. In this context, the Split Summer Festival represents a sustainable model of cultural-tourism integration that can serve as an example for other Croatian and European destinations.

The research suggests several key recommendations for public policy and festival management. First, it is necessary to strengthen the synergy between festivals, hotels, and private accommodation through joint strategic planning, ensuring balanced tourist flows and improved service quality. Second, local agricultural producers (OPGs) should be integrated more directly into the festival offer to promote domestic gastronomy and generate added value for the local economy. Third, diversification of accommodation should be encouraged by developing rural and cultural tourism in inland areas of Split-Dalmatia County, which can reduce seasonality and relieve pressure on the coast. Fourth, sustainable funding models must be established, combining public and private sources, sponsorships, and partnerships with the tourism sector. Finally, coordinated marketing strategies are needed to position cultural events such as the Split Summer Festival as a central component of Croatia's tourism brand, emphasizing cultural diversity and international recognition.

Conflict of interests

The authors declare no conflict of interest.

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MOTIVATIONAL FACTORS INFLUENCING URBAN GARDENING INTENTIONS: INSIGHTS FROM VOJVODINA (SERBIA)

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A R T I C L E I N F O	A B S T R A C T
	This study examines factors influencing residents' intentions to engage in urban gardening, focusing on psychological and physical well-being and key economic, social, and demographic determinants. Data were collected from 473 residents of three cities in Vojvodina (Serbia) using a structured survey. Confirmatory factor analysis validated the motivation scale, while path modeling and regression explored relationships between motivational factors, sociodemographic characteristics, and gardening intention. All motivational factors significantly predicted intention, with psychological well-being emerging as the strongest predictor, followed by healthy food, physical well-being, community engagement, and economic benefits. Women showed higher intentions than men, while younger adults (18–24) were less motivated. Urban gardening is thus primarily driven by psychological well-being, access to healthy food, and physical well-being. Targeted programs emphasizing these benefits, supported by practical guidance and educational campaigns for younger residents, can enhance participation. Gender-inclusive and community-oriented initiatives may further strengthen engagement and contribute to long-term sustainability.

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Introduction

Gardening has become an important strategy for promoting public health, environmental sustainability, and social cohesion in cities. Research shows that participating in urban gardens encourages physical activity, improves access to fresh and healthy food, and supports mental well-being, while also strengthening social ties and fostering community resilience (Haluza et al., 2025; Otieno, Namiripo, 2019). Beyond food production, urban gardens contribute to urban regeneration, educational opportunities, and social integration across diverse populations (Koroļova, Treija, 2018). They provide tangible environmental benefits, including reduced urban heat, enhanced biodiversity, and improved green spaces (Otieno, Namiripo, 2019; Luković et al., 2023). Urban gardening also helps address health disparities, offering support to aging populations and vulnerable groups (Schram-Bijkerk et al., 2018). By combining social, ecological, and health-related functions, urban gardens represent a multifaceted approach to creating more resilient and inclusive cities.

Urban gardening has increasingly attracted the attention of researchers in recent years as a specific form of social and ecological practice that simultaneously meets individual needs and contributes to the wider community. A review of the relevant literature indicates that motivations for engaging in such activities are not uniform, but layered and multidimensional, ranging from intrinsic and personal to functional, social, and ecological.

The most consistently identified drivers are intrinsic motives, such as psychological restoration, enjoyment, relaxation, and personal fulfilment. Home and Vieli (2020) emphasize that restoration represents the strongest motivational component, while Murtagh and Frost (2023) highlight inner satisfaction and a sense of meaning as key predictors of long-term engagement in gardening. Similar findings are reported by Dubová et al. (2020) and Ramirez-Andreotta et al. (2019), underlining the importance of psychological benefits.

Alongside these, numerous studies point to social motives as particularly significant. Sonti and Svendsen (2018) and Kingsley et al. (2019) describe urban gardens as a space for socialization, community engagement, civic activism, and intergenerational learning. Dubová et al. (2020) stress that community contacts and activities are a central reason for participation, while Ramirez-Andreotta et al. (2019) and Partalidou and Anthopoulou (2017) emphasize the importance of friendships and even the creation of virtual communities. Social connections, opportunities for interaction, and the building of networks regularly appear as strong motivations across other studies as well (Cattivelli, 2022; Dubová et al., 2020; Home, Vieli, 2020; Pascoe, Howes, 2017; Partalidou, Anthopoulou, 2017; Sonti, Svendsen, 2018; Kingsley et al., 2019; Nica et al., 2024). Many works also underscore the role of gardens as sites of social infrastructure, places for meeting, knowledge exchange, and public life (Dubová et al., 2020; Pascoe, Howes, 2017; Kingsley et al., 2019). In contrast, some studies (Čepić et al., 2020) do not identify social motives as primary, pointing to the heterogeneity of social drivers across contexts.

Motivational patterns also vary according to demographic and contextual characteristics. For instance, Murtagh and Frost (2023) note that intrinsic motivations are more pronounced among women, while older participants are more strongly motivated by relaxation (Dubová et al., 2020; Čepić et al., 2020). One of the most consistent themes is intrinsic motivation linked to psychological well-being, relaxation, stress reduction, fulfillment, and therapeutic benefits of being in nature (Home, Vieli, 2020; Dubová et al., 2020; Pascoe, Howes, 2017; Cattivelli, 2022; Sonti, Svendsen, 2018; Kingsley et al., 2019; Ramirez-Andreotta et al., 2019).

Food production and access to healthy, high-quality food also emerge as important motivations or additional benefits in most reviewed works (Kingsley et al., 2019; Ramirez-Andreotta et al., 2019; Grebitus, 2021; Čepić et al., 2020; Partalidou, Anthopoulou, 2017; Pantović et al., 2023). In some contexts, particularly during times of social or economic crisis, food production may become the primary motivation (Čepić et al., 2020; Pascoe, Howes, 2017). Motivation linked to sustainable practices and organic approaches also appears, but more often as part of the broader discourse on food quality than as an isolated driver (Kingsley et al., 2019; Pascoe, Howes, 2017; Nica et al., 2018).

Overall, the literature confirms that motivations for urban gardening are multifaceted and interwoven. Social interaction and psychological restoration stand out as universal drivers, while economic and cultural dimensions vary depending on context. These findings highlight the need for urban garden planning to be adapted to specific local conditions and the demographic characteristics of residents.

Based on the literature review, the following hypotheses are proposed (*Figure 1*):

H1: The physical well-being motivational factor exerts a positive effect on the intention to engage in gardening.

H2: The healthy food motivational factor exerts a positive effect on the intention to engage in gardening.

H3: The community engagement motivational factor exerts a positive effect on the intention to engage in gardening.

H4: The economic benefits motivational factor exerts a positive effect on the intention to engage in gardening.

H5: The psychological well-being motivational factor exerts a positive effect on the intention to engage in gardening.

H6: The intention to engage in urban gardening varies across age groups.

H7: The intention to engage in urban gardening differs by gender.

H8: The intention to engage in urban gardening differs by education level.

H9: The intention to engage in urban gardening differs by monthly income.

H10: The intention to engage in urban gardening differs by gardening experience.

Figure 1. Proposed model of research with defined hypotheses
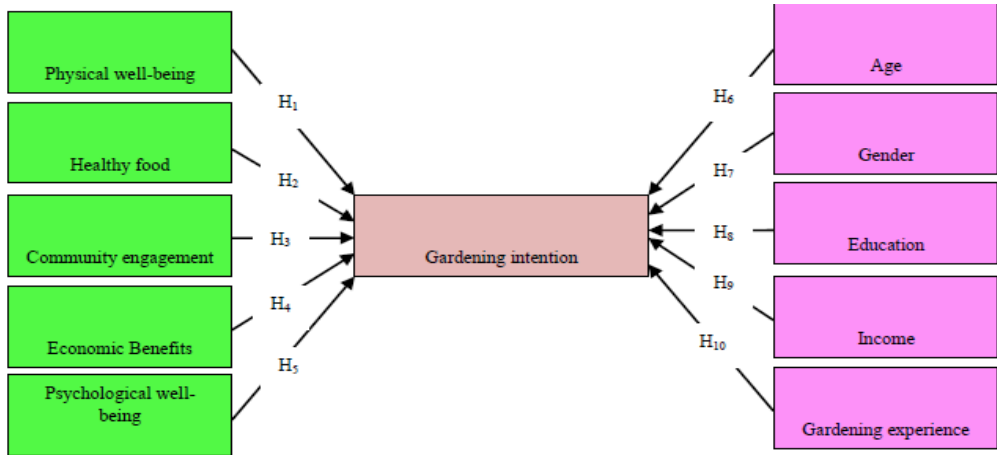
Materials and methods

Instruments

The questionnaire used in this study comprised three sections. The first section collected basic demographic information, including gender, age, income, level of education, and gardening experience. The second section included 26 items designed to measure respondents' motivation to engage in urban gardening. These items were adapted and modified from several previous investigations (Kirby et al., 2021; Chen et al., 2024; Murtagh, Frost, 2023; Ruggeri et al., 2016; Ali, Vaiappuri, 2022). The third section assessed respondents' intention to participate in urban gardening and consisted of six items adapted from Campbell et al. (2024) (Table 3). All items were rated on a five-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree").

Procedure

A pilot study (Study 1) was conducted in January 2025 to evaluate the validity of the measurement instruments and the clarity of the research questions. A linguist reviewed the questionnaire items for grammatical and semantic consistency. A total of 112 respondents from Novi Sad completed a paper-and-pencil survey, and the data were analyzed using principal component analysis with Varimax rotation in SPSS 23.

After confirming the reliability and validity of the instrument, the main study (Study 2) was conducted between January and August 2025. The study targeted residents aged 18 and older from three urban centers (Novi Sad, Sombor, and Vršac). Data were collected online via Google Forms, distributed through emails and social media. Of 658 completed questionnaires, 185 (~28%) were excluded due to incompleteness, leaving 473 valid responses. CFA and path analyses were performed using R (lavaan and semPlot packages), while regression analysis, t-tests, and ANOVA were conducted in SPSS 23. Participation was voluntary and anonymous.

Results

Study Sample

Table 1 presents the descriptive characteristics of the sample in the initial study. The pilot survey included 112 respondents, more than half of whom were women, who had completed secondary education, and reported monthly incomes ranging from €701 to €1,500. Regarding age distribution, the largest share of participants belonged to the 45–64 age group. The vast majority of respondents had never engaged in gardening (82,1%).

Table 1. Sample characteristics of Study 1 (N=112)

Education		Gender	
Secondary school	37,2%	Male	41,8%
Higher school	28,9%	Female	58,2%
Faculty	26,8%	**Age**	
Master/PhD	7,1%	18-24	20,6%
Monthly income		25-44	27,8%
< 500 euro	24,2%	45-64	35,1%
501 – 700 euro	30,1%	65+	16,5%
701 – 1.500 euro	42,3%	Gardening experience	
1.501 – 2.500 euro	2,6%	Yes	17,9%
> 2.501 euro	0,8%	No	82,1%

To evaluate and validate the measurement instruments, principal component analysis (PCA) was conducted on Sample 1 in Study 1, and confirmatory factor analysis (CFA) was performed on Sample 2 in Study 2. The second sample comprised 473 respondents. The majority were between 25 and 44 years of age, with women representing 60.4% of the sample. Further analysis of sample characteristics indicated that the largest proportion of participants had completed secondary education (41.1%) and reported monthly incomes ranging from €701 to €1,500 (40.6%). The vast majority of respondents (78.1%) reported no experience with gardening (*Table 2*).

Table 2. Sample characteristics of Study 2 (N=473)

Education		Gender	
Secondary school	41,1%	Male	39,6%
Higher school	24,8%	Female	60,4%
Faculty	23,8%	**Age**	
Master/PhD	3,2%	18-24	30,7%
Monthly income		25-44	32,5%
< 500 euro	19,9%	45-64	28,9%
501 – 700 euro	34,3%	65+	7,9%
701 – 1.500 euro	40,6%	Gardening experience	
1.501 – 2.500 euro	4,0%	Yes	21,9%
> 2.501 euro	1,2%	No	78,1%

Study 1: Principal component analysis (PCA)

A principal component analysis (PCA) was conducted on the dataset of 112 respondents to examine latent constructs underlying urban gardening motivation. The results of PCA combined with principal component analysis with Varimax rotation (KMO = 0.837, Bartlett's test of sphericity = 2489.610, df = 298, p<0.000) suggested a six-factor solution and explained 61.87% of the variance. Internal consistency of the extracted components was satisfactory, with Cronbach's α coefficients ranging from 0.708 to 0.896, all exceeding the 0.70 threshold. The detailed factor loadings are presented in *Table 3*.

Table 3. The results of Principal Component Analysis (PCA)

Items	Economic benefits	Physical well-being	Psycho-logical well-being	Healthy food	Community engagement	Gardening intention
I1 Gardening can generate additional income.	.587					
I2 Gardening can help reduce household expenses.	.636					
I3 Gardening can develop skills that are valuable for employment.	.689					
I4 Gardening can create opportunities for small business or entrepreneurship.	.657					
I5 Gardening supports the management of body weight.		.663				
I6 Gardening contributes to overall physical health and fitness.		.687				
I7 Gardening provides meaningful physical activity and exercise.		.721				
I8 Gardening helps with coping with everyday physical challenges and enhances physical well-being.		.752				
I9 Gardening helps in managing everyday psychological challenges and improves mental well-being.			.611			

Items	Economic benefits	Physical well-being	Psycho-logical well-being	Healthy food	Community engagement	Gardening intention
I10 Gardening has a positive effect on mood.			.678			
I11 Gardening promotes relaxation and stress reduction.			.701			
I12 Gardening enhances self-confidence.			.637			
I13 Produce grown in a home or community garden is healthier than store.				.756		
I14 Gardening enables the consumption of pesticide.				.722		
I 15 Gardening ensures access to fresh, nutrient.				.625		
I16 Gardening gives me the chance to spend time with family members.					.698	
I17 Gardening offers opportunities for spending quality time with family members.					.742	
I18 Gardening facilitates interaction with other people.					.705	
I19 Gardening creates a pleasant setting for social gatherings.					.690	
I20 Gardening enables contributions to the local community.					.667	
I21 I plan to home garden.						.767
I22 Home gardening is easy.						.658
I23 I will make an effort to home garden.						.576
I24 Home gardening is convenient.						.602
I25 I have the resources to home garden.						.586
I26 I am confident that I can home garden.						.649

Study 2: Confirmatory factor analysis (CFA)

In the second stage of analysis, a confirmatory factor analysis (CFA) was carried out on data from 473 respondents. Seven items exhibiting high residual correlations (I3, I5, M12, M16, M22, M24, and M25; see Table 1) were removed, resulting in a measurement model with an acceptable overall fit (CFI = 0.962, TLI = 0.968, RMSEA = 0.065, SRMR = 0.062). The finalized urban-gardening motivation scale comprised six latent factors represented by 19 observed items, as summarized in *Table 4*.

Table 4. Confirmatory factor analysis results

Factors	Items	β	*t* Value	α	AVE	CR
Physical well-being	Gardening contributes to overall physical health and fitness.	0.832	*	0.878	0.613	0.767
	Gardening provides meaningful physical activity and exercise.	0.869	29.123			
	Gardening helps with coping with everyday physical challenges and enhances physical well-being.	0.871	28.889			
Healthy food	Produce grown in a home or community garden is healthier than store.	0.707	*	0.813	0.758	0.857
	Gardening enables the consumption of pesticide.	0.861	25.669			
	Gardening ensures access to fresh, nutrient.	0.812	21.011			
Community engagement	Gardening offers opportunities for spending quality time with family members.	0.837	*	0.848	0.627	0.712
	Gardening facilitates interaction with other people.	0.809	20.001			
	Gardening creates a pleasant setting for social gatherings.	0.785	21.021			
	Gardening enables contributions to the local community.	0.748	26.069			
Economic benefits	Gardening can generate additional income.	0.819	*	0.708	0.597	0.810
	Gardening can help reduce household expenses.	0.819	29.807			
	Gardening can create opportunities for small business or entrepreneurship.	0.698	28.998			
Psychological well-being	Gardening helps in managing everyday psychological challenges and improves mental well-being.	0.784	*	0.768	0.671	0.714
	Gardening has a positive effect on mood.	0.801	28.789			
	Gardening promotes relaxation and stress reduction.	0.827	18.167			
Gardening intention	I plan to home garden.	0.789	*	0.751	0.687	0.724
	I will make an effort to home garden.	0.821	18.021			
	I am confident that I can home garden.	0.851	24.677			

Notes: * Items fixed to 1 in CFA; β-Std. regression weights; α—Cronbach′s alpha; CR— composite reliability; AVE = average variance expected.

Scale reliability was evaluated through average variance extracted (AVE), composite reliability (CR), and Cronbach's alpha (α) coefficients. Convergent validity for each latent dimension was examined by calculating the AVE, in line with the criteria proposed by Fornell and Larcker (1981). Convergent validity is established when all item-to-factor loadings are statistically significant and the AVE for each construct exceeds 0.50. As reported in Table 4, every dimension achieved an AVE above 0.50 and a CR greater than 0.70, demonstrating strong convergent validity. Cronbach's α values ranged from 0.719 to 0.889, confirming high internal consistency across the scales. Detailed results are presented in *Table 4*.

Study 2 - The findings of the Path model analysis

To examine the effects of sample characteristics (gender, age, income, education, and gardening experience) and five motivational factors: physical well-being, healthy food, community engagement, economic benefits, and psychological well-being on gardening intention, three competing models were tested using robust maximum likelihood estimation (Satorra–Bentler correction).

Table 5. Model fit indicators of the proposed model

Model	S–Bχ2	df	χ2/df	RMSEA	SRMR	CFI	TLI
1	603.46	244	2.47	0.071	0.081	0.85	0.84
2	499.35	217	2.30	0.067	0.065	0.90	0.89
3	385.10	199	1.93	0.047	0.048	0.97	0.96

All independent variables in Model 1 were specified to predict gardening intention. Although $χ^2/df$ was within acceptable limits (< 3) (Kline, 2015), the CFI and TLI were below the recommended 0.90 threshold, indicating a marginal fit. Inspection of standardized residuals and modification indices suggested that some predictors did not contribute significantly.

The Wald test recommended the removal of education and gardening experience (non-significant paths, p > 0.10). Model 2 showed improved fit, approaching the conventional cut-off criteria (CFI ≥ 0.90, TLI ≥ 0.90, RMSEA ≤ 0.06–0.08, SRMR ≤ 0.06–0.08). Refinement of the model, which involved dropping the paths with very low standardized loadings (< 0.10), specifically those from income to gardening intention, and allowing a correlation between physical and psychological well-being, yielded the optimal model fit. Model 3 met all recommended thresholds (CFI ≥ 0.95, TLI ≥ 0.95, RMSEA ≤ 0.05, SRMR ≤ 0.05), supporting it as the most appropriate representation of the relationships between motivational factors and the intention to engage in urban gardening (*Table 5*). These findings indicate that hypotheses H_8, H_9, and H_{10} were not supported.

Further analyses were conducted to examine the relationships between the categorical independent factors and the dependent variable, gardening intention. The model indicates that respondents' gender exerts a positive effect on their intention to engage in gardening. In addition, a t-test was performed to provide a more detailed explanation of this finding. The t-test results reveal that women exhibit a significantly stronger intention

to practice urban gardening (t = 2.903, p < 0.01), thereby supporting hypothesis H_7. The one-way analysis of variance (ANOVA) showed a statistically significant difference among respondents when grouped by age (F = 6.123, p < 0.01). Results of the LSD post-hoc test indicate that participants aged 18–24 are less interested in gardening compared with those aged 25–44 (MD = –0.674, p < 0.01), 45–64 (MD = –0.925, p < 0.01), and 65+ (MD = –0.908, p < 0.01), confirming hypothesis H_6.

To explore the relationship between motivational factors and residents' intention to engage in urban gardening, a standard linear regression analysis was performed. The results show that all motivational factors significantly influence gardening intention. Among these, psychological well-being emerged as the strongest predictor (β = 0.411, p < 0.001), followed by healthy food (β = 0.389, p < 0.001), physical well-being (β = 0.316, p < 0.001), community engagement (β = 0.232, p < 0.001), and economic benefits (β = 0.198, p < 0.001), thereby confirming hypotheses H_1 through H_5. The detailed results are presented in *Figure 2*.

Figure 2. The results of the Path model
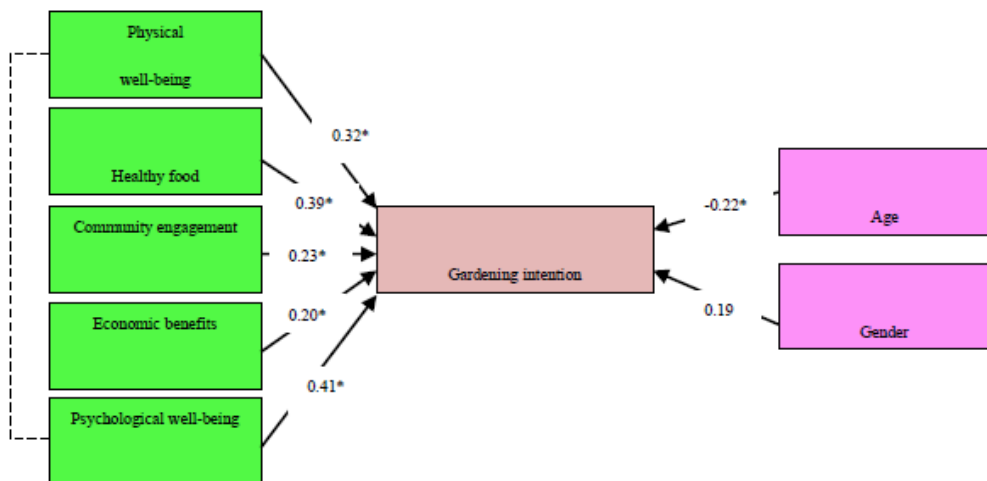
Discussions

Empirical evidence consistently shows that gardening positively affects both physical and psychological well-being across diverse demographic groups. In older adults, participation in a structured five-month gardening program led to significant improvements in nature-relatedness, psychological health, and pro-environmental behavioral intentions (Jo et al., 2022). Group-based gardening therapy also enhances well-being by helping participants develop adaptive coping strategies, adopt positive behavioral changes, and gain practical life skills (Joyce, Warren, 2016). In addition, engagement in home gardening has been linked to healthier dietary patterns, higher levels of physical activity, improved mental health, and strengthened family bonds. Participants in such initiatives also reported fewer depressive symptoms and enhanced

emotional well-being (van Lier et al., 2017). Furthermore, qualitative studies with beginner community gardeners have introduced the concept of a "gardening triad," which includes three core dimensions: caretaking and nurturance, a sense of accomplishment, and connection to nature. These dimensions support continued engagement in gardening and contribute to positive social and emotional outcomes such as stronger relationships, higher self-esteem, and better mental health management (Alaimo et al., 2024).

Urban gardening also provides significant economic benefits that strongly influence people's intentions to participate. Previous research has likewise demonstrated that economic motivations are among the most prominent drivers of engagement in urban gardening. For instance, in Bangalore, participants highlighted notable economic advantages such as year-round availability of vegetables, increased household savings, and reduced expenditure on fruits and vegetables (Kishor et al., 2024). A study among minority urban gardeners in Maryland confirmed these findings. More than half of respondents (57%) cited additional household income as a key motivation, 86% reported increased farm income, and 96% gained knowledge on reducing production costs (Karki, Bhandari, 2023). In the context of Belgrade, gardeners—particularly retired individuals with low income and previous agricultural experience—demonstrated a stronger orientation toward productive and economic benefits rather than social motivations (Čepić et al., 2024). Although psychosocial factors such as attitudes and perceived behavioral control strongly influence gardening intentions, economic benefits remain essential motivators for continued participation (Lake et al., 2012).

Other studies show that community engagement significantly affects urban gardening intentions through various behavioral and social mechanisms. Subjective norms, particularly those shaped by community visibility and social expectations, have been identified as strong predictors of participation in community-based urban farming (Muhammad, 2024). Evidence from the research conducted by Brown-Fraser et al. (2015) supports this finding, showing that a university-led initiative led to a fourfold increase in participation while simultaneously strengthening social connections and promoting healthier lifestyles. Psychosocial factors have been shown to explain up to 58% of the variance in gardening intentions, with perceived behavioral control, subjective norms, and attitudes emerging as the most influential determinants (Lake et al., 2012). At the broader community level, environmental awareness and personal responsibility contribute to the formation of personal norms that significantly affect pro-environmental gardening intentions (Mamun et al., 2023). Overall, these findings suggest that successful urban gardening programs depend on strong collaboration between local authorities and residents. Such cooperation reinforces the importance of community engagement in sustaining participation and building resilient urban agricultural systems.

Research indicates that sociodemographic characteristics, particularly gender and age, influence motivations for engaging in gardening. Women tend to cultivate a greater variety of plant species compared to men (Philpott et al., 2020). Although the study conducted by McFarland et al. (2018) also confirmed gender differences in the types of motivations for

gardening, the authors did not find a significant effect of age on motivation or intention to garden, as similar intentions were reported across different generations.

Conclusions

The present study highlights that urban gardening is influenced by a combination of psychosocial, economic, and demographic factors. Among these, psychological well-being emerged as the strongest predictor of gardening intention, followed by healthy food, physical well-being, community engagement, and economic benefits. Gender differences were evident, with women showing stronger intentions to engage in gardening, while younger adults (18–24) appeared less motivated than older age groups. These results are consistent with previous research demonstrating the physical, mental, and social benefits of gardening, including improved mental health, healthier dietary habits, and stronger social connections. Community engagement and social norms were also found to play a key role in sustaining participation, underscoring the importance of collaborative initiatives between residents and local authorities. To promote urban gardening effectively, programs should highlight both physical and psychological benefits, ensure access to fresh produce, and provide practical guidance on cost-efficient gardening practices. Educational campaigns and incentive schemes could particularly target younger populations to boost their involvement. Gender-inclusive strategies may leverage women's tendency to cultivate a greater diversity of plants while encouraging participation among all groups. Overall, urban gardening offers a multifaceted approach to enhancing well-being, fostering community cohesion, and generating economic advantages. Designing interventions that address both motivational and demographic factors is essential for the long-term success and sustainability of urban gardening initiatives.

Limitations and suggestions for future research

Several limitations of this study should be acknowledged. First, it is important to note that the findings cannot be considered fully generalizable, as the data were collected using a convenience sampling method. Future research should aim to employ a more stratified sampling approach to ensure that all relevant strata are proportionally represented. In addition, the data were gathered from a single urban context, which may limit the applicability of the results to other cities or cultural settings. Finally, self-reported measures are subject to potential biases, including social desirability and recall errors.

Future research could employ longitudinal designs to examine changes in gardening motivations and behaviors over time. Comparative studies across multiple urban areas or countries would help identify context-specific factors and enhance the generalizability of findings. Incorporating qualitative approaches could provide richer insights into the personal and community experiences that shape urban gardening participation. Finally, evaluating the effectiveness of targeted interventions for younger individuals and low-income groups would offer valuable guidance for strategies aimed at increasing engagement and ensuring the long-term sustainability of urban gardening initiatives.

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Conflict of interests

The authors declare no conflict of interest.

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THE AMOUNT, ECONOMIC VALUE AND ENVIRONMENTAL EMISSION OF CEPHAPIRIN AT DRY-OFF IN HOLSTEIN AND SIMMENTAL DAIRY COWS BY HERD SIZE

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A B S T R A C T

The research aim was to quantify the use of cephapirin in dry cow therapy, to estimate the economic value and potential environmental emissions regarding the herd size. The analysis included a 307,531 test-day records from Holsteins and 383,208 from Simmental. Udder health status at the last milk recording before dry-off was classified according to SCC criteria, and the scenario assumed universal use of BDCT, 1.2 g cephapirin per cow (300 mg per quarter × 4). The estimated total amount of cephapirin was 369.0 kg in Holsteins and 459.8 kg in Simmentals. The economic cost of the application was €7.85 million in Holstein and €9.78 million in Simmental herds, with healthy cows generating the largest share of the cost due to their large numbers. The estimated environmental release was 221.4 kg for Holstein and 275.9 kg for Simmental, with PEC/PNEC ratios high above the risk threshold, RQ 4,428.41 and 5,518.19, respectively.

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Introduction

Mastitis is the most common disease of dairy cows and one of the main causes of economic losses in the dairy sector. The consequences include reduced milk yield, increased somatic cell count, reduced milk quality and an increased risk of premature culling (Seegers et al., 2003; Green et al., 2002). The economic burden includes direct treatment costs, milk loss and additional labor, but also indirect effects on long-term herd productivity and farm sustainability (Halasa et al., 2007). Dry cow therapy (DCT) has been developed as a key strategy for treating existing intramammary infections and preventing new ones during the dry period. Cephapirin, commonly used in DCT, is rapidly metabolized to desacetyl-cephapirin, maintaining milk concentrations above MIC values for key pathogens, confirming its effectiveness but also the risk of residues (Stockler et al., 2009). The traditional approach, blanket dry cow therapy (BDCT), involves the routine treatment of all cows with antibiotics, regardless of their health status. Although this approach reduced the prevalence of infections, it also led to a high consumption of antibiotics, including the unnecessary treatment of healthy animals (Weber et al., 2021; Rowe et al., 2020). Alternatively, selective dry cow therapy (SDCT) involves the application of antibiotics only to cows with determined or suspected intramammary infection, while internal teat sealants are applied to healthy cows. Studies (Vanhoudt et al., 2018; McCubbin et al., 2023; Pavesi et al., 2023) have shown that SDCT can effectively reduce antibiotic use without increasing the risk of clinical mastitis or deteriorating udder health, provided that clearly defined selection criteria are met. Furthermore, Pavesi et al. (2023) showed that in healthy cows, antibiotic treatment at dry-off offers no additional udder health benefits and may disturb milk microbiota, while the use of sealant alone provides equivalent results in terms of somatic cell counts and the incidence of intramammary infections. Müller et al. (2023) concludede that antibiotics at dry-off have a limited effect on cure rates, and their actual benefit varies depending on the causative agent of the infection, further emphasizing the importance of a targeted approach. Excessive antibiotic use drives antimicrobial resistance (AMR), one of the major global health and environmental challenges (Bengtsson-Palme & Larsson, 2016). Resistant strains have been isolated from the most important mastitis pathogens, including *Staphylococcus aureus*, *Escherichia coli* and *Streptococcus uberis* (Maksimović et al., 2024). Analyses of antibiotic residues in manure have shown that a significant proportion of the applied doses are excreted in active form and are released into the environment through soil and water, where they can cause disruption of microbial communities and promote the spread of resistance genes (Berendsen et al., 2015; Thiele-Bruhn, 2003). Additionally, cephapirin has been detected in surface waters at concentrations up to 9 ng/L, where it is rapidly hydrolyzed, but its degradation products may be more stable and toxic than the parent substance (Ribeiro et al., 2018a). Environmental risks are evaluated using the PEC/PNEC ratio, where values above 1 indicate potential hazard and selection risk (Tell et al., 2019). Studies of MIC values for various cephalosporins, including cephapirin, have shown very low MIC thresholds for pathogen growth inhibition, supporting the use of conservative PNEC values in environmental assessments (Cortinhas et al., 2013). According to the WHO

Global Antimicrobial Resistance and Use Monitoring System (GLASS), consumption of beta-lactam antibiotics and fluoroquinolones is significantly correlated with an increase in resistance in *E. coli* and *Klebsiella pneumoniae* in the bloodstream, with each unit increase in consumption was associated with an increase in the proportion of resistant isolates of 11% to 40% in the countries analyzed (Ajulo & Awosile, 2024). Such findings confirm that antibiotic consumption patterns in veterinary practice have direct implications for public health, further emphasizing the need for their rational use. In addition to biological and environmental risks, economic aspects also play an important role. Studies have shown that the implementation of selective dry cow therapy (SDCT) can reduce the costs associated with antibiotic use and overall veterinary costs, especially on farms with a low prevalence of intramammary infections (Vissio et al., 2023; Navaei et al., 2025). Regional studies indicate significant differences in antibiotic use patterns and the occurrence of resistance among different production systems, with socioeconomic factors and herd size significantly influencing decisions on dry cow therapy (Popescu & Andrei, 2011; Kupczyński et al., 2024; Tomanić et al., 2024; Očić et al., 2022). At the European Union level, the Farm to Fork Strategy and the Green Deal envisage a 50% reduction in the use of antibiotics in agriculture by 2030, making rationalising antibiotic use in dry cow therapy a key measure for achieving sustainability goals, preserving public health and reducing environmental burden (McCubbin et al., 2023).

The aim of this study was to quantify the use of cephapirin in dry cow therapy of Holstein and Simmental dairy cows in Croatia, with an emphasis on three dimensions: the total amount of antibiotic administered, its economic value and potential emission into the environment regarding the herd size.

Materials and methods

The analysis was conducted on test-day records collected during the national milk recording of cows under breeding and selection programs in Croatia (HAPIH) for the period from January 1, 2013 to December 31, 2022, with sampling and analysis performed according to ICAR guidelines (in Croatia, AT4/BT4 methods with mathematical adjustment to the reference A4 method, SLKM HAPIH, accredited methods). After logical data validation (removal of records with extreme or inconsistent values of production and reproductive parameters), a total of 307,531 Holstein and 383,208 Simmental cows in production were included in the analysis. Herd size classes were defined as follows: for Holstein: < 5, 6–10, 11–50, 51–200, 201–500 and > 500 cows, and for Simmental: < 5, 6–10, 11–50, 51–200 and > 200 cows. Udder health status at the last milk recording before dry-off was classified according to somatic cell count (SCC): healthy cows had <200,000/mL, subclinical mastitis 200,000–400,000/mL, and clinical mastitis >400,000/mL. The assessment focused on the intramammary administration of Cefa-Safe (active ingredient: cephapirin) at dry-off. The standard dose was 300 mg per quarter, i.e. 1.2 g per cow. The total mass of active substance in the group was calculated according to the formula:

$$Amount\ (g) = number\ of\ cows\ treated \times 1.2\ g$$

The economic value was estimated based on the market price provided by the supplier (Medical Intertrade, 2025), where a package of Cefa-Safe (20 injectors × 300 mg) contains 6 g of cephapirin at a price of €127.64, giving a unit price of €21.27/g. The value per group was calculated according to the formula:

$$Value\ (€) = Amount\ (g) \times €21.27/g$$

The potential environmental emission was estimated using a scenario assuming that 60% of the administered dose is excreted in active form via urine and faeces, which enter the environment through manure. This value represents a conservative midpoint within the range of 40–80% reported in the literature (Berendsen et al., 2015; Thiele-Bruhn, 2003). The emission was calculated as:

$$Emission\ (g) = Amount\ (g) \times 0.60$$

A simplified PEC/PNEC approach was used for the preliminary risk assessment. The predicted environmental concentration (PEC) was estimated using a homogeneous dispersion model in which 1 g of antibiotic was considered equivalent to 1,000 µg/L in the aquatic environment, while the predicted no-effect concentration (PNEC) for cephapirin was set conservatively according to literature sources and the ECHA approach (Bengtsson-Palme & Larsson, 2016; Tell et al., 2019; Cortinhas et al., 2013). The low MIC values for cephapirin against the main mastitis pathogens support the use of a conservative PNEC threshold (Cortinhas et al., 2013), while pharmacokinetic data indicate rapid metabolism to desacetyl-cephapirin with prolonged retention of milk concentrations above the MIC value (Stockler et al., 2009). The risk quotient was calculated according to the formula:

$$RQ\ (risk\ quotient) = PEC\ (predicted\ environmental\ concentration)\ /\ PNEC\ (predicted\ no\text{-}effect\ concentration)$$

The results represent statistical calculations and scenario-based estimates of antibiotic use in the blanket dry cow therapy (BDCT) model, and not actual farm-level antibiotic use data. All calculations were performed descriptively (sums and proportions by group), while data validation, variable derivations and aggregations were carried out in SAS 9.4 (SAS Institute Inc., 2019), and graphical presentations were based on the same aggregated results.

