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CONTENT

RURAL TOURISM IMPACT ON THE LIFE QUALITY OF THE LOCAL COMMUNITY: A CASE STUDY OF WESTERN SERBIA

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A B S T R A C T

This study analyzes the impact of rural tourism on the quality of life in Western Serbia, focusing on four tourist villages: Koštunići, Vraneša, Sunčana reka, and Sirogojno. Utilizing a mixed-methods approach with 469 respondents, we assessed local perceptions of economic, social, and environmental influences resulting from tourism development. The Likert scale revealed positive economic effects, significant shifts in social conditions and thinking, and concerns about environmental degradation. The study underscores rural tourism's multifaceted nature, emphasizing positive economic impacts, socio-cultural improvements, and environmental considerations. The conclusions highlight the need for responsible, sustainable practices to optimize benefits while mitigating negative consequences. Recommendations include addressing gender disparities and prioritizing environmental concerns in future rural tourism development. This research contributes to understanding rural tourism's implications, offering insights for policymakers, local communities, and practitioners striving for balanced, prosperous, and sustainable rural development in Western Serbia and beyond.

Introduction

Rural tourism (Gao, Wu, 2017) represents a multifaceted niche within the broader tourism industry. It typically involves visitors seeking authentic, rural experiences by staying in rural communities and engaging in activities related to agriculture, local culture, and nature (Lane, 1994; Nelson et al., 2021). These experiences contrast with

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the more conventional urban and seaside tourism, as they offer a glimpse into the traditional and natural way of life in rural areas. Such experiences can range from farm stays and cultural festivals to outdoor recreational activities and wildlife observation. According to Vytautas & Vytautas (2014), one defining characteristic of rural tourism is its potential to contribute to the economic development of rural areas. By attracting tourists, rural communities (Lindberg et al., 2021) can generate income, diversify their economic activities (Vytautas & Vytautas, 2014), and reduce their dependence on traditional livelihoods (Ling et al., 2023). According to Lindberg et al., (2021), rural tourism often stimulates the preservation of local traditions, customs, and natural resources, which can be key drivers for the long-term sustainability of these destinations.

The influence of rural tourism on rural destinations is multifaceted and can be both positive (Germanovich et al., 2020; Maret et al., 2018; Wardana et al., 2020; Singh et al., 2022) and negative (An, Alarcon, 2020; Cijanović et al., 2021; Temelkov, Gulev, 2019). On the positive side, it can stimulate economic growth, boost local employment, and generate revenue through the sale of local products and services. Rural tourism can lead to infrastructural development, as improved road networks, accommodations, and facilities are necessary to cater to the needs of tourists. These investments can benefit both tourists and residents, enhancing the overall attractiveness of the area. On the flip side, there are potential negative impacts to consider. Increased visitor numbers may put pressure on the environment, particularly if not managed sustainably. Overcrowding, pollution, and overuse of natural resources can harm the very qualities that attract tourists in the first place. Local cultures and traditions might also face erosion, as commercialization and adaptation to tourist demands can alter the authenticity of the rural experience.

While the broader impact of rural tourism on destinations is well-documented (Han et al., 2021; Akhtar, 2023; Quaranta et al., 2016; Kortoci Y., Kortoci M., 2016; Ghaderi, Henderson, 2012), the influence on local communities, and especially the quality of life of residents (Lin et al., 2017), is a dimension that requires further exploration. According to Lin et al., (2017), quality of life is a multifaceted concept encompassing various social, economic, cultural, and environmental aspects. Rural tourism can affect these aspects in different ways. Economically (Ruiz-Real, et al., 2022; Sun et al., 2023; Boley et al., 2018; Kurniawan, Cahyono, 2020) rural tourism can create job opportunities for local residents and generate income through various entrepreneurial activities. This can lead to an improved standard of living and access to services and amenities. However, it can also create disparities in income and employment within the community, as some residents may benefit more than others. Moreover, the seasonal nature of tourism can present challenges, with employment opportunities fluctuating throughout the year. Socially (Jepson, Sharpley, 2015) rural tourism can promote community engagement and interaction between locals and tourists, potentially enhancing cross-cultural understanding. However, it may also strain social structures and traditional ways of life as communities adapt to the demands and behaviors of tourists. Environmentally (Sun et al., 2023; Chen et al., 2023), rural tourism can serve as a motivating factor for environmental conservation. It can encourage the preservation of natural landscapes, biodiversity, and sustainable land use. Conversely, inadequate management of tourism activities can lead to environmental degradation and the depletion of natural resources.

The focus of this paper is on Western Serbia, a region known for its scenic beauty, traditional lifestyle, and rural landscapes. Western Serbia offers a unique blend of natural attractions, cultural heritage, and the warmth of rural hospitality. It is characterized by its geographical diversity, with rolling hills, fertile plains, and pristine rivers. These landscapes provide a rich backdrop for various rural tourism activities such as hiking, fishing, agrotourism, and cultural events. The region is also renowned for its proximity to national parks and protected areas, which further contribute to its appeal as a rural tourism destination. The study area includes four tourist villages: Koštunići, Vraneša, Sunčana reka, and Sirogojno. These villages have embraced tourism to diversify their economies and preserve their cultural and natural heritage. Visitors to these villages can partake in authentic experiences, and traditional craftsmanship, and immerse themselves in the local way of life. The study aims to examine the dynamics of rural tourism in these villages and assess its impact on the quality of life for the local communities.

The research showed that in the observed rural areas of Western Serbia, there are positive economic effects on the life of the local population because of tourist activities. Also, the changes brought about by tourism development have largely shifted social conditions and ways of thinking, as well as some established practices among the local population. However, certain concerns arise as a result of the slight degradation of the natural environment, which unfortunately at this moment is not immune to tourism development and the activities that are carried out within that process.

The research methodology

Study area

The study area includes four tourist villages in the area of western Serbia - Koštunići, Vraneša, Sunčana reka and Sirogojno.

Koštunići, located 32 kilometers northwest of Gornji Milanovac, is a rural settlement with a dispersed layout, primarily dedicated to cattle breeding. It is nestled on the southern slopes of Suvobor, a peak that reaches 866 meters in elevation (Čulić, 2006). Remarkably, in terms of land area, Koštunići stands out as the most extensive rural settlement within the Gornji Milanovac municipality (Pavlović, 2016). Four mountain rivers, namely Grab, Bukovača, Čemernica, and Šiban, course through the village, providing habitats for diverse river fish and crab species (Milošević, 2006). This region is distinguished by its outstanding ecological and scenic attributes. It encompasses the valleys of mountain rivers and streams, featuring well-defined agrarian, forest, and meadow ecosystems, teeming with an abundance of medicinal herbs and forest fruits (Jovanović Tončev, 2016). Due to the conservation of its natural surroundings, this village is the sole ecological village in Serbia.

Vraneša is another charming village in Serbia, situated in the Zlatibor region, close to the town of Nova Varoš which is known for its beautiful landscapes. The Vraneša ethno-eco village is situated within a coniferous forest and comprises multiple bungalows nestled at an elevation of 943 meters, providing guests with picturesque views of Zlatar Lake (Svojić, 2015). The village's construction adheres to the traditional Serbian village architecture, utilizing genuine and environmentally friendly materials indigenous to the goldsmith's region, such as black pine and stone. The wooden components are treated with natural resin, and all the houses are roofed with handcrafted split shingles. The village is surrounded by lush greenery, rolling hills, and pristine rivers, making it a popular destination for outdoor enthusiasts. Visitors can explore the natural beauty, go trekking, and immerse themselves in the local culture (Svojić, 2015).

The village of Sunčana Reka is located on the banks of the Drina River, not far from Loznica. In addition to one of the most beautiful rivers, this ethnic village is surrounded by numerous other natural beauties, such as Banja Koviljača, but also the historically important Gučevo mountain. This tourist complex consists of a total of seven accommodation settlements, with 43 accommodation units and a total of 124 beds. In addition to catering facilities, this village offers various sports and recreational facilities, including activities in the village such as horseback riding, ball sports, and recreational activities on the Drina (Stepanović, 2013).

The village of Sirogojno on Zlatibor, which, as an open-air museum named "*Staro selo"* (eng. Old village), shows the life of Serbian peasants, as well as many forgotten crafts and skills, through the interesting construction architecture, interior decoration of buildings in the hilly and mountainous areas of the Dinaric region (Ranko, 1987). Sirogojno is even located near one of the largest Serbian mountaineering centers, Zlatibor. It covers an area of 5 hectares and has about 50 buildings that were relocated and transferred from the surrounding Zlatibor villages (Đenić, 2008).

Sources of data

In the paper, we used the views of the local population regarding the economic, social, and environmental impacts that tourism has on their quality of life. We used a modified methodology presented in their work by Monterrubio et al., (2020). In that work, the researchers asked the local population to identify the most relevant impacts of tourism development (in this particular case, the construction of an airport) on rural areas and the quality of life in them. In our work, we wanted to present the results of the local population's opinion on the impact of tourism development (in our case, ethnic villages and objects converted into ethnic objects open to tourists), on the quality of their life in the villages to which the given objects gravitate or are located. We assumed that these are positive influences. The research lasted from May 2022 to May 2023, and the local population of the eco-ethno villages of Koštunići, Vraneša, Sunčana reka, and Sirogojno, in the region of Western Serbia, was examined. A total of 469 respondents. They were asked to rate the items on an ordinal scale of 1-5, 1 being the most negative (i.e., much worse or greatly increasing) and 5 being the most positive, with 3 meaning no change. A Likert scale of gradation of attitudes was used.

The goal of the study was to determine the relative importance of certain attitudes within all three influences, in order to minimize the negative, that is, to emphasize the positive aspects of the development of rural destinations. For the purposes of this research, we used the variables that we assumed could have the greatest impact on the quality of life of the local population. Dependent variables are: 1. Economic impacts (Income, Standard of living, Productivity, Transportation, Entertainment 2. Social impacts (Population growth, Friendliness, Kindness, Alcohol and drugs, Prejudice) 3. Environmental impacts (Pollution, Habitat disturbance, and Other). From the independent variables, in the work we used the variable: Gender. In order to see if there is a connection between the variables and the probability of connection, we used Chi-Square Tests. The work started from the assumption that there would be no difference in the answers about the gender of the respondents, and Statistically significant differences are those with $p < 0.05$.

From that perspective, the main and supportive hypothesizes can be drawn out: **H1:** Rural tourism has a significant influence on the quality of life of the local community in Western Serbia; **H1a:** Rural tourism in Western Serbia positively impacts the economic well-being of the local community, leading to increased income, job creation, and business development **H1b:** Rural tourism in Western Serbia positively affects the socio-cultural aspects of the local community, including the preservation and promotion of local traditions, strengthening community ties, and facilitating cultural exchange between tourists and residents; **H1c:** Rural tourism in Western Serbia has positive effects on the region environmental sustainability, with measures in place to mitigate its impact on natural resources and the physical environment, leading to a more sustainable and eco-friendly tourism practice.

Result and Discussion

The study involved 256 male participants and 212 female participants. The subsequent tables showcase the most substantial economic, social, and environmental effects, organized based on the respondents' gender.

Economic impact of rural tourism

The economic impact of rural tourism is a subject of significant interest and importance, as it can contribute to the development and sustainability of rural areas. In this analysis, we were researching the data provided in Table 1, which presents information on gender and the economic impact of rural tourism, specifically regarding income, standard of living, productivity, transportation, entertainment, employment opportunities, arts and handicrafts, agriculture, human relationships, tourism, and other aspects. To understand the relationship between gender and these economic factors, we used Pearson Chi-Square Tests for each variable separately.

When it comes to Income (Table 1), it can be concluded that as many as 88.9% of respondents answered that incomes are much better since tourism started to develop in their area. This is not surprising because numerous studies support the statement that incomes increase significantly when tourism develops in a destination (Balaguer, Cantavella-Jorda, 2002; Blake, 2009; Arslanturk et al., 2011; Nunkoo et al., 2020; Vujko et al., 2021). The reasons for this are numerous, and above all the increased number of jobs (Vunjak et al., 2020), which automatically affects other items within the Economic impact factor.

Table 1. Income

			Gender		Total
			Male	**Female**	
Income	No change	Count	16	16	32
		% of Total	3,4%	3,4%	6,8%
	Better	Count	18	2	20
		% of Total	3,8%	,4%	4,3%
	Much better	Count	222	194	416
		% of Total	47,4%	41,5%	88,9%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

The Chi-Square Test showed statistical significance, given that p=0.005 (Table 2). This suggests that there is a significant relationship between gender and the impact of rural tourism on income. The results indicate that rural tourism has a notable impact on income, with males experiencing a greater improvement in their income compared to females. This kind of result is an indication for some research in the future, where items that affect the empowerment of women in rural destinations would be determined because, in accordance with the mentioned results, there is an indication that men earn more than women (Maksimović et al., 2019).

Table 2. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	10,642[a]	2	,005

Source: Panić, 2023

When it comes to the Standard of living (Table 3), it should be said that the result is directly proportional to the previous result. Namely, the respondents stated in a total score of 87.8% that the standard has been significantly improved by the development of tourism, and that p=0.000 (Table 4), indicating a highly significant relationship between gender and standard of living in the context of rural tourism.

Table 3. Standard of living

			Gender		Total
			Male	Female	
Standard of living	No change	Count	6	11	17
		% of Total	1,3%	2,4%	3,6%
	Better	Count	37	3	40
		% of Total	7,9%	,6%	8,5%
	Much better	Count	213	198	411
		% of Total	45,5%	42,3%	87,8%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

Although both women and men have similar attitudes regarding the item “Standard of living”, the Chi-Square Test indicates that incomes are uneven.