Results

The analysis of udder health at the last milk recording before dry-off showed that slightly more than half of cows were healthy (SCC < 200,000/mL), while the rest showed subclinical (200,000–400,000 SCC/mL) or clinical mastitis (> 400,000 SCC/mL). In the Holstein breed (Table 1), 55.34% of cows (170,201) were healthy, 18.40% (56,571) had subclinical, and 26.26% (80,759) clinical mastitis.

Table 1. Health status of Holstein cows and total amount of cephapirin (Cefa-Safe) at dry-off by herd size.

Herd size	Last milk recording - Cefa-Safe									Total		
	Healthy			Subclinical mastitis			Clinical mastitis					
	N	Amount	%	N	Amount	%	N	Amount	%	N	Amount	%
< 5	18631	22357,2	46,29	7898	9477,6	19,62	13718	16461,6	34,08	40247	48296,4	100
6-10	9622	11546,4	48,18	3973	4767,6	19,89	6378	7653,6	31,93	19973	23967,6	100
11-50	32461	38953,2	53,39	11358	13629,6	18,68	16985	20382	27,93	60804	72964,8	100
51-200	33861	40633,2	57,21	10691	12829,2	18,06	14631	17557,2	24,72	59183	71019,6	100
201-500	34424	41308,8	56,23	11238	13485,6	18,36	15563	18675,6	25,42	61225	73470	100
> 500	41202	49442,4	62,33	11413	13695,6	17,27	13484	16180,8	20,4	66099	79318,8	100
Total	170201	204241,2	55,34	56571	67885,2	18,4	80759	96910,8	26,26	307531	369037,2	100

Source: compiled by the authors based on test-day records

Health status was determined at the last milk recording before dry-off: healthy (<200,000 SCC/mL), subclinical mastitis (200,000–400,000 SCC/mL), and clinical mastitis (>400,000 SCC/mL). Amounts were calculated as number of treated cows × 1.2 g cephapirin per cow.

The total estimated amount of cephapirin (Cefa-Safe) under blanket dry cow therapy (BDCT) was 369,037.2 g. Antibiotic use differed by herd size: the largest herds (> 500 cows) had the highest estimated consumption (79,318.8 g), while herds with 6–10 cows had the lowest (23,967.6 g). The proportion of healthy cows increased with herd size, from 46.29% in herds < 5 cows to 62.33% in those > 500, while clinical mastitis decreased from 34.08% to 20.40%. In smaller herds a greater share of antibiotics was administered to mastitic cows, whereas in larger herds most were given to healthy animals.

Similar patterns were observed in the Simmental breed (Table 2). Healthy cows accounted for 55.83% (213,939), subclinical mastitis for 18.53% (71,015), and clinical mastitis for 25.64% (98,254). The total estimated cephapirin use reached 459,849.6 g, 25% higher than in the Holstein population. The highest antibiotic consumption occurred in herds with 11–50 cows (160,503.6 g), followed by herds with fewer than five cows (137,234.4 g), while the lowest was recorded in herds with more than 200 cows (2,503.2 g). As herd size increased, the proportion of healthy cows rose from 56.08% in herds with fewer than five cows to 66.35% in herds with more than 200 cows, whereas clinical mastitis decreased from 26% to 16%.

Table 2. Health status of Simmental cows and total amount of cephapirin (Cefa-Safe) at dry-off by herd size.

| Herd size | Last milk recording - Cefa-Safe | | | | | | | | | Total | | |
| | Healthy | | | Subclinical mastitis | | | Clinical mastitis | | | | | |
	N	Amount	%	N	Amount	%	N	Amount	%	N	Amount	%
< 5	64137	76964,4	56,08	21024	25228,8	18,38	29201	35041,2	25,53	114362	137234,4	100
6-10	45381	54457,2	54,21	15882	19058,4	18,97	22449	26938,8	26,82	83712	100454,4	100
11-50	74701	89641,2	55,85	24749	29698,8	18,5	34303	41163,6	25,65	133753	160503,6	100
51-200	28336	34003,2	57,48	8993	10791,6	18,24	11966	14359,2	24,27	49295	59154	100
> 200	1384	1660,8	66,35	367	440,4	17,59	335	402	16,06	2086	2503,2	100
Total	213939	256726,8	55,83	71015	85218	18,53	98254	117904,8	25,64	383208	459849,6	100

Source: compiled by the authors based on test-day records

Health status was determined at the last milk recording before dry-off: healthy (<200,000 SCC/mL),

subclinical mastitis (200,000–400,000 SCC/mL), and clinical mastitis (>400,000 SCC/mL). Amounts were calculated as number of treated cows × 1.2 g cephapirin per cow.

In both breeds, healthy cows constituted the majority of the population, but differences in antibiotic use by herd category were more pronounced in Simmentals, where small and medium herds accounted for the largest share of total cephapirin consumption.

The estimated economic value of cephapirin use at dry-off showed clear differences between breeds and herd size categories (Figures 1 and 2). In Holstein cows, the total value was €7.85 million, with the highest cost recorded in herds with more than 500 cows (€1.69 million) and the lowest in herds with 6–10 cows (€0.51 million). The value increased with herd size, reflecting both the greater number of animals and the higher proportion of healthy cows in large herds. Healthy cows accounted for the largest share of the total value (€4.34 million, 55.34%), while subclinical and clinical mastitis contributed €1.44 million (18.40%) and €2.06 million (26.26%), respectively, indicating that most antibiotics were used in cows without signs of mastitis due to their inclusion in blanket therapy.

Figure 1. Economic value of cephapirin at dry-off by herd size (Holstein breed)

Economic value of cephapirin at dry-off by herd size (Holstein breed)

	< 5	6-10	11-50	51-200	201-500	> 500	Total
Total	1.027.264	509.790,8	1.551.961	1.510.586	1.562.706	1.687.110	7.849.421
■ Clinical mastitis	350.138,2	162.792,0	433.525,1	373.441,6	397.230,0	344.165,6	2.061.292
■ Subclinical mastitis	201.588,5	101.406,8	289.901,5	272.877,0	286.838,7	291.305,4	1.443.918
■ Healthy	475.537,6	245.591,9	828.534,5	864.268,1	878.638,1	1.051.639	4.344.210

Herd size
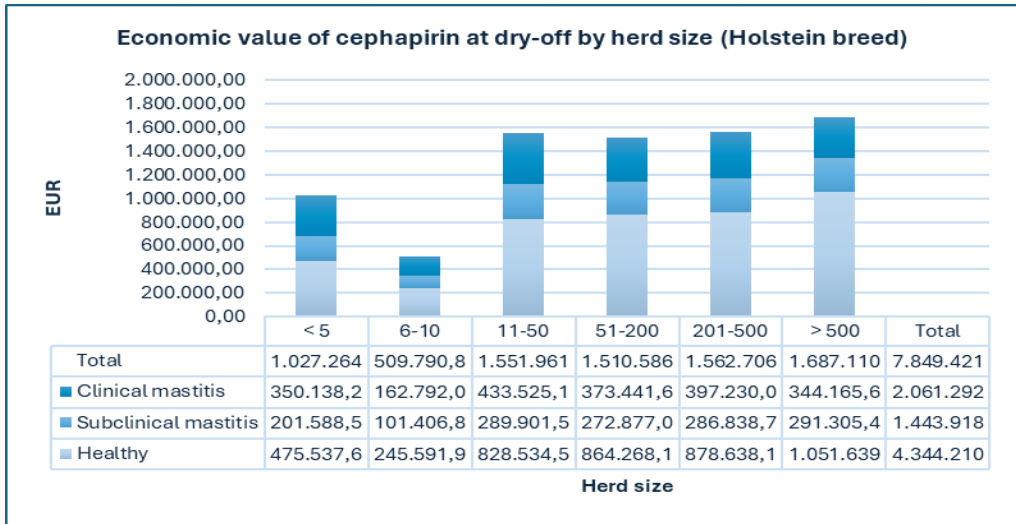
Source: compiled by the authors based on test-day records

The total estimated economic value of the Simmental breed was higher than that of the Holstein population, amounting to 9.78 million euros.

Figure 2. Economic value of cephapirin at dry-off by herd size (Simmental breed)

Economic value of cephapirin at dry-off by herd size (Simmental breed)

	< 5	6-10	11-50	51-200	> 200	Total
Total	2.918.975,6	2.136.665,0	3.413.911,5	1.258.205,5	53.243,06	9.781.000,9
■ Clinical mastitis	745.326,32	572.988,28	875.549,77	305.420,18	8.550,54	2.507.835,1
■ Subclinical mastitis	536.616,58	405.372,17	631.693,48	229.537,33	9.367,31	1.812.586,8
■ Healthy	1.637.032,7	1.158.304,6	1.906.668,3	723.248,06	35.325,22	5.460.579,0

Herd size
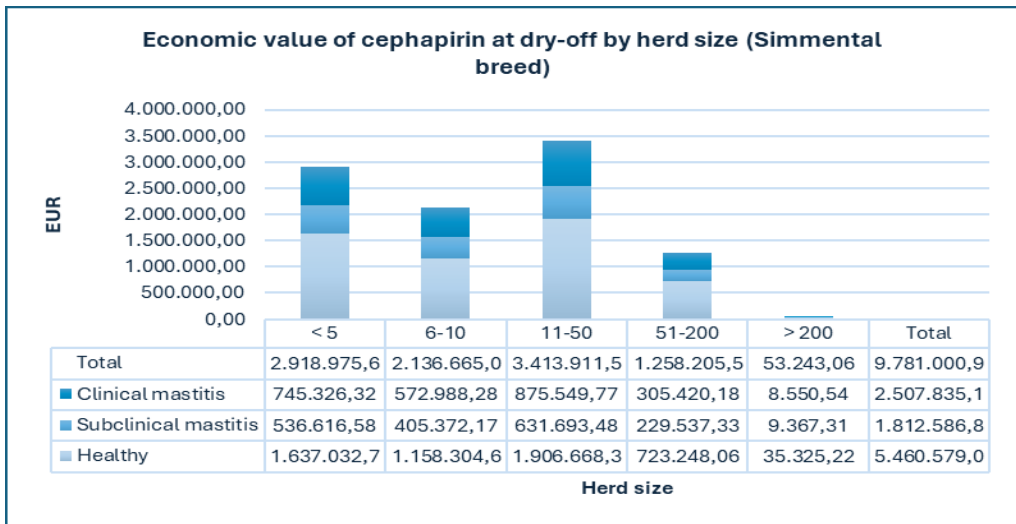
Source: compiled by the authors based on test-day records

The highest values were observed in herds with 11–50 cows (€3.41 million) and the lowest in herds with more than 200 cows (€0.05 million). The distribution pattern differed from Holsteins, as medium-sized herds accounted for the highest total costs, while small and large herds showed lower values. As in Holsteins, healthy cows

represented the largest share (€5.46 million, 55.83%), followed by subclinical (€1.81 million, 18.53%) and clinical mastitis (€2.51 million, 25.64%). A comparison of breeds shows that, despite similar proportions of healthy and mastitic cows, differences in total economic value resulted from herd size structure and animal numbers. In Holsteins, the highest costs were concentrated in large herds, whereas in Simmentals, medium herds dominated, confirming that herd size affects both the distribution of udder health categories and the overall cost of antibiotic use.

The estimated emission of cephapirin into the environment showed significant values in both breeds (Tables 3 and 4). In Holstein cows, the total emission was 221,422.32 g, resulting in a predicted environmental concentration (PEC) of 221.42 µg/L. When compared to the predicted no-effect concentration (PNEC = 0.05 µg/L), the PEC/PNEC ratio reached 4,428.41. These values clearly indicate a potentially high environmental risk, given that the risk quotient (RQ) in all herd categories was several orders of magnitude higher than the threshold value of 1. The highest emissions were recorded in herds with more than 500 cows (47,591.28 g), while the lowest emissions were in herds with 6–10 cows (14,380.56 g). However, regardless of herd size, all categories showed very high RQ values, ranging from 287.61 to 951.82.

Table 3. Estimated environmental emission of cephapirin (Cefa-Safe) and associated risk quotient (RQ) by herd size in Holstein cows

Herd size	Emission (g)	PEC (µg/L)	PNEC (µg/L)	RQ (PEC/PNEC)
< 5	28.977,84	28,98	0,05	579,55
6–10	14.380,56	14,38	0,05	287,61
11–50	43.778,88	43,78	0,05	875,57
51–200	42.611,76	42,61	0,05	852,23
201–500	44.082,00	44,08	0,05	881,63
> 500	47.591,28	47,59	0,05	951,82
Overall	221.422,32	221,42	0,05	4.428,41

Source: compiled by the authors based on test-day records

Emission calculated as Amount × 0.60, representing a conservative scenario of 60 % excretion. PEC values were derived from emission assuming a homogeneous dispersion model (1 g = 1,000 µg/L). The PNEC value of 0.05 µg/L was used as a conservative methodological threshold based on published approaches to environmental risk/selection thresholds for antibiotics (see Bengtsson-Palme & Larsson, 2016; Tell et al., 2019).

In the Simmental breed, the total emission was higher, amounting to 275,909.76 g. The PEC value was 275.90 µg/L, resulting in an overall RQ of 5,518.19. The highest emissions were recorded in herds with 11–50 cows (96,302.16 g), while the lowest values were in the largest herds (>200 cows), where the emission was 1,501.92 g. However, even at these lowest levels, the PEC/PNEC ratio was 30.04, which is still well above the ecologically acceptable threshold.

Table 4. Estimated environmental emission of cephapirin (Cefa-Safe) and associated risk quotient (RQ) by herd size in Simmental cows

Herd size	Emission (g)	PEC (µg/L)	PNEC (µg/L)	RQ (PEC/PNEC)
< 5	82.340,64	82,34	0,05	1.646,81
6–10	60.272,64	60,27	0,05	1.205,45
11–50	96.302,16	96,30	0,05	1.926,04
51–200	35.492,40	35,49	0,05	709,85
> 200	1.501,92	1,50	0,05	30,04
Overall	275.909,76	275,90	0,05	5.518,19

Source: compiled by the authors based on test-day records

Emission calculated as Amount × 0.60, representing a conservative scenario of 60 % excretion. PEC values were derived from emission assuming a homogeneous dispersion model (1 g = 1,000 µg/L). The PNEC value of 0.05 µg/L was used as a conservative methodological threshold based on published approaches to environmental risk/selection thresholds for antibiotics (see Bengtsson-Palme & Larsson, 2016; Tell et al., 2019).

The highest RQ values were observed in herds with 11–50 cows (1,926.04), while the other categories also showed consistently high ratios. A comparison of breeds showed that, although the number of Simmental cows was higher, the average PEC/PNEC ratio was higher than in the Holstein breed. In both populations, blanket dry cow therapy (BDCT) was confirmed to generate significant amounts of antibiotic emissions into the environment, with values in all cases several-fold above the reference threshold of 1, indicating a potentially serious ecotoxic burden.

Discussions

This study analyzed the udder health status of dairy cows and the estimated antibiotic consumption at dry-off, emphasizing differences between breeds and herd size. In both populations, about half of the cows were healthy, while the rest showed subclinical or clinical mastitis, confirming that mastitis remains a leading health challenge in dairy farming, with prevalence ranging from 20 to 40% (Tomanić et al., 2024). The proportion of healthy cows increased with herd size, while clinical mastitis declined, indicating that larger herds, despite higher density, maintain better hygiene and veterinary control (Beggs et al., 2019). Consequently, estimated cephapirin use under BDCT differed by breed and herd size: Holstein cows showed higher consumption in large herds, whereas Simmentals had the greatest costs in medium herds. Although both breeds had similar proportions of healthy and diseased cows, total antibiotic use varied due to herd structure, highlighting the need to consider management organization and breed-specific factors when planning strategies for antibiotic reduction (Kupczyński et al., 2024; Vissio et al., 2023; Krogh et al., 2020).

The estimated economic value of cephapirin use at dry-off indicated that healthy animals accounted for the largest share of total costs. This was mainly a result of their high numbers and obligatory inclusion in blanket therapy (Lipkens et al., 2023; Vissio et al.,

2023). Such a cost pattern clearly demonstrates the fundamental limitation of BDCT, where considerable quantities of antibiotics are used without therapeutic justification, thereby raising production expenses and economic pressure on farmers (Halasa et al., 2007; Seegers et al., 2003). Earlier research has shown that mastitis costs extend well beyond the price of drugs, including substantial indirect losses through reduced milk yield, poorer quality, and impaired fertility, making it one of the costliest diseases in dairy production (Kharel et al., 2023; Halasa et al., 2007). Breed-related differences in the total value of antibiotic use arose primarily from herd structure and the distribution of health categories. In Holstein herds, the highest costs occurred on large farms, while in Simmental herds the burden was greatest in medium-sized systems. This pattern agrees with previous findings that herd size significantly influences both treatment and prevention costs (Smith et al., 2000; Stocco et al., 2023). It also supports the view that management quality and production organization can affect economic outcomes as much as, or even more than, the prevalence of mastitis itself (Tomanić et al., 2024). According to Gantner et al. (2023), environmental conditions such as temperature, humidity, and heat stress further modify production efficiency and cow health, adding complexity to the overall cost structure in dairy farming. Because healthy cows generated more than half of the total value of antibiotics used, they represent the main target for optimizing therapy (Lipkens et al., 2023). Implementing selective dry cow therapy (SDCT) can therefore substantially cut unnecessary costs while maintaining, or even enhancing, udder health and productivity (Vissio et al., 2023; Guadagnini et al., 2023). In addition, reducing blanket treatments contributes to lower antimicrobial resistance risk, a recognized global priority in livestock systems (Ajulo & Awosile, 2024; Peña-Mosca et al., 2025). Economic analyses consistently show that both clinical and subclinical mastitis lead to considerable financial losses (Halasa et al., 2007; Kharel et al., 2023). Yet, the results of this study emphasize that under BDCT, the majority of costs stem from cows that show no signs of infection. This finding further supports a targeted and selective approach to antibiotic use, particularly in herds where the proportion of healthy cows is high (Lipkens et al., 2023; Vissio et al., 2023).

The estimated emission of cephapirin to the environment revealed extremely high values, far exceeding the reference thresholds of acceptable risk. For Holstein cows, total emissions reached 221.42 kg, corresponding to an environmental concentration (PEC) of 221.42 µg/L. When compared with the conservative predicted no-effect concentration (PNEC = 0.05 µg/L), the PEC/PNEC ratio of 4,428.41 indicates a substantial ecological hazard. In this study, the threshold value of PNEC = 0.05 µg/L was adopted following established approaches for environmental risk assessment of antibiotics (Bengtsson-Palme & Larsson, 2016; Tell et al., 2019), taking into account the low MIC levels reported for mastitis pathogens (Cortinhas et al., 2013). As the official PNEC for cephapirin is not listed in the ECHA registration dossier, this value should be viewed as a methodological estimate used for comparative assessment. All herd categories exhibited RQ values well above 1. The highest risk was recorded in herds exceeding 500 cows (RQ = 951.82), and even the lowest, in herds with

6–10 cows (RQ = 287.61), remained far beyond the safety limit. In the Simmental population, total emissions were even higher (275.91 kg) with an overall RQ value of 5,518.19. Medium-sized herds (11–50 cows) showed the highest discharge (96.30 kg, RQ = 1,926.04), while the largest herds (>200 cows) still exceeded acceptable levels (RQ = 30.04). These findings confirm that blanket dry cow therapy (BDCT) creates a considerable ecotoxic burden, largely independent of herd size or breed. The results align with established evidence showing that a substantial fraction of antibiotics used in livestock—estimated at 40–80%—is excreted unchanged into the environment (Thiele-Bruhn, 2003; Berendsen et al., 2015). Once released into soil or water, β-lactam antibiotics such as cephapirin alter microbial communities, reduce biodiversity, and foster the emergence of resistant strains (Peña-Mosca et al., 2025). Experimental data further demonstrate that cephapirin, despite rapid degradation, retains antimicrobial activity capable of affecting algae and bacteria, which supports the high PEC/PNEC ratios observed here (Ribeiro et al., 2018b). Other studies emphasize that data on the environmental behavior and ecotoxicity of cephalosporins remain limited, pointing to the need for continued research (Ribeiro et al., 2018a). Interestingly, Simmental herds exhibited even higher risk values than Holsteins, despite a nearly identical distribution of healthy and mastitic cows. This difference likely stems from herd structure and the distribution of animals across size categories, previously described as a critical determinant of antibiotic emissions at the farm level (Stocco et al., 2023). Comparable patterns have been reported elsewhere, confirming that herd organization and management practices directly influence antibiotic application and, consequently, the risk of environmental contamination (Smith et al., 2000).

The results clearly indicate that continuing the use of blanket dry cow therapy (BDCT) would substantially increase the environmental load within the dairy sector, running counter to the objectives of sustainable production and the EU strategy for reduced antibiotic use. Under the common EU risk assessment framework, RQ values greater than 1 are considered a signal of potential ecological risk and the need for management intervention (Tell et al., 2019). In this study, all recorded values exceeded that threshold several-fold, confirming that BDCT poses an unacceptable level of environmental pressure. These findings reinforce the importance of broader implementation of selective dry cow therapy (SDCT) and complementary preventive measures aimed at safeguarding both the environment and public health (Lipkens et al., 2023; Kupczyński et al., 2024). At the same time, the data reaffirm that mastitis remains the primary factor driving antibiotic use in dairy cattle, with nearly half of all cows in both breeds affected by subclinical or clinical forms of the disease (Tomanić et al., 2024). Economic analysis further demonstrated that healthy animals, although least in need of antimicrobial protection, generated the largest share of BDCT-related costs due to their high prevalence within the population (Halasa et al., 2007; Seegers et al., 2003). Differences between breeds in the cost structure were also evident: larger herds tended to have a higher proportion of healthy cows and better overall management systems, which reduced mastitis occurrence and improved cost efficiency (Beggs et al., 2019).

Finally, the estimated cephapirin emissions to the environment were several-fold above the acceptable threshold in all herd categories, confirming the environmental risk associated with BDCT (Ajulo & Awosile, 2024). These findings clearly support recommendations on the necessity of transitioning to SDCT, in order to reduce unnecessary antibiotic consumption, limit costs, and lower the environmental impact (Lipkens et al., 2023; Kupczyński et al., 2024).

Conclusions

The obtained results showed that although more than half of the cows in both populations were healthy, a significant proportion exhibited signs of subclinical or clinical mastitis, confirming that mastitis remains a major challenge in dairy farming. Herd size affects the cows' health status, with larger herds having a higher proportion of healthy animals and a lower incidence of clinical mastitis, reflecting the impact of better management and veterinary care. Economic analyses showed that healthy cows accounted for the largest share of total antibiotic costs due to their large numbers in the population, even though they would not require treatment under a selective approach. Differences between breeds were primarily related to herd size distribution: in Simmental cows, the highest costs were concentrated in medium-sized herds, whereas in Holsteins, large herds dominated. Environmental emission assessments indicated that cephapirin levels in all herd categories were several-fold above acceptable risk thresholds, confirming the considerable ecotoxic potential of universal therapy. Finally, the obtained results indicate the need to reduce unnecessary antibiotic use in healthy animals and to transition to selective dry cow therapy (SDCT) in order to align with the goals of animal health preservation, economic sustainability, and environmental protection.

Acknowledgements

Conflict of interests

The authors declare no conflict of interest.

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CONSUMER PERCEPTIONS OF GEOGRAPHICAL INDICATIONS, BRANDING, AND INTELLECTUAL PROPERTY IN THE AGRICULTURAL SECTOR

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A R T I C L E I N F O	A B S T R A C T
	This paper examines the role of geographical indications and branding in shaping consumer perceptions of quality in agricultural products, as well as attitudes toward intellectual property protection. A quantitative survey was conducted through an online questionnaire in September 2025, involving 214 respondents from Serbia. Socio-demographic variables such as gender, age, education, place of residence, and frequency of agricultural product consumption were considered to account for differences in consumer attitudes. The results reveal generally low levels of support for geographical indications, branding, and intellectual property protection in agriculture, with mean values consistently below 3 across all measurement scales (ranging from 2.37 to 2.71). However, statistical test results showed that the frequency of consumption significantly influences perceptions of branding, while education and place of residence do not exert a significant effect. These findings provide valuable insights for producers and policymakers in strengthening branding strategies, safeguarding traditional products, and fostering sustainable rural development.

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Introduction

Agricultural production and export are the key drivers of economic growth in developing countries, including Serbia, as demonstrated by both economic indicators and prior research (Gollin, Parente, & Rogerson, 2002). With its abundant natural resources, the agricultural and food sector represents one of the most important pillars of the Serbian economy (Dašić, Stanić, & Živković, 2022). The recent upward trend in global food prices further underscores agriculture as a strategic opportunity for the country's long-term development.

One important instrument for strengthening the competitiveness of agricultural products is the system of Geographical Indications (GIs). GIs safeguard the names of products whose distinctive qualities, characteristics, or reputation are closely linked to their geographical origin. By preventing imitation and misrepresentation, they ensure that products maintain the high-quality standards associated with their place of production (Regolo, Gendre, & Poméon, 2025). In parallel, branding plays a complementary role by creating recognizable identities for agricultural products, differentiating them in competitive markets, and fostering consumer trust and loyalty (Latinović, Ostojić, & Bugarčić, 2023). Strong brands not only communicate quality but also add symbolic value that can influence purchasing decisions (Guenzi & Troilo, 2007). Research confirms the relevance of GIs for consumer perception: Arroyo et al. (2020) found that GI labeling significantly increased consumer acceptance of aromatic rice, particularly among those who valued state-of-origin information. The study also showed that sensory attributes, such as flavor and sweetness, were rated more favorably when GI labels were present. From the producer perspective, Maina et al. (2018) demonstrated that while tea and coffee producers recognize the benefits of intellectual property (IP) protection, they also face challenges such as limited awareness and inadequate resources, which hinder effective use of these instruments.

Against this backdrop, this paper examines the role of geographical indications and branding in shaping consumer perceptions of agricultural product quality, as well as the broader importance of intellectual property protection for enhancing competitiveness and safeguarding the authenticity of domestic agricultural production. The paper aims to explore how consumers perceive geographical origin and branding as indicators of quality, their willingness to pay a premium for products with protected origin or established brands, and their attitudes toward legal protection of agricultural goods.

This paper fills a clear gap in the Serbian literature by jointly examining geographical indications and commercial branding as complementary instruments for signalling quality — and by linking those signals to both consumer willingness-to-pay and the institutional / legal awareness that enables effective legal protection. While recent Serbian studies document consumer knowledge and attitudes toward GIs (Ćirić et al., 2023; Jovićević Simin & Živkucin, 2021; Užar, 2022) and separate papers examines branding or trademark use in the agro-food sector, these streams remain fragmented — there is limited empirical research that simultaneously (1) compares consumer responses

to protected-origin labels versus branded products, (2) measures willingness-to-pay differences between these signals, and (3) relates consumer and producer behaviour to the practical functioning of Serbia's IP/GI institutional framework. Addressing this combined consumer–branding–institutional perspective is important because policy and marketing interventions will be more effective only if grounded in evidence about how Serbian consumers perceive and monetise origin signals and how producers navigate the legal infrastructure that supports protection and enforcement.

The significance of this research lies in its potential to generate insights that are valuable both for producers and policymakers. Findings can inform the design of more effective branding strategies, strengthen the market position of domestic producers, and contribute to the preservation of traditional and local products. Moreover, the results may support improvements in the legislative and institutional framework governing intellectual property protection in the agricultural sector. Finally, the relevance of this study is heightened by current trends in agricultural production and trade, where consumers increasingly prioritize authenticity, origin, and sustainability. In the context of globalization and intensifying competition, the protection of geographical origin and the development of strong brands emerge as essential tools for product differentiation, preservation of competitive advantage, and sustainable rural development.

The paper is structured as follows. The first section outlines the theoretical framework and development of hypotheses, emphasizing the importance of geographical indications, intellectual property rights, and branding. The second section presents the research approach and methodology, followed by the third section, which reports the empirical results. The fourth section discusses the findings in light of the tested hypotheses. Finally, the conclusion highlights the key implications of the study, acknowledges its limitations, and offers directions for future research.

Theoretical framework and hypotheses development

The origin of agricultural products has become a crucial element in shaping consumer preferences, particularly through labels such as Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), Traditional Speciality Guaranteed (TSG), and organic certification (Katerinopoulou et al., 2020). These designations not only highlight unique qualities linked to specific regions or production methods but also contribute to building consumer trust and strengthening rural economies. Ensuring the integrity of such products, however, demands strict quality standards and effective protection against unfair practices.

A Geographical Indication (GI) is a designation applied to products whose characteristics, quality, or reputation are essentially linked to their place of origin (Amilien & Moity-Maïzi, 2019). Beyond identifying geographic provenance, GIs function as markers of quality and authenticity, carrying both significant economic potential and cultural value (Luković et al., 2023; Pantović et al., 2023; Zhao et al., 2022). GI is especially important to development of rural areas, especially in Serbia (Dejanović, Lukić Nikolić

& Ljubojević, 2024). It acts as a signal of quality and reputation, it links products with their regions of origin and consumers, thereby simplifying consumer choices, increasing product demand, and strengthening market bargaining power (Voza & Fedajev, 2020; Xu, Feng, & Wei, 2022). As living standards rise and product quality varies, GIs—often perceived as indicators of high quality—gain popularity and establish a recognized reputation among consumers (Šapić et al, 2018; Zhang, Sun, & Zhang, 2023). With today's advanced communication technologies, information about GI products spreads rapidly, and distribution is more efficient, enabling these products to access larger markets and support the development of regional brands (Zhang et al., 2022; Paraušić et al., 2025).

In line with these considerations, we propose the first hypothesis (H1): Consumer attitudes toward the geographical origin of agricultural products differ based on place of residence.

Intellectual Property Rights (IPR) in agriculture and food systems represent a complex framework of legal mechanisms designed to protect innovations and creative outputs within these sectors (Amentae, Song, & Wang, 2024). The governance of IPR does not occur in isolation but is strongly shaped by international organizations such as the World Intellectual Property Organization (WIPO), the World Trade Organization (WTO), and the Food and Agriculture Organization of the United Nations (FAO). These institutions influence IPR through international conventions, treaties, and regulatory frameworks, thereby defining standards and setting directions for national systems. At the same time, individual states remain responsible for developing and enforcing their own IPR regimes, balancing global obligations with domestic development priorities (Amentae, Song & Wang, 2024; Campi & Nuvolari, 2021). Agriculture significantly benefits from intellectual property developed in other industries. This cross-sectoral exchange accelerates agricultural progress beyond what could be achieved through internal patent activity alone, reflecting the inherently interdisciplinary character of many patents (Skawińska & Zalewski, 2018). In recent years, increasing attention has been directed toward advanced patentable technologies—particularly in biotechnology, nanotechnology, and digitalization—due to their growing significance for the agri-food sector (Barragán-Ocaña, Olvera-Treviño & Silva-Borjas, 2023). At the same time, consumers have become more informed and discerning in their choices of food and beverages. Enabled by new technologies, they now have easier access to comprehensive product information, which shapes their expectations and purchasing decisions (Labus & Lukić Nikolić, 2023). For decades, scholars and policymakers have debated whether IP and trade frameworks should prioritize stimulating innovation or safeguarding the fundamental right to food (Breining-Kaufmann, 2005; Gruni, 2018). At the core of this debate is food security, understood as the reliable availability of affordable, safe, and nutritious food that enables healthy and productive lives (Gallegos et al., 2023). IP regimes—especially those governing seeds, plant varieties, and biotechnology—can play a dual role: fostering agricultural innovation while potentially restricting equitable access to essential resources. These dynamics also raise questions of human rights,

sovereignty, and global governance. International legal frameworks, including human rights and environmental law, have been increasingly applied to examine agricultural governance and address persistent food security gaps (Sheehy & Chen, 2022). In developing countries, debates often emphasize sovereignty over agricultural resources, especially when IP protections conflict with practices such as seed sharing or the preservation of traditional knowledge systems (Adhikari et al., 2021).

Building on the role of IP in agriculture, the second hypothesis (H2) proposed in this paper is: The educational level of consumers positively influences attitudes toward the importance of intellectual property protection in agriculture.

The development of agriculture depends on the interplay of economic and sociological factors, with marketing emerging as a key driver—particularly in organic production, where the application of marketing models is considered a fundamental prerequisite for market visibility, product positioning, and overall success (Latinović, Ostojić, & Bugarčić, 2023). Innovation and market orientation are strongly interconnected, with market-oriented organizations often adopting innovative strategies (Ilić, Stanković, & Ostojić, 2024). Branding in the agricultural sector plays a pivotal role in enhancing product differentiation and signaling quality, authenticity, and trust to consumers. Recent studies emphasize that geographical indications (GI) contribute not only to protecting local traditions but also to stimulating agricultural development globally (Li et al., 2024). In addition to geographical indications, branding itself is a powerful tool for shaping consumer perceptions. Empirical evidence shows that brand trust significantly influences consumer behavior toward agricultural products, strengthening loyalty and willingness to pay for higher-quality goods (Liu & Wang, 2023). Similarly, research from Serbia highlights that consumer habits and attitudes toward GI products are closely tied to awareness of quality standards and regional authenticity, further reinforcing the strategic importance of branding in agriculture (Ćirić et al., 2023).

Reflecting these insights, the third hypothesis (H3) proposed in this paper is: The frequency of agricultural product consumption is associated with stronger perceptions of the importance of branding.

Materials and methods

Research design. Quantitative research design was employed to examine consumer perceptions of geographical indications (GI), branding (BR), and intellectual property protection (IP) in agriculture. Data were collected via a structured online questionnaire distributed during September 2025. The link to the questionnaire was disseminated broadly through voluntary response and snowball sampling: it was initially sent to a wide range of contacts without predefined selection criteria, and recipients were encouraged to forward the link to others in their networks. This approach allowed broad participation and facilitated access to a relatively large number of respondents in a cost-effective and time-efficient manner, particularly useful when targeting a dispersed population such as consumers of agricultural products.

Questionnaire. The questionnaire was structured into two main sections. The first section collected general socio-demographic data: gender (male/female), age (under 30, 31–40, 41–50, over 50), education (primary, secondary, higher education, master/specialist, doctoral studies), frequency of agricultural product consumption (daily, 2–3 times per week, once per week, 2–3 times per month), and place of residence (city or rural area). The second section assessed consumer attitudes across three domains using a five-point Likert scale (1 = strongly disagree, 5 = strongly agree):

Geographical Indication (GI): authenticity, uniqueness of regional characteristics, ease of selection, willingness to pay a premium, and perceived impact of origin on quality. The statements used to construct this measurement scale are shown in *Table 3*.