Table 4. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	27,020[a]	2	,000

Source: Panić, 2023

Table 5 shows us that both men and women when asked about productivity, answered that the productivity of residents has been much better (92.1%) since tourism was developed. This primarily means that residents are aware of the benefits of tourism development, that they earn money from tourism development, and that they are more open and ready for innovation because it benefits them (Vujko et al., 2021).

Table 5. Productivity

			Gender		**Total**
			Male	**Female**	
Productivity	No change	Count	7	6	13
		% of Total	1,5%	1,3%	2,8%
	Better	Count	16	8	24
		% of Total	3,4%	1,7%	5,1%
	Much better	Count	233	198	431
		% of Total	49,8%	42,3%	92,1%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

The Chi-Square Test (table 6) shows that there is no statistical significance in terms of productivity. This suggests the fact that both men and women manage to market their products and services within the tourist offer in the observed areas.

Table 6. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	1,462[a]	2	,481

Source: Panić, 2023

The results of Table 7 indicate a significant improvement in traffic infrastructure and traffic in general, as a result of the development of rural tourism (90.2%). Both sexes report a significant improvement, which implies that rural tourism has had a positive impact on the availability and quality of traffic in the region.

Table 7. Transportation

			Gender		Total
			Male	**Female**	
Transportation	No change	Count	9	17	26
		% of Total	1,9%	3,6%	5,6%
	Better	Count	16	4	20
		% of Total	3,4%	,9%	4,3%
	Much better	Count	231	191	422
		% of Total	49,4%	40,8%	90,2%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

Despite the fact that both sexes express their views on the significant improvement of traffic, there is a certain difference regarding the perception of that satisfaction. Pearson Chi-Square (Table 8) indicates that men notice these changes slightly more, which can be understood in the way that men drive more than women, most likely due to household responsibilities that require the use of cars (Song et al., 2020).

Table 8. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	9,399[a]	2	,009

Source: Panić, 2023

Rural tourism significantly influenced the increase in entertainment content in the observed areas, cumulatively as much as 95.5% (Table 9). This data indicates that both men and women recognize that rural tourism also brings opportunities for entertainment elements in the destination. This can be seen above all during the realization of recreational activities, including campfires, barbecues, local cuisine, diverse sports, excursions, and hiking, making it a more engaging option (Petelca, Garbuz, 2020).

Table 9. Entertainment

			Gender		Total
			Male	**Female**	
Entertainment	No change	Count	10	11	21
		% of Total	2,1%	2,4%	4,5%
	Better	Count	17	18	35
		% of Total	3,6%	3,8%	7,5%
	Much better	Count	229	183	412
		% of Total	48,9%	39,1%	88,0%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

Regardless of the slightly higher percentage of men who emphasized the improvement of entertainment content, the Chi-Square test indicates the balance of these attitudes between the sexes, considering that p=0.581 (table 10).

Table 10. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	1,085[a]	2	,581

Source: Panić, 2023

Social impact of rural tourism

A total of 95,1% of the respondents, regardless of gender, reported a significant increase in population growth (Table 11). Rural tourism could serve as a pivotal factor in the revitalization of Serbian villages, particularly in light of the ongoing population decline in rural regions. These results suggest that rural tourism has the potential to attract or retain residents, especially the younger generation, who may choose to live and work in more favorable economic conditions as a result of tourism growth. With the adoption and successful execution of suitable measures, rural tourism has the potential to catalyze rejuvenating local development (Kelfaoui et al., 2021).

Table 11. Population growth

			Gender		Total
			Male	**Female**	
Population growth	No change	Count	11	12	23
		% of Total	2,4%	2,6%	4,9%
	Increasing	Count	21	16	37
		% of Total	4,5%	3,4%	7,9%
	Greatly increasing	Count	224	184	408
		% of Total	47,9%	39,3%	87,2%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

In terms of population growth, rural tourism has a similar impact on both genders, with a p-value of 0.776, indicating no significant relationship between gender and population growth (Table 12). In other words, the data suggests that gender does not play a significant role in the impact of rural tourism on population growth; both males and females experience similar effects.

Table 12. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	,508[a]	2	,776

Source: Panić, 2023

The majority of respondents reported an increase in friendliness, with a slightly higher proportion of males (Table 13). Bearing in mind that the level of friendliness of the local population directly reflects the quality of the tourist experience, the respondents showed clear indications that with the development of rural tourism, there have been positive changes in this aspect as well. The degree of friendliness displayed by residents towards visitors significantly impacts the tourist experience in a specific rural area to a great extent, and it lies outside the control of any individual service provider (Kachniewska, 2015). Tourists are more attracted to destinations where the local community is friendlier, honest, and hospitable (Fallon & Schofield, 2006).

Table 13. Friendliness

			Gender		Total
			Male	Female	
Friendliness	No change	Count	9	4	13
		% of Total	1,9%	,9%	2,8%
	Increasing	Count	19	7	26
		% of Total	4,1%	1,5%	5,6%
	Greatly increasing	Count	228	201	429
		% of Total	48,7%	42,9%	91,7%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

Results suggest a weak and non-significant relationship between gender and friendliness (Table 14). According to Nunkoo, Ramkissoon (2012) this indicates that among the local population, there is a uniform awareness of how kind they are to each other, regardless of their gender.

Table 14. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	5,069[a]	2	,079

Source: Panić, 2023

Most respondents, regardless of gender, reported a significant increase (87,6%) in kindness (Table 15). What sets apart the attraction for tourists is the affable kindness of the hosts, their dedication to maintaining traditional lifestyles, and their hospitality toward village tourists (Ćurčić et al., 2021). This not only enriches the overall tourism experience but also reflects the cultural richness and community spirit of the area, making it a standout destination for visitors seeking genuine and heartfelt encounters.

Table 15. Kindness

			Gender		Total
			Male	**Female**	
Kindness	No change	Count	10	8	18
		% of Total	2,1%	1,7%	3,8%
	Increasing	Count	29	11	40
		% of Total	6,2%	2,4%	8,5%
	Greatly increasing	Count	217	193	410
		% of Total	46,4%	41,2%	87,6%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

The Chi-Square Test (Table 16) for kindness and gender generated a value of 5.640 with a p-value of 0.060, indicating a weak but non-significant relationship. There are likely other important factors that influence kindness more than gender does.

Table 16. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	5,640[a]	2	,060

Source: Panić, 2023

Regarding the increase or decrease in the distribution of alcohol and narcotics because of the emergence of rural tourism, the largest percentage of respondents estimated that there was a decrease in the presence and consumption of these two vices - 62.4% (Table 17). Nevertheless, almost a quarter of all respondents said that there was no change (24%), and over 13% noticed changes for the worse. This indicates that with the increase in tourist traffic in the observed areas, there have been positive developments regarding the consumption of drugs and alcohol. In addition, it should also be emphasized that part of the traditional gastronomic offer of rural households is also one of the significant attractors, the consumption of local alcoholic beverages (Curtis, 2018), and in this sense, it is not surprising that a quarter of respondents did not notice a change in this aspect.

Table 17. Alcohol and drugs

			Gender		Total
			Male	**Female**	
Alcohol and drugs	Greatly decreasing	Count	13	5	18
		% of Total	2,8%	1,1%	3,9%
	Decreasing	Count	150	123	273
		% of Total	32,1%	26,3%	58,5%
	No change	Count	63	49	112
		% of Total	13,5%	10,5%	24,0%
	Greatly increasing	Count	24	34	58
		% of Total	5,1%	7,3%	12,4%
	Increasing	Count	5	1	6
		% of Total	1,1%	,2%	1,3%
Total		Count	255	212	467
		% of Total	54,6%	45,4%	100,0%

Source: Panić, 2023

Despite the weak significance that is expressed (Table 18), gender must be taken into account as an important variable in the analysis of the use and abuse of alcohol and drugs. Schrock, Schwalbe (2009) and Pavón-Benítez et al., (2021) explain how some risky behaviors are culturally defined as “masculine” and that men use unhealthy behaviors to define their masculinity, such as consuming excessive amounts of alcohol to show their loyalty to her male environment. Similarly, various studies have shown the existence of a gender double standard, with women’s drinking behavior being more socio-culturally sanctioned than men’s (Pavón-Benítez et al., 2021; Romo-Avilés et al., 2020).

Table 18. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	8,479[a]	4	,076

Source: Panić, 2023

The largest number of respondents noticed a decrease in the issue of prejudices among the local population (Table 19). The tourism industry has successfully served as a means to decrease prejudice (Schneider, 2019). As rural tourism development moves forward, it has played a pivotal role in breaking down stereotypes and promoting mutual respect among the local population and visitors.

Table 19. Prejudice

			Gender		Total
			Male	Female	
Prejudice	Greatly decreasing	Count	25	22	47
		% of Total	5,3%	4,7%	10,0%
	Decreasing	Count	144	120	264
		% of Total	30,8%	25,6%	56,4%
	No change	Count	61	42	103
		% of Total	13,0%	9,0%	22,0%
	Increasing	Count	23	28	51
		% of Total	4,9%	6,0%	10,9%
	Greatly increasing	Count	3	0	3
		% of Total	,6%	,0%	,6%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

Regardless of the somewhat larger number of men who assessed that the level of expressing prejudices has decreased as a result of the emergence of rural tourism, the Pearson Chi-Square Test indicates uniformity in attitudes regarding this aspect (Table 20).

Table 20. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	5,278[a]	4	,260

Source: Panić, 2023

Environmental impact of rural tourism

In terms of pollution, rural tourism seems to have a similar impact on both genders with more than 60% of the respondents reporting worse conditions as a result of the tourism activity (Table 21). While bringing economic growth and cultural exchange, rural tourism development has also prompted concerns among residents regarding the observed increase in pollution. The ecological consequences of rural tourism are noteworthy, with increased pollution, extensive land occupation, and potential threats to natural environments, including soil erosion and the endangerment of rare species (Verma et al., 2023). These concerns emphasize the importance of responsible and sustainable rural tourism practices that harmonize with the environment while fostering economic opportunities.

Table 21. Pollution

			Gender		Total
			Male	**Female**	
Pollution	Much worse	Count	47	33	80
		% of Total	10,0%	7,1%	17,1%
	Worse	Count	125	107	232
		% of Total	26,7%	22,9%	49,6%
	No change	Count	84	72	156
		% of Total	17,9%	15,4%	33,3%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

The results of the Pearson Chi-Square Test indicate no significant relationship between gender and pollution (Table 22). This indicates that both men and women are equally concerned about the growing share of pollution as a side effect of tourism activities in their environment.

Table 22. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	,639[a]	2	,727

Source: Panić, 2023

Both males and females reported that rural tourism had made habitat disturbance worse, with a similar distribution (Table 23). The influx of visitors, construction activities, and the need for amenities can disrupt the delicate balance of flora and fauna in these rural areas. Also, often tourist activities that are available to visitors can cause problems for the environment. For example, the utilization of trails and the resulting wear and tear, as well as the deterioration of forests and disruption of habitats due to off-road driving (Ahmadi, et al., 2018). Residents, deeply connected to their surroundings, worry about the impact of habitat disturbance on the indigenous wildlife and the fragile ecosystems that have thrived for generations. Their concerns underscore the need for sustainable practices and responsible tourism management that harmonize with the environment, safeguarding the pristine beauty of their rural habitats.

Table 23. Habitat disturbance

			Gender		Total
			Male	Female	
Habitat disturbance	Much worse	Count	40	30	70
		% of Total	8,5%	6,4%	15,0%
	Worse	Count	145	118	263
		% of Total	31,0%	25,2%	56,2%
	No change	Count	71	64	135
		% of Total	15,2%	13,7%	28,8%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

The results of the Pearson Chi-Square Test (Table 24) indicate no significant relationship between gender and habitat disturbance. This indicates that both sexes are equally concerned about environmental disturbances that come as an effect of tourism activities.

Table 24. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	,430[a]	2	,806

Source: Panić, 2023

In terms of Other environmental impacts, rural tourism seems to have a similar impact on both genders, where the majority haven't noticed any change as a result of tourism activities (Table 25).

Table 25. Other

			Gender		Total
			Male	Female	
Other	Much worse	Count	44	28	72
		% of Total	9,4%	6,0%	15,4%
	Worse	Count	105	73	178
		% of Total	22,4%	15,6%	38,0%
	No change	Count	107	111	218
		% of Total	22,9%	23,7%	46,6%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Panić, 2023

The Chi-Square Test for other environmental impacts and gender resulted in a p-value of 0.071, indicating a weak and non-significant relationship (Table 26).

Table 26. Pearson Chi-Square Test

	Value	df	Statistical significance (p)
Pearson Chi-Square Test	5,292[a]	2	,071

Source: Panić, 2023

Conclusion

The research findings presented in this study offer a comprehensive insight into the impact of rural tourism on the quality of life of the local community in Western Serbia. We tested multiple hypotheses that aimed to investigate the influence of rural tourism on various dimensions of economic, socio-cultural, and environmental aspects. The results of this study provide valuable insights into the nuanced relationship between rural tourism development and the quality of life in this region.

One of the key findings of our research is the substantial positive impact of rural tourism on the economic well-being of the local community. The data revealed that the majority of respondents reported significant improvements in income, standard of living, productivity, and employment opportunities. Specifically, 88.9% of respondents reported increased income since the inception of rural tourism, highlighting the economic benefits derived from the sector. The results support previous research that has shown how tourism can lead to income growth through job creation and increased economic activity. Moreover, rural tourism appeared to have a notably greater impact on income for males compared to females, indicating a gender-based discrepancy that merits further investigation.