Brand Recognition (BR): importance of branding in purchasing decisions, confidence in recognized brands, preference for traditional or regional brands, and preference for well-known agricultural brands. The statements used to construct this measurement scale are shown in *Table 4*.

Intellectual Property Protection (IP): legal protection of regional products, effectiveness of trademarks, usefulness of IP laws in preserving traditional products, need for producer investment in legal protection, and potential of IP to stimulate innovation. The statements used to construct this measurement scale are shown in *Table 5*.

Sample. The sample consisted of individuals who voluntarily completed the online questionnaire, ensuring participation by consumers interested in agricultural products. Socio-demographic variables included gender, age, education level, frequency of agricultural product consumption, and place of residence (urban or rural). These variables were incorporated to account for heterogeneity and potential demographic influences on consumer attitudes. A total of 214 respondents filled out the questionnaire.

Data Analysis. Data were processed using the Statistical Package for the Social Sciences (SPSS), version 21.0. Reliability of the measurement scales was confirmed by Cronbach's Alpha coefficient results presented in *Table 1*, with all coefficients exceeding the 0.70 threshold (DeVellis, 2003), indicating strong internal consistency.

Table 1. Cronbach Alpha coefficients

Scale	N	Cronbach's Alpha
Geographical Indication (GI)	5	0.893
Brand Recognition (BR)	4	0.904
Intellectual Property Protection (IP)	5	0.934

Normality of data distribution was examined through multiple procedures: Kolmogorov-Smirnov test, histogram inspection, skewness and kurtosis values, normal probability plots, and boxplots. Results indicated significant deviations from normality ($p = 0.000$), leading to the application of non-parametric methods. The Mann-Whitney U test was employed for comparisons between two groups, while the Kruskal-Wallis H test was applied for comparisons among three or more groups, using a 95% confidence level. Additionally, Levene's test confirmed homogeneity of variances across groups ($p > 0.05$).

Research results

Table 2 presents the basic information about the respondents who participated in this research. There is a relatively balanced gender distribution: 52.8% male and 47.2% female. In terms of age, the largest group of respondents was under 30 years old (29.0%), followed by those aged 41–50 (27.5%) and above 50 (26.2%), while 17.3% were between 31 and 40 years of age. Educational level was diverse, with most respondents having completed high school (35.0%) or a university degree at the bachelor's or master's level (33.3%). Smaller shares held a college degree (17.3%) or a doctoral degree (10.7%), whereas only 3.7% reported primary education. The majority of respondents lived in cities (63.1%), while 36.9% were from rural areas. Regarding consumption habits, 37.4% reported daily consumption of agricultural products, 26.6% consumed them two to three times per week, and 27.6% once per week, whereas only 8.4% consumed such products two to three times per month.

Table 2. Basic information about respondents

	Answers	N	%
Gender	Male	113	52.8
	Female	101	47.2
Age	Up to 30	62	29.0
	From 31 to 40	37	17.3
	From 41 to 50	59	27.5
	Above 50	56	26.2
Education	Primary School	8	3.7
	High School	75	35.0
	College	37	17.3
	University (bachelor and master studies)	71	33.3
	University (doctoral studies)	23	10.7
Place	City	135	63.1
	Rural area	79	36.9
Frequency of consumption of agricultural products	Daily	80	37.4
	Two to three times a week	57	26.6
	Once a week	59	27.6
	Two to three times a month	18	8.4

Source: Authors' calculations

Table 3 presents the responses to the statements in the measurement scale "Geographical Indication". The findings suggest a relatively low level of agreement with the positive statements regarding geographical origin, as reflected in mean values ranging between 2.44 and 2.68.

More than half of the respondents disagreed that products labeled with a geographical origin feel more authentic (54.7%) or that geographical labeling facilitates product choice (56.5%). Similarly, 59.8% of respondents disagreed with the statement that the place of origin has a direct impact on the quality of agricultural products, indicating skepticism toward origin as a determinant of quality. However, certain aspects of

geographical indications received comparatively stronger support. Almost one-third of respondents (30.8%) agreed that products from specific regions possess unique tastes or characteristics that cannot be easily replicated, while 27.1% stated that geographical origin information increases their willingness to pay a higher price.

Table 3. Results regarding the scale "Geographical Indication"

Statements	Answer	N	%	M	SD
Products labeled with a geographical origin (e.g., protected geographical indication) feel more authentic than others.	Disagree	117	54.7	2.61	1.280
	Neutral	48	22.4		
	Agree	49	22.9		
Indicating geographical origin makes it easier for me to choose a product.	Disagree	121	56.5	2.59	1.186
	Neutral	41	19.2		
	Agree	52	24.3		
I believe that products from certain regions have unique tastes or characteristics that cannot be easily replicated.	Disagree	107	50.0	2.68	1.340
	Neutral	41	19.2		
	Agree	66	30.8		
Information about a product's geographical origin increases my willingness to pay a higher price.	Disagree	105	49.1	2.59	1.366
	Neutral	51	23.8		
	Agree	58	27.1		
I believe that the place of origin has a direct impact on the quality of agricultural products.	Disagree	128	59.8	2.44	1.261
	Neutral	37	17.3		
	Agree	49	22.9		

Source: Authors' calculations

The results presented in *Table 4* reflect a moderate level of importance attributed to brand-related factors, with mean values ranging between 2.37 and 2.71, and a majority of respondents expressing disagreement across the statements. Specifically, 58.9% of respondents disagreed that brand plays an important role in their purchasing decisions, while only 26.1% agreed. Similarly, 61.2% disagreed that a recognizable brand increases their confidence in product quality, and just 25.2% agreed. When asked about preferences for brands that highlight tradition or regional connection, 57.5% of respondents disagreed, compared to 23.8% who agreed, indicating limited sensitivity to branding strategies that emphasize heritage. Finally, although over half of respondents (51.0%) reported not preferring well-known brands, about one quarter (24.2%) expressed a clear preference for them, with another 24.8% remaining neutral.

Table 4. Results regarding the scale "Brand Recognition"

Statements	Answer	N	%	M	SD
Brand plays an important role when I purchase agricultural products.	Disagree	126	58.9	2.50	1.335
	Neutral	32	15.0		
	Agree	56	26.1		
A recognizable brand gives me greater confidence in a product's quality.	Disagree	131	61.2	2.37	1.357
	Neutral	29	13.6		
	Agree	54	25.2		

Statements	Answer	N	%	M	SD
I prefer brands that highlight a connection to tradition or region.	Disagree	123	57.5	2.40	1.376
	Neutral	40	18.7		
	Agree	51	23.8		
I personally prefer to buy well-known brands of agricultural products.	Disagree	109	51.0	2.71	1.186
	Neutral	53	24.8		
	Agree	52	24.2		

Source: Authors' calculations

The findings in *Table 5* indicate generally cautious attitudes of respondents toward intellectual property (IP) protection in the agricultural sector. Across all statements, the mean values remain relatively low (ranging from 2.53 to 2.71), with disagreement prevailing as the dominant response.

More than half of the respondents (51.0%) disagreed that protecting geographical indications should be a priority in rural development policies, and a similar share (50.5%) did not view trademark registration as an effective means of protecting local producers from imitation. Likewise, 50.9% expressed disagreement with the idea that intellectual property laws play an important role in preserving traditional products. Nevertheless, certain responses suggest emerging awareness of the potential benefits of IP protection. Nearly one-third of respondents (29.5%) agreed that producers should invest more in the legal protection of their products, and 25.7% acknowledged both the role of trademarks in protecting local producers and the importance of IP laws in preserving tradition. Similarly, 25.7% agreed that IP protection could stimulate innovation in agriculture, although a majority (54.6%) disagreed.

Table 5. Results regarding the scale "Intellectual Property Protection"

Statements	Answer	N	%	M	SD
Protecting geographical indications should be a priority in rural development policies.	Disagree	109	51.0	2.71	1.186
	Neutral	53	24.8		
	Agree	52	24.2		
Registering a brand (trademark) is an effective way to protect local producers from imitation.	Disagree	108	50.5	2.68	1.234
	Neutral	51	23.8		
	Agree	55	25.7		
I believe intellectual property laws play an important role in preserving traditional products.	Disagree	109	50.9	2.61	1.261
	Neutral	50	23.4		
	Agree	55	25.7		
Producers should invest more in the legal protection of their regional products (e.g., GIs, trademarks).	Disagree	109	50.9	2.58	1.311
	Neutral	42	19.6		
	Agree	63	29.5		
Intellectual property protection can stimulate innovation in agriculture.	Disagree	117	54.6	2.53	1.345
	Neutral	42	19.7		
	Agree	55	25.7		

Source: Authors' calculations

To test the first hypothesis, a Mann-Whitney U test was applied, and the results are presented in *Table 6*. The analysis indicated no statistically significant difference in responses between respondents from urban areas (Md = 2.60, n = 135) and those from rural areas (Md = 2.20, n = 79), U = 5173.500, Z = -0.365, p = 0.715. This suggests that place of residence does not significantly influence consumer attitudes toward the geographical origin of agricultural products.

Table 6. Mann-Whitney U test results for H1 hypothesis examination

	Answers	N	M	Md	U	Z	p
Place	City	135	2.64	2.60	5173.500	-0.365	0.715
	Rural areas	79	2.49	2.20			

Source: Authors' calculations

Additionally, the Kruskal-Wallis H-test was applied to further examine the proposed hypotheses (H2 and H3), with results presented in *Table 7*. The analysis showed no statistically significant differences in responses across education levels, χ^2(df = 4, n = 214) = 8.377, p = 0.079, indicating that the level of education does not significantly influence respondents' attitudes toward intellectual property protection in agriculture.

In contrast, the test revealed statistically significant differences in responses based on the frequency of agricultural product consumption, χ^2(df =3, n = 214) = 28.737, p < 0.001. This finding suggests that respondents who consume agricultural products more frequently tend to assign greater importance to branding compared to those with lower consumption frequency.

Table 7. Results of the Kruskal-Wallis H-test for H2 and H3 hypotheses examination

	Answers	N	M	Md	χ^2	df	p
Education	Primary School	8	3.48	3.40	8.377	4	0.079
	High School	75	2.58	2.40			
	College	37	2.47	2.20			
	University (bachelor and master studies)	71	2.75	2.40			
	University (doctoral studies)	23	2.32	1.80			
Frequency of consumption	Daily	80	2.85	2.75	28.737	3	0.000*
	Two to three times a week	57	2.19	1.75			
	Once a week	59	2.05	1.75			
	Two to three times a month	18	3.35	3.50			

Source: Authors' calculations

Discussion of research findings

Table 8 presents the summary of the proposed hypotheses, the statistical tests applied, and the corresponding outcomes.

Table 8. Summary of hypotheses and statistical test outcomes

Hypothesis	Applied test	Result	Decision
H1: Consumer attitudes toward the geographical origin of agricultural products differ based on place of residence.	Mann-Whitney U test	U = 5173.500 Z = -0.365 p = 0.715	Not supported
H2: The educational level of consumers positively influences attitudes toward the importance of intellectual property protection in agriculture.	Kruskal-Wallis H-test	χ^2 = 8.377 df = 4 p = 0.079	Not supported
H3: The frequency of agricultural product consumption is associated with stronger perceptions of the importance of branding.	Kruskal-Wallis H-test	χ^2 = 28.737 df = 3 p < 0.001	Supported

Source: Authors' calculations

The results of hypothesis testing provide valuable insights into the role of socio-demographic and behavioral factors in shaping consumer perceptions of agricultural products. Out of the three proposed hypotheses, only H3 was supported, indicating that the frequency of agricultural product consumption is significantly associated with stronger perceptions of the importance of branding. In contrast, H1 and H2 were not supported, suggesting that neither place of residence nor educational level exert a statistically significant influence on consumer attitudes. The rejection of H1 indicates that consumer attitudes toward the geographical origin of agricultural products do not differ substantially between urban and rural respondents. These results challenge common assumptions that rural consumers, being closer to production and tradition, might attribute higher value to geographical origin. Instead, it suggests that perceptions of origin may be shaped more by individual preferences and market exposure than by geographical context.

Similarly, H2 was not supported, as educational level did not significantly affect attitudes toward the importance of intellectual property protection in agriculture. While higher education is often associated with greater awareness of legal and institutional frameworks, the results indicate that attitudes toward intellectual property protection are relatively uniform across educational groups. This could reflect limited public awareness of the practical implications of intellectual property rights in agriculture or the perception that such issues are distant from everyday consumer choices.

In contrast, H3 was strongly supported, with consumption frequency emerging as a decisive factor in shaping branding perceptions. Respondents who consumed agricultural products either on a daily basis or only a few times per month expressed higher appreciation of branding, compared to those with moderate consumption patterns. Respondents who consumed agricultural products daily (M = 2.85, Md = 2.75)

or two to three times per month (M = 3.35, Md = 3.50) demonstrated higher evaluations of branding importance compared to those consuming such products weekly (M = 2.05, Md = 1.75) or two to three times a week (M = 2.19, Md = 1.75). These results suggest a non-linear relationship: branding appears to be most valued among the most frequent and the least frequent consumers, while moderate-frequency consumers assign lower importance to branding. This suggests that both highly engaged consumers (who purchase daily) and selective, occasional consumers (who purchase monthly) rely on brand cues when making purchasing decisions—though for different reasons: the former due to habitual reinforcement, and the latter to reduce risk or ensure quality.

Overall, these findings highlight the complexity of consumer perceptions in agriculture. Whereas socio-demographic characteristics such as residence and education did not prove influential, behavioral patterns of consumption demonstrated a significant impact. This suggests that marketing and policy strategies aimed at strengthening branding and intellectual property protection in agriculture should place greater emphasis on consumer behavior and market engagement, rather than relying solely on socio-demographic segmentation.

Conclusion

The findings of this study in which participated 214 respondents from Serbia reveal a generally low level of consumer support for geographical indications, branding, and intellectual property protection in agriculture, as reflected in mean values consistently below 3 across all measurement scales (ranging from 2.37 to 2.71). Respondents expressed the greatest skepticism toward the role of branding in purchasing decisions (M = 2.37–2.71) and the impact of geographical origin on product quality (M = 2.44–2.68). Intellectual property protection was also viewed cautiously (M = 2.53–2.71), with more than half of respondents disagreeing with its importance for rural development or product preservation. Nevertheless, a notable minority—ranging from 25% to 30% depending on the statement—recognized the potential benefits of geographical indications, branding, and legal protection, indicating scope for targeted strategies that could enhance consumer awareness and strengthen the competitiveness of domestic agricultural products.

The findings regarding hypotheses indicate that the frequency of agricultural product consumption significantly influences the perceived importance of branding, while socio-demographic factors such as place of residence and education level have little impact on attitudes toward product origin or legal protection. This suggests that consumer behavior, rather than demographic characteristics, is a key driver in evaluating product quality and making purchasing decisions.

The findings of this study *contribute to the literature* by highlighting the weak signaling power of geographical indications, branding, and intellectual property protection in the Serbian context. Contrary to assumptions that these instruments universally enhance consumer trust and perceived quality, respondents reported consistently low levels of

support across all measures. This suggests that the effectiveness of institutional quality signals is highly context-dependent, particularly in transitional economies where consumer awareness remains limited. Moreover, the results show that consumption frequency, rather than socio-demographic factors, is the key determinant of attitudes toward branding and origin. This shifts the theoretical focus from demographic profiling to behavioral engagement, underscoring the importance of experiential variables in shaping perceptions of product quality. *From a practical perspective*, the findings indicate that neither legal protection nor brand labeling alone is sufficient to influence consumer choices in Serbia. Policymakers and producer organizations should therefore complement institutional frameworks with targeted awareness campaigns that communicate the benefits of GIs, branding, and IP protection for authenticity, quality assurance, and rural development.

Despite valuable insights into consumer perceptions of geographical indications, branding, and intellectual property protection in agriculture, this study has several limitations. First, the sampling approach relied on voluntary response and snowball dissemination, which increases the risk of self-selection bias. Individuals with a stronger interest in issues of product origin, branding, or intellectual property protection may have been more inclined to participate, potentially skewing the results. Second, the lack of demographic or geographic restrictions limits the representativeness of the sample, making it difficult to claim that the findings accurately reflect the attitudes of the broader Serbian consumer population. Consequently, the results should be interpreted primarily as indicative and exploratory, rather than as fully generalizable conclusions. Third, cross-sectional design captures attitudes at a single point in time, limiting the ability to observe changes in consumer behavior over time.

Future research could address these limitations by employing a randomized or stratified sampling approach to achieve a more representative sample. Longitudinal studies would allow researchers to track changes in consumer perceptions and behavior over time, providing insights into trends and evolving preferences. Additionally, future studies could examine specific product categories or regions in greater detail, and explore the interaction between branding, geographical origin, and other factors such as sustainability certifications or marketing strategies. Such research would further enhance understanding of how legal protection and marketing tools influence consumer decision-making in agriculture and inform both policy and producer strategies.

Conflict of interests

The authors declare no conflict of interest.

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GENERATION Z's ATTITUDES TOWARD AGRO-ENTREPRENEURSHIP: EXAMINING MOTIVATIONS, CHALLENGES, AND FUTURE PERSPECTIVES

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A R T I C L E I N F O	A B S T R A C T
	This paper examines Generation Z attitudes toward agro-entrepreneurship, with particular emphasis on their motivation, perceived challenges, and perspectives on the future of agro-based business ventures. A structured questionnaire was used as the primary data collection instrument, targeting both rural and urban members of Generation Z. Using a snowball sampling method, 263 respondents participated in research during October 2025. Statistical analyses, including Mann-Whitney U and Kruskal-Wallis H tests, revealed that urban members of Generation Z, those from agricultural households, and those with personal agricultural experience exhibit higher motivation, perceive fewer barriers, and express more positive attitudes, highlighting the role of contextual and experiential factors in shaping agro-entrepreneurial engagement. These findings have practical and theoretical significance, providing insights for policymakers and educators to design targeted support programs, promote youth participation in agro-business, and foster sustainable rural development through entrepreneurship initiatives.

Introduction

Sustaining agricultural growth increasingly depends on engaging young people and promoting youth-led agro-entrepreneurship initiatives and activities (Giwu et al.,

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2024). Generation Z, entering the labor market with distinct values, expectations, and behavioral traits, differs significantly from previous generations (Bencsik et al., 2016; Benítez-Márquez et al., 2022; Paspalj et al., 2024; Grow & Yang, 2018). By 2025, Generation Z is projected to comprise approximately 27% of the global workforce (Koop, 2021), posing challenges for employers seeking to attract and retain this digitally native and socially conscious generation (Lukić Nikolić & Lazarević, 2023).

Agro-entrepreneurship is becoming increasingly significant in the agribusiness sector, as small and medium-sized enterprises demonstrate high adaptability and responsiveness to market changes and technological innovations (Nikolić et al., 2025). For Generation Z, employment preferences such as competitive remuneration, meaningful work, and comprehensive benefits (Workplace Institute at Kronos Incorporated, 2019), highlight the need for agro-business models that balance financial sustainability with social relevance. While valuing job security, Generation Z tends to pursue dynamic career paths and rarely remains with a single employer long-term, making entrepreneurship particularly appealing due to its autonomy and flexibility (Lukić Nikolić & Lazarević, 2022). Moreover, this generation expects access to modern technologies and exhibits low tolerance for outdated systems, emphasizing the need for digital integration and smart business solutions (Workplace Institute at Kronos Incorporated, 2019). Their strong orientation toward achievement and professional growth suggests that mentorship, innovation opportunities, and clear career pathways can effectively support engagement (Lukić Nikolić & Lazarević, 2023; Schroth, 2019). Additionally, Generation Z prioritizes work-life balance, transparent communication, and respectful workplace culture (O'Boyle et al., 2017; Schwieger & Ladwig, 2018), dimensions that should underpin agro-entrepreneurial ventures to attract and retain talent.

Despite its potential, Generation Z engagement in agriculture remains limited due to structural barriers such as insufficient policy support, restricted access to land and finance, inadequate market infrastructure, and limited practical experience (August, 2020). Promoting participation of Generation Z in agro-entrepreneurship is particularly important, as it can harness their creativity and innovation while fostering sustainable and modern agricultural practices (Giwu et al., 2025).

This study is motivated by persistent demographic and attitudinal challenges: an aging farming population and declining youth interest in agricultural careers threaten food-system resilience and rural livelihoods. Empirical evidence highlights both structural barriers and the ambivalence many young people feel toward agricultural careers (Food and Agriculture Organization of the United Nations, 2014; Girdziūte et al., 2022), underscoring the need to understand Generation Z's perceptions of agro-entrepreneurship.

The paper examines Generation Z's attitudes toward agro-entrepreneurship by assessing (a) motivational drivers, (b) perceived challenges, and (c) perspectives on future agro-enterprise development, with a comparison between rural and urban areas. The study is grounded in entrepreneurial intention models, particularly the Theory of Planned Behavior, which posits that attitudes, subjective norms, and perceived behavioral control shape

entrepreneurial intent (Ajzen, 1991). Applying this framework to Generation Z allows the linking of individual dispositions with broader contextual constraints and opportunities.

This research contributes both theoretically and practically. Theoretically, it situates Generation Z's agro-entrepreneurial orientations within established intention models, improving understanding of how generational traits interact with sectoral features to shape entrepreneurial intentions. Practically, insights into motivations and barriers can inform policies, curricula, and employer practices designed to make agriculture a more attractive entrepreneurial pathway for young people, aligning with their preferences for meaningful, technology-enabled, and secure livelihoods (Food and Agriculture Organization of the United Nations, 2014; Zupur, 2024; Francis & Hoefel, 2018; Heřmanová et al., 2024).

The paper is structured as follows. The theoretical background and hypotheses development section provides an overview of agribusiness and agro-entrepreneurship, situating Generation Z's engagement within relevant theoretical frameworks and presenting the research hypotheses. The Methodology section explains the research design, sample characteristics, data collection procedures, and analytical techniques used to test hypotheses. The Results section reports empirical findings, including statistical analyses, while the Discussion section interprets these results in the context of existing literature, highlighting both theoretical and practical implications for agro-entrepreneurship and the engagement of Generation Z.

Theoretical framework and hypotheses development

Agribusiness encompasses the comprehensive network of business activities associated with agriculture, including the production, processing, distribution, and marketing of agricultural goods (Ilić et al., 2024; Latinović et al., 2023). It can be divided into three interdependent sectors: the input sector, which provides essential resources such as seeds, fertilizers, machinery, and feed; the farm sector, responsible for crop and livestock production; and the product sector, which handles processing, storage, distribution, and retailing of agricultural products (Ikuemonisan et al., 2022).

Agro-entrepreneurship refers to the application of business principles and innovative approaches to agriculture to enhance efficiency, profitability, and sustainability. By transforming farming into a market-oriented and technology-driven activity, agro-entrepreneurs promote innovation, optimize resource use, and implement effective risk management strategies. Their activities contribute to rural employment, food security, and economic growth, while fostering sustainable practices that strengthen the competitiveness and resilience of the agricultural sector (Kademani et al., 2024).

Human capital is a crucial determinant of youth engagement in agro-entrepreneurship, as it not only embodies the knowledge, skills, and competencies within a community but also underpins the effective use of other forms of territorial capital, such as social networks, natural resources, infrastructure, and institutional support (Dejanović et al., 2024). Closely related, agricultural entrepreneurship emphasizes the integration

of entrepreneurial thinking and business innovation within farm management and agricultural production. Agricultural entrepreneurs employ strategic planning, innovation, and risk management to enhance operational efficiency and sustainability (Yoon et al., 2021). They make informed decisions regarding production choices, resource allocation, and technology adoption to improve output and profitability. Given agriculture's high exposure to environmental and market risks, including weather variability, pest outbreaks, and price fluctuations, entrepreneurial skills are critical for mitigating uncertainty through innovation, diversification, and proactive planning (Gadanakis, 2024). By optimizing resources, improving productivity, and responding to evolving consumer preferences, agricultural entrepreneurs support both sectoral modernization and sustainability. Historically perceived as a traditional, low-technology industry dominated by small family farms, agriculture has undergone profound transformation. The integration of advanced technologies and engineering innovations has revolutionized production efficiency and sustainability on a global scale (Dias et al., 2019).

Building on this conceptual foundation, the study formulates three hypotheses concerning factors influencing Generation Z's engagement with agro-entrepreneurship:

H1: Respondents from urban areas are statistically more likely to report higher motivation to start an agro-entrepreneurial venture than respondents from rural areas. In contexts where agriculture remains the primary economic activity, rural Generation Z's aspirations may critically influence whether they pursue farming or not (Giwu et al., 2025). Rural youth often possess greater familiarity with agricultural activities and direct exposure to farming practices, enhancing both interest and self-efficacy in pursuing agricultural business opportunities (Tabares et al., 2022). The Theory of Planned Behavior (TPB) suggests that perceived behavioral control and sectoral familiarity influence entrepreneurial intentions, supporting the notion that a rural upbringing may positively shape motivation toward agro-entrepreneurship (Ajzen, 1991). On the other hand, some studies indicate that individuals from urban areas tend to be more motivated to initiate agro-entrepreneurial ventures (Girdziūte et al., 2022).

H2: Respondents whose parents or household members are actively engaged in agribusiness perceive significantly fewer challenges in starting an agro-entrepreneurial venture than those from households without agricultural involvement. Social learning theory posits that individuals acquire knowledge, skills, and confidence through observation and interaction with experienced role models (Bandura, 1977). Exposure to family members involved in agriculture provides practical insights and informal mentoring, reducing perceived barriers related to financial constraints, resource access, and market uncertainties. Empirical evidence demonstrates that familiar involvement in farming enhances entrepreneurial confidence and lowers risk perception among youth considering agricultural ventures (Plana-Farran et al., 2023).

H3: Respondents with personal experience working in agriculture express a significantly more positive attitude toward the long-term prospects of agro-entrepreneurship than

those without such experience. Youth attitudes and aspirations toward agriculture are strongly shaped by access to resources, livelihood assets, and prior exposure to farming activities (Stojković & Kocić, 2024; Henning et al., 2022). Individuals with direct agricultural experience acquire practical skills, deepen their understanding of farming operations, and build self-efficacy, fostering favorable attitudes toward the profitability and sustainability of agro-businesses. Within the TPB framework, relevant experience enhances perceived feasibility and benefits of entrepreneurial activity (Ajzen, 1991). Empirical studies indicate that youth with hands-on agricultural experience are more optimistic about the sustainability and profitability of agro-enterprises than those without such experience (Geza et al., 2021).

Materials and methods

Research design. This study utilized a structured questionnaire as the primary data collection instrument to examine Generation Z attitudes toward agro-entrepreneurship. The questionnaire was designed to assess motivational factors, perceived challenges, and future perspectives related to starting an agro-business, with a particular focus on differences between rural and urban members of Generation Z.

Questionnaire. The questionnaire was structured into two main sections. The first section focused on profile information and included six items capturing key background variables: gender, age, level of education, place of residence (categorized as rural or urban area), parent and household involvement in agribusiness, and personal experience in agricultural work. The second section of the questionnaire consisted of 15 attitudinal statements divided into three thematic scales: Motivation toward agro-business entrepreneurship (5 items), Perceived challenges in agro-business participation (5 items), and Perspectives on agro-business development (5 items). Each item was assessed using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). This format enabled quantitative analysis of Generation Z' attitudes and facilitated comparisons across demographic subgroups.

Sample. The study employed a snowball sampling method, a non-probability approach commonly used in exploratory research involving specific populations. Initial participants that belong to Generation Z were identified and invited to complete the questionnaire, after which they were encouraged to share the questionnaire link with peers who met the inclusion criteria. This referral-based process facilitated the expansion of the sample through existing social networks, enabling broader participation among young individuals from Generation Z interested or involved in agro-entrepreneurship. Data were collected during October 2025.

Data Analysis. Collected data from 263 respondents were processed using the Statistical Package for the Social Sciences (SPSS), version 21.0. Reliability of the measurement scales was confirmed by Cronbach's Alpha coefficient results presented in *Table 1*, with all coefficients exceeding the 0.70 threshold (DeVellis, 2003), indicating strong internal consistency.

Table 1. Cronbach Alpha coefficients

Scale	N	Cronbach's Alpha
Motivation toward agro-business entrepreneurship	5	0.831
Perceived challenges in agro-business participation	5	0.862
Perspectives on agro-business development	5	0.921

To assess the distribution characteristics of the dataset, several statistical techniques were utilized, including the Kolmogorov-Smirnov test, visual inspection of histograms, evaluation of skewness and kurtosis coefficients, analysis of normal Q-Q plots, and boxplot interpretation. The findings revealed notable departures from normality ($p = 0.000$), which warranted the use of non-parametric statistical procedures. For group comparisons, the Mann-Whitney U test was applied when analyzing two independent samples, whereas the Kruskal-Wallis H test was used for comparisons involving three or more groups, maintaining a 95% confidence threshold. Furthermore, Levene's test indicated that the assumption of equal variances across groups was met ($p > 0.05$).

Research results

Table 2 presents the basic information about the respondents who participated in this research. The sample consists of a relatively balanced gender distribution, with slightly more males (54%) than females (46%), and is predominantly composed of young adults aged 18 to 28 (96%). Most respondents have attained higher levels of education, with 41% holding a university degree and smaller proportions having college, high school, primary, or doctoral-level education. In terms of residence, the majority live in urban areas (62%), while the remaining respondents come from rural areas. The respondents also have varied agricultural backgrounds: about 29% come from households where a family member is actively engaged in agriculture, 36% report occasional family involvement, and 35% have no family connection to the agriculture. Similarly, personal experience in agriculture ranges from regular participation (30%) to occasional help (38%), with nearly one-third (32%) having no experience at all.

Table 2. Basic information about respondents

	Answers	N	%
Gender	Male	142	53.99
	Female	121	46.01
Age	Up to 18	10	3.80
	From 18 to 28	253	96.20
Education	Primary School	10	3.80
	High School	76	28.90
	College	51	19.39
	University (bachelor and master studies)	107	40.68
	University (doctoral studies)	19	7.23
Place	Rural area (village, smaller settlements)	99	37.64
	Urban area (cities, larger settlements)	164	62.36

	Answers	N	%
Parents or household members involved in agrobusiness	Yes, they are actively engaged in agriculture as their main occupation	76	28.90
	Yes, they occasionally engage in agriculture (additional activity)	94	35.74
	No, no one in the household is engaged in agriculture	93	35.36
Personal experience working in agriculture	Yes, I regularly participate in agro-business	78	29.66
	Yes, I help occasionally	101	38.40
	No, I have no experience	84	31.94

Source: Authors' calculations

The results from *Table 3* indicate that overall motivation toward agro-business entrepreneurship among Generation Z is relatively low. This is reflected in the mean values, which range from 2.34 for motivation to establish an agro-business to 3.06 for perceived profitability, suggesting only moderate acknowledgment of the agriculture sector's potential. Similarly, agreement levels are generally limited: for example, only 14.83% of respondents agree that they are motivated to start their own agro-business, while 61.22% disagree. Other statements, such as viewing agriculture as a platform for creativity or being inspired by environmental and sustainability aspects, also show low mean values (2.88 and 2.65, respectively) and relatively higher disagreement percentages. Even perceptions of agriculture's societal contribution, although slightly higher (mean 3.05), reflect a cautious rather than strong positive attitude. These findings indicate that while members of Generation Z recognize some benefits of agro-entrepreneurship, their personal motivation and engagement remain limited.

Table 3. Results regarding the scale "Motivation toward agro-business entrepreneurship"

Statements	Answer	N	%	M	SD
I believe agro-entrepreneurship offers strong potential for profitability.	Disagree	99	37.64	3.06	1.196
	Neutral	79	30.04		
	Agree	85	32.32		
I am motivated to establish my own business within the agricultural sector.	Disagree	161	61.22	2.34	1.141
	Neutral	63	23.95		
	Agree	39	14.83		
I perceive agricultural work as contributing positively to society.	Disagree	95	36.12	3.05	1.327
	Neutral	71	27.00		
	Agree	97	36.88		
I perceive agro-entrepreneurship as a platform for creative expression and innovation.	Disagree	114	43.35	2.88	1.340
	Neutral	65	24.71		
	Agree	84	31.94		
The environmental and sustainability aspects of agriculture inspire my interest in this field.	Disagree	138	52.47	2.65	1.322
	Neutral	51	19.39		
	Agree	74	28.14		

Source: Authors' calculations

The results in *Table 4* suggest that respondents perceive moderate challenges in engaging with agro-business, with mean values indicating neither strong agreement nor strong disagreement. For instance, securing initial capital and the physically demanding nature

of agricultural work show relatively low mean scores (2.81 each), with disagreement percentages higher than agreement, indicating that many members of Generation Z do not view these as considerable barriers. In contrast, limited knowledge and skills (M = 3.02) and the perception that young agro-entrepreneurs are undervalued by society (M = 3.07) show slightly higher means, reflecting a more prominent concern among respondents. Agreement levels for these statements are substantial: 35.74% for skills and 41.45% for social undervaluation, highlighting areas where members of Generation Z feel more constrained. Overall, while some structural and social challenges are recognized, the findings indicate that perceived obstacles are moderate and vary across different dimensions of agro-entrepreneurship.

Table 4. Results regarding the scale "Perceived challenges in agro-business participation"

Statements	Answer	N	%	M	SD
Securing initial capital for agribusiness ventures is challenging.	Disagree	110	41.83	2.81	1.175
	Neutral	87	33.08		
	Agree	66	25.09		
The limited availability of modern agricultural technologies discourages my interest in the sector.	Disagree	140	37.26	2.59	1.139
	Neutral	70	27.00		
	Agree	53	35.74		
I lack sufficient knowledge and skills to successfully run an agro-based business.	Disagree	98	37.26	3.02	1.336
	Neutral	71	27.00		
	Agree	94	35.74		
I perceive agricultural work as physically demanding and less appealing.	Disagree	110	41.82	2.81	1.276
	Neutral	73	27.76		
	Agree	80	30.42		
I feel that young agro-entrepreneurs are undervalued by society.	Disagree	100	38.02	3.07	1.380
	Neutral	54	20.53		
	Agree	109	41.45		

Source: Authors' calculations

The results in *Table 5* indicate that respondents hold moderately cautious perspectives on agro-business development. Mean values for all statements are relatively low, ranging from 2.52 for openness to collaborate with peers to 2.91 for perceived need for government support, reflecting a generally restrained optimism. Disagreement generally exceeds agreement, particularly for collaboration with other young individuals (56.65% disagree) and the potential of digital technologies to enhance agriculture (46.77% disagree). While a slightly higher proportion agree that government support is needed (34.60%) or that agro-entrepreneurship can positively impact local communities (33.08%), disagreement remains the dominant response. Overall, these findings suggest that members of Generation Z recognize the potential of agro-entrepreneurship and policy support but remain cautious about its feasibility and collaborative opportunities, highlighting the need for targeted interventions to strengthen confidence and engagement.

Table 5. Results regarding the scale "Perspectives on agro-business development"

Statements	Answer	N	%	M	SD
I believe that digital technologies can enhance the agricultural sector.	Disagree	123	46.77	2.77	1.290
	Neutral	68	25.86		
	Agree	72	27.37		
I think the government should provide greater support for young agro-entrepreneurs.	Disagree	122	46.39	2.91	1.384
	Neutral	50	19.01		
	Agree	91	34.60		
I perceive agro-entrepreneurship as a field with strong long-term potential.	Disagree	126	47.91	2.81	1.434
	Neutral	50	19.01		
	Agree	87	33.08		
I am open to collaborating with other young individuals to launch an agro-based business.	Disagree	149	56.65	2.52	1.361
	Neutral	50	19.01		
	Agree	64	24.34		
I believe agro-entrepreneurship can positively impact the development of local communities.	Disagree	128	48.67	2.77	1.439
	Neutral	48	18.25		
	Agree	87	33.08		

Source: Authors' calculations

The Mann-Whitney U test was conducted to examine differences in respondents' motivation to start an agro-entrepreneurial venture between those from urban and rural areas. The result in *Table 6* shows a statistically significant difference between the two groups (U = 6,521.000, Z = -2.678, p = 0.007). This indicates that place of residence plays a significant role in shaping respondents' motivation toward agro-entrepreneurship. The mean and median scores reveal that respondents from urban areas (M = 2.91; Md = 2.80) reported higher levels of motivation compared to those from rural areas (M = 2.61; Md = 2.60). This finding suggests that urban members of Generation Z may view agro-entrepreneurship as a novel and promising opportunity, potentially linked to innovation, sustainability, or self-employment prospects. In contrast, rural respondents, who are more familiar with the traditional challenges of agricultural work, may perceive it as less attractive or less profitable.

Table 6. Mann-Whitney U test results for H1 hypothesis examination

	Answers	N	M	Md	U	Z	p
Place	Urban areas	164	2.91	2.80	6,521.000	-2.678	0.007*
	Rural areas	99	2.61	2.60			

Source: Authors' calculations

The Kruskal-Wallis H test was used to examine whether there are statistically significant differences in attitudes toward agro-entrepreneurship depending on family involvement in agriculture (H2) and personal experience working in agriculture (H3).

For H2, the test revealed a significant difference among groups (χ^2 = 31.746, df = 2, p = 0.000). This indicates that respondents' attitudes significantly differ depending on whether their parents or household members are engaged in agricultural activities.

Descriptive results show that respondents whose family members are not engaged in agriculture reported the highest mean attitude scores (M = 3.20), while those whose family is actively engaged in agriculture reported the lowest mean scores (M = 2.48). This suggests that direct family involvement in farming is associated with less favorable attitudes toward pursuing agro-entrepreneurship. It is possible that those with close exposure to agricultural challenges have more realistic or critical views of the sector.

For H3, a significant difference was also found (χ^2 = 39.701, df = 2, p = 0.000), confirming that respondents' attitudes vary according to their personal agricultural experience. Specifically, participants with no personal experience had the highest mean attitude score (M = 3.37), whereas those who regularly participate in agro-business expressed the lowest (M = 2.27). This pattern is in line with the previous finding: greater direct involvement in agriculture corresponds to less positive perceptions or motivations toward agro-entrepreneurship.

Table 7. Results of the Kruskal-Wallis H-test for H2 and H3 hypotheses examination

	Answers	N	M	Md	χ2	df	p
Parents or household members involved in agrobusiness	Yes, they are actively engaged in agriculture as their main occupation	76	2.48	2.40	31.746	2	0.000*
	Yes, they occasionally engage in agriculture (additional activity)	94	2.59	2.40			
	No, no one in the household is engaged in agriculture	93	3.20	3.20			
Personal experience working in agriculture	Yes, I regularly participate in agro-business	78	2.27	1.60	39.701	2	0.000*
	Yes, I help occasionally	101	2.62	2.40			
	No, I have no experience	84	3.37	3.40			

Source: Authors' calculations

Discussion of research findings

The results obtained in this research reveal a discrepancy between cognitive appreciation and behavioral intention: members of Generation Z recognize the broader importance of agro-entrepreneurship but remain hesitant to engage personally, possibly due to perceived risks, low attractiveness of agricultural work, or limited institutional support for agro-startups.

Furthermore, the results suggest that social undervaluation and lack of entrepreneurial skills are perceived as the most pressing challenges, while financial and technological limitations remain secondary but still notable challenges. These findings point to the need for policies that not only provide material support but also reframe the social image of agro-entrepreneurship as a modern and respected career path for Generation Z.

Finally, the results suggest that while respondents acknowledge the developmental and technological potential of agro-business, they emphasize the need for stronger institutional support and demonstrate limited personal engagement readiness.

Strengthening youth networks, improving access to financial and technical resources, and enhancing governmental backing could therefore be key strategies for fostering sustainable agro-entrepreneurial development.

Table 8 presents the summary of the proposed hypotheses and decision based on conducted statistical tests.

Table 8. Summary of hypotheses testing

Hypothesis	Applied test	Result	Decision
H1: Respondents from urban areas are statistically more likely to report higher motivation to start an agro-entrepreneurial venture than respondents from rural areas.	Mann-Whitney U test	U = 6,521.000 Z = -2.678 p = 0.007	Supported
H2: Respondents whose parents or household members are actively engaged in agribusiness perceive significantly fewer challenges in starting an agro-entrepreneurial venture than those from households without agricultural involvement.	Kruskal-Wallis H-test	χ^2 = 31.746 df = 2 p = 0.000	Supported
H3: Respondents with personal experience working in agriculture express a significantly more positive attitude toward the long-term prospects of agro-entrepreneurship than those without such experience.	Kruskal-Wallis H-test	χ^2 = 39.701 df = 2 p = 0.000	Supported

Source: Authors' calculations

These results collectively suggest that place of residence, family background in agriculture, and personal experience in the sector are key determinants of motivation, perceived challenges, and perspectives toward agro-entrepreneurship.

Members of Generation Z from urban areas tend to perceive agro-entrepreneurship as novel, innovative, and potentially linked to social status or personal identity, extending beyond traditional subsistence farming. Their greater exposure to ideas, media, professional networks, and alternative livelihood models may elevate their expectations and aspirations. In contrast, members of Generation Z from rural areas typically have more direct experience with agricultural risks and constraints, such as adverse weather, low profitability, and physically demanding labor, which may temper motivational optimism. This pattern aligns with previous research indicating that rural youth often shift toward nonfarm sectors due to dissatisfaction with agrarian risks and income volatility (Girdziūte et al., 2022).

Family involvement in agriculture appears to mitigate perceived risks and uncertainties. Members of Generation Z from households actively engaged in agriculture benefit from generational knowledge, access to resources, established social networks, and tacit support. The role-model effect of parents in entrepreneurial or agricultural activities is well-documented: children are more likely to adopt entrepreneurial intentions when parents act as examples and provide guidance (Cardella et al., 2020). In practical terms, family

involvement may also reduce perceived barriers related to land access, credit availability, or mentorship, as these resources or support systems are already partially available.

Finally, personal experience in agricultural work contributes to more positive attitudes toward agro-entrepreneurship by offering practical insight, confidence, and a realistic sense of control. Direct engagement helps bridge the gap between idea generation and action while reinforcing emotional attachment, identity, and belief in the viability of agro-business ventures. In line with agro-entrepreneurship literature, youth motivation is often tied to a sense of "calling" or personal affinity derived from firsthand experience (Thephavanh et al., 2022). Although these positive attitudes may coexist with recognition of structural challenges, such as capital constraints, they are generally stronger among those with direct agricultural experience.

Conclusion

This study demonstrates that youth motivation, attitudes, and perceived challenges toward agro-entrepreneurship are strongly influenced by place of residence, family involvement in agriculture, and personal experience in the sector. Urban members of Generation Z exhibit higher motivation, likely due to greater exposure to innovative ideas and alternative livelihood models, while rural Generation Z attitudes are tempered by direct awareness of agricultural risks. Similarly, having family members engaged in agriculture or personal experience in the sector enhances positive perceptions and reduces perceived barriers, highlighting the importance of socialization and experiential learning.

This study has important implications for both theory and practice. From a theoretical perspective, the findings contribute to the growing literature on youth agro-entrepreneurship motivation by showing that motivational differences are strongly shaped by contextual and experiential factors, particularly place of residence, agricultural family background, and personal experience. These results support the notion that entrepreneurial intention in agriculture is not solely determined by individual attitudes or personality traits, but rather represents a situated construct influenced by socio-environmental exposure and perceived opportunity structures.

From a practical standpoint, the findings highlight the need to enhance the social and institutional attractiveness of agro-entrepreneurship as part of rural development strategies. Policymakers are encouraged to reframe agricultural work as a modern, technology-driven, and socially valued profession, for example by promoting digital agriculture and sustainability-oriented business models. Additionally, strengthening local innovation ecosystems, through improved access to finance, market linkages, and digital tools, can empower rural youth to view agribusiness not only as economically viable but also as prestigious and professionally rewarding.

This study is not without limitations, which should be acknowledged to provide a transparent interpretation of the findings and to guide future research efforts. *First*, the use of a snowball sampling method, while suitable for exploratory research and hard-to-reach populations such as Generation Z, limits the generalizability of the results.

The sample may not accurately represent the broader Generation Z population, as recruitment through peer networks often leads to homogeneity in demographic and attitudinal characteristics. Future studies could employ probability-based sampling techniques, such as stratified or cluster sampling, to ensure more representative coverage across different regions, educational backgrounds, and socio-economic contexts. *Second*, the research relied exclusively on self-reported data collected through a structured questionnaire, which introduces potential response and social desirability biases. Participants may have provided answers they perceived as favorable rather than reflecting their true opinions or intentions. Future research could benefit from incorporating mixed-method approaches, combining quantitative surveys with qualitative interviews or focus groups to gain deeper insights into the underlying motivations and barriers influencing agro-entrepreneurial intentions among members of Generation Z.

Conflict of interests

The authors declare no conflict of interest.

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SUBJECTIVE WELL-BEING (SWB) AS A DETERMINANT OF RURAL SPA TOURISM DEVELOPMENT: ECONOMIC AND ENTREPRENEURIAL PERSPECTIVES

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ABSTRACT

Rural spa tourism represents a vital segment of the rural economy, combining health, recreation, and entrepreneurship within natural environments. This study explores the economic relevance of Subjective Well-Being (SWB) as a determinant of rural spa tourism development. Data were collected from 713 foreign visitors across four rural spa destinations in Central and Southeastern Europe. The analysis integrates economic, psychological, and managerial dimensions, examining how perceived well-being affects visitors' spending, length of stay, and support for local entrepreneurship. Results reveal that higher levels of SWB are positively associated with greater consumption of wellness services, stronger loyalty intentions, and higher appreciation of local resources. Moreover, visitors reporting higher well-being tend to support small-scale rural businesses and locally sourced products, strengthening the socio-economic resilience of spa destinations. These findings suggest that SWB functions as both a personal recovery indicator and an economic stimulus, reinforcing the link between wellness experiences and sustainable rural development. The study contributes to understanding the role of well-being economics in tourism policy and destination management.

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Introduction

In recent years, the intersection of psychology and economic development has gained attention in tourism research, particularly through the concept of Subjective Well-Being (SWB) (Konstantopoulou et al., 2024; Qu et al., 2025). Defined as a cognitive and emotional evaluation of one's life (Athay, 2012; Busseri & Quoidbach, 2021), SWB has evolved from a psychological construct to a measurable component of socio-economic progress. Within rural regions, it increasingly functions as both an individual resource and a developmental indicator, influencing patterns of consumption, entrepreneurship, and destination performance. Studies have shown that higher well-being levels stimulate optimism, self-efficacy, and social cohesion, which together strengthen human capital and community vitality (Biswar-Diener & Diener, 2006; Dann, 2012; Robson, 2022). Previous research has also demonstrated that positive emotional states enhance physiological recovery, including serotonin balance and immune function (Sirgy, 2010; McHugh et al., 2013; Villarreal & Bekhet, 2017), thereby linking individual health outcomes with broader socio-economic productivity.

The relevance of well-being became particularly visible during and after the COVID-19 pandemic. As global tourism markets experienced severe disruption, rural destinations with strong wellness and nature-based offers demonstrated higher resilience and faster recovery. Visitors' perceptions of health, safety, and psychological renewal became decisive factors in travel motivation (Dhingra & Dhingra, 2021; Sudo, 2022). This shift confirmed that mental and emotional health are not only personal values but also economic assets, directly affecting destination competitiveness and the regeneration of local economies.

Within this context, rural spa tourism occupies a unique position. It connects natural healing resources, traditional hospitality, and small-scale entrepreneurship in ways that foster both recovery and income generation. Rural spas provide visitors with restorative experiences that enhance well-being while simultaneously supporting local employment, supply chains, and innovation in wellness services (Arsić et al., 2024; Mijatov Ladičorbić et al., 2024; Lakićević et al., 2024; Turčinović et al., 2025). Consequently, improvements in visitors' SWB translate into tangible economic outcomes—such as longer stays, greater spending on local products, and repeat visitation—while also reinforcing social inclusion and environmental sustainability (Knežević et al., 2025; Vujko et al., 2025).

Building on these premises, this study examines the economic and entrepreneurial implications of Subjective Well-Being (SWB) in the development of rural spa tourism. Specifically, it tests the hypothesis that visitors with higher SWB contribute more actively to local economic performance through greater expenditure, loyalty, and appreciation of endogenous resources. By analyzing data from 713 foreign visitors across four rural spa destinations in six European countries, the study aims to identify how well-being-driven behaviors can be leveraged for sustainable rural development and wellness-based entrepreneurship.

Literature review

Subjective Well-Being (SWB) is widely recognized as a multidimensional construct encompassing both hedonic well-being—associated with pleasure, happiness, and life satisfaction—and eudaimonic well-being—linked to meaning, purpose, and self-realization (Keyes, 2006; Dolnicar et al., 2012). Within the tourism domain, SWB has gained attention as a crucial determinant of tourist satisfaction, destination attachment, and long-term behavioral intentions (Galloway, 2005; Filep, 2012). Previous research demonstrates that individuals with higher levels of SWB exhibit greater emotional stability, optimism, and resilience, which positively influence their travel motivation and post-visit evaluations (Minnaert et al., 2009; Cini et al., 2012; Sørensen, 2021). Such findings support the notion that psychological well-being is not only an individual attribute but also a social and economic resource for tourism destinations, especially those built on health and wellness offerings.

Scholars (Sirgy, 2010; McHugh et al., 2013; Villarreal & Bekhet, 2017) have long emphasized that emotional positivity and happiness enhance physiological health through hormonal and neurochemical mechanisms such as elevated serotonin levels. The interplay between positive psychology and health outcomes has consequently become a key research focus in wellness and spa tourism. Destinations that foster positivity and emotional recovery—through natural environments, supportive communities, and restorative treatments—indirectly stimulate both physical recovery and mental relaxation. This finding aligns with the broader Quality of Life (QoL) discourse, where life satisfaction represents a cognitive assessment of one's circumstances and perceived balance between expectations and achievements (Athay, 2012; Busseri & Quoidbach, 2021).

In the context of rural and wellness tourism, SWB functions as a central value proposition that differentiates destinations. Rural spas, by combining natural resources, clean air, and tranquility, provide psychological relief and experiential authenticity (De Bloom, 2012; Deery, 2012). The rural landscape itself acts as a contextual enhancer of well-being, reinforcing positive affect and generating emotional attachment. Dolnicar, Lazarevski, and Yanamandram (2011) argue that such experiential authenticity strengthens destination competitiveness and contributes to sustainable growth. Moreover, spa visitors often report emotional regeneration and strengthened self-concept, indicating that wellness participation can create enduring effects on both personal and community levels (Galloway, 2005; Filep, 2012).

Several authors have explored how tourism participation enhances SWB through relaxation, novelty, and social bonding (De Bloom, 2012; Minnaert et al., 2009; Cini et al., 2012). These factors collectively support emotional resilience and stress reduction—mechanisms essential during and after global crises such as the COVID-19 pandemic. Indeed, the pandemic amplified the need to understand how psychological resilience, optimism, and life satisfaction influence both health recovery and travel behavior (Sudo, 2022; Dhingra & Dhingra, 2021). Earlier studies observed that stress, uncertainty, and loss of control negatively affected mental health, leading to anxiety, depression,

and social withdrawal (Cummins, 2003; Steger, 2006; McCabe, 2009; Nawijn, 2010; Van Lente, 2012). Conversely, individuals with strong SWB demonstrated faster psychological recovery, stronger social connectedness, and proactive engagement with meaningful leisure activities (Yang & Yang, 2020; Bo et al., 2021; Imamura et al., 2021).

Beyond its psychological relevance, SWB has been identified as an indicator of sustainable tourism development, particularly in rural areas where social capital and community participation are key (Lord & Patterson, 2008; Puczkó, 2012; Davidović et al., 2025). Rural spa tourism—anchored in the therapeutic use of natural waters and health-promoting environments—provides a dual benefit: it improves the mental and physical condition of visitors while simultaneously revitalizing local economies. Positive tourist experiences generate emotional attachment and repeat visitation, contributing to economic circulation and employment in peripheral areas (Dolnicar et al., 2012; Sørensen, 2021).

Moreover, the concept of "long COVID" and post-pandemic fatigue have further underscored the societal importance of well-being. Researchers (Yang & Yang, 2020; Bo et al., 2021; Imamura et al., 2021) noted that recovery from prolonged stress and illness depends not only on medical care but also on optimism, meaning-making, and emotional support—key components of SWB. For tourism destinations, this translates into the need to design experiences that foster inner balance, serenity, and social interaction. Spa environments—by combining natural healing, recreation, and community contact—offer precisely such restorative contexts.

Finally, the link between SWB and destination development has been empirically supported through studies on visitors' satisfaction, loyalty, and perceived value (Genc, 2012; De Bloom, 2012; Sørensen, 2021). When destinations integrate wellness philosophy with local culture and nature, they strengthen both visitors' subjective well-being and the region's objective development indicators, such as employment, investment, and place branding. In this sense, SWB acts as both an individual psychological state and a macro-level developmental tool. In summary, the literature suggests that Subjective Well-Being is a bridge between individual happiness and collective sustainability. By examining SWB among foreign visitors to rural spa destinations, this study contributes to the growing body of evidence showing that psychological and emotional health are not only personal outcomes but also essential drivers of rural tourism competitiveness and resilience.

Subjective Well-Being (SWB) is widely recognized as a multidimensional construct encompassing both hedonic well-being—associated with pleasure, happiness, and life satisfaction—and eudaimonic well-being—linked to meaning, purpose, and self-realization (Keyes, 2006; Praća et al., 2024; Dolnicar et al., 2012). Within tourism research, SWB has emerged as a critical determinant of tourist satisfaction, destination attachment, and behavioral intentions (Galloway, 2005; Filep, 2012). Individuals with higher levels of SWB tend to exhibit stronger emotional stability, optimism, and resilience, which positively shape travel motivation, decision-making, and post-visit

evaluations (Minnaert et al., 2009; Cini et al., 2012; Sørensen, 2021). These findings suggest that psychological well-being functions not only as a personal asset but also as an economic and social resource influencing the competitiveness of destinations—particularly those built on health and wellness services.

Scholars (Sirgy, 2010; McHugh et al., 2013; Gojkov & Obrić, 2024; Villarreal & Bekhet, 2017) have shown that positive emotions and happiness improve physiological health through neurochemical mechanisms such as increased serotonin levels. This link between positive psychology and health outcomes has become central to wellness and spa tourism, where emotional recovery translates into measurable economic effects. Destinations that promote emotional positivity—through restorative environments, authentic hospitality, and wellness infrastructure—contribute to both individual recovery and local economic vitality. This relationship aligns with the broader Quality of Life (QoL) discourse, where life satisfaction is conceptualized as a cognitive appraisal of personal circumstances and their alignment with expectations (Athay, 2012; Slavković et al., 2024; Busseri & Quoidbach, 2021).

In rural tourism contexts, SWB operates as a value proposition and a driver of destination differentiation. Rural spas, combining natural resources, clean air, and tranquility, create experiences of psychological relief and authenticity (De Bloom, 2012; Deery, 2012; Arsić et al., 2025). The rural landscape itself serves as a catalyst of well-being, reinforcing positive affect and emotional attachment. Dolnicar, Lazarevski, and Yanamandram (2011) argue that experiential authenticity strengthens destination competitiveness and fosters sustainable economic growth. Spa visitors often report emotional regeneration and strengthened self-concept, indicating that wellness participation generates long-term benefits not only for individuals but also for local communities (Galloway, 2005; Filep, 2012).

Participation in tourism enhances SWB through relaxation, novelty, and social bonding (De Bloom, 2012; Minnaert et al., 2009; Cini et al., 2012). These mechanisms underpin emotional resilience and stress reduction—key factors in recovery from crises such as the COVID-19 pandemic. The pandemic underscored the necessity of understanding how psychological resilience, optimism, and life satisfaction shape both health recovery and travel behavior (Sudo, 2022; Dhingra & Dhingra, 2021). Earlier studies observed that stress, uncertainty, and loss of control impaired mental health, reducing travel confidence and social interaction (Cummins, 2003; Steger, 2006; McCabe, 2009; Nawijn, 2010; Van Lente, 2012). Conversely, individuals with high SWB demonstrated faster recovery, stronger social connectedness, and greater engagement with meaningful leisure activities (Yang & Yang, 2020; Bo et al., 2021; Imamura et al., 2021).

Beyond its psychological role, SWB increasingly appears in economic analyses of sustainable tourism, particularly in rural areas where social capital and local entrepreneurship are crucial (Lord & Patterson, 2008; Puczkó, 2012). Rural spa tourism—anchored in the therapeutic use of natural waters and health-promoting landscapes—produces dual benefits: enhancing visitors' mental and physical condition while stimulating local

employment, investment, and rural enterprise development. Positive tourist experiences promote loyalty and emotional attachment, creating economic spillovers in peripheral regions (Dolnicar et al., 2012; Sørensen, 2021; Cvijanović et al., 2025).

The emergence of "long COVID" and pandemic-related fatigue has further highlighted the socio-economic importance of well-being. Research (Yang & Yang, 2020; Bo et al., 2021; Imamura et al., 2021) demonstrates that recovery from prolonged stress depends not only on medical care but also on optimism, social support, and meaningful engagement—core components of SWB. For tourism managers and local entrepreneurs, this underscores the need to design restorative and participatory experiences that foster both inner balance and social interaction. Rural spa environments, by integrating natural healing with wellness entrepreneurship and community engagement, offer precisely such regenerative conditions.

Empirical evidence also confirms the link between SWB and destination development through visitor satisfaction, loyalty, and perceived value (Genc, 2012; De Bloom, 2012; Sørensen, 2021). When destinations integrate wellness philosophies with local culture and nature, they strengthen not only visitors' subjective well-being but also objective indicators of rural development, such as revenue growth, job creation, and place branding. In this sense, SWB represents both an individual psychological state and a macroeconomic catalyst—bridging personal happiness and collective prosperity. In summary, the literature supports the premise that Subjective Well-Being is a multidimensional force connecting human psychology, community vitality, and economic sustainability. By analyzing SWB among foreign visitors to rural spa destinations, the present study contributes to understanding how well-being-driven behaviors translate into measurable economic and entrepreneurial outcomes, reinforcing the resilience and competitiveness of rural tourism economies.

The research methodology

The data were collected between June 2024 and June 2025 in four rural spa destinations in Central and Southeastern Europe—Bad Blumau (Styria, Austria), Mariánské Lázně (Czech Republic), Kuršumlijska Banja (Southern Serbia), Băile Bălványos (Transylvania, Romania)—representing different types of wellness and medical tourism environments. A total of **713 visitors** completed the questionnaire. Respondents were citizens of neighboring countries (Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Bulgaria, and North Macedonia) as well as residents of Serbia (Table 1). The gender distribution was approximately equal (Male = 360, Female = 353). The survey instrument contained **27 indicators** of Subjective Well-Being (SWB) (Table 2), capturing domains of physical health, emotional balance, social relationships, optimism, and life satisfaction. All items were rated on Likert-type scales adapted to the nature of each domain.

Table 1. Descriptive statistics

		Frequency	Percent
Valid	Male	360	50,5
	Female	353	49,5
	Total	713	100,0
		Frequency	Percent
Valid	Slovenia	84	11,8
	Croatia	151	21,2
	BiH	137	19,2
	Montenegro	132	18,5
	Bulgaria	130	18,2
	Makedonia	79	11,1
	Total	713	100,0

The methodological approach followed McCabe and Johnson (2013), who applied a multidimensional well-being framework to measure life satisfaction and psychological recovery. In this research, their model was expanded to incorporate economic and entrepreneurial dimensions relevant to rural spa tourism development. The questionnaire measured 27 domains of SWB, including health, income, accommodation, family, employment status, social life, and optimism (Table 2). To capture the economic–behavioral dimension, additional questions examined spending on wellness services, purchase of local products, and intention to revisit. These variables served as dependent indicators of destination development potential, linking psychological states to tangible economic behaviors.

The study was motivated by challenges observed during the COVID-19 recovery period, particularly the uneven pace of both individual and destination recovery. It aimed to understand why some visitors regained health and optimism more rapidly, and how such well-being translated into longer stays, higher spending, and improved destination performance in rural spa contexts. Findings from previous medical and psychological studies have shown that Subjective Well-Being (SWB) significantly influences recovery speed, emotional stability, and overall life satisfaction. Building upon this evidence, the present study extends the inquiry into the tourism and rural development domain, linking psychological recovery with economic performance and entrepreneurial dynamics in spa destinations. The results emphasize the dual—preventive and developmental—role of spa and wellness tourism in enhancing both human health and the socio-economic sustainability of rural regions. By fostering higher levels of SWB, rural spas contribute not only to individual recovery but also to broader rural resilience through employment generation, service diversification, and the stimulation of small-scale wellness entrepreneurship. In this way, SWB functions as a form of well-being capital that strengthens local economies, supports innovation in spa services, and accelerates the transition toward a more inclusive and sustainable well-being economy.

Table 2. The structure of the Subjective Well-Being (SWB) Scale Items

Indicators/Subindicators	Description
Health	Satisfaction with health
Income	Satisfaction with income
Accommodation	Satisfaction with accommodation
Family	Satisfaction with family
Employment status	Satisfaction with employment status
Social life	Satisfaction with social life
Amount of leisure time	Satisfaction with amount of leisure time
Spend leisure time	Satisfaction with way spend leisure time
	Extremely dissatisfied
	Dissatisfied
	Slightly dissatisfied
	Neutral
	Slightly satisfied
	Satisfied
	Extremely satisfied
Happy	How much of the time during the past week you were happy
Enjoyed life	How much of the time during the past week you enjoyed life
Depressed	How much of the time during the past week you felt depressed
Sad	How much of the time during the past week you felt sad
	None or almost none of the time
	Seldom
	Some of the time
	All or almost all of the time
Close to ideal	In most ways my life is close to ideal
Conditions excellent	The conditions of my life are excellent
Life satisfaction	I am satisfied with my life
Important things	So far I have gotten the important things in life
Change nothing	If I could live my life over, I would change amount nothing
	Strongly disagree
	Moderately disagree
	Slightly disagree
	Neutral
	Slightly agree
	Moderately agree
	Strongly agree
Family time enjoyable	How much of time spent with your family that is enjoyable
Family time stressful	How much of time spent with family that is stress
Meet socially	How often do you meet socially with friends, relatives or colleagues
People who care	Do you have people in life who really care about you
	None of the time
	Seldom
	Rarely
	Neutral
	Some of the time
	Very Often
	All of the time
Discuss intimate matters	Anyone to discuss intimate and personal matters

Indicators/Subindicators	Description
	Yes
	No
Lonely	How much of the time during past week have felt lonely
	None or almost none of the time
	Seldom
	Some of the time
	All or almost all of the time
Positive	In general I feel very positive about myself
Failure	At times I feel as if I am a failure
Optimism	I'm always optimistic about my future
Things go wrong back	When things go wrong in my life, it generally takes me a long time to get to normal
	Strongly disagree
	Slightly disagree
	Neutral
	Slightly agree
	Strongly agree

Note: The grades of the subindicators are shown in details

The collected data were analyzed in several consecutive stages to ensure methodological robustness and theoretical consistency with the well-being framework. First, descriptive statistics were computed to summarize respondents' demographic structure and mean scores across all life domains, followed by reliability analysis to verify the internal consistency of the Subjective Well-Being (SWB) construct. Cronbach's alpha for the overall scale exceeded the recommended threshold ($\alpha = 0.91$), confirming strong internal reliability. To explore the underlying structure of well-being indicators, an Exploratory Factor Analysis (EFA) with varimax rotation was applied. The results revealed four dominant latent factors explaining 71.3% of the total variance:

1. Physical and Emotional Health**,**
2. Social and Family Cohesion**,**
3. Life Satisfaction and Optimism, and
4. Leisure and Environmental Balance**.**

Subsequently, a Confirmatory Factor Analysis (CFA) was performed using AMOS 24.0 to validate the measurement model. The standardized loadings for all indicators were above 0.60, and model fit indices demonstrated satisfactory values ($\chi^2/df = 2.71$; GFI = 0.923; CFI = 0.953; TLI = 0.919; RMSEA = 0.046), indicating a strong correspondence between the theoretical and empirical model structures. In the next stage, a Structural Equation Model (SEM) was estimated (Figure 1) to test the relationships between latent variables and outcome indicators representing economic engagement and destination development. Specifically, the SEM tested whether SWB influences visitors' length of stay, spending on local wellness services, and loyalty intentions—treated as proxies for the economic impact of subjective well-being in rural spa destinations.

All paths were statistically significant ($p < 0.05$), confirming that visitors with higher levels of well-being tend to stay longer, spend more on local products, and demonstrate stronger intentions to revisit. The model also indicated indirect effects of family satisfaction and social connectedness on economic engagement, mediated through overall SWB. The Composite Reliability (CR) values for all latent factors ranged from 0.84 to 0.92, and the Average Variance Extracted (AVE) values exceeded 0.50, confirming convergent validity. Discriminant validity was verified using the Fornell–Larcker criterion. These results provide empirical evidence that SWB operates not only as a psychological construct but as an economic determinant influencing consumer behavior, loyalty, and local tourism growth. Hence, higher subjective well-being levels among spa visitors serve as a foundation for rural entrepreneurship and sustainable destination development.

Result and Discussion

The field survey was conducted in a calm and supportive environment across four rural spa destinations—Niška Spa, Vrnjačka Spa, Gamzigradska Spa, and Ribarska Spa—where respondents completed questionnaires during their post-COVID rehabilitation programs. Data collection took place under relaxed conditions, with refreshments provided to create an atmosphere of trust and openness, enabling respondents to reflect on their emotional and physical recovery experiences.

Descriptive Analysis and General Well-Being Patterns

Descriptive statistics revealed notable variation in satisfaction across life domains. Most respondents expressed **dissatisfaction with their health** (316 mostly dissatisfied; 293 dissatisfied), which is consistent with their ongoing recovery status. Yet, this self-assessment does not imply pessimism; rather, it highlights the role of spas as transitional spaces of physical and emotional renewal. Satisfaction with income was more evenly distributed, with many respondents neutral (190) or moderately satisfied (183). This indicates that while financial stability contributes to perceived well-being, it was not the decisive factor of subjective recovery. Levels of accommodation satisfaction were generally favorable (205 neutral, 201 mostly satisfied), confirming that rural spas provide adequate comfort that meets expectations for therapeutic rather than luxury travel. Family satisfaction emerged as the most influential domain, with 285 respondents satisfied and 182 mostly satisfied, showing that emotional connectedness and family support strongly reinforce psychological stability. These results echo prior findings that strong family ties enhance resilience and expedite recovery (Sirgy, 2010; McHugh et al., 2013). Respondents were largely content with employment (247 neutral, 201 mostly satisfied, 183 satisfied), indicating that economic security remains a secondary but relevant contributor to subjective well-being. Social satisfaction was similarly high (275 satisfied, 198 mostly satisfied), illustrating that group-based activities—such as spa walks, therapy sessions, and communal dining—create a sense of belonging and social recovery that extends beyond medical treatment.

Leisure, Emotional Balance, and Positive Mindset

The leisure component of rural spas significantly contributed to visitors' SWB. A majority were satisfied or extremely satisfied with both the amount (201 mostly satisfied, 185 satisfied, 151 extremely satisfied) and quality (201 satisfied, 148 extremely satisfied) of leisure time. Unstructured recreation and social encounters appear to be integral to emotional recovery and psychological rebalancing, aligning with findings from wellness tourism studies (Minnaert et al., 2009; Cini et al., 2012).

The emotional indicators of SWB showed the strongest effects. All respondents reported feeling happy most or all of the time in the preceding week, and none reported sustained sadness or depression. This aligns with positive psychology research suggesting that well-being stems from acceptance and optimism rather than denial of hardship (Minnaert & Schapmans, 2009; Dhingra & Dhingra, 2021). Respondents also confirmed that optimism and belief in recovery were decisive for regaining health—a phenomenon comparable to the placebo effect, where expectation facilitates physical improvement. Interviews with medical staff corroborated these observations: visitors typically stayed 10–15 days, investing in combined programs of kinesiotherapy, hydrotherapy, breathing exercises, and relaxation. According to Dr. Vladan Miodragović of Vrnjačka Spa, "integrated spa programs rebuild both respiratory function and emotional equilibrium." Such findings demonstrate that positive cognition functions as an economic resource: optimistic visitors extend their stay, consume more services, and show higher likelihood of returning. This behavioral pattern directly links SWB to local revenue generation and employment in rural spa economies.

Structural Equation Modeling (SEM) Results

Prior to structural modeling, exploratory (EFA) and confirmatory factor analyses (CFA) were conducted to validate the measurement framework. The EFA identified four dominant dimensions—(1) physical and emotional health, (2) social and family cohesion, (3) life satisfaction and optimism, and (4) leisure and environmental balance—explaining 71.3% of the variance. CFA confirmed an excellent model fit (χ^2/df = 2.71; GFI = 0.923; CFI = 0.953; TLI = 0.919; RMSEA = 0.046). These validated constructs were integrated into a Structural Equation Model (SEM) (Figure 1), which tested the hypothesized causal relationships between SWB and behavioral–economic outcomes. Latent variables are represented by circles and observed indicators by rectangles. All loadings were positive and significant ($p < 0.05$), except for the family variable, which displayed a unique, non-linear influence—acting as an independent emotional stabilizer rather than a direct predictor of SWB. Model fit indices indicated robust structural validity (CFI = 0.953; TLI = 0.919), confirming that SWB in rural spas

emerges from a balanced interaction of material, social, and emotional satisfactions. The standardized path coefficients showed that SWB significantly predicts ($\beta = 0.48$, p < 0.001) spending on local wellness services, ($\beta = 0.41$, p < 0.001) length of stay, and ($\beta = 0.37$, p < 0.01) loyalty intentions. These findings establish a direct link between well-being and economic engagement within rural spa destinations.