Rural tourism in Western Serbia has demonstrated a positive influence on socio-cultural aspects, including the preservation and promotion of local traditions, strengthened community ties, and cultural exchange between tourists and residents. The data showed a significant improvement in the standard of living for 87.8% of respondents, highlighting the perceived enhancement in the overall quality of life. This is particularly important as it reflects the well-being and satisfaction of the local community. The results suggested that both males and females were equally inclined to support rural tourism development, indicating a unified perception of the positive socio-cultural impact.

The environmental sustainability of rural tourism in Western Serbia was also assessed, with a focus on pollution, habitat disturbance, and other environmental impacts. The findings revealed that more than 60% of respondents reported worse pollution conditions as a result of tourism activities. While rural tourism has brought about economic growth and cultural exchange, it has also raised concerns regarding increased pollution and habitat disturbance. These concerns emphasize the importance of responsible and sustainable tourism practices that harmonize with the environment.

The results of the research helped us to examine the validity of the previously set hypotheses. In this sense, by looking at the research results from tables 1-9, we concluded that rural tourism in Western Serbia positively impacts the economic well-being of the local community, leading to increased income, better standard of living, job creation, increased productivity, and business development thus the hypothesis H1a is confirmed. Furthermore, the results that emphasized the social impact of rural tourism showed that rural tourism had positive social effects on the observed tourist areas, which was manifested in population growth, a greater degree of friendliness and kindness towards other people, but also a reduced level of prejudice among the local population. This confirms the hypothesis H1b. Finally, when it comes to the matter of environmental issues, the results showed that rural tourism did not contribute to the improvement of the environmental image of the observed region. On the contrary, the results showed that there was more pollution and habitat disturbance as a result of tourist activities. This is an indication that it is necessary to invest additional energy to solve this problem more thoroughly in the future. This refutes the hypothesis H1c. Based on everything presented, we can conclude that rural tourism has a positive impact on the sociological and economic aspects of the quality of life of the local population, while on the other hand, we see certain negative impacts on the environment. Thus, we can only partially confirm our main hypothesis H1 that rural tourism has a positive effect on the overall quality of life of the local population in the region of Western Serbia.

The analysis also touched upon potential gender disparities in the impact of rural tourism. While both genders reported similar improvements in most aspects, some subtle differences were observed. For instance, males appeared to experience a greater impact on income and population growth, suggesting that future research could explore the underlying reasons for these variations.

In conclusion, the results of this study provide strong evidence that rural tourism in Western Serbia has a significant influence on the quality of life of the local community. The positive economic impact, improvement in socio-cultural aspects, and acknowledgment of environmental concerns underscore the multifaceted nature of rural tourism development. These findings offer valuable insights for policymakers, local communities, and tourism practitioners, highlighting the need for responsible and sustainable practices to maximize the benefits of rural tourism while mitigating its negative consequences.

The outcomes of this study contribute to the growing body of knowledge on rural tourism and its implications for rural development and quality of life. Future research endeavors should delve deeper into understanding the specific mechanisms that drive gender-based disparities and focus on developing strategies to empower women in rural destinations. Furthermore, addressing environmental concerns should remain a top priority, as rural tourism continues to evolve and shape the future of Western Serbia and similar regions. Ultimately, the findings emphasize the potential of rural tourism as a driver of positive change and prosperity in rural communities, and the importance of continued efforts to balance economic development with cultural preservation and environmental conservation.

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Conflict of interests

The authors declare no conflict of interest.

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ASSESSMENT MODEL FOR SUSTAINABLE RURAL DEVELOPMENT AT NUTS 3 LEVEL: A MULTI-CRITERIA APPROACH

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A B S T R A C T

Sustainable rural development, encompassing economic growth, social equity, and environmental protection, is a multifaceted concept with inherent complexities. Achieving it often involves navigating trade-offs between these three pillars. To effectively allocate resources and achieve convergent development in the EU, measuring rural sustainability at the regional level is crucial. The multi-criteria approach addresses this challenge by considering the diverse perspectives of stakeholders involved in rural development. This paper presents a model for measuring sustainable rural development at the NUTS 3 level in Croatia, utilizing the Analytic Hierarchy Process (AHP) within a multi-criteria analysis framework. Based on a survey of rural development stakeholders, 15 indicators were selected, weighted, and incorporated into the model. The survey revealed that economic indicators received the highest weight (0.415), followed by social (0.309) and environmental (0.275) considerations. This model offers a valuable foundation for local and regional decision-makers to develop strategies and implement actions that promote sustainable development in rural areas.

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Introduction

Sustainable development reconciles environmental, social and economic needs despite their complexity and resource constraints (Chatzinikolaou & Manos, 2012). Ideally, these components progress together, but in practice, trade-offs exist. The Environmental Kuznets Curve (EKC) indicates an initial deterioration of the environmental situation with economic growth, followed by an improvement at higher income levels (Kordej-De Villa et al., 2009). Šimleša (2003) argues that economic progress since the industrial revolution has often been detrimental to the environment. At its core, sustainability aims to conserve resources (natural, human and created) while promoting efficiency and fairness (EC-ADG, 2001).

The European Union (EU) has been encouraging sustainable development to be the primary priority in all future endeavours across countries, sectors and industries (Bilas et al., 2021).

Sustainable development encompasses many areas, the most interesting of which for the agricultural profession is sustainable rural development. It is generally recognized as the result of human activities that use rural resources to enhance the well-being of its inhabitants (Permanent secretariat of the Alpine Convention, 2011).

Sustainable rural development can be observed at various levels, from the international to the national or local level. One of the reasons why sustainable rural development needs to be researched at the level of local government units is because rural areas within the EU are incredibly diverse, even within the same country. By understanding the specific context of each rural county, researchers and policymakers can design solutions that are tailored to address the local needs and opportunities. A "one-size-fits-all" approach wouldn't be effective in addressing the diverse challenges faced by different rural areas.

Despite the need for measurement tools to assess rural sustainability progress, there's no international consensus on the number and type of indicators, frameworks, or conceptual models for national use. This lack of agreement is even more pronounced at regional and local levels (Ramos, 2009).

Given the multiple dimensions of rural development (economic, social, environmental), policymakers are highly interested in better understanding the extent and patterns of overall well-being in rural regions. Convergence aims to strengthen sustainability in less developed European Union countries, which will also be achieved through the reallocation of financial resources to achieve this goal.

This paper focuses on sustainable rural development at the county (NUTS 3) level. While data availability is a key factor, this focus also aligns with the principle of achieving national development through the balanced progress of all regions. National-level indicators, like GDP per capita growth, can mask disparities between counties. Similar inconsistencies likely exist in other aspects of sustainable development. Therefore, comparing regions is crucial to identify those lagging behind and support them in overcoming their specific challenges.

Most of the indicators proposed to date are based on a top-down definition of sustainability and use data available at the national level, which can lead to ignoring critical sustainability issues at the local level and failing to measure what is important to people at the local level (Reed et al., 2006).

Indicators, as emphasized by the EU Commission (2001), should be tailored to policy and decision-making. They should reveal policy gaps and track impact, while also informing resource allocation based on development levels and their causes (Boggia et al., 2014).

Kahila et al. (2023) summarized the conclusions of the European Commission's Eighth Report on Economic, Social and Territorial Cohesion (2021) into eight groups of sustainability indicators. These groups include three traditional indicators supplemented with indicators for digitalization, demographics, efficient transportation, quality of life/well-being, and governance.
The drawback of new indicators is that they are not yet integrated into official statistical overviews, especially at regional levels, which makes their use in comparisons at the county level difficult.

Due to the heterogeneity of rural development stakeholders in terms of professional, political, and interest orientations, and the need to balance the various components of sustainable development, the application of the multi-criteria approach is common in scientific and professional practice for appraising rural sustainability (Boggia et al., 2014; Hedayati-Moghadam, 2014; Chantzinikolaou, 2013; Boggia and Cortina, 2010; Poursaeed et al., 2010; Ferrarini et al., 2001).

Therefore, the objectives of this paper are:

(1) to identify the most appropriate indicators to measure sustainable rural development at the NUTS 3 level,

(2) to create a model to measure sustainable rural development at the NUTS 3 level using the method of multi-criteria analysis.

Measuring sustainable rural development globally is challenging due to diverse local contexts, including environmental and socio-economic factors. In poorer regions, the fight against hunger takes precedence, while in developed ones, concerns shift towards cultural access and CO2 reduction (Swain & Yang-Wallentin, 2020). Croatia, while not facing hunger issues, still lags behind the EU average in GDP per capita, suggesting the economic dimension of sustainability remains crucial for the nation.

On this basis, the following research hypothesis can be made:

Economic indicators will determine sustainable rural development in Croatia to the greatest extent, i.e. they have an advantage over environmental and social indicators.

Materials and methods

The first step of the research was to make an overview of the indicators used so far or proposed only in the literature to measure sustainable rural development (14 environmental, 15 economic and 18 social). The indicators proposed in the literature are indicators proposed by certain institutions in their templates for assessing the sustainability of rural areas, but for which no examples of their application in actual research were found. The indicators are divided into three groups: environmental, economic and social. Respondents were required to rate, on a scale of one to five, how important they thought each proposed indicator should be in the model for measuring sustainable rural development. Respondents also had the opportunity to suggest indicators they thought were important that were not included in the survey. The survey was conducted in person and via e-mail, and 47 respondents participated. The respondents consisted of representatives of scientific and teaching institutions dealing with rural development, sociology and economics, representatives of counties dealing with rural development and agriculture, representatives of various relevant agencies and associations, and leaders of local action groups (LAGs) operating in Croatia. 20 representatives of scientific and teaching institutions, 20 representatives of LAGs and associations, and seven representatives of state institutions (counties, ministries, agencies) participated in the survey.

Data were processed using the SPSS Statistics 17.0 program, with average scores calculated for each indicator. Five indicators from each of the three groups that achieved the highest average scores were included in the model for measuring sustainable rural development.

A multi-criteria analysis, the Analytical Hierarchy Process, was used to create a model for measuring sustainable rural development at the NUTS 3 level. Key indicators selected by respondents were entered into the Expert Choice 2000 program and then comparatively scored. This program was also used in some other sustainable development researches that were using AHP method. For example, Huehner et al. (2016) used AHP to evaluate Agro-Environmental measures of the rural development program in Slovenia. Evaluation of China’s rural development strategy based on SWOT-AHP was used by Guo et al. (2019).

Kusakci et al. (2022) used a hybridized version of the AHP to assess the sustainability of urbanization policies in Turkey. Ameen and Mourshed (2018) also used AHP to rank and weight sustainability indicators for the purpose of assessing urban sustainability in Iraq.

Using the Saaty scale, respondents made an expert assessment of the relative importance of the selected indicators in relation to the specified goal - achieving sustainable rural development. Part of the respondents’ judgments were obtained through personal contact, while the other part of the participants received paired indicators sent to e-mail addresses. The expert judgments were obtained from the same respondents as in the first part of the research. The participation was lower, the judgment was given by 32 respondents, of which 18 were representatives of scientific and teaching institutions, nine were from LAGs and associations, and five were respondents from county offices for economy and rural development.

The AHP model can be divided into the following stages: (1) formation of the hierarchical structure which is the most significant action in the AHP model (Çimren et al., 2007). (2) After completing the questionnaires by 32 relevant experts and specialists of the field, the relative importance of the subcriteria to each other was calculated through forming a pairwise comparison matrix via assigning scores 1 to 9. (3) Evaluation of system consistency and inconsistency is the last step in the AHP model, and the value was estimated using Expert Choice software in the present study. In a pairwise comparison matrix, if the inconsistency rate (IR) is less than 0.1, the comparisons will be acceptable and represent consistency (Tzeng et al., 2002). Of the 32 expert judgments, 25 were included in the model, while the remaining seven were rejected due to too high inconsistency. After prioritization, the data are entered into the model and the aggregate priorities of the alternatives are calculated by summing their weighted local priorities, starting from the lowest level of the hierarchical model. The sum of priorities of all criteria is one, as well as the sum of sub-criteria of a criterion and all alternatives in the model.

In this model, criteria are groups of indicators – environmental, economic, and social and sub-criteria are individual indicators in each of the above mentioned groups. Alternatives are NUTS 3 areas compared with this model (that is not subject in this paper).

Results

Proposed indicators for measuring sustainable rural development with indication of the authors who proposed and/or used them

Through the analysis of previous research on sustainable rural development, the indicators listed in Table 1 were summarized. The given indicators are divided into three groups: ecological, economic and social. In the ecological group 14, in the economic 15 and in the social 18 indicators were proposed.

Table 1. List of proposed indicators for measuring sustainable rural development with indication of the authors who proposed and/or used them

Economic	Ecological	Social
Budget revenues of local or regional self-government units per capita *(Khalifa and Connelly, 2009)*	Share of organic agriculture in the whole agriculture *(EC-ADG, 2001; Boggia et al., 2014; EEA, 2005; Golusin and Munitlak Ivanović, 2009; Dantsis et al., 2010; EC-DGAGRI, 2013; OECD, 2001; Priorr, 2013; OG 30/2009)*	Number of women in local self-government councils in relation to the total number of councilors *(Golusin and Munitlak Ivanović, 2009; Niggemann, 2009; FAO, 2013)*
Number of beds in rural tourism in relation to the total population *(EC-ADG, 2001; Boggia et al., 2014; EC, 2013)*	Number of livestock units/ha *(Boggia et al., 2014; Ferrarini et al., 2001)*	Number of agricultural holdings in which women are stakeholders *(Niggemann, 2009; FAO, 2013)*

Diversification of sources of income on the farm (additional activities on the farms) *(EC-ADG, 2001; Dantsis et al., 2010; EC, 2013)*	Area under special protection *(EEA, 2005; OG 30/2009; Niggemann, 2009; EC, 2013a)*	Age structure *(EC-ADG, 2001; EC-DGAGRI, 2013)*
Diversification of economic activities in the rural area (GVA of individual activities, number of employees in individual sectors) *(EC-ADG, 2001; EC-DGAGRI, 2013; Niggemann, 2009)*	Biodiversity of plant and animal species *(Ramos, 2009; OECD, 2001; FAO, 2013; EC, 2013; Hilden et al., 2012; Van der Werf and Petit, 2002)*	Number of single person households in rural areas
Number of EU-level protected products in each county in relation to the total number of such products in the country *(EC-ADG, 2001; Boggia et al., 2014)*	Availability of drinking water per inhabitant *(Khalifa and Connelly, 2009; UN, 2007)*	Availability of health institutions -– number of general practice clinics per km^2 *(Ramos, 2009; Khalifa and Connelly, 2009; OG 30/2009; UN, 2007; Dolata, 2013)*
Unemployment rate *(EC-ADG, 2001; Ramos, 2009; Boggia and Cortina, 2010; Ferrarini et al., 2001; Khalifa and Connelly, 2009; Golusin and Munitlak Ivanović, 2009; EC-DGAGRI, 2013; Niggemann, 2009)*	Consumption of drinking water per inhabitant *(Ramos, 2009; Boggia and Cortina, 2010; Ferrarini et al., 2001; Niggemann, 2009)*	Availability of postal services -– number of post offices per km^2
GDP per capita *(EC-ADG, 2001, Ramos, 2009; Khalifa and Connelly, 2009, Golusin and Munitlak Ivanović, 2009; EC-DGAGRI, 2013; UN, 2007)*	Amount of municipal waste per household *(Ferrarini et al., 2001; OG 30/2009; Niggemann, 2009; UN, 2007)*	Availability of basic groceries – number of grocery stores per km^2 *(Niggemann, 2009)*
Productivity of agricultural production (GVA / agricultural land area) *(EC-ADG, 2001; EC-DGAGRI, 2013)*	Existence of infrastructure for recycling and composting *(Ramos, 2009; Ferrarini et al, 2001; OG 30/2009; Dolata, 2013)*	Availability of educational institutions – number of primary and secondary schools per km^2 *(OG 30/2009; Global Ecovillage Network, n.a.)*
Number of entrepreneurs in agricultural and nonagricultural activities in rural areas *(EC-DGAGRI, 2013)*	Investment in renewable energy sources and energy efficiency *(Global Ecovillage Network, n.a.)*	Quality and frequency of public transport lines *(Ferrarini et al., 2001; OG 30/2009; Niggemann, 2009)*
Education as a prerequisite for using innovation *(Dantsis et al., 2010; Niggemann, 2009)*	Use of mineral and organic fertilizers per ha *(EEA, 2005; Golusin and Munitlak Ivanović, 2009; Dantsis et al., 2010; OECD, 2001; Priorr, 2013; OG 30/2009; Van der Werf and Petit, 2002, Bosshaq et al., 2012)*	Tradition and cultural facilities *(Global Ecovillage Network, n.a.)*
Number of cars per household *(Niggemann, 2009)*	Use of pesticides per ha *(EEA, 2005; Golusin and Munitlak Ivanović, 2009; Dantsis et al., 2010; OECD, 2001; Priorr, 2013; OG 30/2009; Hilden et al., 2012; Bosshaq et al., 2012)*	Voter turnout in the last local and parliamentary elections *(Ramos, 2009; Niggemann, 2009)*

Internet access – number of connections / number of inhabitants or households *(EC-ADG, 2001; Golusin and Munitlak Ivanović, 2009; OG 30/2009; EC, 2013; UN, 2007)*	Number of cars and tractors per inhabitant *(Ferrarini et al., 2001)*	Crime rate *(Ramos, 2009; OG 30/2009; Niggemann, 2009; UN, 2007; Global Ecovillage Network, n.a.)*
Availability of infrastructure facilities connected to agriculture *(Bosshaq, 2012)*	Number of farms included in the quality assurance system for farms producing beef, lamb and goat meat, or in other authors research animal welfare *(EC-ADG, 2001, Van der Werf and Petit, 2002)*	Number of active theaters, cinemas and cultural and artistic societies in the county in relation to the number of inhabitants *(Niggemann, 2009)*
Economic vitality – the number of blocked vs. the number of newly established companies *(Niggemann, 2009)*	Areas under forests *(Golusin and Munitlak Ivanović, 2009; EC-DGAGRI, 2013; UN, 2007)*	County expenditure (NUTS 3 region) for culture *(Niggemann, 2009)*
Land fragmentation — average farmland size in ARKOD		Population growth between two censuses *(Ramos, 2009; Khalifa and Connelly, 2009; OG 30/2009; UN, 2007)*
		Age and gender structure *(EC-ADG, 2001; Niggemann, 2009)*
		Institutional efficiency (legislative framework, informal links, governance mechanism) *(EC-ADG, 2001)*
		Educational structure *(EC-ADG, 2001; Ramos, 2009; EC, 2013)*

Source: Authors's' synthesis based on literature.

Among the indicators listed in Table 1, the expert group selected five indicators from each group (Table 2) that will be included in the model for measuring sustainable rural development.

Table 2. List of indicators included in the model with the average ratings of the experts

Economic	Ecological	Social
Unemployment rate (4.49)	Availability of drinking water per inhabitant (4.60)	Age structure (4.70)
Availability of infrastructure facilities connected to agriculture (4.47)	Investment in renewable energy sources and energy efficiency (4.38)	Availability of educational institutions (4.45)
GDP per capita (4.45)	Share of organic agriculture in the whole agriculture (4.15)	Educational structure (4.34)
Productivity of agricultural production (GVA / agricultural land area) (4.21)	Existence of infrastructure for recycling and composting (4.13)	Availability of health institutions (4.32)
Diversification of economic activities in the rural area (4.13)	Biodiversity of plant and animal species (4.09)	Population growth between two censuses (4.32)

Source: Author

The five best-ranked indicators within each group depended on the expert's workplace. A statistically significant difference in the selection of indicators related to the expert's workplace exists for the indicators: Share of organic agriculture in the whole agriculture, availability of drinking water per inhabitant, amount of municipal waste per household, existence of infrastructure for recycling and composting, use of pesticides per ha, GDP per inhabitant, and age structure of rural residents ($p < 0.05$; $N=47$).

Development of a model for assessing sustainable rural development

After selecting the five highest ranked indicators from each group, their pairing and comparative evaluation was done to obtain weights (importance factors) for the model.

Figure 1 shows the local priorities of all criteria and sub-criteria based on the opinions of all respondents who met the criteria (inconsistency factor less than or equal to 0.10). The sum of the local priorities of all three criteria is 1, as well as the sum of all five sub-criteria within each of the three criteria.

Economic indicators (L: .415) have the highest local priority in this model, followed by social (L: .309) and environmental (L: .275). Looking at the sub-criteria of all three criteria, it can be seen that the indicator of availability of drinking water (L: .286) has the highest local priority, followed by educational structure (L: .267) and investment in renewable energy sources (L: .254). The indicator share of organic agriculture in total agriculture has the lowest local priority (L: .127).

Figure 1. Local priorities of criteria and sub-criteria - excerpt from the Expert Choice Program

Source: Author

Discussions

The advantages of the AHP over other multi-criteria methods, as often cited by its proponents, are its flexibility, intuitive appeal to the decision- makers (experts and stakeholders here), and its ability to check the inconsistencies in judgments (Saaty, 2000 according to Ramanathan, 2001).

The recent disputes on environmentally sensitive projects have led to the necessity to con-sider all the stakeholders (i.e. key actors) of a project (such as the authorities, local and affected people, engineers, and others). Several studies on environmentally and socio-economically sensitive projects consider such a stakeholder analysis (Grimble and Chan, 1995; Grimble and Wellard, 1997; Adger et al., 1998 according to Ramanathan, 2001).

Among its many advantages, the AHP method used in the paper also has a major disadvantage, namely the impossibility of complete elimination of subjectivity (Trstenjak and Ćosić, 2015), which implies that the results of the paper are significantly determined by the preferences of the model maker and his selection of criteria and sub-criteria. Tesfamariam and Sadiq (2006) state that AHP involves human subjectivity, which leads to ambiguity and uncertainty in decision making. Dalalah et al. (2010), on the other hand, state that AHP incorporates subjective and objective evaluations, making it a useful tool for assessing the consistency of evaluations, thereby reducing variation in the decision-making process. In order to minimize the influence of the author's subjectivity on the selection of sustainable development criteria, different groups of rural development stakeholders were involved and their over-all average rating determined which of the proposed indicators were included in the sustainable rural development measurement model. On the other hand, complete elimination of subjectivity is not possible in any model, including the one created using the AHP method, but Tahriri et al. (2007) state that AHP is a way of channeling the subjective judgments of experts, their experiences, and intuition into a rational evaluation model. Participants in the research conducted by Maruthur et al. (2015) indicated that the AHP method improved transparency, coherence, and understanding of others' perspectives.

From the obtained results it is evident that there are differences in the selection of indicators depending on which group the respondents belong to (scientific and teaching institutions, LAGs, governmental institutions), suggesting that different life experiences shape different judgments about the importance of individual indicators. The differences become visible when considering the place of work of the respondents; respondents from LAGs are predominantly residents of rural areas, while representatives from science and teaching institutions are predominantly from larger cities. Keseru et al. (2015) also concluded in their study, which involved multiple stakeholder groups, that there is a great deal of het-erogeneity in the responses.

The paper used the overall average score of all respondents, but it is interesting to see the thoughts of each group, each of which is involved in rural development in its own way.

In the group of ecological indicators, the only indicator chosen by all three groups of respondents is the availability of drinking water. The choice of this indicator and its very high average value are surprising, considering that Croatia does not belong to the group of underdeveloped countries where the availability of drinking water is questionable. Gleick (1998) states that access to drinking water is a universal human right and that there should be no differences between rich and poor parts of the world. He also states that people in developed countries take access to drinking water for granted, which was not the case in this study. The fact that water is available to almost everyone in Croatia is also shown by the fact that the possibility of connecting to the public water supply network is 92% at the Croatian level. It should also be taken into account that the public water supply networks are not the only source of drinking water, but there are also local water supply networks and private wells, so it can be said that water is available to almost everyone in Croatia. Therefore, the question remains unanswered why this indicator is considered the most important by the respondents, when it should be clear that nowadays in Croatia water is available for everyone.

In the group of economic indicators, the selection coincides on two indicators - unemployment rate and availability of infrastructure facilities connected to agriculture. The greatest agreement in the selection of indicators was found in the group of social indicators, where the selection agrees on three indicators - age structure, availability of educational institutions and educational structure.

Although the unemployment rate indicator has the lowest value of local priorities of all economic indicators in this research, it is very important for the sustainable development of rural areas. Its importance, as well as the importance of the employment rate as an indicator of economic development, is emphasized by Živić and Pokos (2005). The importance of this indicator is reflected in the fact that employed residents are more likely to decide to stay in rural areas, perhaps sacrificing some other things. When unemployment rate is high, dissatisfaction is high and people leave rural areas in search of work, which affects the sustainability of these areas. The importance of this indicator is highlighted in the measurement of the county development index, where the unemployment rate participates in the final assessment with 30% (OG 63/2010). Looking at all Croatian counties, it can be seen that in all counties where population growth was recorded, with the exception of Zagreb, the unemployment rate is lower than the Croatian average. In Zagreb County, the unemployment rate is only one percentage point higher than the Croatian average.

It is interesting to note the indicator “quality and frequency of public transport lines”, which would be included in the model according to the average evaluation of respondents from LAGs and state institutions, but not according to the choice of representatives of scientific and teaching institutions. The reason for this is most likely the fact that the majority of respondents representing scientific and teaching institutions live in Zagreb and Osijek, cities where the public transport network is well developed, and they do not consider public transport important. Leaders of the LAGs and the representatives of the institutions live in smaller municipalities and understand the importance of having a good public transport network, that is, they feel the shortcomings first hand.

With this overview of the indicators chosen by different groups of respondents, we wanted to point out the importance of involving the different stakeholders of sustainable rural development in the whole process, because everyone has their own opinion and perception of the meaning of the term "sustainable rural development" and how it should be achieved. In addition to involving different stakeholders, a heterogeneous group of respondents was selected to reduce the subjectivity of judgments as much as possible, since each of the groups has its own priorities. The importance of heterogeneity of groups in re-search with sensitive topics (environment, sustainable development, and socially responsible enterprises) is also emphasized by Mardle et al. (2004) and Von Solms (2009). The short-coming of the conducted research is that respondents from all groups did not respond equally to the research and the opinion of representatives of scientific and teaching institutions, mostly from big cities, predominates, as mentioned above.

Table 3 shows that the values of local priorities of the three groups of indicators are different in relation to the respondents' workplace. For example, for respondents representing science and teaching institutions, social indicators are the most important, followed by economic and environmental indicators. For respondents representing LAGs and associations and state and county institutions, economic indicators are most important. For the respondents, the representatives of LAGs, the social indicators are in the second place and the environmental indicators are in the last place, while for the representatives of state and municipal institutions the situation is reversed: for them the environmental indicators are in the second place and the social ones in the third place. The same order of groups of indicators as in the LAGs is given in the IUCN program according to Frajman Ivković (2012) as the current status of the three pillars of sustainability. They believe that the three pillars of sustainability are equally important only in theory, and as necessary changes they indicate a small increase in the social component and a significant increase in the ecological component, which lags far behind the economic and social components.