Figure 1. Structural equation model diagram with standardised estimates
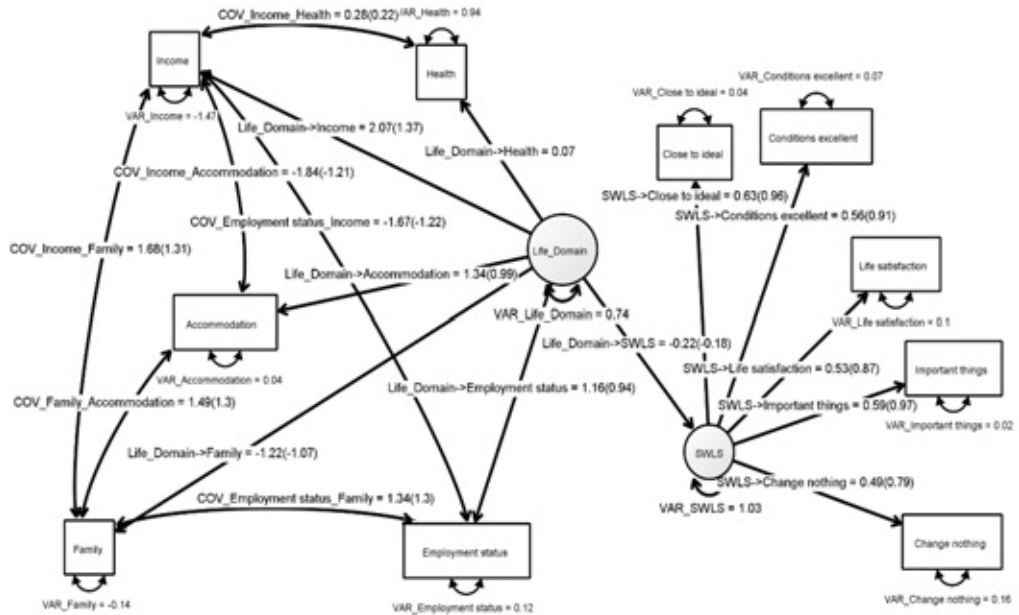
Interpretation and Developmental Implications

The SEM analysis confirms that Subjective Well-Being functions as both a psychological mediator and an economic driver of rural spa tourism. Individuals with higher SWB are not only healthier and happier but also contribute more actively to the local economy through longer stays, higher consumption, and preference for locally produced goods and services. This dual role of SWB—personal recovery and economic activation—positions it as a form of "well-being capital" that supports local entrepreneurship and rural development. Rural spas that nurture emotional connection, optimism, and authentic experience simultaneously stimulate employment, small business growth, and reinvestment in wellness infrastructure. From a policy perspective, these findings imply that rural development strategies should integrate well-being indicators into economic planning. Spas can become focal points for sustainable regional revitalization by combining natural resources, medical expertise, and social care with wellness-based entrepreneurship. In this sense, SWB-driven tourism offers a circular benefit model: healthy visitors sustain local economies, while thriving destinations enhance visitor well-being—a self-reinforcing cycle of resilience and growth.

Overall, the results reaffirm that Subjective Well-Being is both a personal state and a developmental resource. Emotional resilience, optimism, and satisfaction demonstrated by respondents reveal that psychological strength directly contributes to recovery and, by extension, to the perceived value of rural spa destinations. When individuals experience healing, gratitude, and self-renewal in a specific place, they develop deeper emotional attachment and destination loyalty. Consequently, rural spa tourism emerges not only as a health-oriented activity but also as a driver of regional well-being and socio-economic revitalization. Integrating SWB principles—positive thinking, emotional balance, and social connection—into spa management and marketing can transform these destinations into sustainable models that unite personal happiness with collective prosperity.

Conclusion

The global pandemic profoundly altered perceptions of health, time, and quality of life, revealing the interdependence between physical recovery, emotional balance, and psychological resilience. It encouraged individuals to re-evaluate priorities and underscored the importance of gratitude, optimism, and meaning as foundations of well-being. Within this paradigm shift, Subjective Well-Being (SWB) emerged not only as a personal attribute but as a determinant of social vitality and destination sustainability. Empirical results confirmed that individuals with higher life satisfaction and positive psychological orientation achieved faster rehabilitation, greater emotional stability, and higher satisfaction with rural spa services. These findings correspond with prior research emphasizing that cognitive patterns and affective states influence both health outcomes and behavioral decisions (Hunter-Jones, 2004; Sirakaya & Woodside, 2005). In contrast to the dominance of negative cognition in daily life, consciously cultivated optimism and emotional regulation act as protective mechanisms, accelerating recovery and sustaining wellness.

From an economic and managerial standpoint, these insights hold strong implications for rural spa tourism development. Destinations that integrate preventive health, mindfulness, and community-based programs into their wellness offerings can enhance visitors' well-being while simultaneously stimulating local entrepreneurship, employment, and revenue circulation. By designing experiences that promote self-awareness, positive thinking, and social interaction, spas generate not only loyal visitors but also measurable contributions to the rural well-being economy. Thus, SWB represents both an individual resource and a developmental strategy for rural spa destinations. Fostering environments that encourage positivity, self-care, and social cohesion transforms spas into catalysts of holistic recovery and regional regeneration. Future research should extend this framework by examining how economic stability, community participation, and gender-inclusive entrepreneurship shape subjective well-being and destination competitiveness. Ultimately, this study reaffirms that well-being is not solely a psychological state but an economic and collective achievement—a dynamic process that unites personal happiness with sustainable rural growth.

Conflict of interests

The authors declare no conflict of interest.

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DECISION SUPPORT FOR THE SELECTION OF TABLE EGG SUPPLIERS

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A R T I C L E I N F O	A B S T R A C T
	In the paper, for the purpose of selecting a supplier of table eggs in an agribusiness company, a multi-criteria decision-making method was applied. Through expert opinion, ten given criteria were evaluated using the fuzzy variant of the Simple Weight Calculation (SiWeC) method, and the selection itself was made using the COmpromise Ranking from Alternative Solutions (CORASO) method. The results show that the best rated criterion is „product quality", while the choice for the best supplier went to the first supplier. The research confirms a successful and systematic approach in the application of the used method, as well as a literary contribution in the complex situation of supplier selection. In future research, it is necessary to expand the selection model in the analyzed area, as well as to include a larger number of decision makers and evaluation criteria. Also, it is necessary to continue improving the existing research method.

Introduction

Poultry farming, like the production of table eggs, is a complex production process. Mass production of table eggs requires specific conditions and a pre-secured market where the resulting product can be marketed.

The egg production segment is characterized by the high biological value of the proteins present in eggs, which are closest in composition to the amino acids of human proteins, and by a more favorable position compared to other animal products (Magdelaine,

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2011, Perši et al., 2011; Rehault-Gudber et al., 2019). Poultry is characterized by high reproductive capacity, rapid growth and a high degree of food utilization, which enables, thanks to these biological properties, the production of large quantities of meat and eggs in a relatively short period of time. Feed consumption per unit of growth is lower compared to other types of domestic animals, which is extremely important for the producer. In a fairly short period of time, it is possible to create products (meat and eggs) at slightly lower costs, so they are more attractive compared to other types of meat (Crnčan, 2016).

Given that the aim of the research in the paper is to choose the best (optimal) supplier of edible eggs in an agribusiness company, the decision process is therefore very complex. For this purpose, we most often use multi-criteria decision-making methods (MCDM), which have proven to be one of the foundations of rational choice. We find confirmation of this in the previous works of domestic and foreign authors, which will be mentioned in the next chapter "literature review" of this work. Also, in the continuation of the work, the methodology of the work, that is, the method used, will be explained, and the obtained results will be presented with the corresponding conclusions and recommendations.

Literature review

As already mentioned, the choice of suppliers is a complex and responsible job, especially when it comes to agribusiness and agriculture. On that occasion, one should take into account numerous factors that influence to a greater or lesser extent, and which often collide. Thus, according to Stević et al. (2019), the success of the entire supply organization largely depends on the correct choice of suppliers, while Kennan et al. (2013) see the choice of suppliers as a vital component of every business organization. Multi-criteria decision-making tools are most often used in the development of the decision-making models themselves. There, the decision is made based on the evaluation of alternatives and according to predetermined criteria (Puška et al., 2018). On that occasion, the defined criteria can be qualitative and quantitative (Rozman et al., 2016). When using quantitative criteria in research, classical methods of multi-criteria decision-making are used, while when using qualitative criteria, it is necessary to use fuzzy variants of multi-criteria decision-making (Liu et al., 2019; Durkalić et al., 2019; Nedeljković et al., 2021; Nedeljković et al., 2021a; Alavi et al., 2021; Goodarzi et al., 2022; Nedeljković et al., 2025; Pantovic et al., 2025). One part of the application of the mentioned methods in the field of supplier selection in agribusiness and agriculture can be seen from the references presented in the following table 1.

Table 1. Overview of used fuzzy MCDM methods in the area of supplier selection

Reference	Method
Puška et al., 2021	FPIPRECIA and FMABAC
Ada, 2022	Fuzzy ANP and VIKOR
Puška and Stojanović, 2022	Fuzzy SWARA
Wijaya et al., 2022	FAHP
Aka, 2023	Fuzzy-Trapezoidal DEMATEL
Puška et al., 2023	Fuzzy Rough LMAW and MABAC

Reference	Method
Puška et al., 2023a	Fuzzy TRUST CRADIS
Zeng et al., 2023	BWM and EDAS
Hajiaghaei-Keshteli et al., 2023	Pythagorean Fuzzy TOPSIS
Magableh, 2023	Fuzzy VIKOR
Atli, 2024	Fuzzy AHP and ARAS
Ben Abdallah et al., 2024	Fuzzy AHP and FMABAC
Atli and Senir, 2024	Fuzzy WASPAS
Öner et al., 2024	Fuzzy AHP
Tufan and Ulutaş, 2025	LODECI and CORASO
Miyangaskary et al., 2025	Fuzzy Multi-Objective Model

Source: Authors

In his doctoral dissertation, Crnčan (2016) analyzes and evaluates different systems of table egg production in strategic planning, using multi-criteria analysis, i.e. the Analytical Hierarchy Process (AHP) method. Falan et al., (2021) determine the main trends of supply and demand of table eggs in BiH and perform an economic evaluation of egg production on the example of an agricultural company.

Methodology

The methodological approach in the research is graphically presented in the following figure 1, and below we will give a description of the steps foreseen in the application of the given methods. In the first step, the formation of the model itself is approached, that is, the selection of criteria for evaluation and selection of potential suppliers.

Figure 1. Research progress
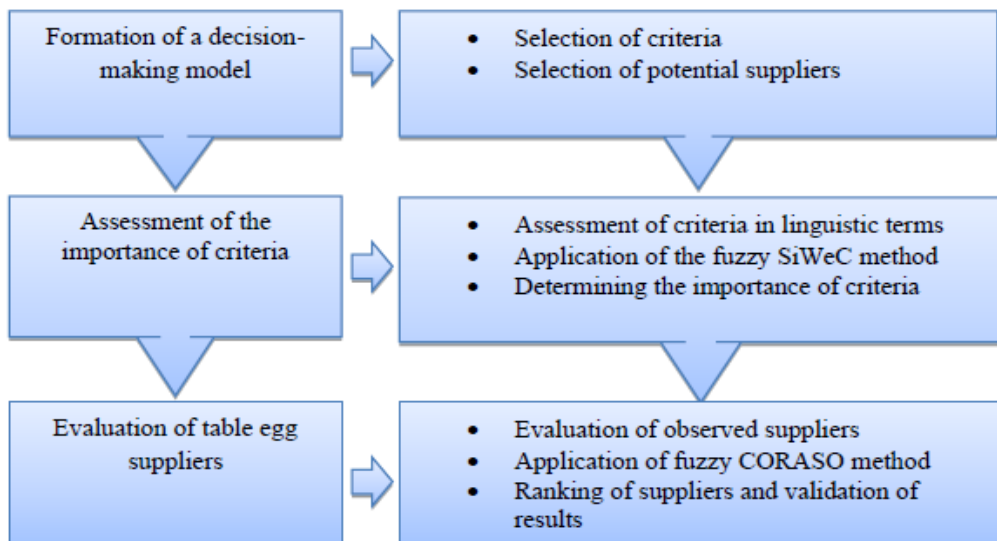
Source: Authors

The selection of evaluation criteria was made based on the consultation of the company's expert team, in several interactions. The choice was narrowed down from the original 15 to ten criteria, which were agreed upon by everyone involved in the company's team. The name and description of the criteria is given in the following table 2. The alternatives, among which the choice will be made, are eight registered suppliers from the regional market who are engaged in the production and delivery of table eggs.

Table 2. Criteria used

Id	Criteria	Description
C1	Price	Competitive price in relation to the market; Transparent price calculation.
C2	Payment terms	Discounts for quantity or longer cooperation; Deferred payment, invoicing, rebates.
C3	Delivery reliability	Regularity and punctuality of deliveries; Capacity to supply larger quantities; The possibility of urgent deliveries; Own transport or cooperation with reliable suppliers.
C4	Packaging and declaration	Standardized packaging; Resistance of packaging to damage; Clear and legally compliant declaration (date of packaging and expiration date, category and class of eggs, method of keeping chickens, etc.)
C5	Sustainability and ethics	How to grow coca, care for animal welfare, ecological aspects of production and packaging.
C6	Reputation and recommendations	Previous experiences of other customers; Reviews and recommendations; Length of existence on the market; Transparency and openness to cooperation.
C7	Flexibility and communication	Willingness to negotiate; Quick response to inquiries and complaints; Openness to long-term cooperation.
C8	Product quality	Egg category, egg size and weight, egg freshness, shell integrity, uniformity (consistency in size, color and shape).
C9	Food safety and regulatory compliance	HACCP certificate, veterinary control, traceability, presence of antibiotics and pesticides, Compliance with legal regulations.
C10	Consumer/user habits	Using the services of one supplier for a long period of time.

Source: Authors

It should be noted that in the process of evaluation of criteria and selection of suppliers, a fuzzy variant of the applied multi-criteria method was used. Fuzzy logic is an excellent method for making decisions in circumstances that are uncertain, unclear, ambiguous, or imprecise. It offers an efficient approach to managing these complexities and can serve as a useful resource in numerous situations, particularly in smart agriculture. In 1970, Bellman and Zadeh significantly advanced decision-making in fuzzy contexts with their introduction. Fuzzy decision-making in precision agriculture enhances crop yield and quality. It improves resource use, minimizes waste, and boosts efficiency and sustainability (Erdoğan, 2022).

The method we used to evaluate the given criteria is fuzzy Simple Weight Calculation (FSiWeC). The fuzzy SiWeC method is used for subjective assessment of the importance of criteria based on the application of linguistic terms. The steps of this method are (Puška et al., 2024):

Step 1. Evaluation of the importance of criteria.

Step 2. Transformation of grades into fuzzy numbers.

Step 3. Data normalization.

$$\tilde{n}_{ij} = \frac{x_{ij}^l}{max\ x_{ij}^u}, \frac{x_{ij}^m}{max\ x_{ij}^u}, \frac{x_{ij}^u}{max\ x_{ij}^u}$$

Where is $max\ x_{ij}^u$ maximum value for all criteria.

Step 4. Calculation of the standard deviation ($st.\,dev_j$).

Step 6. Plotting normalized scores with standard deviation values.

$$\tilde{v}_{ij} = \tilde{n}_{ij} \times st.\,dev_j$$

Step 7. Calculating the sum of weights for individual criteria.

$$\tilde{s}_{ij} = \sum_{j=1}^{n} \tilde{v}_j$$

Step 8. Calculating criteria weights.

$$\widetilde{w}_{ij} = \frac{s_{ij}^l}{\sum_{j=1}^{n} s_{ij}^u}, \frac{s_{ij}^m}{\sum_{j=1}^{n} s_{ij}^m}, \frac{s_{ij}^u}{\sum_{j=1}^{n} s_{ij}^l}$$

The innovative fuzzy COmpromise Ranking from Alternative Solutions (FCORASO) method will be used to evaluate the suppliers based on the ranking. As concluded by Mahmoodirad & Niroomand (2023), in order to simplify the decision-making process, the methods used must include as few steps as possible, that is, they must be as simple and flexible as possible. It is for this reason that the fuzzy CORASO method was applied, which ranks the alternatives based on how close or far they are from the best or worst values for certain criteria. This calculates the deviation of each alternative and determines the final ranking. The method was developed by Puška et al., 2024 and has the following steps:

Step 1. Evaluation of alternatives.

Step 2. Transformation of grades into fuzzy numbers.

Step 3. Normalization of fuzzy numbers.

$$n_{ij} = \frac{x_{ij}^l}{max\ x_j^u}, \frac{x_{ij}^m}{max\ x_j^u}, \frac{x_{ij}^n}{max\ x_j^u}\ ;\ \text{for benefit criteria}$$

$$n_{ij} = \frac{\min x_j^l}{x_{ij}^n}, \frac{\min x_j^l}{x_{ij}^m}, \frac{\min x_j^l}{x_{ij}^l}; \text{ for cost criteria}$$

Where is: $x_{j\ min}$ – the minimum value of a particular criterion, and $x_{j\ max}$ – the maximum value of one criterion.

Step 4. Calculation of alternative solutions, namely the maximum alternative solution ($max\ AS$) which is the highest value of alternatives for individual criteria, while the minimum alternative solution ($min\ AS$) which is the lowest value of alternatives for individual criteria.

Step 5. Weighting of normalized data.

$$\tilde{v}_j = \tilde{w}_j \cdot \tilde{n}_{ij}$$

Step 6. Calculation of aggregate values of difficult alternatives.

Step 7. Calculation of deviations from alternative solutions.

$$\tilde{R}_j = \frac{\tilde{S}_j}{\tilde{S}_{j\ max\ AS}}$$

$$\tilde{R}'_j = \frac{\tilde{S}_{j\ min\ AS}}{\tilde{S}_j}$$

Step 8. Defuzzification.

$$R_{j\ def} = \frac{R_i^l + 4R_i^m + R_i^u}{6}$$

$$R'_{j\ def} = \frac{R'^l_i + 4R'^m_i + R'^u_i}{6}$$

Step 9. Calculation of the value of the FCORASO method.

$$Q_i = \frac{R_j - R'_j}{R_j + R'_j}$$

Results and Discussion

The subject of the analysis is an agribusiness company based in the area of the City of Belgrade, which is engaged in the production of confectionery. The company belongs to the ranks of medium-sized companies with over 50 employees and as many seasonal workers in certain parts of the year. The range of products is varied, which represents an additional challenge when it comes to the organization of work and production. In its

mid-term business plan, the company has the task of improving operations, that is, the logistics segment, given that it is dependent on incoming raw materials for production, and at the same time, in that part of the business, to reduce the associated costs. For this reason, the company hires an expert team that, based on this research, should offer the results of the analysis. The expert team, i.e. the decision-makers, consists of six experts with many years of experience in logistics and supply, as well as in the field of food quality and safety.

Based on the questionnaire, the experts gave ratings for each of the given criteria, whose linguistic values are presented in the following table 3. Based on the corresponding linguistic scale (table 4), the rating values were converted into numerical expressions and shown in table 5.

Table 3. Evaluation of the importance of criteria

CRITERIA	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Expert 1	VG	G	G	ML	MG	G	G	G	G	M
Expert 2	G	VG	MG	MG	M	G	G	VG	MG	M
Expert 3	G	G	G	ML	M	MG	VG	VG	G	L
Expert 4	G	VG	MG	ML	M	MG	G	VG	M	L
Expert 5	VG	MG	VG	ML	M	VG	G	VG	MG	ML
Expert 6	MG	MG	G	M	M	VG	G	VG	MG	M

Source: Authors

Table 4. Linguistic scale

Very low	VL	(1,1,2)
Low	L	(1,2,4)
Medium Low	ML	(2,4,6)
Medium	M	(3,5,7)
Medium Good	MG	(5,7,9)
Good	G	(7,9,10)
Very good	VG	(9,10,10)

Source: Puška et al., 2024

Table 5. Expert assessment

CRITERIA	C1	C2	C3	C4	C5	...	C10
Expert 1	(9,10,10)	(7,9,10)	(7,9,10)	(2,4,6)	(5,7,9)	...	(3,5,7)
Expert 2	(7,9,10)	(9,10,10)	(5,7,9)	(5,7,9)	(3,5,7)	...	(3,5,7)
Expert 3	(7,9,10)	(7,9,10)	(7,9,10)	(2,4,6)	(3,5,7)	...	(1,2,4)
Expert 4	(7,9,10)	(9,10,10)	(5,7,9)	(2,4,6)	(3,5,7)	...	(1,2,4)
Expert 5	(9,10,10)	(5,7,9)	(9,10,10)	(2,4,6)	(3,5,7)	...	(2,4,6)
Expert 6	(5,7,9)	(5,7,9)	(7,9,10)	(3,5,7)	(3,5,7)	...	(3,5,7)

Source: Authors

x

The final expert ratings of the given criteria are given in table 6, and there we can see that some criteria have the same ratings, that is, importance. Thus, the most important criterion is "product quality", which includes egg category, egg size and weight, egg freshness, shell integrity, uniformity, etc., followed by criteria C1, C2 and C7, i.e. "price", "payment terms" and "flexibility and communication". In the final evaluation of the criteria, the quality of the goods was decisive, given that it is about the goal of increasing competition and preserving quality in the company's operations. Economic criteria such as payment conditions, i.e. the price of the product itself, as well as the supplier's willingness to negotiate, quick response to inquiries and complaints, as well as openness to stable cooperation, still play a major role. The research partly coincides with the results of supplier selection in other studies in the field of agribusiness (Nedeljković, 2022; Puška et al., 2023a), according to which the most important factor, i.e. the criterion of expert evaluation, is precisely economic, i.e. price.

Table 6. Criteria weight

Criteria	w_{ij}		
C1	0,08	0,12	0,17
C2	0,08	0,12	0,17
C3	0,08	0,11	0,17
C4	0,03	0,06	0,11
C5	0,04	0,07	0,13
C6	0,08	0,11	0,17
C7	0,08	0,12	0,17
C8	0,10	0,13	0,17
C9	0,06	0,10	0,16
C10	0,02	0,05	0,10

Source: Authors

Based on the applied steps of the FCORASO method, we obtain the final ranking (order) of the selected suppliers, which is presented in Table 7. The highest value of the coefficient Q_i was obtained by the first supplier, while the lowest value, i.e., the rating, was obtained by supplier 2.

Table 7. Rang alternative

Alternative	Q_i	Rank
1	0,13	1
2	-0,11	8
3	-0,03	5
4	-0,06	7
5	0,04	3
6	0,08	2
7	-0,01	4
8	-0,04	6

Source: Authors

In the last stage, before drawing conclusions in the work, we validated the obtained results in such a way that the ranked results obtained by the FCORASO method were

compared with the ranked results of other methods using the Spearman correlation coefficient using the following expression (Božanić et al., 2022):

$$SCC = 1 + \frac{6 \sum_{i=1}^{n} D_i^2}{n(n^2 - 1)}$$

In this equation, D_i is the difference between the rank of an item in the vector w and the rank of the corresponding item in the reference vector, and n is the number of ranked items. (Božanić et al., 2022) The value of SCC varies between -1 and +1. An SCC value of 1 indicates a perfect positive relationship. An SCC value of -1 indicates a perfect negative relationship. A SCC value of 0 means that there is no relationship between the variables. (Katranci et al., 2025)

Figure 2. Ranking of alternatives using different MCDM methods
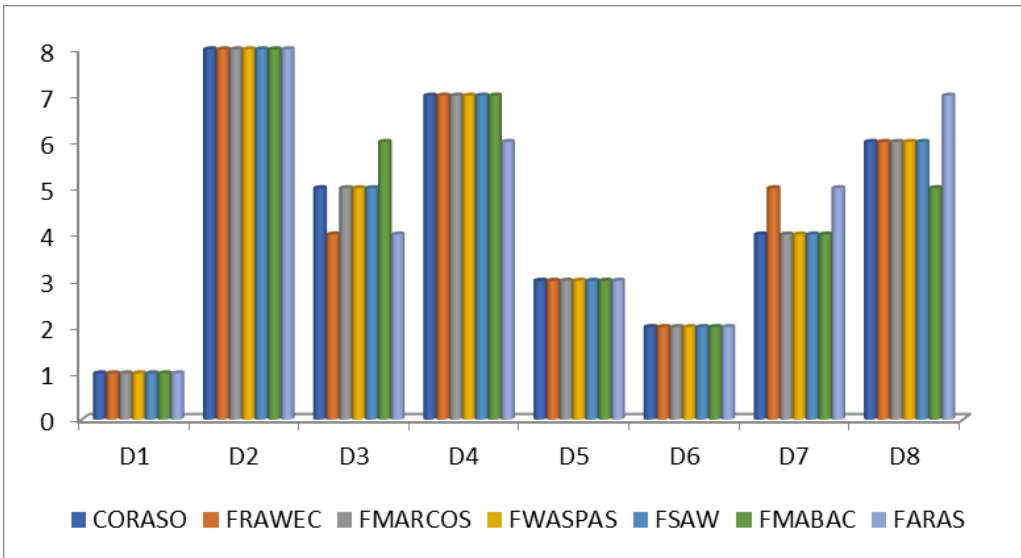
Source: Authors

The resulting correlation matrix shows that almost all variables are highly correlated. The lowest correlation is between FMABAC and FARAS ($\rho = 0.857$). This means that the value ranks between most factors are very similar, that is, the variables move in the same direction (monotonically related). (table 8)

Table 8. Correlation matrix

	FCORASO	FRAWEC	FMARCOS	FWASPAS	FSAW	FMABAC	FARAS
FCORASO	1.000	0.964	1.000	1.000	1.000	0.964	0.929
FRAWEC	0.964	1.000	0.964	0.964	0.964	0.893	0.964
FMARCOS	1.000	0.964	1.000	1.000	1.000	0.964	0.929
FWASPAS	1.000	0.964	1.000	1.000	1.000	0.964	0.929

	FCORASO	FRAWEC	FMARCOS	FWASPAS	FSAW	FMABAC	FARAS
FSAW	1.000	0.964	1.000	1.000	1.000	0.964	0.929
FMABAC	0.964	0.893	0.964	0.964	0.964	1.000	0.857
FARAS	0.929	0.964	0.929	0.929	0.929	0.857	1.000

Source: Authors

Conclusion

In the conducted research, a selection of regional suppliers of edible eggs was made in an agribusiness company. Of the given criteria, the "product quality" criterion, which included egg category, egg size and weight, egg freshness, as well as shell integrity and uniformity (consistency in size, color and shape), was rated the best. Also, the criteria "price", "payment terms" and "flexibility and communication" received a good rating. Of the suppliers, the first supplier is ranked best. The research in this case study showed the justified role of the applied integrated innovative method of multi-criteria decision-making fuzzy SiWeC-CORASO, and created solid assumptions for the continuation of research in this area, i.e. business development on the strengthening of influencing factors when it comes to the supply of raw materials. In the following, the applied research method should be further developed, as well as the scope of the research should be expanded to a larger number of criteria and suppliers, and the transparency of such research in the field of supply in agribusiness and agriculture should be increased. This would lead to an increase in rational decisions in the business of companies in this area.

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Conflict of interests

The authors declare no conflict of interest.

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RURAL TOURISM THROUGH THE LENS OF INSTAGRAM USERS

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A B S T R A C T

Rural tourism is a form of tourism that takes place in a rural environment and in which the tangible and intangible culture of the destination is experienced. Along with the growing interest of tourists in these elements, the attractiveness of rural tourism and its representation in Instagram posts is also increasing. The purpose of this research is to evaluate trends in rural tourism by analyzing Instagram images as a useful information base. The key methodological tool in research is image content analysis. The results of the research made it possible to draw conclusions about the most represented rural tourism destinations, key attractions and activities, gender specificities of participants in rural tourism, as well as its pronounced seasonality. In particular, the research led to the identification of education as an emerging activity in rural tourism. The research results can be useful for management organizations, rural communities, and tourism marketers. At the same time, the research emphasizes the usability of user-generated images on social media platforms in researching trends in the tourism market.

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Introduction

Rural tourism is a concept that has gained importance in the last few decades. While commercial practices appeared at the beginning of the second half of the twentieth century, greater professional and academic interest in the concept of rural tourism dates back to the eighties of the last century (Karali et al., 2024). Along with the changes in the wishes and demands of tourists, where the stay and experiences in nature are becoming more valued, the opportunities for the development of rural tourism also grew. The evolution towards a new way of life, which includes dynamic, innovative and environmentally responsible activities, gives rural tourism an increasingly important role (López-Sanz et al., 2021). The natural environment, the intangible cultural heritage of rural areas, local products and sustainable agriculture are the core resources on which the development of rural tourism is based (Chen et al., 2023; Marković et al., 2023). The question that has arisen since the earliest period of the development of rural tourism is the balance between the use of available resources in a sustainable way and economic interests (Rosalina et al., 2023). Hence, sustainable development, with its subcomponents of economic well-being, preservation of cultural and historical heritage, and social sustainability and environmental protection, is a very often discussed topic in academic research on rural tourism (Dimitrijević, 2025; Fons et al., 2011; Rosalina et al., 2021). The economic contribution of rural tourism and the development of underdeveloped areas are emphasized as particularly important (Liu et al., 2023). However, the contribution of rural tourism to the socio-cultural, environmental and educational aspects of the development of rural communities is also significant and undoubted. Rural tourism is a community-based form of tourism with the active participation of local community members in its development. Rural tourism is a chance for the local community to interpret and develop its traditional culture, but also to accept the integration of those cultures that differ from the domicile (Lazović et al, 2024; Tang & Xu, 2023). In this context, rural tourism can be seen as an instrument of social inclusion and overcoming socio-economic challenges in society (Kumar & Shekhar, 2020). Rural tourism is a motivating and desirable form of tourism, which can encourage the local population to engage and participate, but which can also meet the demands of modern tourists and enable them to spend their time in a socially acceptable way.

In addition to the resource base, infrastructure, financial and other forms of support from the government, the community and the private sector, the motivation of tourists and their recommendations have been identified as important factors in the development of rural tourism (Kumar et al., 2022). Meaningful experience of tourists and their satisfaction are an inseparable segment of sustainable rural tourism, regardless of whether the core of that experience is in the rural environment or activities (An & Alarcón, 2021). On the other hand, there are numerous advantages that rural tourism provides to tourists. Direct contact with nature and interaction with the local community are perhaps the most frequently highlighted benefits of rural tourism from the perspective of tourists. Also, due to the lower prices, rural tourism represents a form of tourism that enables the involvement of social categories of lower income levels (Kataya, 2021). When

opting for rural tourism, tourists choose those forms and destinations that provide them with the greatest utility in terms of the various attributes they consider (An & Alarcón, 2021). Landscapes, activities, location and hospitality of the local population are highly valued attributes. At the same time, the picturesque rural environment will probably be the first thing that will attract tourists. This raises the question of potential ways, opportunities and channels for its marketing and presentation to potential tourists, where modern technology achievements can play a major role.

In modern conditions, there is an immeasurable role of social media in informing and making decisions of tourists. Content generated by social media users has a huge impact on these processes. This fact is also valid for tourists in rural tourism whose behavior is very often shaped under the influence of social media (Hussain et al., 2024). Empirical research confirms that among the numerous factors influencing the intention to travel to rural destinations, social media has the greatest importance and that, in this sense, information placed on social media must be the focus of organizers of promotional activities in rural tourism. (Azhar et al., 2022). Social media represent a link between tourists and local products and culture of rural areas and, at the same time, enable inclusiveness by involving different social and age groups (Dašić et al., 2024). Social media and content generated by images that tourists post can be seen as a compendium of a tourist destination's image (Pan et al., 2014). The visibility and attractiveness of rural destinations is significantly increased by the distribution of authentic, impactful and high-quality content on social media platforms (Stylianou et al., 2025). The focus of tourists in rural tourism is not only attractive landscapes and tourist attractions, but the sharing of experiences of tourists on social media also plays a significant role in forming the image of the destination and future intentions of the visit.

The role of Instagram in these processes is particularly significant. Posts and images published on this platform are an important source of information for future tourists and also becoming an increasingly used tool in academic research. Siegel et al. (2023) research the behavior of tourists by analyzing the content of images published on Instagram and come to the conclusion that this platform represents an impression management tool. Agustí (2021) analyzing user-generated content on Instagram comes to conclusions about the differences in the behavior of tourists depending on gender and states that the gender of tourists will have an influence on the place they want to visit. Blanco-Moreno et al. (2024), by applying artificial intelligence in the analysis of posts on Instagram, come to the conclusion about interaction with people as a key aspect of a positive tourist experience, but also the feedback effect of a positive experience on the intention to generate content on Instagram during and after the trip. In the context of rural tourism, Sugino et al. (2023) using Instagram data and combined analysis of images, hashtags and descriptions left by tourists, make efforts to see the potential of this platform in the promotion of fishing villages as tourist destinations. They come to the conclusion that the results of such analyzes are highly usable for future tourism development strategies of the analysed rural areas. Galiano-Coronil & Blanco-Moreno (2025) explore the impact that tourists' Instagram images have on the perception and

attractiveness of the most visited rural destinations in Spain and find that images that evoke emotional engagement or those that depict landscape beauty play the most significant role in this process.

While the promotional capacity of social media in practice is indisputable, and a review of academic literature indicates their significant use as a tool for researching the behavior and perception of tourists, their potential in assessing trends in the tourism market remains insufficiently exploited. In this sense, the subject of this research is trends in the rural tourism market evaluated through the lens of Instagram users. The aim of the research is to conclude on the geographical distribution of rural tourism, key attractions and activities, gender characteristics of the involved tourists, as well as to assess the seasonality of rural tourism. In order to identify emerging trends in rural tourism through these four features, a set of research questions was formulated:

a) What is the geographical distribution of Instagram posts related to rural tourism and which rural destinations appear most frequently?

b) Which attractions and activities are most commonly depicted in rural tourism posts?

c) What is the gender distribution and connection with the attractions and activities of Instagram users in rural tourism posts?

d) Are there seasonal trends in the frequency of rural tourism-related Instagram posts?

Materials and methods

This paper employed a qualitative content analysis of Instagram images to explore how rural tourism is visually represented and spatially distributed through user-generated content in order to make conclusion about certain trends in the rural tourism market. Image content analysis is a widely accepted method in tourism research, particularly when examining user preferences and representations on social media platforms, which serve as powerful tools for travel inspiration, promotion, and decision-making. The primary data source for this study was the social media platform Instagram. Images were retrieved using the hashtag #ruraltourism, selected for its direct relevance to the research focus. Following the methodology adopted in previous similar studies on Instagram (Boepple & Thompson, 2016; Tiggemann & Zaccardo, 2018; Le Busque et al., 2021; Lazarević et al., 2024; Stanišić et al., 2024), the first 600 publicly available images under the "top posts" category were collected and analyzed. The dataset was extracted on September 29th, 2025. "Top posts" were deliberately chosen because they generate the highest user engagement (likes, shares, and/or comments), and therefore will reflect dominant trends, themes, and narratives surrounding rural tourism. All images were coded manually based on visual inspection, and categorized into predefined thematic groups developed through both inductive observation and reference to existing literature. The following categories of rural tourism attractions and activities were

used: Adrenaline sports, Agricultural production, Architecture, Food and beverage, Gastronomic events, Nature, Preserved folk customs, Education, Traditional lifestyle, and Hiking. Each image was assigned to a single dominant category based on its primary visual content. For each post, geotag information was extracted when available and used to determine the geographical location where the image was taken, allowing for a spatial analysis of rural tourism representation. In addition to geotag analysis, the date of each post was recorded in order to analyze seasonal variation. Images were grouped by the month in which they were posted, allowing insight into temporal trends of rural tourism-related content. To better understand the social structure of content creators, user profiles were analyzed and classified according to gender. Three categories were established: female, male, and group accounts. The third category included posts of people belonging to associations, organizations, institutions and fan pages dedicated to rural tourism. Profile gender was determined based on the user's name, biography, and visual indicators, where identifiable. This multifaceted methodology provides a comprehensive understanding of how rural tourism is portrayed on Instagram and how different user groups contribute to its representation.