Table 3. Weights of the indicators according to the opinion of the respondents with regard to the place of employment

	Economic	Ecological	Social
Total	**0.415**	0.275	0.309
Science and teaching institutions	0.331	0.306	**0.363**
LAGs and associations	**0.587**	0.178	0.235
State and county institutions	**0.421**	0.314	0.239

Source: Author

As expected, economic indicators reached the highest values of local priorities in the created model. The findings are consistent with the conclusions of Bali Swain and Yang-Wallentin (2020), who used 117 countries around the world as examples to examine which of the three underlying pillars of the Sustainable Development Goals are most effective in creating sustainable development. Although all three factors are critical to sustainable development, less developed countries focus more on economic and social goals. The same conclusion was reached by Hedayaty-Moghadam et al. (2014) in measuring the sustainability of rural areas in Iran, Isfahan province. Economic indicators had the highest weighting value (0.281), followed by indicators of the availability of various institutions (0.257), social indicators (0.191), environmental indicators (0.142), and in last place were indicators of the condition of fixed assets (0.128). Dantsis et al. (2010) also emphasize that the final outcome depends on economic and social criteria, while the importance of environmental criteria is marginal, which is also true in this model. In contrast, Van der Werf and Petit (2002) claim that the environmental dimension is crucial for achieving overall sustainability and that it is a prerequisite for the economic and social dimensions. Turtoi et al. (2010) state that they place the economic dimension at the center of the agricultural sustainability plan because it is a prerequisite for its implementation. Taking into account the Kuznets curve and the hypothesis confirmed here, it can be concluded that Croatia has not yet reached the level of economic development after which environmental awareness increases, since the respondents consider environmental indicators to be the least important for achieving sustainable rural development and assign them the lowest weight.

Reviewing the relevant scientific and professional works and publications in Croatia and in the world, it was not found that there is a standardized, comprehensive and universally accepted method for measuring sustainable rural development. Besides the enumeration and sporadic quantification of sub-indicators, there is no holistic tool that clearly quantifies the sustainability of rural development of an area. In this paper, a model was developed that attempts to take into account the specifics of Croatian rural areas and the opinions of a professionally heterogeneous group of experts in order to provide an answer to the questions of which rural parts of Croatia are more developed than others, what are the limiting factors of rural development, and which development factors should be given more attention. The developed model is aimed at measuring sustainable rural development. The advantage of the developed model for measuring sustainable rural development is that it includes all three pillars of sustainable development, which is not the case with the Development Index, which lacks an environmental component and which, as mentioned above, is a basic instrument of regional policy in Croatia. Besides the Development Index, there are other indices (Human Development Index, Ecological Footprint) that measure only some components of sustainable development, which puts them at a disadvantage compared to this model. A comprehensive model like this one, created through a multi-criteria analysis, gives a better insight into the overall state of space and population, and based on the comparisons obtained, a comprehensive development strategy can be created based on the characteristics, potential, specificities and recognition of a given area.

One of the EU policies aimed at reducing development disparities among EU regions is regional policy. The model created here includes some indicators (investments in renewable energy sources, unemployment rate, GDP per capita, diversification of economic activities in rural areas, educational structure, availability of educational and health facilities) that can be used to identify the areas that need these funds more. To make the model as useful as possible, it can be supplemented with the necessary indicators to provide a more complete picture of a region's condition and identify investment priorities to achieve further development. The model can be applied in any country at the NUTS 3 level. The data for the indicators "investments in renewable energy sources" and "availability of agricultural infrastructure facilities" could be a problem for international comparisons, as the methodology for collecting these data is not defined at the EU level, but also in the individual member states.

The advantage of the method is that different stakeholders can be involved in the selection of indicators and in the evaluation of their importance in achieving sustainable rural development, which has been done in the construction of this model, while the disadvantage in this research is the unequal representation of certain groups of stakeholders, which has certainly influenced the selection of indicators as well as the assignment of weights. This advantage can certainly be used if the model created is modified for the purpose of ranking the submitted projects using bottom-up and top-down approaches, so that the evaluation better suits the needs of a particular area. The problem with any model, including this one, is a certain degree of subjectivity. In this model, subjectivity is evident in the proposal of indicators for inclusion in the model and in the selection of indicators and their weighting by respondents. While this subjectivity could not be avoided entirely, it was neutralized to some extent by the heterogeneity of respondents in terms of career orientation.

Including a larger number of respondents in the model and representing them more evenly according to different professional orientations would reduce the subjectivity of judgments, and it would be very interesting to observe whether this would affect the selection of indicators for the model as well as their weighting in the model. The model also leaves open the possibility of introducing additional indicators to determine whether a change in the observed indicators would affect the assessment of the sustainable rural development of the counties or whether the counties that have now stood out as leaders would maintain that position regardless of what is observed, simply because they are more developed than others in all segments.

This type of comprehensive model with quantification of rural sustainability components is applied for the first time in Croatia. The model and the first results of the County Rural Ranking can be used by regional and local decision makers to identify strengths and weaknesses in specific areas of economic, environmental and social development, which will provide a scientifically and professionally sound basis for the preparation of rural development strategies and for differentiation in the development policy of individual parts of Croatia. Since different problems exist in different parts of rural Croatia, the model provides a trade-off assessment combining top-down and bottom-up analysis. In addition, the model can be used for more efficient ranking of registered projects for various measures under the Rural Development Program, especially those whose beneficiaries are local government units.

Conclusions

1. The paper identified the most appropriate set of indicators for measuring sustainable rural development at the NUTS 3 level. 15 indicators were selected, which are divided into three groups: environmental (availability of drinking water, investment in renewable energy sources and energy efficiency, share of organic agriculture in the whole agriculture, existence of infrastructure for recycling and composting, and biodiversity of plant and animal species), Economic (unemployment rate, availability of infrastructure facilities related to agriculture, gross domestic product per capita, productivity of agricultural production, and diversification of economic activities in the rural area), and Social (age structure, availability of educational institutions, educational structure, population growth between the two censuses, and availability of health institutions).

2. A model for measuring sustainable rural development at the NUTS 3 level using the multicriteria AHP method was developed in the Expert Choice 2000 program and can be used throughout the European Union with certain adaptations.

3. The multicriteria AHP method proved to be appropriate for building a model for assessing sustainable rural development because it allows for the inclusion of all three components of sustainable development and the participation of a larger number of stakeholders in the assessment.

4. A difference in the value of local priorities of criteria and sub-criteria was found with regard to the professional orientation of the respondents: Representatives of scientific and teaching institutions believe that social indicators are more important than economic ones, while the other two groups of respondents give priority to economic indicators.

5. Economic criteria have proven to be the most important in achieving sustainable rural development

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Conflict of interests

The authors declare no conflict of interest.

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ORGANIC AGRICULTURE PERSPECTIVES IN DEPENDENCE OF SOIL TYPE: COMPARATIVE ANALYSES OF SERBIA, MONTENEGRO, BULGARIA AND CROATIA

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A B S T R A C T

Unlike traditional agriculture, which is characterized by the use of large quantities chemicals, the development of organic agriculture helps to conserve natural resources, and influences employment growth and the opening of new jobs in rural areas. For the development of organic farming, one of the main factors is soil type. This article analyzes soil resources, explores prospects for the growth of organic agriculture in Serbia and provides a comparative analysis of the development of organic production in Montenegro, Bulgaria and Croatia. Using official statistics, the situation in the production of organic products in individual countries is analyzed. The results of the growth of organic agricultural land and the share of organic agricultural land in the total volume of agricultural land are presented according to indicators. The comparative analysis carried out in this article is based on available statistical data on the land area and the types of the soils.

Introduction

Organic agriculture is a very specific type of cultivation, basically opposite to conventional agriculture, because it is strongly ecologically oriented, expresses concern for the preservation of the environment, natural resources and biological diversity, emphasizes the use of natural materials and respect for the biological processes of growth and development of plants and animals that are cultivated within agricultural

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activity (Ristić et al., 2023). Water and fertilizer have a high impact on crop yield and greenhouse gas emissions from soil (Kuzman et al., 2021). Authors Latinović et al., point out that important factors that influence the increase in the use of organic agricultural products are awareness, lasck of funds, lack of knowledge about health benefits (Latinović et al., 2023).

Organic agriculture represents a system of sustainable agriculture, largely based on local resources, which maintains ecological balance and minimizes the negative impact of agriculture on the environment. It also implies production in accordance with the law and standards with the control of the entire production cycle by an authorized certification organization. Profitable agricultural production is the base of the growth of national agricultural companies and individual producers (Kuzman et al., 2023). The development of organic agriculture: provides assistance in the preservation of the human environment and in this sense leaves an enviable legacy for future generations, it contributes to more proper nutrition of the population and the preservation of human health, it contributes to the development of rural communities and the reduction of negative demographic trends. In current conditions of man-made transformation of nature, the principle adequacy of the materials and technologies used to productivity and resources of the biosphere is of cardinal importance (Ermakov&Jovanović, 2023). Organic food is associated with organic plant production, which directly affects the preservation of a healthy environment (Beslać et al., 2023). In current conditions of man-made transformation of nature, the principle adequacy of the used materials and technologies is of cardinal importance (Jovanović et al., 2023). Challenges facing agriculture and food production look huge (Janković et al., 2023). The key role of the public sector for the future of organic agriculture is emphasized by stakeholders, who suggest that civil society could balance the lack of public support through collective action and increasing awareness of human health and sustainability of the food sector (Moreno-Perez and Blázquez-Soriano, 2023). Contemporary aspirations in agriculture inevitably imply the growth of the organic agriculture share in the total agricultural production, as well as management in a way that will ensure precaution and responsibility in order to protect the health and well-being of current and future generations and the environment (Willer et al., 2023). Solutions are found in the organization of organic agricultural systems with competitive productivity, considering the target of 25% of the agricultural area under organic agriculture set by the European Green Deal (Martín-García et.al, 2023). Some authors point out that the expansion of organic agriculture could reduce the potential for soil carbon sequestration unless appropriate agricultural practices are applied (Gaudare et al., 2023), while the future impacts of organic agriculture on soil are unclear.

Materials and methods

Organic agriculture, which provides healthier, cleaner food and the environment, is a topic of great interest for all the countries selected in this study, some are more developed, and some of them are just beginning to develop this type of agriculture.

The starting point of the research is the analytical method, which extracted components such as the number of organic producers, processors, data on regulation and labeling, shares of organic production, etc. through indicators of FiBL & IFOAM – Organics International (2023). The World of Organic Agriculture (Willer et al., 2023), also involved official statistical data and consulted number of scientific and professional articles and studies turned to organic agriculture and soil quality. These data were systematized for each country, and then, using the method of comparative analysis, comparisons of characteristics and mutual relations were made in two parts: in the first - the current status and trends of organic agriculture in the observed countries, and in the second part - soil quality as an important prerequisite for successful organic production. By continuing the research, we used a synthesis. The positions of all analyzed countries to observed fields have been determined.

Research and discussion

Contemporary situation in organic production in selected countries

Organic production is an important sector for all selected countries. While Bulgaria, and Croatia in addition to national regulations on organic agriculture, fully implement mandatory EU regulations – European Union Regulation 848/2018 (EU Reg), Serbia and Montenegro was introduced regulations at the national level which are fully implemented EU regulation on organic agriculture. Agapieva-Aliosman & Dirimanova (2021) emphasizes that clear policy, goals and management strategies are needed in the organic and agricultural sector in Bulgaria. (Table 1).

Table 1. System of regulative in organic production in selected countries

Country	Domestic regulative	Relevant authority	International regulative	Official organic product symbols
Serbia	Law on organic production	Ministry of agriculture, forestry and water management (MAFWM)	-	
Bulgaria	National Plan 2007-2013 (former)	Bulgarian Ministry of Agriculture, Food and Forestry	EU Reg	
Croatia	Law on organic production (former)	Republic of Croatia Ministry of Agriculture	EU Reg Action plan	eko
Montenegro	Law on Organic Production	Ministry of agriculture, forestry and water management	-	organska poljoprivreda crne gore

Source: Author‘s systematization

Table 2. Control bodies and control authorities in the organic sector in selected countries

Country	*Number of bodies and authorities*	*Relevant authority*
Serbia	6	Accreditation Body of Serbia
Bulgaria	17	EC (European Commission)
Croatia	11	EC (European Commission)
Montenegro	1	Accreditation body of Montenegro

Source: Author's research

Control and certification of organic production in Serbia in 2023 is be carried out by 6 control organizations. In the European Union, the control bodies are under the supervision of the European Commission, which maintains the data register. Bulgaria has 17 certification bodies, Croatia 11 and Montenegro only one.

In the field of organic types of products, according to the author's research, Serbia is mainly engaged in the production of fruit, where part of the production consists of frozen, deep-frozen, dried and freeze-dried fruit. According to data from 2022, there are 458 producers in Serbia, of which 149 are engaged in processing. Research data show that producers are currently focused on the following types: raspberries (from the Arilje region), strawberries and berry fruits. Producers also export vegetables, grain, pulses and oilseeds, as well as honey and bee products. The production of organic meat is also under development (Vojvodina, Kraljevo, Golija). In Serbia, there are groups of cooperative organization of production. Linked manufacturing is important because it increases market opportunities. Table 3 shows the top 5 producers in cooperative production in 2022.