Results and Discussions

The geographical spread of Instagram posts tagged with rural tourism shows a marked concentration in specific countries. India accounts for 32.83% of all posts, followed by Spain, USA, Croatia, Peru, Costa Rica, and South Africa (Table 1). Together, these seven countries represent over 60% of the observed sample, indicating a pronounced unevenness in the global distribution of rural-tourism content on Instagram. The leading position of India suggests that rural areas within the subcontinent are among the most frequently portrayed destinations on Instagram. The high presence of European countries (Spain, Croatia, Portugal, North Macedonia) alongside Latin American and African destinations (Peru, Costa Rica, South Africa, Morocco) illustrates that rural tourism on Instagram is a genuinely global phenomenon, but with strong national hubs of activity.

Table 1. Location of Instagram posts

Percent of posts	Country
32.83%	India
8.17%	Spain
5.67%	USA
4.5%	Croatia
4%	Peru
3.83%	Costa Rica
3.67%	South Africa
3.33%	Lebanon
2.83%	North Macedonia
2.67%*	Korea, Portugal
2.17%*	Iran, Malaysia
1.83%	Canada

Percent of posts	Country
1.17%	Italy
1%*	Hong Kong, Nicaragua, Thailand
0.83%*	China, Philippines, Uganda
0.67%*	Andora, Australia, Montenegro, Morocco, United Kingdom
0.5%*	Buthan, Georgia, Netherlands, Tanzania
**	Finland, Indonesia, Serbia, Malta
***	Albania, Armenia, Bangladesh, Cyprus, France, Germany, Greece, Kuwait, Kyrgiz Republic, Nepal, Pakistan, Panama

Legend: * means percent of posts for each country; ** means two Instagram posts for each country; *** means one Instagram post for each country

Source: Authors' research

When grouped by economic status (The World Bank, 2025), approximately two-thirds of all posts originate from developing or emerging economies, such as India, Peru, Costa Rica, and South Africa. In contrast, developed economies (Spain, USA, Portugal, South Korea) collectively account for a smaller proportion. This finding contrasts with traditional tourism flows, which tend to be dominated by developed countries as both origin and destination markets. On Instagram, however, developing countries are more prominently featured, likely reflecting the visual appeal and authenticity associated with rural settings in these regions. Countries with a larger proportion of rural land and population (e.g., India, Peru, Croatia) appear to dominate on Instagram posts. This pattern suggests a positive relationship between a nation's rurality and its representation in rural tourism posts. Vice versa, countries with smaller rural populations (e.g., USA, South Korea) appear less represented. While this does not establish causality, the observed distribution suggests that nations with a strong rural identity or extensive agrarian landscapes are more likely to be visually portrayed under rural tourism hashtags.

The analysis of rural tourism posts indicates that the most frequently depicted attractions revolve around nature-based, architectural, and cultural experiences (Table 2). Images categorized under Nature and Architecture dominate the Instagram posts, illustrating that visual representations of rural tourism on Instagram continue to emphasize scenic landscapes, historic buildings, and traditional village aesthetics. This predominance suggests that the visual appeal of rural environments, particularly the combination of natural beauty and cultural heritage, remains the primary driver of engagement and content creation. Activities related to Traditional lifestyle, Food and beverage, and Agricultural production further enrich the spectrum of rural tourism representation. These categories highlight the experiential aspect of rural travel, focusing on interaction with local customs, cuisine, and community life. Users tend to share posts that portray daily activities such as cooking, farming, or participating in traditional everyday life, which collectively promote the image of rural destinations as authentic and welcoming. Lower-frequency categories such as Preserved folk customs, Hiking, and Adrenaline sports demonstrate that while active and ritualistic elements are present, they are less central in shaping the dominant visual narrative of rural tourism.

Table 2. Key rural tourism attractions and activities represented in images

Percentage of posts	Rural tourism attraction
27.67%	Nature
25.17%	Architecture
10.33%*	Education, Traditional Lifestyle
10%	Food and Beverage
8.17%	Agricultural Production
5.17%	Preserved Folk Customs
1.17%	Hiking
1.33%	Adrenaline Sports
0.17%	Gastronomic Event

Legend: * means percent of posts for each country;

Source: Authors' research

A particularly noteworthy finding in this analysis is the appearance of the Education category, which represents a new and emerging dimension of rural tourism. Unlike traditional categories found in previous literature, such as nature, heritage, or agritourism (Rogers, 2002; Fons et al., 2011; Carneiro et al., 2015; Huang et al., 2016; Lupi et al., 2017; Streifeneder et al., 2023; Galiano-Coronil & Blanco-Moreno, 2025), this type of content illustrates how rural destinations are being recognized as spaces for academic events, educational programs, and professional knowledge exchange. Posts within this category often depict university-organized field trips, scientific workshops, rural and sustainability conferences, and student training programs hosted in rural or semi-rural settings. The prominence of this theme on Instagram suggests a broadening conceptualization of rural tourism, where intellectual and educational engagement complements leisure and recreation. This emerging form of rural attraction highlights a transformation of rural spaces from purely consumptive destinations to interactive and developmental environments. The integration of science, education, and tourism aligns with broader global trends toward sustainable and multifunctional rural development – where learning, innovation, and community collaboration coexist alongside traditional tourism activities.

There is a heterogeneous gender composition among Instagram accounts posting about rural tourism. More than half of all posts (54%) originate from group accounts, male users account for 25.83%, while female users make up 20.17% of all posts. This distribution suggests that institutional and collective actors dominate rural-tourism communication on Instagram, reflecting the growing role of destination organizations, rural associations, and hospitality businesses in shaping online visibility. However, the individual-level posts reveal a slightly higher male presence than female among single-user accounts, although the difference is modest. When focusing solely on individual users, a gendered differentiation in portrayed activities becomes evident (Table 3). This is aligned with the research findings of Agustí (2021), which state that the gender of tourists in rural tourism has an impact on the activities and places they visit.

Table 3. Comparative review of the participation of men and women in rural tourism

Category of images	Percentage of posts	
	Male (of 25.83%)	Female (of 20.17%)
Adrenaline sports	1.94%	/
Agricultural production	9.68%	5.79%
Architecture	27.74%	16.53%
Food and beverage	5.16%	15.7%
Gastronomic event	0.65%	/
Nature	23.87%	28.1%
Preserved folk customs	6.45%	12.4%
Education	13.55%	7.44%
Traditional lifestyle	9.03%	14.05%
Hiking	1.94%	/

Source: Authors' research

Male users are more frequently associated with Architecture, Nature, and Education categories. These results indicate that men tend to engage in or highlight content related to exploration, structure, and professional or knowledge-based contexts. Female users, by contrast, are most active in Nature, Food and beverage, Traditional lifestyle, and Preserved folk customs categories. These categories emphasize emotional, aesthetic, and cultural dimensions of rural life. The difference is particularly visible in posts connected to Food and beverage, where female representation is roughly three times higher than male (15.7% vs. 5.16%), highlighting women's dominant role in gastronomic and hospitality-related content. Conversely, male accounts contribute a much higher share of posts in Education (13.55% vs. 7.44%), suggesting that men may be more active in documenting academic, professional, or training events held in rural contexts. Across all categories, both genders show notable engagement with Nature, confirming its universal appeal as the central visual motif of rural tourism. This diversity implies that gender not only shapes who posts about rural tourism but also influences the types of narratives and values being communicated – men focus more on structure and function, while women highlight experience and culture.

The monthly distribution of rural tourism-related Instagram posts demonstrates distinct seasonal fluctuations throughout the year (Figure 1). The data show that posting activity peaks sharply in September, followed by May, while the lowest levels are recorded in March and August. These fluctuations suggest that Instagram content creation related to rural tourism corresponds closely with both tourism seasonality and agricultural or cultural rhythms typical of rural environments.

Figure 1. Monthly distribution of Instagram posts
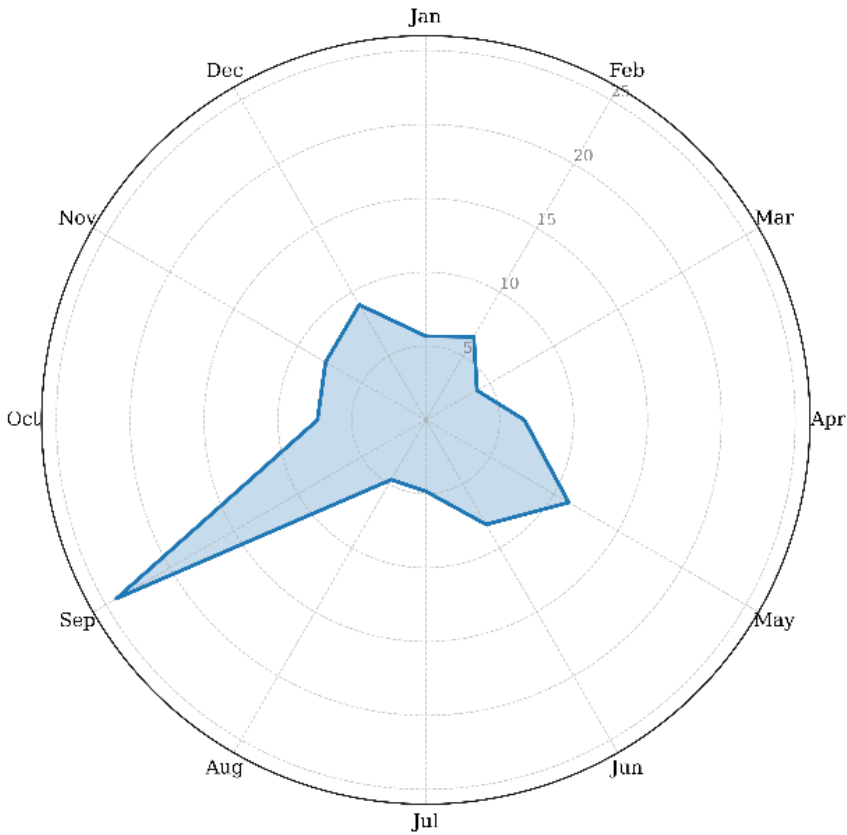
Source: Authors' research

The general pattern indicates three main temporal phases: spring growth phase (April-June) – steady increase in posting frequency, reflecting the beginning of the tourism season, pleasant weather conditions, and the reactivation of rural destinations after winter; autumn peak (September) – the most prominent period of online activity, associated with harvest festivals, agritourism events, and the visual appeal of autumn landscapes; winter recovery phase (November-December) – moderate but notable posting activity, often tied to winter rural retreats and local holiday traditions. The pronounced September peak stands out as the dominant posting period, surpassing all other months by a significant margin. This surge likely corresponds to the culmination of agricultural and harvest-related activities, which are visually appealing and culturally meaningful; increased tourist visitation to rural areas during early autumn, when weather remains favorable but destinations are less crowded than in summer; enhanced event-driven content, such as educational workshops organized in rural settings and scientific conferences; but it may also be due to the date of analysis. The secondary peak in May reflects the spring awakening of rural destinations and the symbolic start of the tourism season. This period

also coincides with national holidays and long weekends in many countries, providing additional motivation for rural travel and social media sharing. In contrast, summer months (July-August) show surprisingly lower posting rates, which may be attributed to a potential shift of users toward coastal or urban tourism during mid-summer, and the relative scarcity of organized rural events compared to spring and autumn.

Conclusions

The paper explored how rural tourism is represented on Instagram through a multidimensional analysis of image content, geotag data, user characteristics, and temporal patterns. The findings demonstrate that Instagram serves as a valuable mirror of contemporary rural tourism trends, revealing not only spatial concentrations of content but also evolving narratives surrounding rural experiences. The results indicate a geographically uneven distribution of rural-tourism posts, with India, Spain, and the United States as leading destinations. Developing countries dominate rural tourism imagery, reflecting the visual and experiential appeal of their authentic landscapes and traditional lifestyles. Content analysis revealed that nature, architecture, and cultural heritage remain the most visually dominant themes. The emergence of education posts marks a novel and important expansion of rural tourism representation, indicating that rural areas are increasingly perceived as spaces for learning, professional exchange, and innovation. Gender-based analysis showed a heterogeneous structure of content creators, with group accounts collectively contribute to the majority of posts. Among individuals, men more frequently post about architecture and professional events, while women emphasize gastronomy, lifestyle, and cultural expression, suggesting gendered storytelling patterns in digital portrayals of rural experiences. The temporal analysis identified a strong seasonal pattern with a major posting peak in September and a smaller one in May, corresponding to harvest periods and pleasant weather. These results highlight the synchronization between Instagram activity and the cyclical nature of rural life and tourism.

Scientifically, the study contributes to the increasing volume of literature on digital representations of rural tourism by integrating visual, spatial, temporal, and demographic dimensions. It expands methodological approaches to social media research through a combined use of content, geotag, and user-profile analysis, demonstrating how user-generated images can serve as a valid proxy for understanding tourism dynamics. The discovery of the Education category represents an original contribution, providing evidence of how rural tourism narratives are evolving beyond traditional leisure and nature-oriented frameworks. Practically, the findings can inform destination management organizations, rural communities, and tourism marketers. Understanding when, where, and how rural tourism is represented online can help stakeholders plan targeted promotional campaigns and develop content strategies aligned with seasonal peaks and audience interests. Moreover, recognizing gender-specific preferences in visual storytelling enables more inclusive and effective marketing approaches, while the rise of educational and scientific events suggests opportunities for diversifying rural tourism products.

Despite its comprehensiveness, the study has several limitations. First, the sample was limited to 600 top posts under the #ruraltourism hashtag, which may overrepresent highly visible or algorithmically favored content while excluding less-engaged users. Second, the temporal analysis is based on posting dates rather than the actual time of travel, which may cause slight discrepancies between digital activity and real-world tourism flows. Future studies should expand the dataset to include a larger and more diverse range of hashtags. Comparative research across social media platforms (e.g., TikTok or YouTube) could reveal differences in visual communication styles. Finally, incorporating user engagement metrics (likes, comments, shares) and sentiment analysis would deepen understanding of how audiences perceive and interact with rural tourism content.

Overall, the study demonstrates that Instagram is not only a platform for sharing aesthetic images but also a dynamic space of cultural production that shapes the perception of rural destinations. By capturing the intersection of nature, tradition, education, and community, these visual narratives contribute to redefining rural tourism as a multifunctional and sustainable experience, bridging leisure, learning, and identity.

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Conflict of interests

The authors declare no conflict of interest.

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AI-DRIVEN DAIRY FARMING: A CASE STUDY OF TECHNOLOGICAL ADOPTION AND ORGANIZATIONAL ADAPTATION IN A CZECH SME

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ABSTRACT

This paper analyzes the use of artificial intelligence (AI) and smart technologies in dairy cattle farming through a case study of the Czech SME Agrosoft. The study assesses how AI-based management systems affect operational efficiency, animal welfare, and environmental sustainability, and identifies challenges in their implementation. It focuses on automated milking, thermal imaging for health monitoring, and IoT-supported environmental control. A qualitative approach was applied, combining semi-structured interviews with developers and implementation specialists with an analysis of internal documentation. The findings show that AI enables earlier detection of health issues, more efficient feeding and barn-climate control, and reduced labor demands, contributing to improved herd welfare and lower operating costs. At the same time, the research highlights organizational barriers, especially the need for staff training and gradual workflow adaptation. The paper concludes that AI can significantly advance sustainable, welfare-oriented livestock farming, provided that farms ensure sufficient technological readiness and human-centered change management.

Introduction

Smart technologies and AI play a crucial role in various fields of industry, including agriculture and animal production (e.g. Bhagat et al., 2022; Wang et al., 2023). In today's rapidly evolving technological landscape, the integration of smart technologies

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and AI has according to Gras et al. (2024) become increasingly important for enhancing efficiency, productivity, and sustainability in livestock farming.

The utilization of smart technologies such as IoT (Internet of Things) sensors and data analytics enables real-time monitoring and management of various parameters within livestock production systems. These technologies allow farmers to collect and analyze large volumes of data related to animal health, behaviour, and environmental conditions. By leveraging AI algorithms, this data can be processed to extract valuable insights, optimize decision-making processes, and predict potential issues or anomalies (Dayoub et al., 2024).

One of the key advantages of smart technologies and AI in animal production is their ability to improve animal welfare and health outcomes. Some researches (e.g. Neethirajan, 2017; Dhanaraju et al., 2022) explain that by continuously monitoring parameters such as feeding behavior, activity levels, and environmental conditions, farmers can identify and address potential health issues or stressors in a timely manner, leading to improved animal welfare and productivity

Furthermore, smart technologies and AI contribute to the optimization of resource management and environmental sustainability in livestock farming. By precisely controlling factors such as feed distribution, water usage, and energy consumption, farmers can minimize waste, reduce environmental impact, and enhance resource efficiency (Gras et al., 2024; Dayoub et al., 2024).

In summary, the integration of smart technologies and AI offers immense potential for revolutionizing livestock farming practices. By harnessing the power of data-driven insights and automation, farmers can achieve higher levels of efficiency, productivity, and sustainability, ultimately leading to improved outcomes for both animals and producers (Zhang et al., 2022).

The objective of this study is to evaluate how AI-based farm management systems influence operational efficiency, animal welfare, and environmental sustainability in dairy cattle farming. Using a qualitative case study of the Czech SME company Agrosoft, the research analyses the implementation of automated milking systems, thermal imaging for health monitoring, and IoT-based barn climate control.

Theoretical background

It was recognized by Bao and Xie (2022) that the number of related studies has increased significantly since 2016, and the most intensive studies were focused on animal behaviour detection and recognition, and concentrated mostly on farm animal species of pig (37.95%), cattle (37.44%), and poultry (16.92%). Moreover, most scientific research in animal farming driven by sensors and AI models were focused on data collection, processing, assessment, and analysis in the areas of animal behaviour detection, disease monitoring, growth estimation, and environment monitoring at the experimental stage. Moreover, some technical challenges on AI like the accuracy and cost need to be improved before it could come into use in the commercial animal farming. According to Liu et al. (2021) many of these technologies have been previously used in what is known as Industry 4.0 and are now being applied and adapted to agriculture.

Many authors (for example Gerdan Koc et al., 2024; Rebez et al., 2024; Sindiramutty et al., 2024) have already addressed the utilization of smart technologies and AI in animal production, with several notable mentions among them. In agriculture, smart technologies involve the use of IoT devices, cloud computing, and AI to monitor and manage farm operations, from environmental conditions to livestock health. These technologies enable farmers to automate processes such as irrigation, feeding, and environmental control, making farming more sustainable and efficient (Liakos et al., 2018).

Artificial intelligence (AI) refers to the ability of a digital computer or computer-controlled robot to perform reasoning tasks commonly associated with intelligent beings. (De Vries et al., 2023). Al-Ahmed and Ahamed (2024) or Kawagoe et al. (2023) explain that in the context of agriculture, AI involves the use of machine learning and advanced data processing algorithms to make predictive analyses, automate processes, and enhance decision-making. AI enables real-time monitoring of livestock health, crop conditions, and environmental factors, leading to increased efficiency and productivity in farming. AI in animal health is specifically used for monitoring physiological parameters, early disease detection, and automating treatments, all based on data collected from sensors or diagnostic devices. This helps in the timely management of health issues in livestock (Dayoub et al., 2023; Melfsen et al., 2023).

Smart technologies, also known as Intelligent Systems, correspond to technologies used for sensing, decision-making, and actuation in systems that can work autonomously and act and modify the world (Verschae, 2023). An intelligent system senses the environment, makes decisions, and acts in the environment. Applications of these smart technologies in agriculture can be grouped into four domains (Araujo et al. 2021): Monitoring, Control, Prediction, and Logistics.

Table 1. Main application domains of smart technologies in agriculture. (Araujo et al. 2021)

Monitoring:	Control:
Weather monitoring	Smart greenhouses
Crop monitoring	Irrigation systems
Soil monitoring	Fertilization and fertigation
Water monitoring	Weed, pest, and disease control
Animal monitoring	Harvesting systems
Prediction:	Logistics:
Forecasting weather conditions	Handling
Crop development	Storage
Yield estimation	Transport and distribution
Animal development	Supply chain management
Forecasting market demand	Provenance traceability

Source: Araujo et al. 2021

According to Verschae (2023) these technologies can help optimize the use of resources (such as water, fertilizer, and energy), help increase production quantity and quality, support postharvest operations, and make agroecosystems more sustainable.

Smart technologies in agriculture can play an essential role in promoting sustainable agriculture in various ways, including (Verschae, 2023):

- It can support farmers to optimize the use of resources such as water, fertilizer, and energy.
- It can help farmers to monitor their crops and livestock more effectively, allowing them to detect and respond to problems early on.
- It can allow to increase in the transparency and traceability of food products by providing accurate and detailed information about the origin, quality, and sustainability of food products.
- It can also help to connect farmers with buyers and marketplaces, allowing them to sell their products directly to consumers or other businesses.

Charfeddine and Jemai (2018) examine recent methods for forecasting electricity consumption, with potential applications in optimizing energy usage in livestock farming operations. Similarly Ahmadi et al. (2018) investigate the application of machine learning techniques in predicting energy usage in social housing, suggesting potential applications in optimizing energy consumption in livestock farming facilities.

The review paper by Hruska et al. (2019) offers a comprehensive analysis of how artificial intelligence (AI) is reshaping precision agriculture. It explores AI's impact across various farming practices, from enhancing crop monitoring to optimizing resource management and refining decision-making processes. Overall, the article provides a succinct yet comprehensive overview of AI's pivotal role in advancing efficiency, sustainability, and productivity in agriculture. The study by Garcia et al. (2018) offers a comprehensive review of the application of artificial intelligence in the livestock sector, highlighting its potential to improve animal health, optimize breeding programs, and enhance overall productivity in livestock farming operations. Carabaňo et al. (2020) explores the applications and perspectives of precision livestock farming tools in promoting sustainable cattle production, emphasizing their role in optimizing resource utilization, improving animal welfare, and reducing environmental impact.

From the other side, Bannink and France (2016) investigate nutritional approaches to mitigate enteric methane emissions in ruminants, highlighting the importance of dietary manipulation in reducing greenhouse gas emissions from livestock production. A research by Hu et al. (2005) presents artificial neural network models for predicting ruminal fermentation in continuous culture, demonstrating their potential utility in optimizing feed formulations for dairy cattle. Or Massel et al. (2020) discuss the use of chemical repellents and deterrents in vertebrate management, highlighting their potential role in protecting livestock from predation and minimizing wildlife-related conflicts on farms.

The findings by Berckamans (2017) underscore the pivotal role of precision livestock farming (PLF) technologies in improving welfare management within intensive livestock systems. Through advanced monitoring and management systems, PLF enables proactive interventions to address welfare issues, optimize conditions, and enhance animal well-being and productivity. Additionally, PLF contributes to more efficient resource utilization, reduced environmental impact, and improved economic sustainability in intensive livestock operations. The article by Venkatesan and Thirunavukkarasu (2019) delves into the realm of real-time data analytics in agriculture, focusing on the utilization of Internet of Things (IoT) and big data technologies. It provides a comprehensive overview of how these advanced technologies can revolutionize livestock farming operations by enabling real-time monitoring and management. Through the integration of IoT sensors and big data analytics, farmers gain valuable insights into various aspects of livestock farming, including health monitoring, environmental conditions, and resource management. This article sheds light on the potential applications of real-time data analytics in enhancing efficiency, productivity, and sustainability in agricultural practices.

AI has become an integral part of modern agriculture, with a significant focus on animal health. AI's ability to process vast amounts of data and predict potential health issues in livestock has revolutionized the way farmers monitor their herds (Monteiro et al., 2021). For instance, sensors integrated with AI systems can continuously track physiological parameters such as body temperature, heart rate, and movement patterns. These data points are analysed in real-time, allowing early detection of diseases before symptoms are visible, thus reducing the spread of illness and improving overall animal welfare.

Moreover, AI is also instrumental in disease control and prevention. By analysing environmental factors such as temperature and humidity in combination with animal behaviour, AI systems can identify conditions that may lead to disease outbreaks. Early identification allows farmers to take proactive measures, thus limiting the impact of potential diseases on the livestock population (Arsevska et al., 2018). For instance, AI-driven monitoring of respiratory diseases in cattle has been particularly successful, as it enables farmers to isolate affected animals and administer treatment promptly (Charlier et al., 2024).

In addition to health monitoring, AI plays a key role in feeding optimization. Automated feeding systems use AI algorithms to analyse data on individual animals' consumption habits and energy needs. This ensures that each animal receives the correct amount of nutrients, enhancing growth and productivity while minimizing feed waste. Such precision feeding reduces the environmental footprint of farms and contributes to more sustainable agricultural practices (Bök and Micucci, 2024). The integration of AI with other technologies, such as the Internet of Things (IoT), has further enhanced its applications in agriculture. AIoT systems are used not only to monitor animal health but also to manage environmental conditions within farming facilities. For example, IoT sensors measure air quality, temperature, and humidity, while AI systems adjust these conditions in real time to maintain an optimal environment for livestock. This

holistic approach helps prevent stress-related illnesses and promotes better growth and reproductive outcomes in animals (Ezanno et al., 2021).

In summary, AI in agriculture has significantly improved animal health management by enabling early disease detection, optimizing feeding, and creating healthier living conditions. These advancements not only boost farm productivity but also contribute to more sustainable and ethical farming practices.

Methods and Data

The authors have chosen Agrosoft as the subject of the study, considering its significance in the utilization of smart technologies and artificial intelligence in animal production. Interviews were conducted with key members of the company's team, including software developers, technical specialists, and project managers, to gain an in-depth insight into the application of smart technologies and artificial intelligence within the company. Documentation of Agrosoft, including technical specifications, strategic plans, and internal reports, will be analysed to understand the implementation and development of technological systems. Specific smart technologies and applications of artificial intelligence utilized by the company will be identified, such as sensors for monitoring animal health and behaviour, algorithms for optimizing feeding regimes, and software platforms for automation of farming. Based on the collected data, the benefits and limitations of applying these technologies in relation to the company's goals and strategy were evaluated.

The research aims to assess the impact of AI-driven technological solutions on three core areas of dairy cattle farming: (1) operational efficiency, (2) animal health and welfare, and (3) environmental resource management. To achieve this, we conducted a qualitative case study of Agrosoft, involving semi-structured interviews with software developers and system implementation specialists, and an analysis of internal documentation. The methodological goal is to understand not only the technical performance of these systems, but also the practical challenges, organizational adjustments, and human factors influencing their successful adoption.

In this study on the application of smart technologies and artificial intelligence (AI) in livestock farming, we adhered to the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist to ensure methodological transparency and rigor. Compliance with the COREQ guidelines entailed detailed documentation of researcher roles, participant recruitment processes, and the contextual environment of the interviews. This comprehensive approach facilitated in-depth exploration of AI integration within Agrosoft, providing a robust framework for assessing its implications on productivity, animal welfare, and sustainability in livestock farming.

The research team comprised four academic scholars, three of whom were female Ph.D. holders with over a decade of expertise in the domain. Participants from Agrosoft were introduced to the objectives of the project and study prior to their involvement. Researchers disclosed their motivations and interests in the topic to enhance rapport

and understanding. Importantly, no theoretical framework was imposed during the interviews to ensure that responses were authentic and unbiased.

Data collection was conducted within the company's office environment, ensuring confidentiality and minimizing external influences. No individuals other than the interviewees and researchers were present during the sessions. The interview protocol, developed by the authors, was pilot tested prior to implementation to refine its effectiveness. Each interview session lasted approximately 60 minutes, and transcripts were subsequently shared with participants for validation and feedback. The findings were presented to Agrosoft following the analysis phase, ensuring alignment with the study's objectives and fostering transparency in communicating the results. The data collection involved semi-structured interviews with key members of Agrosoft. These interviews were recorded and transcribed verbatim, and a thematic analysis was conducted to identify patterns related to the benefits and challenges of implementing AI systems in animal farming.

Table 2: Questions for the interviews.

Questions	Area/Topic
Opening Questions	
What specific factors motivated your company to adopt AI?	Value
Which specific areas of your marketing/sales/export activities benefit the most from AI technologies?	Value
Has the introduction of AI changed the workflows within your marketing, sales and export team?	Technology, Management
Who was or is involved in AI projects focusing on Marketing, Sales and Export? How are they involved (what are their roles)?	Management
AI Strategy Formulation and Results	
Can you outline your company's overarching AI strategy for implementation?	Technology, Management, Ethics
Which performance metrics were used to measure the success of AI implementation in your company?	Value
How do you assess the overall impact of AI on your business?	Value
How do you communicate the benefits of AI to external stakeholders, such as customers, investors and partners?	Ethics
Talent and Culture	
What qualifications are required to hire employees skilled in AI?	Technology, Management, Ethics/legal
What kind of AI trainings do you offer for your employees?	Technology, Management, Ethics/legal
What corporate cultural changes (continuous learning, shift in decision making process, curiosity over fear) have been initiated to support AI integration?	Management
How does the company manage AI-related apprehensions among staff?	Ethics
How does the AI strategy of your company correspond to the company's value and culture?	Value

Challenges and Solutions	
Did you encounter any problems during the AI implementation?	Technology, Management, Value, Ethics
What organizational challenges have been encountered, and what strategies were used to address them?	Management
What technical obstacles have you faced during AI implementation and how were they resolved?	Technology
Have you noticed any ethical or legal issues during and after the AI application? If yes, can you describe those issues a little bit more?	Ethics/legal
How do you think does the AI system relate to power relations between the management and employees?	Ethics
Future Outlook	
How does your company envision the long-term impact of AI on your operations and the wider industry?	Value
How do you think will the AI Act impact your company?	Ethics/legal
Lessons Learned and Recommendations	
What insights have you gained through the AI adoption process?	Value
What recommendations would you give to companies which are planning to implement AI?	Value

Source: Authors

Case study (Results)

Agrosoft is a purely Czech company with a tradition dating back to 1985. Their products are utilized in hundreds of operations, ranging from family farms to multi-level large-scale breeding facilities. In addition to the Czech Republic and Slovakia, they also operate in the Russian Federation, Belarus, Poland, Kazakhstan, and Tajikistan.

Their core program focuses on software and barn-related electronically controlled technologies. The traditional Agrosoft SKOT program holds a significant position in the market. Agrosoft have expanded product portfolio to include a system for monitoring and controlling the microclimate in the barn. Thermal cameras are utilized for monitoring the health status of hooves. For other company - Farmtec, they have developed a complete system for managing barn technologies and supporting cattle farming – Farmsoft. This system includes electronic identification of dairy cows, data collection from the milking parlor, selection gates, automatic concentrate feeder (ACF), and monitoring of locomotor activity. The Vitalimetr 5P not only monitors the movement of the dairy cow but also tracks feeding and rumination time. The Farmsoft system is offered to users as a complete assembly or its individual technological components (e.g., concentrate dosing via ACF).

In collaboration with the University of South Bohemia in Ceske Budejovice and other Czech companies, they have successfully completed research project QJ1210144 "Development of a New Information System and Applied Technological-Organizational Innovations of Control Systems in Dairy Cattle Farming to Strengthen the Competitiveness of Breeders and Animal Welfare." Outputs from this project –

microclimate parameters, new ACF design, pass-through weighing system, locomotor activity monitoring function, control software algorithms – were utilized in the development of the Farmsoft system. They continue to collaborate with the University of South Bohemia on projects related to milk quality monitoring, automated system for monitoring barn indices, and animal identification through image analysis. The most extensive project is the development of a robotic arm for conventional milking parlors.

In addition to software, hardware development, and identification, Agrosoft has have a quality team for implementing the aforementioned systems, including zootechnical and operational consultancy services. Another team handles assembly, servicing, and repairs of mainly technologically-driven systems controlled by electronic systems (milking robot, milk vending machine, milking parlor and milking system, etc.), both of domestic and foreign origin.

The findings reveal significant improvements in both animal welfare and operational efficiency due to AI adoption. For example, the AI-powered milking robots have reduced human labor dependency and provided a more consistent milking routine for cows. The robotic arms detect and adapt to the size, shape, and position of cow teats, ensuring precise milking while minimizing animal discomfort.

Figure 1. Robotic arm for milking of the cow (internal documents of the company).

AI in health monitoring has also proven effective. A body condition monitoring system installed at the exit of the milking robot or milking parlor determines whether any of the cows is rapidly losing condition, i.e., losing weight. If such a case is detected, the farmer receives a notification and reviews the animal's vital data (milk yield, activity, body temperature). Using the positioning system, the farmer can locate the animal

within the barn and then mark it with a visual (light) signal. This allows the cow to be examined within minutes of the alert, enabling timely administration of a nutritional drench to support its vitality.

Some of the cows are diverted by the sorting gate into a separation pen equipped with a restraint option. The farmer confirms these animals based on the list that he reviewed on his mobile phone early in the morning. He examined the information reported for each animal and, based on current data on milk yield, milk quality, body condition, locomotor activity, feed intake, rumination, thermal camera imagery, and body temperature, issued a command in the system to separate the respective cows. The relevant data are also available from the morning on the smart devices of service providers—namely the veterinarian, the insemination technician, and the hoof trimmer. In addition to conditions inside the barn, the situation on the pasture can also be monitored via the application. Here, a drone flying over the grazing area provides significant assistance. The primary focus is on animal behavior and the functionality of the electric fencing. Thanks to the localization feature and the illuminated LED indicator, the breeding cow can be easily located.

The behavior of dairy cows in the barn is continuously monitored using a camera system with integrated image analysis. This system contributes to the assessment of animal welfare, automatically calculates barn performance indices, and sends an SMS notification to the farmer in the event of atypical behavior.

Animal monitoring components and management software systems, which provide appropriate reporting based on the collected data, have a significant impact on animal welfare. In practice, this mainly involves sensors that record the animal's locomotor and feeding activities, physiological parameters, spatial location, and interactions with other individuals. Monitoring of animals and their living conditions is also supported by integrated camera systems equipped with dedicated analytical software.

Thermal imaging allows for continuous, non-invasive monitoring of cow hooves, which helps detect inflammation at an early stage. Diagnosis of disease using AI is usually significantly ahead of human-observable symptoms. The cows are experiencing hoof problems because their nutrition is not sufficiently balanced. Five degrees of lesion severity (inflammation development) are distinguished. At levels 1–2, the cow can still be milked and treatment is relatively simple; at levels 4–5, the cows must be removed from the production process. When the cows enter the milking parlor, a thermal camera scans each hoof. The collected data are then processed using AI, which identifies the cows exhibiting inflammatory lesions. As a result, veterinary interventions can focus on nutritional changes rather than costly medical treatments like antibiotics. Moreover, it is also possible to monitor the cow's reaction to the applied treatment. This proactive approach reduces treatment costs while improving overall herd health.

AI's ability to process large datasets generated by IoT sensors has improved the barn environment by controlling microclimate conditions. Sensors continuously monitor both the internal barn environment (methane emissions, temperature, and humidity)

and the external meteorological conditions. A modern criterion used to evaluate the quality of the barn microclimate is the kata-value, a physical parameter that reflects the thermal comfort of the animals. This value is determined using a kata-thermometer, which illustrates the development from a mechanical measuring device to an electronic one. Based on the collected data, the software sends control commands to the barn technology systems, such as fans, ventilation openings in the building envelope, heating, misting systems, and lighting. This helps meet EU environmental standards for reducing greenhouse gases while lowering operational costs related to energy consumption.

Figure 2. Thermal cameras (internal documents of the company).
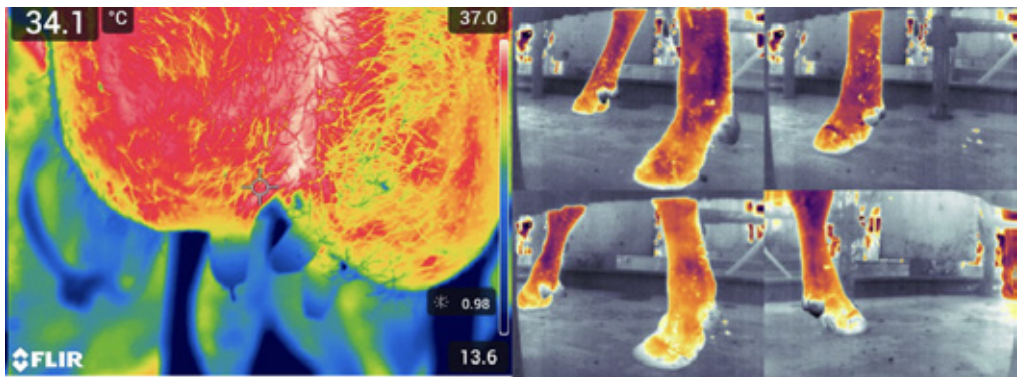
Furthermore, AI has a notable impact on resource management. By analysing data from feeding patterns, AI-driven systems adjust the distribution of feed, ensuring that no food is wasted while each cow receives optimal nutrition. This precision in feeding management has led to a measurable reduction in feed waste, contributing to both economic savings and environmental sustainability.

To summarise, the key AI technologies used at Agrosoft include:

• Robotic arms for milking, equipped with AI-powered vision systems that recognize and analyse the geometry of each cow's udder

• IoT-based systems for monitoring barn environments, integrating sensor networks that control air quality, temperature, and humidity

• Thermal cameras used for hoof health monitoring, which detect issues such as inflammation early, allowing non-invasive interventions

• AI-driven feeding systems that adjust feed distribution based on animal behaviour and environmental data, ensuring optimal nutrition and reducing waste

These technologies are part of Agrosoft's broader effort to bring Agriculture 4.0 into livestock farming, where AI plays a critical role in predicting health issues, optimizing resource use, and improving operational efficiency. Managers would particularly recommend "taking it slow, step by step, and thoughtfully, preparing employees for changes, and accounting for their conservative approach" when implementing AI.

Discussion

The findings of our case study on Agrosoft align with several key themes identified in the literature regarding the integration of AI and smart technologies in livestock farming. For instance, Berckmans (2017) emphasizes the role of precision livestock farming (PLF) technologies in improving animal welfare through advanced monitoring systems. Similarly, our study found that Agrosoft's AI-driven milking robots and health monitoring systems, particularly through thermal imaging of cow hooves, contributed to enhanced animal well-being by enabling early detection of health issues and reducing the need for invasive treatments. This is consistent with the literature, which highlights AI's potential in improving both operational efficiency and animal welfare in intensive livestock systems (Carabaño et al., 2020).

In livestock production, AI is used to diagnose health problems in livestock (Contla Hernández et al., 2021), analyze poultry behavior (Li et al., 2020), and automatically monitor cattle ethology (Pavlovic et al., 2021). The greatest benefit is in the milking process. Currently, about 400 milking robots are working in the Czech Republic. It is estimated that in 2025 there will be 43,000 milking robots in the world (Bumbalek et al., 2022). In plant production we find applications in the identification of fruits, their metric properties and count (Gai et al., 2021; Parico and Ahmed, 2021) or the detection of plant diseases (Alguliyev et al., 2021).

Kumar et al. (2018) identify dairy cows by processing muzzle images using deep neural networks. The central premise of their approach lies in the uniqueness of the pattern and texture of the muzzle surface, which can be compared to a human fingerprint. The first phase of their study involved the creation of a relatively small yet high-quality dataset consisting of 500 photographs of an equal number of individual animals. During the preprocessing stage, the acquired images are first converted to grayscale and then enhanced through histogram equalization using the CLAHE method. Subsequently, the images are processed using two deep learning approaches—Convolutional Neural Networks (CNN) and Deep Belief Networks (DBN)—which perform feature extraction and analysis for classification. In the reported results, the DBN method achieved the highest performance, reaching an identification accuracy of nearly 96% (Bumbalek et al., 2021).

Moreover, the literature reviewed by Hruska et al. (2019) and García et al. (2018) suggests that AI enhances decision-making and optimizes resource management by analyzing large datasets in real time. Our case study supports this claim, as Agrosoft's IoT-based systems for environmental control and AI-driven feed distribution systems demonstrated significant reductions in resource wastage, particularly in feed and energy consumption. This not only improved the economic sustainability of operations but also aligned with the broader environmental goals mentioned in the studies by Bannink and France (2016) and Venkatesan and Thirunavukkarasu (2019), who stress the importance of AI in reducing the environmental footprint of farming practices.

Conclusions

This study demonstrates that the integration of artificial intelligence and smart technologies in livestock farming has the potential to significantly improve operational efficiency, animal welfare, and environmental sustainability. The case of Agrosoft illustrates how automated milking systems, sensor-based health monitoring, and AI-supported environmental control can reduce labor demands, enable earlier interventions, and optimize resource use. These findings are consistent with broader trends in precision livestock farming, where data-driven decision-making is increasingly replacing manual observation and routine procedures.

However, the successful adoption of AI in agricultural settings requires more than the implementation of advanced technologies. It depends on organizational readiness, staff training, and the gradual adjustment of workflows and responsibilities. Farmers and managers must understand the capabilities and limitations of AI systems and remain actively involved in decision-making to ensure that technology complements, rather than replaces, human expertise.

More generally, AI should be viewed as a tool supporting the transition toward more sustainable and animal-centered farming practices. As the technology continues to evolve, future research should focus on evaluating long-term impacts, developing user-friendly training programs, and ensuring ethical and regulatory frameworks that maintain trust among farmers, consumers, and animal welfare advocates. The broader implication is that while AI can transform livestock production, its effectiveness ultimately depends on a balanced integration of technological innovation and human judgment.

Declaration of competing interest

There are no financial and personal relationships with other people or organizations that could inappropriately influence (bias) our work.

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Conflict of interests

The authors declare no conflict of interest.

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CONSUMER BEHAVIOR IN THE SOURDOUGH BREAD MARKET: ECONOMIC AND MARKETING FACTORS AS DETERMINANTS OF PURCHASE

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A B S T R A C T

Sourdough bread has been gaining popularity among consumers, driven by an increasing interest in healthier dietary choices. Experts in food technology, nutrition, medicine, and gastronomy emphasize the numerous health benefits associated with its consumption, including improved digestion and a lower glycemic index. The aim of this study was to segment consumers using cluster analysis based on their attitudes and habits related to sourdough bread consumption. Four distinct consumer clusters were identified, each characterized by different perceptions of the product. The second part of the analysis examined the influence of economic and marketing factors on consumer attitudes, while the socio-demographic analysis provided insights into dietary habits and bread consumption patterns. The results contribute to a deeper understanding of consumer behavior and can serve as a foundation for the development of targeted marketing strategies, as well as for improving sourdough bread production and promotion. This research highlights the importance of aligning food production with consumer expectations and the growing demand for nutritionally beneficial products.

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Introduction

The term "sourdough bread" refers to bread made using starter cultures. Sourdough is a mixture of flour and water that is subsequently fermented by both homofermentative and heterofermentative lactic acid bacteria (LAB) and yeasts (El Sheikha & Mahmoud, 2016; Vrček et al., 2014; Catzeddu, 2019). This fermentation results in a product with a characteristic flavor, aroma, and volume (El Sheikha & Mahmoud, 2016; Vrček et al., 2014; Papadimitriou et al., 2019). Lactic acid bacteria and yeasts can develop spontaneously or through the process of inoculation. Spontaneous fermentation is the oldest known method of producing this type of bread. In the bread-making process, the primary role of yeast is to generate carbon dioxide, while lactic acid bacteria are responsible for producing lactic acid, acetic acid, or both (Catzeddu, 2019). Although sourdough is an equally valid method for leavening dough, baker's yeast is far more commonly used today. One reason for the preference toward this method is the complexity involved in maintaining sourdough starters and monitoring the fermentation process (Catzeddu, 2019). There are notable differences between sourdough bread and bread made with baker's yeast, particularly in terms of sensory qualities, texture, and nutritional value. Sourdough bread has a more pronounced flavor, a denser crumb structure, and a longer shelf life compared to bread made with baker's yeast. It also offers superior nutritional benefits, as documented in numerous scientific studies, including a lower glycemic index (GI) and increased mineral bioavailability. In recent years, growing consumer demand for tastier and healthier bread has contributed to the rising popularity and price of sourdough bread (Brant, 2007; Catzeddu, 2019).

Product quality can be defined as a product's ability to fulfill a specific function, which may involve attributes such as durability, ease of use, reliability, and other valuable features (Amanah, 2010). Consumers often base their purchasing decisions on the perceived quality of the product (Malekpour, 2022). Quality can also be viewed as the outcome of a subjective process in which the customer compares their expectations with experience (Suchánek, 2017). As a multidimensional concept, product quality requires manufacturers to focus on and emphasize specific attributes of the product (Matzler & Sauerwein, 2002; Witell & Lofgren, 2007). Moreover, producers need to identify the key attributes that drive consumer satisfaction and motivate consumption (Harrington, 2017). These key factors typically include the product itself, its price, associated services, distribution channels, and brand image (Zamazalová, 2008). The Total Food Quality Model is commonly used to explore how consumers perceive the quality of gastronomic products. This model encompasses four key, interrelated dimensions: the hedonic characteristics of the food (or gastronomic product), its health aspects, convenience, and the production process (Mascarello, 2014). Since consumer assessments and perceptions can vary significantly, their consequences are inevitable. These consequences manifest in consumer behavior and attitudes, as well as in the ways consumers seek out and process information about specific products (Brunsø et al., 2002; Grunert, 2005). In addition to this model, food and beverage quality is also evaluated by consumers based on external and internal product attributes (Lee & Lou,

2011). Extrinsic attributes are features related to a product that do not form part of its physical composition, such as price, brand, country of origin, quality seals, or even store layout (Ampuero & Vila, 2006; Gellynck et al., 2009). In contrast, intrinsic attributes pertain to the product itself and include elements such as appearance, color, shape, and presentation (Gellynck et al., 2009). In addition to these attributes, perceptions of product quality are also influenced by sensory characteristics, health-related aspects, and factors associated with preparation and storage suitability (Choroszy, 2021). The relative importance of these attributes depends on the consumer's sociodemographic profile (Choroszy, 2021). Sociodemographic characteristics typically include gender, age, socioeconomic status, and household size. Environmental factors encompass economic variables, while marketing factors relate to the labeling and declarations of food products. One of the key attributes influencing a consumer's decision to purchase a product, including bread, is taste. Producers have recognized the importance of this sensory characteristic, as consumers often perceive taste as the primary indicator of bread quality (Longin et al., 2020; Rapp et al., 2017). The flavor of bread, including sourdough varieties, is shaped by compounds found in both the crumb and crust. Microbial activity during the fermentation process plays a crucial role in determining the final flavor profile. Although over 510 compounds (both volatile and non-volatile) have been identified in bread, only a limited number contribute significantly to its overall taste (Pu et al., 2019a). Among the most important flavor-contributing chemical compounds are aldehydes, alcohols, esters, ketones, and pyrazines (Pico et al., 2016; Warburton, 2021). The baking process also contributes to flavor development through the Maillard reaction (Xu et al., 2020; Dong, 2020). Studies have shown that the regulation of temperature and baking time during this reaction is a key factor influencing the formation of flavor-active compounds in the final product (Antonella et al., 2020; Fu et al., 2020).

Texture is another important parameter influencing consumer decisions when purchasing ready-to-eat products (Altamirano-Fortoul et al., 2012). The understanding of texture as a sensory property of food varies between consumers and scientific literature (Chen, 2015). Within scientific circles, several definitions exist, all converging on the notion that food texture is a multisensory experience (Chen, 2015). However, texture can also be a point of criticism among consumers. For example, a study examining barley bread investigated the correlation between sensory perception (specifically texture) and the perception of satiety. The results confirmed a relationship between these two variables. In the context of bread, texture refers to the uniformity and freshness of the crumb, the crispness of the crust, and the overall mouthfeel (Altamirano-Fortoul et al., 2012). Fermentation plays a crucial role in shaping bread texture. Organic acids, such as lactic and acetic acid, lower the product's pH, which in turn slows starch retrogradation. The result is a softer texture and extended shelf life (Islam & Islam, 2024). However, attention must be paid to the duration of fermentation. If fermentation is prolonged beyond optimal levels, changes in gluten proteins can occur, leading to reduced loaf volume and a firmer, less desirable texture.

Materials and methods

This study aimed to examine the factors influencing consumer perceptions of bread quality, with a particular focus on sourdough bread, in Serbia. The research was conducted in the spring of 2025 through an online survey. The study was based on the research model developed by Gellynck et al. (2009) and adapted from the work of Bajkanović et al. (2024). The survey questionnaire was derived from these studies, with certain modifications. These modifications primarily concerned the structure of the questions: in addition to general questions about bread, respondents were also presented with items specifically related to sourdough bread. The survey was divided into three sections. The first section addressed sociodemographic characteristics, including gender, age, household size, and socioeconomic status. The second section of the survey focused on questions designed to provide insight into respondents' bread purchasing and consumption habits. Participants were asked to indicate how frequently they consume bread, with which meals they typically consume it, whether they bake bread themselves or purchase it, and, in the case of purchasing, to specify the place of purchase. Regarding sourdough bread in particular, respondents were informed that its preparation involves the use of wild yeast, i.e., yeast produced naturally rather than obtained industrially. Based on this, one of the questions in this section asked respondents who bake their bread to indicate whether they use industrial or wild yeast in the process. The third section of the survey examined consumer perceptions of bread quality based on internal and external attributes. Using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), respondents rated their level of agreement with statements related to these attributes. The internal attributes assessed focused on the nutritional and health-related aspects of the product. Respondents were asked to indicate the extent to which they agreed with statements such as "Sourdough bread is healthier" and "Sourdough bread is suitable for diabetics." Statements such as "Bread is suitable for digestion" and "Bread is a basic foodstuff" reflected the nutritional aspect of bread. In addition to these, the survey also included attributes related to food properties, sensory qualities, and production. Examples of statements within these categories included "Sourdough bread has a distinctive taste" and "Few people are familiar with the bread-making process." As noted in the introduction, quality perception was also assessed in relation to factors linked to the external environment, namely economic and market-related aspects. Within these dimensions, respondents expressed their level of agreement with statements such as "Bread is expensive" and "Bread from artisanal bakeries is of better quality." A total of 310 respondents participated in the study. The collected data were analyzed using SPSS 15.0. The framework for identifying the key structural variables was adapted from the study conducted by Bajkanović et al. In their research, the structural variables included sensory, health, and nutritional dimensions, whereas in the present study, the focus was on sensory, health, and production variables. These variables served as the basis for analyzing consumer perceptions of bread quality. Cluster analysis was employed to segment consumers according to their perceptions of bread quality. To identify differences among clusters for the selected factors, a one-

way ANOVA was conducted. Additionally, chi-square tests were used to examine associations between clusters and respondents' sociodemographic characteristics, as well as their bread-purchasing habit

Results and discussions

Cluster analysis identified four distinct consumer groups. The results indicate clear differences between the clusters. The first cluster consists of enthusiasts – consumers for whom all three factors (sensory, health, and production) have positive loadings. The second cluster comprises consumers for whom none of the examined aspects are important, as reflected in their negative factor loadings. Notably, the strongest negative loading in this group is associated with the production aspect. These consumers also tend to perceive bread as "unhealthy." The third cluster includes consumers who place importance on the health aspect of bread (positive factor loading) but hold negative views toward both the production and sensory aspects (negative factor loadings). The fourth cluster consists of consumers who have a positive attitude toward the production and sensory aspects but a negative attitude toward the health aspect. For this group, the strongest positive loading is associated with the sensory aspect.

Table 1. Market segmentation based on the perception of bread quality using cluster analysis (n=310)

Cluster Market segmentation	1 Enthusiasts	2 Unhealthy	3 Healty	4 Taste	Sig.
Shere %	47,7	9,4	26,1	17,1	
Factors Health aspect Senzory aspect Produce aspect	1.04 0.90 0.88	-1.22 -1.22 -1.34	0.32 -0.47 -0.37	-0.57 0.51 0.47	0.000 0.000 0.000

$p < 0.05$

As noted in the introduction, consumer perceptions of bread quality can be shaped by a variety of factors, including environmental influences (economic and marketing), socio-demographic characteristics, and product-related attributes. The attributes corresponding to the latter category are presented in *Table 2*. One of the sensory-related statements included in the survey was "The taste of bread is uninteresting (boring)." The analysis revealed no statistically significant differences between the clusters regarding this statement. However, for the other two sensory-related statements, "Sandwiches are a popular product" and "Special types of bread go well with festive meals," statistically significant differences were observed. Consumers from three of the clusters expressed a positive attitude toward these statements, whereas members of the "unhealthy" cluster maintained a neutral stance. The highest ratings for these two items were recorded among the first and fourth clusters. For the fourth cluster, this finding is unsurprising,

as the sensory aspect of bread is an important factor for these consumers. The first cluster, labeled enthusiasts, demonstrates a particularly strong interest in the sensory experience of bread. This group can be characterized as consumers who are open to trying new products and eager to explore diverse sensory experiences offered by food.

Table 2. Factors influencing the perception of bread quality
(attributes related to food properties)

Consumer segment	Enthusiastic	Unhealthy	Healty	Taste	Sig.
Sensory taste The taste of bread is perceived as uninteresting (boring).	2.39	2.24	2.50	2.26	0.513
Sandwiches are considered a popular product.	4.71	3.16	4.31	4.45	0.000
Special types of bread complement festive meals well.	4.65	3.02	3.86	4.45	0.000
Health attributes Additives are used in bread production.	4.40	3.35	4.14	4.51	0.000
I have limited knowledge about the nutritional value of bread.	3.26	2.82	3.29	3.16	0.156
Production attribute Few people are familiar with the bread production process.	4.03	3.04	3.80	3.92	0.000

$p < 0.05$

Based on the above findings, it can be concluded that clusters with a positive attitude toward these statements equally enjoy both additive-free bread and bread served with spreads or fillings. Regarding the health-related attributes of bread, statistically significant differences were observed between the identified clusters. In modern food production, the use of additives has become almost unavoidable (Bajkanović et al., 2021). However, research conducted by Bajkanović and colleagues indicates that many consumers lack sufficient awareness of the presence of additives in food products and their potential negative effects on human health. Given that certain additives may adversely affect consumer health, an important question arises: is it possible to produce any consumer food product entirely without them? A study conducted in 2016 by Jonkuvienė and colleagues offers a promising perspective. The researchers highlighted the potential of Lactobacillus reuteri as a starter culture additive that could enhance both the safety and shelf life of bread, presenting an alternative to conventional chemical additives.

All consumer groups agreed that additives are used in bread production, except for those in the second cluster, whose responses indicated a neutral stance. Considering that this group demonstrates a negative attitude toward all examined aspects, it is reasonable to assume that they either do not consume bread or consume it in minimal quantities. While most consumers are aware that additives are used in the production of food products, a more concerning issue emerges: their insufficient knowledge about the nutritional value of bread. Bread remains a staple food in many countries and represents an important component of a balanced diet (Rybicka, 2019; Canesin, 2021).

Consequently, ensuring a balanced and optimized nutrient profile in bread is essential (Aghalari et al., 2022). Bread provides key nutrients, including carbohydrates, proteins, iron, calcium, and vitamins (Alsuhaibani, 2018). With an average daily consumption of 300 grams, bread can supply the body with a meaningful proportion of essential nutrients, thereby contributing to the maintenance of an adequate nutritional status (Namayandeh SM, 2015–2016). Scientific studies have demonstrated that sourdough fermentation can enhance the bioavailability of nutrients and lower the glycemic index (GI) of bread. However, it remains unclear whether these effects on cereals translate into tangible clinical benefits (Ribet et al., 2023). Although our findings reveal no statistically significant differences between cluster groups on this issue, the generally neutral attitudes expressed by consumers are cause for concern. Particularly noteworthy is that even the group for whom the health aspect is of primary importance also expressed neutrality toward this claim. This result suggests that consumers may possess only partial awareness of bread's nutritional properties, with much of their knowledge likely derived from limited or superficial sources, most often media channels such as advertisements, rather than from comprehensive dietary education.

The environmental factors examined in this study included economic and marketing influences *(table 3)*. Based on the collected and processed data, we can conclude that statistically significant differences exist between clusters concerning economic factors. Although all cluster groups generally expressed either a neutral stance or disagreement with the presented statements, notable differences still emerged. For the first statement ("Bread is expensive"), significant statistical differences were observed between the first and second cluster groups, as well as between the first and fourth cluster groups. In both cases, enthusiasts perceived bread as expensive compared to consumers in the second cluster. The second statement ("Because of the current inflation, I cannot afford better-quality bread") revealed significant differences between the second and fourth clusters. Consumers in the fourth cluster group agreed that inflation limits their ability to purchase higher-quality bread. The third statement explored the role of price in bread selection, aiming to capture the extent to which cost considerations influence consumer purchasing decisions. Based on the collected and processed data, the following results were obtained: significant statistical differences were found between the fourth and second, fourth and first, and second and third consumer groups. For consumers in the fourth group, price plays an important role when choosing bread, particularly in comparison with the second group. Likewise, for the first group of consumers, price is somewhat more important than it is for the fourth group. In the comparison between the second and third groups, price was found to be more important to the third group of consumers. Globally, bread consumption often increases during times of crisis (Stanković et al., 2007). However, data from the Statistical Office of the Republic of Serbia show the opposite trend: bread consumption in Serbia has been declining since 2015. In 2007, average consumption was 109.5 kilograms per person per year. The most recent research indicates that a three-member household consumes 282 kilograms of bread annually, corresponding to approximately 97 kilograms per person.

A similar decline has been observed in parts of Europe. Research conducted in the Czech Republic shows that the population consumes more wheat-based pastries than bread. Historical data indicate that immediately after World War II, bread consumption exceeded 80 kilograms per capita, but by 2016 this figure had fallen by almost 50%, reaching just 39 kilograms per person. In contrast, the consumption of pastries in 1949 was 16 kilograms per capita, but in the following decades, this figure tripled (Suchánek et al, 2018) It is also important to consider the broader economic and social consequences arising from recent global events, particularly the COVID-19 pandemic and the Russian–Ukrainian war. A relevant study conducted in Italy by Amicarellio and colleagues examined the state of artisanal bakeries and the production of artisanal bread in 2021. The paper analyzes the costs of bread production in artisanal bakeries before and during the crisis caused by the COVID-19 pandemic and the war. The aim of the study was to use economic assessments and analysis to highlight methods for reducing or avoiding these costs, with the goal of helping artisanal bakeries maintain their competitiveness and secure their place in the market (Amicarellio et al., 2023) Given these contextual factors, the neutral attitude observed among the cluster groups toward bread consumption is somewhat unexpected. This result may indicate that even within these clusters, overall bread consumption is relatively low. Regarding marketing aspects, the analysis revealed significant statistical differences between the clusters. For the first statement ("Bread is an artisanal product") and the third statement ("Bread from artisanal bakeries is of better quality compared to others"), the first and second cluster groups agreed, while the third and fourth clusters displayed a neutral attitude. To proceed with the analysis, it is necessary to clarify the term artisanal, specifically, what types of foods fall under this category and whether sourdough bread qualifies as such. According to the School of Artisanal Food, artisanal products share several defining characteristics: they are produced using non-industrialized methods; the preparation process is often passed down from generation to generation; producers maintain a special relationship with, and respect for, the ingredients used; and the creators possess extensive experience, a scientific understanding of the preparation process, and a strong sense of environmental and economic responsibility. What further distinguishes artisanal products, according to this school, is the continuous pursuit of education and refinement of craft by their makers. Based on these criteria, sourdough bread can be confidently classified as an artisanal product.

Table 3. Factors influencing the perception of bread quality (external factors)

Consumer segment	Enthusiastic	Unhealthy	Healthy	Taste	Sig.
Economic factors Bread is expensive	3.26	2.53	3.12	3.44	0.001
Due to the current inflation in the market, I cannot afford better-quality bread	2.86	2.06	2.65	2.41	0.008
The price of bread is important to me when choosing it	3.22	2.12	3.09	2.92	0.000

Consumer segment	Enthusiastic	Unhealthy	Healthy	Taste	Sig.
Marketing Bread is an artisanal product.	4.22	4.20	3.32	3.45	0.000
The description of the bread is more important than the nutritional value and/or the brand.	3.37	3.12	2.79	2.86	0.016
Bread from artisan bakeries is of better quality than others.	4.09	3.98	3.04	3.17	0.000

p<0.05

Based on the presented results, significant statistical differences within the socio-demographic framework were found for the variables Age and Average income, while no significant differences were observed for Gender. Although gender differences were not statistically significant, certain tendencies can still be noted. More women than men participated in this research, with the majority belonging to the tasta cluster group; interestingly, most male respondents were also in this same group. Regarding age, the healthy cluster group was characterized by a higher proportion of younger respondents. In terms of income, the majority of participants reported earnings below the national average. This fact is likely to influence their decisions regarding where they purchase bread, as well as their daily bread consumption. Consequently, given that most respondents have below-average incomes, the results obtained for economic factors, particularly in terms of price sensitivity, are not surprising. The place of bread purchase by cluster group is presented in *table 4*. Based on the data, there are significant statistical differences among the clusters. Unlike the research on which this study was based, where as many as 80% of respondents reported buying bread from artisanal bakeries, in our study, respondents generally do not have the habit of visiting such establishments. The largest proportion of participants purchase bread from grocery stores. Possible reasons include the wide product assortment, shopping convenience (e.g., discounts), and lack of time to visit a bakery or artisanal bakery. Although there are no official statistics on the number of bakeries offering sourdough bread, their presence is notably smaller compared to commercial bakeries and supermarkets. Another contributing factor is price: sourdough bread is generally more expensive than bread sold in standard bakeries or supermarkets, which may further influence purchasing decisions.

Table 4. Influence of socio-demographic characteristics on the perception of bread quality

Characteristic	Costumer segment								p
	Enthusiastic		Unhealthy		Healthy		Taste		
Gender	n	%	n	%	n	%	n	%	
Male	26	29,2	8	9	28	31,5	27	30,3	p=0,105
Female	46	20,8	41	18,6	76	34,4	58	26,2	
Age									
18-30	14	23,9	14	7,7	75	41,4	46	25,4	p=0,000
31-45	17	23,9	22	31	10	14,1	22	31	

Characteristic	Costumer segment								p
	Enthusiastic		Unhealthy		Healthy		Taste		
Over 45	9	15,5	13	22,4	19	32,8	17	29,3	
Income									p=0,005
Below average	16	18,8	6	7,1	38	44,7	25	29,4	
Average	48	32,7	9	31	19	23,5	22	41,5	
Above average	72	23,2	49	15,8	104	33,5	84	27,4	

p<0.05

Table 5 presents the results on daily bread consumption across all four cluster groups. The analysis indicates significant statistical differences (p = 0.005). The majority of respondents consume less than 100 grams of bread per day, which is slightly more than 60%, with most of them belonging to the "unhealthy" group. This finding aligns with data from the Republic Institute of Statistics, which confirms a steady decline in bread consumption in Serbia. When the place of purchase and bread consumption patterns are considered alongside economic factors, the results are unsurprising. The table also includes information on the type of yeast used by respondents who bake bread at home. These results are consistent with expectations: only 20 respondents in total (across all cluster groups) reported using wild yeast. Future research could explore the factors that discourage individuals from making their yeast and engaging in the process of preparing sourdough bread.

Table 5. Analysis of consumer habits when consuming bread

Characteristic	Costumer segment								p
	Enthusiastic		Unhealthy		Healthy		Tasste		
Place of bread purchase	n	%	n	%	n	%	n	%	p=0,002
Bakery	20	27,8	9	18,4	36	34,6	41	48,4	
Artisan bakery	5	6,9	6	12,2	4	3,8	4	4,7	
Grocery store	38	52,8	24	49	59	56,7	33	33,8	
I don't buy it, I make it myself	9	12,5	10	20,4	5	4,8	7	8,2	
Daily consumption of bread									
Less than 100 grams	30	41,7	32	65,3	49	47,1	47	55,3	p=0,113
100-200	37	51,4	15	30,6	44	42,3	29	34,1	
More than 200 grams	5	6,9	2	4,1	11	10,6	9	10,6	
Use of yeast									p=0,090
Starter (Wild yeast)	9	17	5	13,2	4	6,9	2	3,6	
Commercial yeast (dry, fresh)	44	83	33	86,8	54	93,1	53	96,4	

p<0.05

Conclusions

The study identified four distinct consumer segments in terms of their perception of sourdough bread quality. The structural variables used as the basis for market segmentation were derived from the work of Gellynck et al. and Bajkanović et al. The first segment, labeled enthusiasts, comprises consumers with a positive attitude toward all three factor loadings: health, sensory, and production aspects. The second segment consists of consumers who perceive bread as unhealthy. The third segment includes those who prioritize the health aspect of bread, while the fourth segment is characterized by consumers who place the greatest importance on the sensory (taste) aspect. From this, we can conclude that each group's perception of bread quality reflects its specific priorities. For enthusiasts, bread is not only healthy and tasty, but the production process also plays a significant role in shaping their positive perception. For this group of consumers, price is not a determining factor when choosing bread. They recognize bread as an artisanal product and believe that it is of superior quality when purchased from artisanal bakeries. Although the price of artisanal bread is higher than that of bread sold in commercial bakeries or supermarkets, this does not appear to influence their purchasing decisions. Considering the income structure, it can be inferred that this segment includes individuals with above-average earnings. Furthermore, it is noteworthy that some enthusiasts bake bread themselves using wild yeast, and a higher proportion of them consume 100 grams or more of bread per day.

The second cluster group consists of consumers who perceive bread as unhealthy, as reflected by the negative factor loadings across all three dimensions: sensory, health, and production. When considering economic and marketing factors, the latter appear to carry somewhat more weight for this group. Interestingly, these consumers maintain a neutral attitude toward all economic variables. Despite viewing bread as unhealthy, they hold a positive opinion of products from artisanal bakeries, believing that bread from these establishments is of better quality. Notably, within this cluster, the largest proportion of respondents bake their own bread, making them second only to the enthusiasts in terms of using wild yeast for bread preparation. These observations suggest that this group primarily regards commercially available bread in stores and bakeries as unhealthy. Consistent with this perception, their bread consumption tends to be low, mostly less than 100 grams per day.

The third cluster group consists of consumers who, unlike the previous group, perceive bread as healthy, as indicated by a positive factor loading for this variable. However, despite this perception, their familiarity with the nutritional value of bread remains neutral. Additionally, they agree with the notion that few people are familiar with the bread production process. The most common places for bread purchase within this group are bakeries or local grocery stores. Notably, only a small proportion of these consumers bake bread themselves or buy it from artisanal bakeries. Given their positive perception of bread's health benefits, it was expected that this group would include a higher number of individuals who bake bread at home using wild yeast or who purchase bread from artisanal bakeries. However, the results indicate otherwise. The last group

consists of consumers for whom the sensory aspect of bread is particularly important. Similar to previous groups, they believe that bread from artisanal bakeries is of superior quality. However, when examining their purchasing habits, it becomes evident that this group, too, generally does not frequent artisanal bakeries. Based on the findings of this research, several conclusions can be drawn. Firstly, the overall nutritional knowledge and appreciation of sourdough bread among all consumer groups remain low. Although the majority of respondents report incomes below the national average, the price of bread does not appear to be a decisive factor in their purchasing decisions. This suggests that most consumers could afford higher-quality bread but generally do not frequent bakeries that produce it (dopuniti). Additionally, among those who bake bread at home, a larger proportion use commercially purchased or fresh yeast rather than wild yeast in the preparation process.

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Conflict of interests

The authors declare no conflict of interest.

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A BIBLIOMETRIC MAPPING OF RESEARCH TRENDS AND DIRECTIONS ON THE RELATIONSHIP BETWEEN INFRASTRUCTURE AND RURAL DEVELOPMENT

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A B S T R A C T

This paper explores how infrastructure is connected to rural development by analysing trends in academic research over the past three decades. Infrastructure is essential for improving the quality of life and supporting economic growth in rural areas. As rural regions often face challenges like isolation, limited services and population decline, developing adequate infrastructure is seen as a key solution. To better understand how this topic has been studied, the research uses a bibliometric method based on articles indexed in the Web of Science™ Core Collection. A total of 166 publications from 1993 to 2025 were analysed using the VOSviewer software. Three main clusters were identified: Socio-political dimensions of rural infrastructure, Sustainable transformation and rural development, Economic performance and public infrastructure. The paper highlights the increasing international interest in these topics, with strong contributions from countries like China, the United States and Romania, but still international collaboration remains modest.

Introduction

In recent decades, rural development has become one of the key priorities on both national and European policy agendas, particularly in light of the challenges posed by territorial equity, social cohesion and economic sustainability. Rural areas, often

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characterized by low population density, considerable distance from urban centres and underdeveloped infrastructure, face significant difficulties in integrating into an increasingly competitive and digital economy. In this context, infrastructure development is not merely a technical goal, but a fundamental condition for the sustainable transformation of rural spaces (OECD, 2016).

The concept of "rural development" plays a central role in the analysed network, being closely linked to key terms such as policy, infrastructure, poverty, growth and sustainable development. This shows its importance in connecting economic, social and institutional aspects of rural transformation. Likewise, "rural infrastructure" appears as an important term in the literature, mentioned frequently and associated with ideas like economic progress, inequality and public policy. Studies increasingly describe rural infrastructure as a key factor in reducing poverty, improving living conditions and supporting local development. In the academic literature, these components are often described as the "backbone" of balanced territorial development (World Bank, 2009). Their absence or underdevelopment leads to isolation, high living costs, accelerated migration and a reduced capacity to attract investment. Numerous international studies emphasize that investments in infrastructure directly stimulate rural economies by supporting local markets, reducing production costs and improving labour mobility (Heijman and Van der Heide, 2000; Satish, 2007; Lenz et al., 2017; European Commission, 2021; European Commission, 2024).