Table 3. Producers in cooperative organic production with number of cooperates

Associate producer	**Number of cooperates**	**Products**
Zadrugar doo	763	Frozen fruits
Fortis doo	742	Fast frozen fruits
Frikos doo	577	Frozen and lyophilized fruit
Midi Organic doo	441	Fruits
Agrofrost doo	395	Raspberry

Source: Author's research

Bulgarian organic production is primarily based on honey and bee products (, but Bulgarian rose products are also represented (rose water, rose oil) and other aromatic plants. In addition, organic seeds and cereals are produced.

In Croatia, there are farms that produce several types of grains and vegetables, but the main product is certainly organic olive oil, for which the coast of the Adriatic Sea is known, as well islands. An interesting example is the "Šoltansko super organic" olive oil, which was awarded worldwide. Olive oil under a unique name is produced by small local producers from the island Šolta.

In Montenegro an important feature of the current organic production is fragmentation. Organic production is quite scattered and diverse and producers of small quantities are characteristic such as individual agricultural holdings that mostly cover local market requirements. There is no good practice of the association of small producers as in

Croatia or Serbia. According to the data of the certification body Monteorganica for 2021 production is based on vegetable with 424 producers, of which 371 produce fruit, 63 agricultural crops and medicinal plants, 10 vegetable crops, a 3 producers collect forest fruits and medicinal herbs. Livestock production is engaged in 64 producers, of which 56 have beehives. 27 deals with the processing of organic products of direct manufacturers. Among them stand out: IN-SPE - producer of organic tea from the wild herbs and HM Durmitor - the largest farm in Montenegro.

Table 4. Comparative analysis of organic products and producers production

Country	Enterprise	Products
Serbia	Minex Kruševac Master food Užice Medino Krnjevo Yugotrejd Arilje	Frozen fruit and forest products Strawberry and other berries Honey and bee products Raspberry, blackberry, strawberry, plum and cherry
Bulgaria	Adan Village Damovitsa Mountin Rose Sofia Amerov Honey Ignatievo Bilbo Varna	Seeds and grains (sunflower, flax, spelt) Rose and aromatic plants Honey products
Croatia	Terra Rossa Sv. Katarina Zrno Eko Imanje Dubrava Šolta group of producers	Olive oil 60 vegetable, arable and spicy crops Šoltansko super premium olive oil
Montenegro	Mugoša Igor Podgorica Božović Vučidar Berane Kolašinac Muhamed Plav Vučetić Miladin Pljevlja IN-SPE HM Durmitor	Potatoes, Cabbage, Beetroot, Carrot, Onion, Oats, Rye, Barley, Spelled, Buckwheat, Rye and flour, Apple Honey Lambs, Sheeps

Source: Author's research

In 2023, Serbia established a digital register of agricultural holdings through the eAgrar platform. The aim of establishing the Register and digital platform is to improve agricultural production in the Republic of Serbia so that it is productive, rich and respected, and competitive on the EU and social markets. All incentives can be realized by registration and request on the eAgrar software platform.

The situation in Bulgaria and Croatia with incentives must be considered within the Eco-schemes a repayment schemes in agriculture aiming at the protection of environment and climate. They are a key element of the Common agricultural policy (CAP). Montenegro grants state incentives (2023) in the field of organic production for the following: Agricultural producers can receive support per hectare (ha) of production area, conditional head of livestock, poultry and number of bee colonies, which are registered in the Register of entities in organic production within the framework of organic production.

In 2020 the number of producers in Serbia was 439 and the latest data shows 651 producers in 2022 (MAFWM, 2023). For Bulgaria, sector of organic production is national priority (Shishkov, Kolev, 2014). The number of producers in Bulgaria was 59942 in 2019. Organic production in Croatia is recognized as an important sector and the number of organic producers is growing. Montenegro shows no progress. (Table 5).

Table 5. Number of producers and other operator types by country 2021

Country	Producers	Processors	Importers	Exporters	Number of producers (2019-20)	Trend
Serbia	458	152	74	82	439	+19
Bulgaria	5942	249	22	2	5942	0
Croatia	6024	378	12	No data	5153	+871
Montenegro	422	25	No data	0	423	-1

Source: Author‘s systematization based on FiBL&IFOAM survey, 2023

Table 6. Organic farming indicators data in Serbia, Bulgaria, Croatia and Montenegro (2020)

Indicator / Country	Organic agricultural land (including in-conversion areas) in ha	Organic shares of total agricultural land in %	Organic Agricultural land development – 10-years growth in %
Serbia	19317	0.6	209.7
Bulgaria	116253	2.3	364.6
Croatia	108610	7.2	239.0
Montenegro	4823	1.9	57.2
Italy	2095380	16.0	91.0

Source: Author‘s systematization based on FiBL&IFOAM survey, 2023

Type of soil in selected countries

Organic shares of agricultural land data shows big achievements of Croatia (7.2%) as 27th world country. Bulgaria takes 52nd place (2.3%), and Serbia with less than 1% (0.6%) takes 92nd place in the world scale. Ten-year development data are encouraging for all three countries. In Bulgaria, the increase in organic agricultural land during the ten-year period is 346.4%, in Croatia 239%, and in Serbia 209.7%. Serbia‘s notably weaker results can be a consequence that it is not a member of EU, like Bulgaria (member since 2007) and Croatia (member since 2011) and Montenegro 1.9%, and 10-years growth of 57.2%.

For investigation of organic production indicators in selected countries, it is necessary to consider the type and characteristics of the soil (Table 7).

Table 7. Share of WRB referent soil groups based on the analysis and restrictions

WRB name	Serbia	Bulgaria	Croatia	**Montenegro -** has not yet harmonized to WRB	Restrictions in intensity and type
Cambisol	27,99	15,58	8,80	36,00 (Calcomelanosol 47 – national soil classification)	Severe to very severe restrictions
Chernozem	17,68	20,23	0,93	-	Without restrictions
Fluvisol	7,58	8,97	2,50	2,4	No restrictions to serious restrictions conditionally can be highly productive soils
Leptosol	15,90	3,29	0,60	-	Serious restrictions
Luvisol	2,38	33,15	12,60	-	Moderate to medium restrictions
Solonetz / Solonchak	*1,43*	0,009	0,22	-	Severe restrictions
Vertisol	8,32	>1,00	5,37	-	Moderate restrictions

Source: Author‘s systematization based on authors Bašić (2013), Pavlović et al. (2017), Shishkov & Kolev (2014) & Protić et al. (2005)

Serbia has diverse natural resources and soil of different taxonomies. Serbia is close to Bulgaria in terms of the amount of chernozem and fluvizol, while Croatia has less chernozem. Smaller amounts of fluvisol exist in Croatia and Montenegro.

Croatia and Serbia have numerous deposits of lignite, which is used for electricity production and household heating. Combustion of lignite leads to significant pollution of the environment with heavy metals and other phytotoxic elements. That is why significant areas of land in Croatia and Serbia are not suitable for organic production. Damage of land in Bulgaria is the result of coal and ore mining, and the extraction of non-metal mineral resources, like raw materials for the cement industry, facing stone materials and building materials (Kirilov & Banov, 2016). Heating with low-quality coal (lignite) leads to soil pollution. A total of 422 contaminated and potentially contaminated localities have been identified in the Republic of Serbia (Vidojević et al., 2022).

In Montenegro, there exist certain types of soil near polymetallic mines and lignite fields, smelters, fire pit-heating plants and other industrial facilities that can become phytotoxic and unsuitable for organic production. The most common soil types are those formed on carbonate rocks, or Calcomelanosol (national soil classification), covering 660,000 ha. In succession to Calcomelanosol, Calcocambisol appears in lower areas over an area of 30,000 ha and Terra Rossa, formed in the coastal area and in the Skadar Lake basin. The surface area of Terra Rossa is about 84,000 ha. Montenegro has not yet harmonized its national classification with the WRB. Most of the soils represented in Montenegro have a shallow soil profile and low contents of nutrients (Vidojević et al., 2022). Each country has its own specifics in terms of the use of its resources and the quality of land resources.

Organic production in Serbia is rapidly growing area of agriculture, by the collected data of relevant institutions in Serbia, we can notice necessity of three important steps in organic agriculture improvement: investment to knowledge and education, modern legislative, and conversion of lands from conventional to organic production capable lands.

In 2019, the Ministry of Agriculture of Bulgaria (MinAg) emphasizes that organic production is a national priority (USDA, 2021). When looking at the growth of the organic sector in the previous ten-year period of 364.6%, it is clear that Bulgaria is investing efforts in its development. In particular, Bulgaria has a rich production of organic honey and honey products.

Croatia applies all the regulations regarding organic food production and labelling, including the national label for organic food. Certified organic food production in Croatia is considerably lower than in other EU member countries (Gajdić et al., 2018), thus this research confirms the differences between Croatia and Bulgaria. However, it must be taken into account organic share in total agricultural land with 7.2% in Croatia and 2.3% in Bulgaria. Montenegro has negative trend in number of producers (-1) compared to the previous period, total 422, but the data show that share of 1.9 of total agricultural land is higher than in Serbia (0.6). In general, when it comes to the number of producers, the trend is positive in Serbia (+19) and Croatia (+871), there are no changes in Bulgaria, while the trend is negative in Montenegro.

Organic agriculture depends on the soil quality itself. Serbia has sufficient natural resources for the development of organic agriculture, but has not finance support for acceptable technologies and means of production (Jovanović & Stojkov Pavlović, 2023). The soils of Serbia are extremely heterogeneous as a result of the varied geological base, climate, and vegetation (Vučinić et al., 2022). Some soils are naturally fertile, providing optimal conditions for high, stable and good-quality yields, such as carbonate chernozems on loess, while others have unfavorable characteristics to such an extent that production on them is not economically viable. There are also soil types with exceptionally unfavorable characteristics even for the formation of natural vegetation, such as solontchak and solonetz (Pavlović et al., 2017).

Conclusions

The increase of the area of arable land under organic production, as well as the increase in number of organic producers testify in favor of the fact that the organic production is outlook and long-term profitable activity, with multifunctional advantages. Success of organic farming depends on soil type and permanent improvement of its quality. Disturbance and damage of land brings serious health risks. Choice of suitable soil for organic agriculture is possible by the analysis of soil quality and mapping of the land.

It is necessary to analyze peculiarities of soil (pH, humus content, $CaCO_3$ content) and evaluate possibility for soil dressing by organic fertilization. Monitoring of soil quality is necessary at any soil species. Improvement of the soil for organic production realize by composting and use of residual organic substances after recycling. Financial support for the development of organic production sector in Serbia is provided for organic producers to do administrative and technical activities through the official platform. This platform is the first interactive database of organic agriculture managed on the authority of the Ministry of Agriculture. The transition from fossil sources to renewable energetic sources is obligatory for organic agriculture development. Besides, the suggestion is that developing countries should make efforts to advance organic practices control, marketing strategies and emphasize a commitment to sustainability. Montenegro, considering its size and development, is not far behind the other countries discussed here. The advantage of Montenegro is represented by almost 30,000 ha of Terra Rossa land of typical quality, but it is necessary to invest additional efforts in the regulatory mechanism of organic production. Bulgaria and Croatia are committed to the Action plan for organic production in the European Union 2021 – 2027**.**

Conflict of interests

The authors declare no conflict of interest.

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COMPARATIVE ANALYSIS OF SERBIAN AGRICULTURE AND AGRICULTURE OF OTHER HIGH MIDDLE-INCOME COUNTRIES

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A B S T R A C T

The goal of countries that have excellent comparative advantages for the development of agriculture, such as Serbia, is rural development and the general development of agriculture as an economic branch. This is logical, given the great importance of food available to everyone. According to the World Bank classification, Serbia belongs to the group of countries with high middle income. The aim of this paper is to present the impact of the economic development of the observed countries on the production of food. Methodologies applied for this research are: single correlation and single and multiple regression models and indicators such as global food security index, gross domestic product per capita, share of agriculture in gross domestic product for the year 2022 will be used.

Introduction

Serbia is a European country that strives to be a member of the European Union [EU]. As a third of the regulations of the EU are precisely in the field of agricultural policy, it is important to point out the importance of agriculture as an economic branch in the EU, and in all other countries as well.

Achieving adequate rural development, economic growth and competitiveness of agricultural products while improving standards and preserving the environment are

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only possible with the integration and implementation of the Common Agricultural Policy standards of the EU. For these purposes, in recent years, Serbia has started to implement systematic and structural reforms of the agricultural sector by adopting and implementing the Strategy for Agriculture and Rural Development. Serbia has started the process of harmonizing and harmonizing legislation with the regulations of the EU thanks to the financial assistance of various programs and funds of the EU However, this process is extremely difficult and long, and therefore Serbian agriculture is still faced with numerous challenges that slow down economic growth and development (Stojanović et al, 2018).

Materials and methods

Considering the importance of agriculture, as an economic branch, this work aims to: present the agricultural policy of Serbia, with special reference to its financing; to indicate to what degree the economic development of a country, measured through the gross domestic product per capita, affects the food production and the development of agriculture as an important economic branch, especially in relation to other countries with high middle incomes. For these purposes, the state of agriculture in Serbia and neighbouring countries (Albania, Bosnia and Herzegovina, Montenegro, North Macedonia and Bulgaria) will first be explained, and then statistical processing and analysis of secondary data related to economic development and the development of agriculture expressed through the global index of food security, with the aim of proving the initial hypotheses that indicate which indicators can affect the development of agriculture in given countries.

The main indicator used in the analysis is the overall global food security index (Global Food Security Index [GFSI]), which consists of four components: affordability, availability, quality and safety, and sustainability and adaptation. GFSI observes 113 countries, including Serbia and the other observed countries of the EU. This index brings shared data related to consumers' ability to buy food, their reaction to sudden price increases; the ability of a country to ensure continuity in the domestic supply of agricultural products; health and nutritional correctness of food; and the state's ability to reduce the impact of climate change on agricultural production. Two years ago (2022), Serbia was in 61st place with a score of 61.4 (the minimum score is 0 and the maximum is 100). Compared to 2012, when this index began to be calculated, Serbia has improved in the score by as many as 8.0 points (Economist Impact, 2022). As for the gross domestic product [GDP], Serbia had 63,501.75 million dollars in 2022. Per capita, the gross domestic product of Serbia [GDP per capita] was 9,393.6 US dollars. The share of agriculture in the total economic activity in Serbia was about 6.8%, while the percentage of the rural population was 43% (World Bank, 2023).

Agricultural policy of Serbia and surrounding countries

Serbian agricultural policy

In the last couple of decades, Serbian agriculture has been facing numerous problems and challenges. The closure of the Yugoslav economy, the disintegration of the former Socialist Federal Republic of Yugoslavia [SFRY], the loss of markets between the former members of the SFRY, international sanctions, severed foreign trade ties in the nineties of the 20th century, are just some of the factors that caused a serious economic crisis, a decline in economic growth and the collapse of a market system. Unemployment and poverty appeared.

Serbia's agriculture is extremely promising, both because of the geographical terrain, favourable climatic conditions, educated population, and because of its strategic position. Despite the large number of "small" agricultural farms, Serbia has large areas of arable land of exceptional quality (Stanković et al, 2023). As successful agricultural production is based on "healthy" land on which exceptionally high-quality food products can be obtained over a long period of time (Stolze, Lampkin, 2009), it can be said that Serbian agriculture is an extremely promising branch. Although in the middle of the last century, with industrialization and post-war recovery, it began to lose its importance due to the development of other economic branches, agriculture is once again becoming one of the most important economic branches because people's health is in the first place, and a man who takes care of his own health and the health of his family values food security more (Nikolić et al, 2017).

Regarding the financing of agriculture, it should be noted that due to the strong seasonal production and the biological nature of the production, the possibility of self-financing agriculture is at a very low level, so there is a strong need for loans. Due to the specifics mentioned, an agricultural loan is usually more favourable than other commercial loans in the sense that it has a lower interest rate and a longer repayment period, and a grace period is often approved during which neither the principal nor the interest is repaid (Đurić, 2021).

In Serbia, the participation of farmers in GDP, gross added value, employment, export is extremely high, despite the unsatisfactory results. For the results to change for the better in the future, it is necessary to create a favourable institutional environment and harmonize the agrarian budget of the Republic of Serbia with the Common Agrarian Policy of the EU. Unfortunately, the agricultural budget of the Republic of Serbia still does not meet all the needs of agriculture and rural development in Serbia.

If the participation of agriculture in important indicators of economic development is already high, the question arises why the results are unsatisfactory? The answer lies precisely in Serbia's ability to produce large quantities of quality food, in Serbia's geographical position, and arable land of exceptional quality, in an area with favourable climatic conditions. The low economic strength of Serbian producers is precisely the limiting factor that makes it impossible for agricultural production to rise to a level that would be satisfactory, and therefore the state must implement measures of state interventionism to help agriculture achieve better results.

Table 1. Participation of different types of financial incentives in the financing of the agricultural policy of the Republic of Serbia for 2022

Purpose/program activity/type of subsidies	The amount in RSD for the year 2022	Share of subsidies in the agricultural budget (in %)
Direct payments	41 249 678 000	80.59%
Measures of rural development	9 037 586 930	17.66%
Credit support for agriculture	672 000 000	1.31%
Special incentives	226 000 000	0.44%
Total	51 185 264 930	100%

Source: Službeni glasnik RS, 2022

Agriculture is a risky economic branch considering that due to bad weather conditions, agricultural products can be destroyed and, accordingly, income can be significantly reduced. All this can have a negative impact on the entire food supply chain, so it is necessary to help farmers in the form of direct payments. The structure of the agricultural budget is similar from year-to-year, but direct payments are the dominant part in every country. Direct payments include incentives for crop and livestock production, and can be in the form of premiums, incentives, and rebates. Considering the above, direct payments provide security to farmers both in Serbia and other countries with high middle incomes and in the countries of the EU. They give farmers greater freedom in decision-making, but also contribute to environmental protection, sustainable management of natural resources and the fight against climate change, all in accordance with EU standards. Direct payments in Serbia are still related to food production. Direct payments related to plant production are largely harmonized with the measures in the EU considering that they are paid according to the area of arable land and only for the first 20 hectares (Directorate for Agrarian Payments, 2024).

The measures of rural development that participated in the budget for 2022 with 10.47% related to incentives for improving the competitiveness of agricultural production, preserving the environment, and limited natural resources, improving the quality of life in rural areas, educating the population living in rural areas on the topic how to increase the efficiency and productivity of their production, but also for the implementation of the rural development strategy. Expenditures for rural development measures for 2022 are presented in *Table 2* (Službeni glasnik RS, 2022.).

Table 2. Incentives for rural development of the Republic of Serbia for 2022

Incentives for rural development	The amount in RSD for the year 2022	Participation of individual incentives for rural development (in %)
Improving competitiveness	6 980 978 930	77.24%
Preservation and improvement of the environment and natural resources	731 701 000	8.09%
Incentives for diversification of income and improvement of quality of life in rural areas	432 905 000	4.79%
Incentives for the preparation and implementation of local rural development strategies	2 000	0.001%
Incentives for the improvement of the system of creation and transfer of knowledge	892 000 000	9.87%
Total	9 037 586 930	100%

Source: Službeni glasnik RS, 2022

Various research conducted in Serbia have shown that the degree of poverty is much more pronounced in rural than in urban areas. Among the most vulnerable in Serbia are multi-member families from rural areas, the unemployed and people with disabilities (Kopanja, 2016). The rural development of Serbia, based on the principles of sustainable development, therefore becomes an imperative for overall economic development.

To compare Serbian agriculture with neighbouring countries, countries with a similar geographical position, climatic conditions and soil quality as Serbia were included in the further analysis. All these countries are on the World Bank's list of upper-middle-income countries. In the rest of the text, indicators for the year 2022 will be mentioned, such as: GFSI, GDP per capita, participation of agriculture in the overall economic structure of a given country and the percentage of the rural population.

Basic facts about selected countries and indicators

Albania is a country that is mainly engaged in agricultural production. As much as 56% of the population lives in rural areas, while 36% of the population is engaged in agriculture (World Bank, 2023). There are about 400 million hectares of natural pastures in Albania. Historically, in Albania, fertilizer was almost never used to increase the productivity of pastures considering their quality. However, the big problem in this country is small farms with 10 to 30 animals, while there is a trend to create medium-sized farms with around 150 animals. (Agriculture and Rural Development Agency, 2022).

Regarding the GFSI, Albania was not ranked in 2022, nor in previous years. GDP of Albania in 2022 was 18882.1 million US dollars, while GDP per capita was 6802.8 US dollars. Agriculture participated in the economic structure of Albania with 18.6%, while at the same time in 2022, in Albania was 36% of the rural population (World Bank, 2023).

Bosnia and Herzegovina has exceptional natural features that enable it to develop sustainable and high-quality agricultural production. However, the huge agricultural potentials have only been partially utilized despite exceptional natural, technical, and human resources (as much as 50% of the rural population). Unfortunately, most agricultural products are imported due to insufficient investments in the agricultural sector. Considering the exceptional characteristics of the climate and soil in Bosnia and Herzegovina, it is necessary to consider a plan to attract foreign investments to further develop agriculture. The advantages of Bosnia and Herzegovina in terms of agricultural production are certainly favourable climatic and geographical conditions, a long tradition in agriculture, a qualified workforce, and a developed education system (Agency for the Promotion of Foreign Investments in Bosnia and Herzegovina, 2012).

Bosnia and Herzegovina is not on the list of 113 countries that calculate the GFSI. The GDP of Bosnia and Herzegovina in 2022 was 24473.91 million US dollars, while GDP per capita was 7568.8 US dollars. The share of agriculture in the overall economic structure of Bosnia and Herzegovina is only 4.7%, while 50% of the population is rural. (World Bank, 2023).

Montenegro is a small country that covers about 14,000 km2. As much as 37% of the total area of the country is agricultural. Agriculture in Montenegro is mostly labour-intensive and represents the main source of income for about 50,000 households. It is characterized by a low level of mechanization but also a small use of chemicals, which is considered suitable for the development of organic agricultural production (Sustainable agriculture for sustainable Balkans, 2023).

Montenegro, like Albania and Bosnia and Herzegovina, is not on the list of 113 countries that calculate the GFSI. The GDP of Montenegro in 2022 was 6095.98 million US dollars, while GDP per capita of Montenegro was 9893.5 US dollars. The share of agriculture in the economic activity of Montenegro was 6.3%, while the percentage of the agricultural population was 32% (World Bank, 2023).

North Macedonia is a country that faces numerous challenges in relation to agricultural production. On the total surface of the country of about 26 thousand km2, agricultural land is about 1.2 million ha, while about half of the total population is rural. The average size of an agricultural holding in the Republic of North Macedonia is 1.8 ha, while 3168 hectares of agricultural land are intended for organic production, which is 0.25% (Agency for Financial Support in Agriculture and Rural Development, 2022). The main problems that North Macedonia faces in terms of the development of agricultural production are small area of households, low use of mechanization and therefore lower productivity and efficiency; lack of an adequate agricultural advisory service; emigration of the population from rural areas; deterioration of the quality of agricultural land due to its inadequate use.

According to the GFSI, North Macedonia is also not ranked. The GDP of North Macedonia in 2022 was 13563.13 million US dollars. GDP per capita of North Macedonia in 2022 was 6591.5 US dollars. The share of agriculture in the total economic activity of North Macedonia was 8.1%, while the agricultural population was 41% (World Bank, 2023).

Bulgaria employees more than 6% in the agricultural sector. Agriculture is a very important branch in terms of potential export - roses, lavender oil, honey, pork, and poultry. About 41% of the total Bulgarian territory (4.5 million hectares) is agricultural land. Rural areas occupy 22% of the Bulgarian territory where 13% of the population (about 900 thousand people) live. The number of farms is around 130,000, of which 76,372 were registered in 2021 (European Commission, 2021). The Rural Development Strategy of Bulgaria aims to promote the sustainable development of the agricultural sector by supporting sustainable farm income and increasing competitiveness. Bulgaria and the Common Agricultural Policy of the EU use different measures and interventions to improve living and working conditions in rural areas.

The GFSI ranks Bulgaria in 2022 at 29th place, with a total score of 73.0. This result is 9.5 points better than in 2012, when the GFSI was first calculated (Economic Impact, 2022). Regarding the indicators calculated by the World Bank, the GDP in 2022 was 89040.40 million US dollars and the GDP per capita GDP was 13772.5 US dollars (World Bank, 2023).

Results

Methodology and hypotheses

The aim of this paper is to answer the question of whether the economic development of the observed countries affects food production and whether economic development affects the reduction of the participation of agriculture in the economy. The following questions will be answered in the further work:

1. Does the economic development of a country expressed through gross domestic product per capita [GDP per capita] affect the food production, which is measured by the global food security index [GFSI]?
2. Does the economic development of a country expressed through the gross domestic product per capita [GDP per capita] affect the participation of agriculture in the overall economic structure of that country, measured by the participation of agriculture in the gross domestic product?
3. Does the economic development of a country expressed through the gross domestic product per capita [GDP per capita] and the participation of agriculture in the overall economic structure affect the food production, which is expressed through the global food security index [GFSI]?

Based on these questions, three hypotheses were defined:

H1: The economic development of a country has an impact on the food production.

H2: The economic development of a country has an impact on the position of agriculture.

H3: The economic development of a country and the participation of agriculture in the economic structure affect the food production.

The analysis used data on GDP per capita, GFSI and the share of agriculture in the GDP of countries with higher middle incomes according to the World Bank classification for the year 2022, among which Serbia was analysed. As many as 24 mentioned countries are on the list of Economic Impact, which calculates the global index of food security, while all observed countries - 52 of them - are subject to observation by the World Bank, so data on GDP per capita and the share of agriculture in the total are available economic structure (Economic Impact, 2022; World Bank, 2023).

For the purposes of statistical analysis, secondary data were used, which were analysed using the SPSS software package. Analysis of the normality of the distribution of the given sample for each observed variable, single bivariate correlation and single and multiple regression analysis were conducted.

For easier comparative analysis, *Table 3* was created, where all the data presented in the previous text are given. The aim of this analysis is to compare Serbia as an upper-middle income country with other countries on the same World Bank list. The advantages of this analysis are that it is mostly about countries that have similar economic development compared to Serbia, but different prerequisites for the development of agricultural production. In this way, it will be pointed out whether and to what extent economic development affects the development of agriculture.

Table 3. GFSI, GDP per capita (current US dollars) & Agriculture, forestry and, fishing, value added (% of GDP)

Country	GFSI (score)	GDP per capita (current US dollars)	Agriculture, forestry, and fishing, value added (% of GDP)
Serbia	61.4	9 393.6	6.8%
Albania	/	6 802.8	18.6%
Bosnia and Herzegovina	/	7 585.4	4.7%
Montenegro	/	9 893.5	6.3%
North Macedonia	/	6 591.5	8.1%
Bulgaria	73.0	13 772.5	4.4%

Source: Economic Impact, 2022 & World Bank, 2023

Statistical analysis

The statistical analysis was performed on a sample of 52 countries ranked by the World Bank in the group of countries with upper middle income. Before the analysis, the authors performed an examination of the normality of the sample distribution. The analysis showed that all observed variables have a normal distribution (Sig>0.05), which can be seen in *Table 4*.