The contemporary discourse on rural development increasingly highlights infrastructure as a decisive factor shaping social and economic transformation. Jiang et al. (2021) analyze the dynamic relationship between rural infrastructure and energy consumption patterns. Building on this perspective, Luo et al. 2022 investigate the coupling mechanism between rural revitalization and urbanization through a system coordination model. The empirical assessment of Ya'an (2011–2018) shows that sustainable rural progress depends on the coordinated growth of rural and urban systems. Infrastructure integration, therefore, emerges as a central pillar for achieving balanced regional development within the broader urbanization process. Kumar et al. (2022) extend this analysis to rural tourism, identifying infrastructure as a core enabler of tourism-based economic diversification. Wang, (2022) integrates technological innovation into the rural development discourse, employing multisensor and geographic big data to map and evaluate tourism resources. Liu (2022) explores gender inequalities in rural education and landownership, revealing how infrastructure deficits perpetuate socio-economic disparities. Yin et al. (2023) examine rural traffic infrastructure from a safety perspective, focusing on night driving conditions. Gong et al. (2023) explore the influence of smart city initiatives on urban–rural collaboration. At the same time, social infrastructure plays a crucial role in building human capital and reducing social exclusion (Yu et al., 2024). A relatively new, yet increasingly important topic in the scientific literature concerns digital infrastructure in rural areas. Access to high-speed internet, e-government platforms, electronic banking services and online markets is reshaping the socio-economic dynamics of rural communities (Salemink et al., 2017;

Arcuri et al., 2023; Ma et al., 2023). Supporting microenterprises and social enterprises in rural areas directly depends on the availability of such enabling infrastructure (FAO, 2019; Popa, 2023). Well-developed infrastructure also stimulates local cooperation, attracting public-private partnerships, associative forms and community-driven initiatives (Cheshire et al., 2015). Rural development is a complex process, shaped by the action of economic, social, cultural, environmental and governance-related factors (Calatrava-Requena, 2016). The progress in rural areas depends on how these elements are used and put together (Popa et al., 2024). It is not enough to just support agriculture; is needed an integrated approach that allows people to use public services, encourages rural entrepreneurship and improves digital connectivity (Wang et al., 2025). The infrastructure has to play a central role in achieving these goals. Over the past two decades several research directions have emerged, including the economic impact of infrastructure investments, the link between social infrastructure and migration, the role of digital infrastructure in reducing rural exclusion and the integration of green and sustainable infrastructure into local development strategies (Wubayehu, 2020; Hindersah et al., 2020; Kalinowski and Rosa 2021; Maloney et al., 2024). In this context, a bibliometric analysis of current trends and research directions becomes necessary for organizing the existing body of knowledge and identifying theoretical or methodological gaps. Bibliometrics quantifies the volume of scientific output, and maps author networks, research themes and institutional affiliations, offering a coherent overview of the field (Aria and Cuccurullo, 2017).

This study aims to explore the relevant scientific literature in order to understand how rural infrastructure is conceptualized and examined in relation to territorial development. By analysing keyword networks, thematic clusters and the temporal evolution of publications, the research highlights the main directions in the field. The bibliometric approach is based on data extracted from the Web of Science™ Core Collection, known for its relevance and international coverage. The VOSviewer software is used to visualize semantic networks, enabling a qualitative interpretation of quantitative results.

Methodology used in the bibliometric analysis

Infrastructure, in its various forms and classifications and regardless of whether it is owned by a public or private entity (Torrisi, 2009), is an essential component of human civilization. Rural development, in turn, is a key process for reducing territorial disparities, improving quality of life and strengthening social and economic cohesion within a country (Atkinson, 2017). It is natural to examine the link between the creation of infrastructure and the emergence of signs of development in the communities that use it (Cantu, 2017).

The bibliometric analysis conducted in this paper followed, as suggested in the specialized literature (Donthu et al., 2021; Pantović et al., 2023; Seočanac et al., 2024; Davidović et al., 2025), four main steps: defining the methodology, searching for and identifying relevant information, collecting data and interpreting the results. The

sequence of the methodological steps is illustrated schematically in Figure 1, providing a concise overview of the workflow followed in this study. The scientific approach began with the definition of a clear research direction, formulated as a central question focusing on how the academic literature has reflected the relationship between the major concepts of rural infrastructure and rural development: "To what extent does the existing scientific literature reflect relevant connections between the concepts of rural infrastructure and rural development?". This was accompanied by a secondary question aimed at identifying patterns of conceptual interconnection in existing research: "How is the interdependence between these two concepts addressed in academic publications?"

Figure 1. The steps applied in the bibliometric analysis
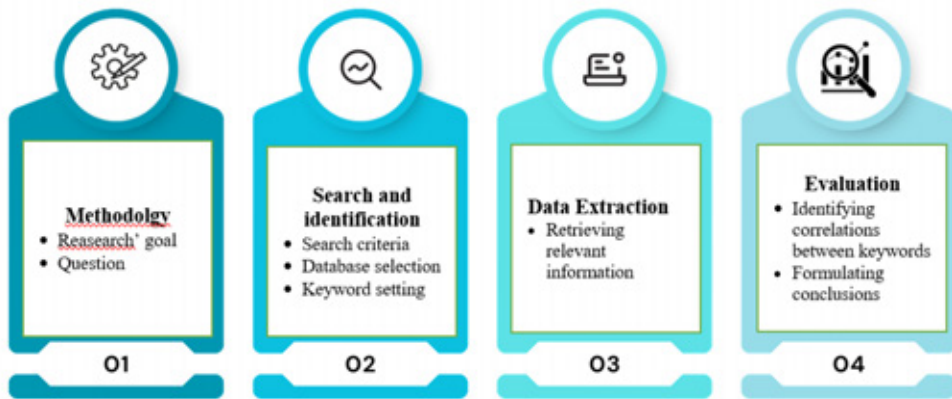
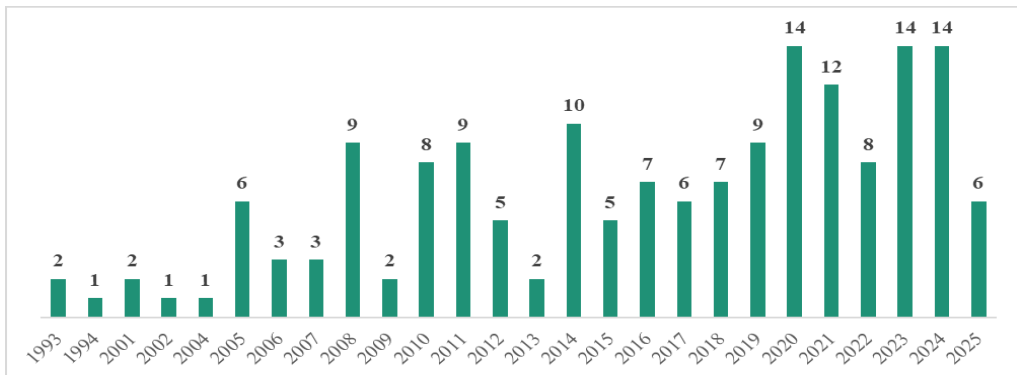### Implementing the methodology and exploring the results

During the bibliographic exploration phase, relevant terms were identified to define the analytical framework, logically selected based on the initial research questions. These included: "rural infrastructure", "public infrastructure", "economic infrastructure", "basic infrastructure", "business infrastructure", "rural development", "rural progress", "rural growth", "rural transformation", "welfare of rural population" and "improvement of rural livelihoods".

To collect bibliometric data, the Web of Science™ Core Collection (WoS) was used, providing a solid foundation for bibliometric analysis (Clarivate, 2025). The data extraction process was carried out between May 22 and 25, 2025. To query the WoS database, a search chain was formulated using the logical operators "AND" and "OR", applied in the "Topic" field, which includes the title, abstract and keywords of publications. The query combined two sets of relevant terms as follows: Topic search (TS) = (("rural infrastructure" OR "public infrastructure" OR "economic infrastructure" OR "basic infrastructure" OR "business infrastructure") AND ("rural development" OR "rural progress" OR "rural growth" OR "rural transformation" OR "welfare of rural population" OR "improvement of rural livelihoods")).

Figure 2. Top 25 scientific fields – number of indexed articles per category
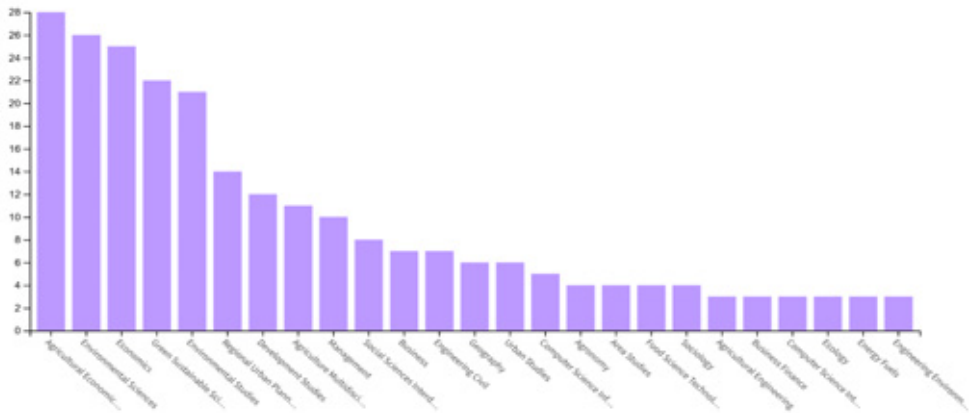
Source: Processing based on the number of research articles identified in WoS, classified by category

As a result of the selection process through bibliometric analysis, 166 relevant scientific articles were identified, published between 1993 and 2025. These publications address the investigated topics from multiple thematic perspectives and are distributed across 64 distinct scientific fields, according to the classification provided by WoS, reflecting both the disciplinary diversity and the cross-cutting nature of the analysed literature. Figure 2 presents a visualization of the 25 most frequently represented categories in which the articles were indexed. A single article can be assigned to multiple categories depending on its content and the classification criteria applied at the time of inclusion in the WoS database. For this reason, the total number of entries associated with the first 25 categories represented in the Figure 2 may exceed the absolute number of 166. The visual analysis of the 25 most frequently occurring scientific categories reveals that economic and environmental fields are dominant in the selected literature. Additionally, the existence of articles in the categories "Green Sustainable Science Technology" (22 articles), "Environmental Studies" (21 articles) and "Development Studies" (12 articles) shows the growing attention of academia to ecological and sustainable aspects of infrastructure and rural development. In the agricultural sphere, "Agriculture Multidisciplinary" (11 articles) suggests an integrated approach to the topic, while the presence of "Management" (10 articles) and "Social Sciences Interdisciplinary" (8 articles) points to the involvement of social and organizational research in understanding the phenomena analysed. Other notable categories include "Business" (7 articles), „Engineering Civil" (7 articles), „Urban Studies" and "Geography" (6 articles each) and "Regional Urban Planning" (14 articles), indicating a concern for territorial development and urban-rural infrastructure. Overall, the thematic distribution reveals the highly interdisciplinary nature of the research, capturing the complex interdependencies between infrastructure development and rural dynamics.

Figure 3. Temporal distribution of published articles

From a temporal perspective, the relevant articles cover a long period, from 1993 to 2025. However, their distribution over time is not uniform, with clear differences between early and recent phases. The first two decades are marked by a low and fluctuating number of publications. After 2015, a clear upward trend emerges, signalling a shift in publishing dynamics. The 2020-2024 interval is the most prolific, reflecting the growing scientific interest in topics related to rural infrastructure and territorial development (Figure 3).

To analyse the bibliometric relationships between fundamental concepts, the final step of the methodology involved the use of VOSviewer (version 1.6.20), a widely recognized tool for mapping and interpreting networks of publications and terms in academic literature. This software was chosen for its open-access nature, excellent compatibility with the Web of Science (WoS) database and proven reliability in previous reference studies (Gillani et al., 2022; Van Eck & Waltman, 2010).

The next step involved exporting and uploading the 166 selected articles from WoS into VOSviewer, which generated the essential files containing detailed information about the extracted terms (including their frequency), semantic links between them and their spatial positioning. To examine how semantic relationships between key concepts are structured in the selected literature, a co-word occurrence analysis was performed using the bibliometric files generated. The core of the investigation focused on the concepts central to the research and how they are associated in existing studies. After processing the data, out of 860 identified keywords, 25 terms met the inclusion criterion of appearing at least four times across the analysed documents.

Regarding the analysis of international collaboration, the co-authorship by country function was used to explore the geographical dimension of author networks. By applying a minimum threshold of three documents per country, 21 out of 56 countries met the criterion, reflecting significant international participation in the researched domain.

Discussions. Exploring the relationships between infrastructure and rural development through bibliometric analysis of the three thematic clusters identified with VOSviewer

The analysis of how keywords were grouped was based on examination of the terms used in scientific publications, considering that terms that frequently appear together in the same articles are most likely thematically related. These terms form groups, called clusters, which represent specific and well-defined topics within the broader research field. Each cluster contains terms that are connected by their frequency of co-occurrence and the strength of their links, helping to reveal the overall structure of the literature and to identify the main themes and the relationships among key concepts. To better understand the connections between major ideas related to infrastructure and rural development, which are central topics in this study, the three thematic clusters identified using VOSviewer were analysed. To understand how these concepts are interlinked, the following section will examine in detail the density of the term network, and how it has changed over time and the content of each cluster.

Overlay Visualization of the Bibliometric Network's Temporal Evolution

The bibliometric map presented in Figure 4 was generated in VOSviewer using the overlay visualization mode. The map enables us to track how certain terms have become more prominent over time, highlighting both thematic continuities and emerging research directions. Colour interpretation, based on the temporal scale shown in the bottom right corner of the diagram, covers the period between 2012 and 2022. Terms displayed in darker shades (blue, violet) correspond to earlier studies, while lighter tones (green, yellow) reflect more recent interests in the literature. For instance, terms such as "rural infrastructure" "growth" "productivity" or "rural poverty" are mostly associated with older publications and are shown in darker colours, typically linked to the 2012-2016 period. In contrast, terms like "impact" "areas" or "rural revitalization" appear in lighter tones such as yellow or light green, indicating a growing research interest in these topics in more recent years. Between these two temporal poles, transitional terms like "sustainable development" and "rural areas" have maintained consistent relevance throughout the entire timeframe. This variation in colour provides valuable insights into the thematic evolution of research on infrastructure and rural development, allowing for the identification of current hot topics as well as promising directions for future research. Looking at the overall structure of Figure 4, there is a strong concentration in the central area of the network, dominated by terms such as "rural development", "rural infrastructure", "policy", "impact", "economic growth" and "areas".

**Figure 4.** Visual network overlay map

Source: View generated with VOSviewer

Density map of the bibliometric network (density visualization)

An appropriate way to show the level of interest and frequency of topics in the analysed literature is through the density visualization, which helps identify areas within the network where terms appear frequently and are strongly related, offering a clear picture of the intensity of research on certain subjects. The bright yellow areas in Figure 5, which is a density visualization generated in VOSviewer, indicate regions with the highest concentration of terms and connections, pointing to key topics that are often discussed in academic literature. In contrast, green and light blue shades represent moderate densities, while dark blue or purple areas mark the outer edges of the thematic network, where terms appear less frequently and have weaker connections, suggesting either lower scientific interest or topics that are still emerging. At the centre of the map shown in Figure 5, the terms „rural development" and „rural infrastructure" stand out clearly with bright colours, confirming their dominant position in the academic literature, forming the thematic core around which other important concepts revolve. Their presence in the highest density area indicates that they are not only frequently mentioned, but also strongly connected to other terms in the network. In close proximity to these central terms are concepts such as "impact", "poverty", "areas", "policy", "economic growth", "agriculture" and "sustainable development", marked in green-yellow tones. This indicates a moderately high frequency and a strong thematic connection to the dominant topics. These elements outline the main directions of research that support debates around rural development, emphasizing economic, social

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and governance dimensions. The fact that "policy" and "economic growth" are near the core terms confirms the importance of the institutional framework and the economic dimension in addressing these issues. On the edge of the network, terms like "system", "development", "rural" or "urban" appear in bluish-green tones, which reflect lower intensity or weaker connections to the central terms.

Figure 5. Network density visualization
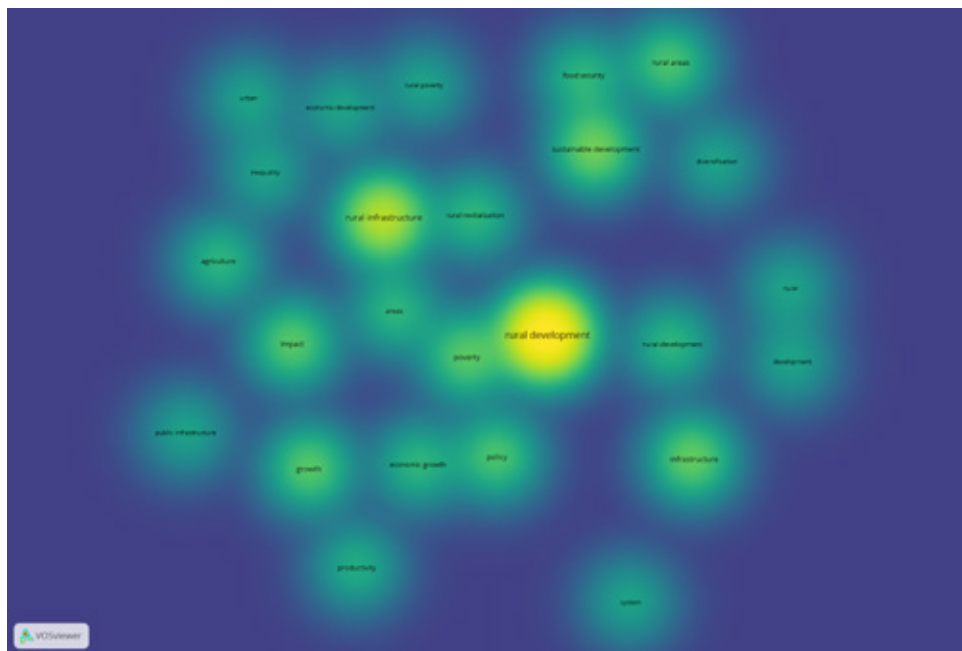
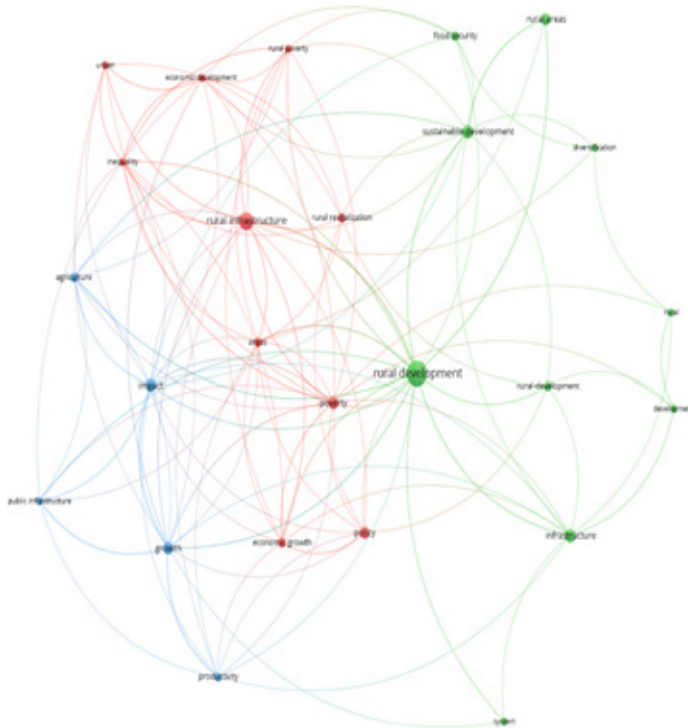*Source*: View generated with VOSviewer

Network visualization and VOSviewer clusters

The visual map of the network provides a clear overview of the key concepts found in the analysed literature and how they are connected, making it easier to understand the overall thematic structure and the semantic relationships between the topics discussed in the research. Figure 6 presents a detailed visual representation of the semantic links between the main concepts frequently found in the literature on infrastructure and rural development, highlighting both the core areas of interest and the connections between various thematic fields. The visual analysis highlights the existence of at least three main clusters: a green cluster focused on concepts such as "rural development", "sustainable development", "rural areas", "infrastructure" and "diversification", reflecting an emphasis on sustainability and rural transformation; a red cluster centred around the term "rural infrastructure" and associated with themes such as "economic development", "rural poverty", "urban" and "inequality", which points to a socio-economic approach to rural infrastructure issues; and a blue cluster, where terms like "public infrastructure", "growth", "productivity", "impact" and "policy" appear,

clearly reflecting an economic and institutional dimension of development. The central positioning of the terms "rural development" and "rural infrastructure", along with their links to a wide range of terms from all three clusters, highlights their pivotal role in the entire network. These concepts act as connecting points between different research directions, supporting the cohesion of the overall thematic structure.

In conclusion, the term network illustrates a complex and well-connected research field, where public policy, economic performance, physical infrastructure and sustainability consistently converge around the theme of rural development. Table 1 shows details about the three clusters and their associated nodes. The interactions among the three thematic clusters reveal a coherent and densely connected conceptual network, where central terms like "rural development" and "rural infrastructure" serve as key connection points.

Figure 6. Network visualization

Source: View generated with VOSviewer

Cluster 1, shown in red and composed of 10 terms, reflects the socio-political and economic dimensions of rural infrastructure, including concepts such as "policy", "economic development", "rural poverty", "urban" and "inequality", forming a thematic core focused on analysing spatial imbalances and government interventions. The presence of terms "rural revitalization" and "areas" suggests an integrated approach that addresses not only the physical construction of infrastructure but also the social and economic improvement of rural spaces. The strong links between these terms indicate that they are frequently discussed together in the academic literature.

Cluster 2, highlighted in green and made up of 10 terms, focuses on themes related to sustainable development, rural transformation and economic diversification. Concepts like "sustainable development", "rural areas", "food security" or "infrastructure" show a clear orientation toward sustainability and adaptability to new economic and environmental conditions. Terms such as "system", "rural-development" and "diversification" point to a systemic approach, where rural development is no longer seen in isolation but as part of a broader context that includes agriculture, food security, basic services and economic mobility. As shown in Figure 6, the green cluster is strongly connected to the network's central nodes, indicating that these themes are well integrated into current academic discussions.

Cluster 3, marked in blue and containing 5 terms, addresses topics related to economic performance, public infrastructure and productivity. Although smaller in size, this cluster holds strategic relevance, linking concepts such as "impact", "growth", "agriculture", "productivity" and "public infrastructure." The position of these terms at the intersection with the other two clusters shows that economic efficiency and administrative infrastructure are often discussed alongside social and environmental concerns. This cluster complements the larger picture of rural development research by indicating measurable outcomes and the capacity of infrastructure to create both direct and indirect economic effects.

Table 1. Cluster structure and distribution of terms analysed in VOSviewer

Cluster	Identified nodes
1. Socio-political dimensions of rural infrastructure (red colour - 10 terms)	areas, economic development, economic growth, inequality, policy, poverty, rural infrastructure, rural poverty, rural revitalization, urban
2. Sustainable transformation and rural development (green colour - 10 terms)	development, diversification, food security, infrastructure, rural, rural areas, rural development, rural-development, sustainable development, system
3. Economic performance and public infrastructure (blue colour - 5 terms)	agriculture, growth, impact, productivity, public infrastructure

Source: Own interpretation of clusters resulting from VOSviewer analysis

Structurally, the network made up of 25 nodes and 120 links has a total connection strength of 176, indicating high semantic density. The terms across the three clusters do not operate in isolation but are often used together in the same scientific work, suggesting a high degree of interdisciplinary and complementarity among fields like economics, public policy, rural development and sustainability. The central nodes link all three thematic groups, contributing to strong conceptual cohesion across the network, which confirms the complex and integrative nature of current research in this field.

The main relevant terms identified in the analysis

The analysis of keywords in academic literature is an essential step in understanding the conceptual structure of the field under investigation. The frequency of terms, their position in the network and the connections they establish with other terms provide valuable insights into dominant topics, preferred research directions and the level of thematic integration.

The term "rural development" stands out as the central node in the analysed semantic network, with the highest frequency of occurrence (37 instances) and the greatest number of direct connections (18 links) to other terms in the network. It belongs to Cluster 2 (green), a thematic group focused on the sustainable transformation of rural areas. However, due to its central position in the visual representation and its dense relationships with terms from all three clusters, "rural development" plays a key connecting role across the social, economic and institutional dimensions of development. The direct connections of this term, as shown in Figure 6, include a range of key concepts such as "policy", "infrastructure", "poverty", "impact", "growth", "rural infrastructure", "sustainable development", "public infrastructure", "system", "food security" and "economic growth." These links, represented by thick lines, indicate a total connection strength of 42, reflecting not only how often these terms appear together in the literature but also their conceptual importance in the analytical framework of the topic. "Rural development" is thus embedded in discussions on infrastructure and public policy, as well as in those related to sustainability, agriculture, inequality and economic efficiency. The central position of "rural development" on the map shows that it is not treated as a separate topic, but rather as a key concept that brings together different views on territorial change, policy action and economic growth.

The term "rural infrastructure" holds a central place in the analysed semantic network, being one of the most frequently used and well-connected concepts in the entire system. It appears 18 times, establishes 15 direct links with other key terms in the network and records a total link strength of 27, indicating a high level of association with multiple topics addressed in the specialized literature. As shown in Figure 6, this term is part of Cluster 1 (red), together with concepts such as economic development, poverty, policy and urban, which together outline the political and economic dimension of rural infrastructure. The visible connections of the term "rural infrastructure" confirm its role as a linking point between the institutional, social and economic dimensions of

rural development. Among the key related terms are "economic growth", "impact", "growth", "inequality", "agriculture" as well as "policy" and "rural development". Its position near the centre of the network and its connections to nodes across all three clusters show its cross-cutting relevance. Rural infrastructure is seen not only as a physical component of development but also as a factor that supports social inclusion, economic performance and effective public policy. An important aspect of the analysis is its strong link with "poverty", "inequality" and "rural poverty", suggesting that infrastructure is seen in research as a tool for reducing gaps and improving living conditions in marginalized areas. Its connections to "impact" and "growth" also point to growing interest in measuring the effects of infrastructure on local development, in terms of added value, economic mobility and access to essential services. In conclusion, "rural infrastructure" is a key concept in the analysed thematic network, playing a dual role both as a subject of technical and institutional analysis and as a strategic means for rural development policy. Its importance in the literature is confirmed by the central position and the density of its connections, which make it an essential indicator of the potential to transform rural areas.

Limits of bibliometric analysis

Although bibliometric analysis is a powerful tool for exploring the structure, dynamics and research directions of a scientific field, it has several methodological and interpretive limitations. In this study, these limitations mainly arise from the choice of database, the method of term extraction and the parameters used to generate the visualizations.

Conclusions

The bibliometric analysis conducted in this study provided a detailed and systematic overview of how the international scientific literature has addressed the relationship between infrastructure and rural development over the past three decades, helping us understand what topics are most studied, how ideas are connected, and where research is heading. The results reveal the presence of three main thematic clusters: (1) the socio-political dimensions of rural infrastructure, (2) sustainable transformation and rural development and (3) economic performance and public infrastructure. These clusters reflect not only the diversity of perspectives in the literature but also the interdependence of economic, institutional and social factors in the rural development process. The terms "rural development" and "rural infrastructure" occupy central positions in the network, reinforcing the idea that infrastructure is a key lever in transforming rural areas. The international contributions identified underline the global nature of concerns regarding rural infrastructure, with significant involvement from countries such as China, the United States and Romania. However, the relatively low level of transnational collaboration suggests there is considerable room for improvement in international academic cooperation.

This study contributes to the systematization of existing knowledge and the identification of future research directions, including the deepening of analysis on digital and green

infrastructure in rural areas, the integration of qualitative methods into bibliometric studies for deeper contextual understanding and the expansion of investigations into public policies that support integrated rural development. While the analysis provides valuable insights, it is based solely on patterns observed in the academic literature. As such, it does not capture the full complexity of real-world policy implementation, nor the diverse local contexts in which rural development unfolds. Future research could address these aspects by combining bibliometric methods with case studies, interviews or policy evaluations and by exploring the evolution of these concepts over time. Despite these limitations, the current approach remains useful because it offers a structured overview of how scientific thinking has evolved in this domain. It can help researchers identify emerging areas of interest and support decision-makers in designing targeted, evidence-based interventions.

In conclusion, rural infrastructure can no longer be treated as a purely technical component but must be understood as a fundamental pillar of balanced territorial development, social cohesion and long-term sustainability. Interdisciplinary and collaborative approaches are therefore essential for designing effective policies and interventions that are adapted to the complex realities of the contemporary rural environment. The insights revealed by this study can guide policymakers in prioritizing infrastructure investments that contribute not only to economic growth, but also to inclusive, sustainable rural development.

Conflict of interests

The authors declare no conflict of interest.

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Introduction

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Paper volume up to 30.000 characters (without spaces) or 15 full pages including the text, figures, tables, references list and appendices. Articles should not be shorter than 10 pages. Depending on papers' quality, Editorial Board could also accept longer articles. Article has to be prepared electronically (on computer), in program MS Word 2003 or some later version of this program.

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Many papers are rejected by journal editors because of a fault Discussion.

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The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a *Discussion* or *Results and Discussion* section. Conclusions should provide a summary of important findings and their implicants to the area of research that is the forms of the article.

Acknowledgements

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.). They should be brief.

Conflict of interests

The authors declare no conflict of interest.

References

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2. Hjalager, A. M., & Richards, G. (Eds.). (2003). *Tourism and gastronomy*. Routledge, London.

3. Mićović, A. (2017). Tourism Development and Evolution of Tourism Related Rules, *2nd International Scientific Conference – Thematic Proceedings II*, Faculty of Hotel Management and Tourism, Vrnjačka Banja, 181-202. Retrieved from http://www.hit-vb.kg.ac.rs/conference/images/thematic_proceedings/2017_ II.pdf

4. Stošić, L., & Stošić, I. (2013). Diffusion of innovation in modern school. *International Journal Of Cognitive Research In Science, Engineering And Education (IJCRSEE),* 1(1), 12-24.

5. Domanović, V., Vujičić, M., & Ristić, L. (2018), Profitability of food industry companies in the Republic of Serbia, *Economic of Agriculture*, 65(1), 11-32. doi:10.5937/ekoPolj1801011D

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Example:

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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Figure 1. Agriculture, value added (% of GDP)
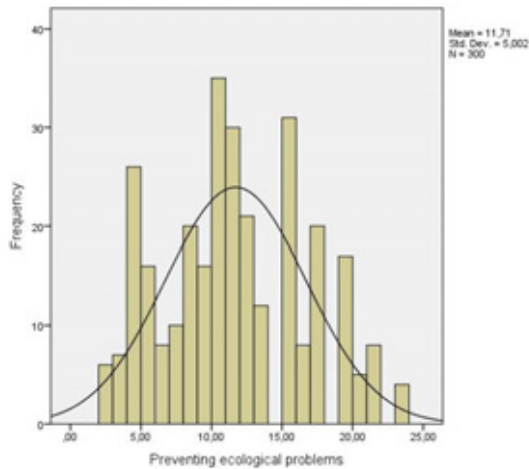

Source: Authors' calculations

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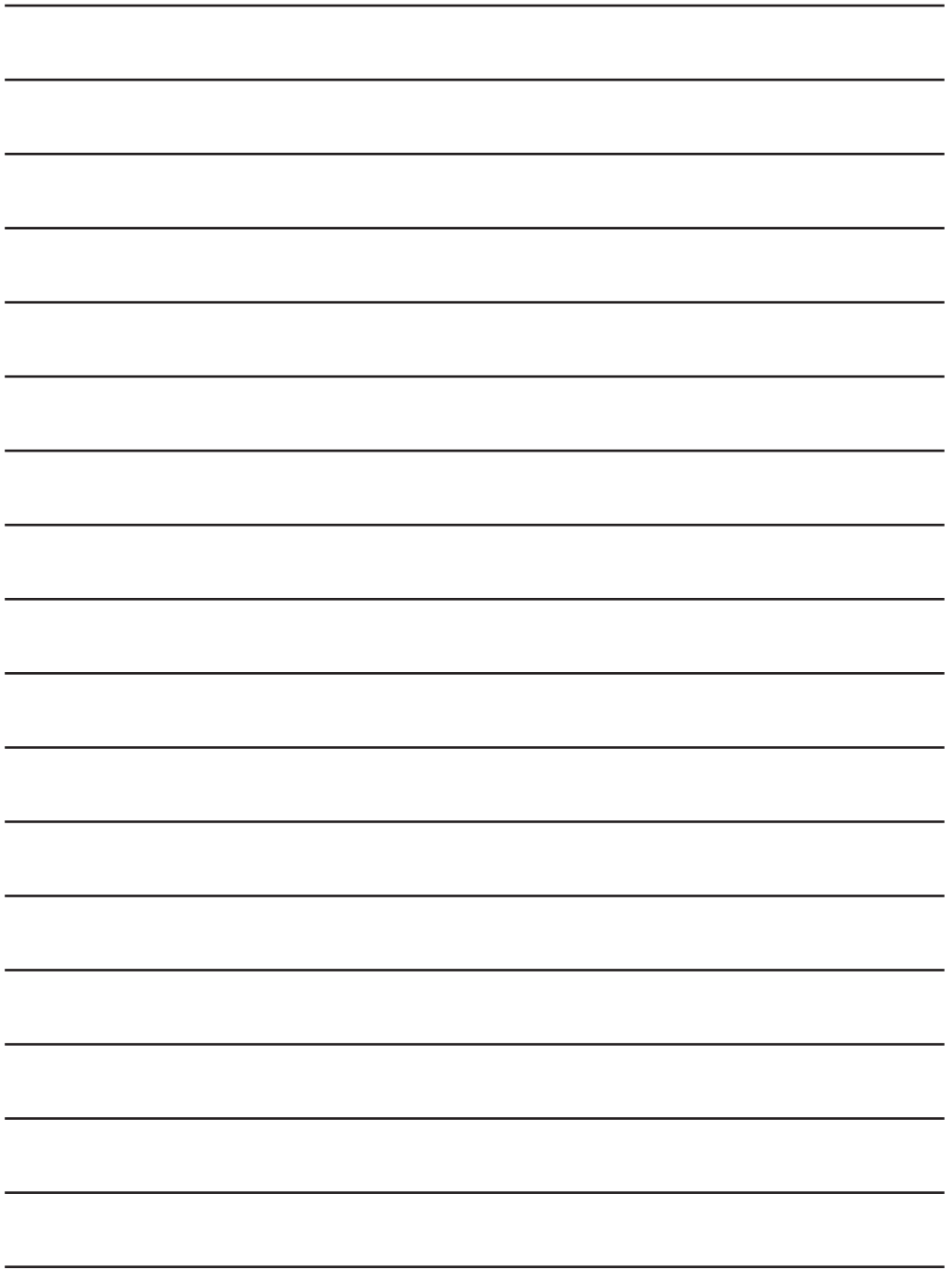
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