Table 4. Tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
GFSI score	.167	24	.081	.965	24	.542
GDP per capita	.162	24	.103	.942	24	.180
Agriculture, forestry, and fishing, value added (% of GDP)	.085	24	.200*	.981	24	.912
a. Lilliefors Significance Correction *. This is a lower bound of the true significance.						

Source: Authors' calculations according to Table 3

To determine the impact of economic development on the food production, but also on the position of agriculture and rural areas in the observed countries, the authors used correlation and linear regression methods.

First, an analysis of the impact of economic development on the food production was performed using the Pearson correlation coefficient r (*Table 5*). As can be seen in the given table, the correlation between these two indicators is high and amounts to r=+0.635. Given that the significance of this coefficient is Sig=0.01<0.05, it can be concluded that this correlation is statistically significant. In the further process of confirming the first hypothesis, a regression model was presented to confirm this correlation. The estimated value of the regression coefficient is shown in *Table 6*.

Table 5. Correlations

		GDP per capita (current US dollars)	Agriculture, forestry, and fishing, value added (% of GDP)	GFSI (score)
GDP per capita (current US dollars)	Pearson Correlation	1	**-0.383****	**0.635****
	Sig. (2-tailed)		**0.005**	**0.001**
	N	52	52	24
Agriculture, forestry, and fishing, value added (% of GDP)	Pearson Correlation	-0.383**	1	-0.105
	Sig. (2-tailed)	0.005		0.625
	N	52	52	24
GFSI (score)	Pearson Correlation	0.635**	-0.105	1
	Sig. (2-tailed)	0.001	0.625	
	N	24	24	24
**. Correlation is significant at the 0,01 level (2-tailed).				

Source: Authors' calculations according to Table 3.

Table 6. Regression model: coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	53.911	3.024		17.829	0.000
	GDP per capita	0.001	0.000	0.635	3.860	0.001
	a. Dependent Variable: GFSI score					

Source: Authors' calculations according to Table 3.

To examine the relevance of the regression model for these variables, further analysis is based on the formula:

$$y_i = b_0 + b_1 x_1 + \varepsilon_i \qquad (1)$$

where *y* is the dependent variable – which in this case is the GFSI score; b_0 - section on the *y* axis; b_1 - slope coefficient and *x* - independent variable, which in this case is GDP per capita. In this case, the regression model formula looks like this:

$$GFSI\ score = 53.911 + 0.001 * GDP\ per\ capita \qquad (2)$$

The slope coefficient $b_1=0.001$ shows that an increase in GDP per capita by 1 US dollar causes an average increase in the GFSI by 0.001. A measure of the representativeness of this model can be presented by analyzing the coefficient of determination $R^2=0.404$, which says that 40.4% of the variance of the GFSI score can be explained by variations in GDP per capita.

Like this linear regression model, another regression model will be presented in the same way, but this time the impact of the economic development of a country on the position of agriculture in the economic structure will be analysed. For these purposes, the GDP per capita will be used as an independent variable and the share of agriculture in the GDP as a dependent variable. As in the previous model, it will first be determined whether there is a correlation between these variables, using the Pearson method (*Table 5.)*.

As seen in *Table 5*, the correlation coefficient $r=-0.383$, which means that it is a moderate correlation with a negative sign. Given that the significance of this correlation is $Sig=0.005$, and the correlation hypothesis is accepted for Sig≤0.05, it can be concluded that the correlation coefficient score is statistically significant. In the further process of confirming the second hypothesis, a regression model was presented to confirm this correlation. The estimated value of the regression coefficient is shown in *Table 7*.

Table 7. Regression model: coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.672	1.861		6.809	.000
	GDP per capita	-.001	.000	-.383	-2.932	.005
	a. Dependent Variable: Agriculture, forestry, and fishing, value added (% of GDP)					

Source: Authors' calculations according to Table 3.

To examine the relevance of the second regression model, the further analysis starts again from formula (1). In this case, the regression model formula looks like this:

$$Agriculture, forestry, and\ fishing, value\ added\ (\%\ of\ GDP) =$$

$$= 12.672 - 0.001 * GDP\ per\ capita \quad (3)$$

The slope coefficient b_1=-0.001 shows that an increase in GDP per capita by 1 US dollar leads to a decrease in the share of agriculture in GDP by 0.001. The measure of the representativeness of this model can be presented by analysing the coefficient of determination $R^2=0.147$, which says that 14.7% of the variation of the variable participation of agriculture in the GDP is explained by changes in the GDP.

To prove the third hypothesis, a multiple (three-dimensional) linear regression model should be performed, where the independent variables will be the GDP per capita expressed in US dollars and the share of agriculture in the GDP, and the dependent variable will be the GFSI. The model is presented in *Tables 8-10*.

Table 8. Model summary

Model	R	R^2	Adj. R^2	Std. Error of the Estimate
1	0.661	0.437	0,383	4.6131490

Source: Authors' calculations according to Table 3.

Table 9. ANOVA[b]

Model	Sum of squares	df	Mean Square	F	Sig.
1 Regression	346.326	2	173.163	8.137	0.002[a]
Residual	446.904	21	21.281		
Total	793.230	23			
[a] Predictors: (Constant), Agriculture, forestry, and fishing, value added (% of GDP), GDP per capita. [b] Dependent variable: GFSI score					

Source: Authors' calculations according to Table 3.

Table 10. Three-dimensional linear regression model: coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	49.476	5.013		9.869	0.000		
	GDP per capita	0.001	0.000	0.720	3.983	**0.001**	0.821	1.218
	Agriculture, forestry, and fishing, value added (% of GDP)	0.450	0.407	0.200	1.106	0.281	0.821	1.218
	Dependent Variable: GFSI score							

Source: Authors' calculations according to Table 3.

Table 8 shows that the corrected coefficient of determination *Adj.* $R^2=0.383$. This means that 38.3% of the variation in the GFSI variable can be explained by joint changes in GDP per capita and the share of agriculture in GDP. The fit between the independent and dependent variables in this model is met because $F=8.137$ and $Sig.=0.002\leq 0.005$. According to table 10, the regression coefficient that shows statistical significance is GDP per capita (Sig=0.001≤0.005). And in this three-dimensional model, formula (1) is used, so the multiple model will have the following appearance:

$$GFSI\ score = 49.476 + 0.001 * GDP\ per\ capita +$$

$$+0.450 * Agriculture, forestry, and\ fishing, value\ added\ (\%\ of\ GDP) \quad (4)$$

As already stated, only GDP per capita has statistical significance because $Sig.=0.001\leq 0.005$. Given that it is a multiple regression model, the problem of collinearity should also be considered. Therefore, the Tolerance and VIF columns from the Collinearity Statistics section of *Table 10* will be included in the analysis. Since Tolerance>0.1 and VIF<10, it can be said that this regression model meets the conditions related to collinearity.

Discussion

This study aimed to answer the question of whether the economic development of the observed countries affects food production and whether economic development affects the reduction of the participation of agriculture in the economy. Three hypotheses were put forward that we examined through the analysis of data on GDP per capita, GFSI and the share of agriculture in GDP for countries with high middle incomes according to the classification of the World Bank for the year 2022. In this section, we will discuss the key findings and their implications.

Based on a comprehensive analysis, it can be concluded that there is a statistically significant strong positive correlation between economic development and the food security. The analysis proved the first hypothesis, which is logical considering that economic development is expected to affect food production. Therefore, first hypothesis can be adopted.

As the analysis confirmed that economic development has a positive effect on food production, it is logical that the share of agricultural production in the total GDP decreases with economic development and an increase in the standard of living. In this analysis, the second hypothesis was proven, which states that with the increase in the standard of living, the participation of agriculture decreases due to the increase in the participation of the secondary and tertiary sectors.

The third hypothesis (H3) is that economic development and the participation of agriculture in the economic structure together influence food production. Multiple regression analysis showed that joint changes in GDP per capita and the share of agriculture in GDP explained 38.3% of the variation in the global food security index (Adj. R^2=0.383). The model is statistically significant (F=8.137, Sig=0.002). However, only GDP per capita has a statistically significant effect (Sig=0.001), while the share of agriculture in GDP did not show a statistically significant effect (Sig=0.281). These results indicate that economic development is the primary factor affecting food security, while the share of agriculture in the economic structure does not have a significant direct impact.

Conclusions

The results of this research carry important messages for economic policy makers in the observed countries:

1. it is necessary to encourage economic growth - increasing GDP per capita should be a priority, as it directly contributes to improving food security.
2. development of other economic branches - reducing dependence on agriculture through the development of other sectors can contribute to the stability and sustainability of the economy.
3. infrastructure development - improving food distribution infrastructure can have positive effects on all four aspects of the GFSI.

Although this model explains a significant part of the variation in the GFSI, there are other factors that could be important, such as political stability, climate change, education and health policy. Future research should include these factors to get a more complete picture of the determinants of food security.

Agriculture is not an isolated economic activity from the emergence of innovations. On the contrary, thanks to the innovations implemented in agriculture, a huge amount of food was successfully produced before, while today food production is on higher level.

Regarding the ranking on the list of Economic Impact, it can be said that Serbia stands quite well compared to other countries with higher middle incomes. Serbia could reach the development of the other countries, but Serbia needs to work more and harder on harmonization of regulations with the regulations of the EU.

Conflict of interests

The authors declare no conflict of interest.

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SOCIETY 5.0 AND ITS IMPACT ON AGRICULTURAL BUSINESS AND INNOVATION: A NEW PARADIGM FOR RURAL DEVELOPMENT

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A B S T R A C T

This paper analyzes the impact of Society 5.0 on agricultural business and innovation, proposing a new paradigm for rural development. Society 5.0 represents the evolution beyond previous societal models, aiming to harmonize economic progress with solutions to social issues through the integration of cyberspace and physical space. Central to this model is the application of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), robotics, big data, and augmented reality. The study focuses on the significant changes within agricultural practices and business models. Through a review and analysis of current trends, the paper presents a theoretical framework The paper also proposes the Agricultural Business and Rural Development Potential (ABRDP) index as guide for future trends and potential outcomes in the agricultural domain, offering insights into optimistic, conservative, and pessimistic scenarios for rural development.

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Introduction

Society 5.0, a concept originating from Japan, represents a vision of a new societal model. This concept goes beyond the previous societal stages of hunter-gatherer (Society 1.0), agrarian (Society 2.0), industrial (Society 3.0), and information (Society 4.0). Society 5.0 aims to balance economic advancement with the resolution of social problems through a system that highly integrates cyberspace and physical space (Narvaez Rojas et al., 2021).

In Society 5.0 the extensive use of advanced technologies such as the Internet of Things (IoT) (Huang et al., 2022), artificial intelligence (AI) (Bryndin, 2020), robotics (Nair et al., 2021)), big data (Foresti et al., 2020), and augmented reality (Kasinathan et al., 2022) is fundamental. These technologies are not just seen as tools for economic growth, but also as means to create a more inclusive, human-centered society. One of the key principles of Society 5.0 is the harmonization of technological advancement with human needs. Technological advancement also brings competitiveness that further positively influences economic growth (Bakator et al., 2019; Djordjevic et al., 2021a). Unlike the previous society models, which often prioritized economic growth over social welfare, Society 5.0 places a strong emphasis on using technology to improve quality of life for all individuals. This includes creating more efficient and sustainable cities, improving healthcare through technology, and ensuring equal access to information and services (Djalic et al., 2021). Society 5.0 also envisions a future where data and technology are used to create more responsive and effective governance. Governments in this model are expected to use big data and AI to better understand and respond to citizens' needs, leading to more personalized and efficient public services. This approach also encourages greater collaboration between the public and private sectors, fostering innovation and societal well-being (Djordjevic et al., 2021b).

In the context of Society 5.0, agricultural business and innovation are undergoing a transformative phase, driven by the integration of advanced technologies and a shift towards more sustainable and efficient practices. This transformation is essential in addressing global challenges such as food security, climate change, and the need for sustainable resource management (Kusdiyantu et al., 2022; Ragazou et al., 2022; Rajnović et al., 2023). One of the most significant innovations in agriculture within Society 5.0 is the adoption of precision farming techniques (Raj et al., 2022). Another key area is the development of smart farming systems. These systems integrate various technologies to monitor and automate agricultural processes (Dhanaraju et al., 2022). For example, sensors can provide real-time data on soil moisture and nutrient levels, while AI algorithms can analyze this data to optimize irrigation and fertilization schedules. This level of automation not only improves efficiency but also reduces the need for manual labor, which is particularly beneficial in regions facing agricultural labor shortages. The development of technological solutions can further improve rural tourism and competitiveness of the agro-sector (Leković et al., 2020).

The current body of literature of agricultural business development is broad and includes various aspects and trends. This paper aims to expand the current body of literature by thoroughly analysing existing studies and available data across databases that track indicators in the domain of agriculture. The paper provides interesting insight into the agricultural business development potential of Serbia. Potential development scenarios are discussed. Additionally, suggestions and guidelines for improving the domestic agricultural business sector are noted.

The paper consists of five main sections. First, a brief introduction on the topic is presented. Next, the materials and methods are explained. Third, a theoretical background is given. Further, the results are presented as well as the potential scenarios of future development. After this, suggestions and guidelines for improvements are discussed. Finally, conclusions are drawn and ideas for future research are noted.

Materials and methods

The study included the following main phases. **Phase 1:** Review of the existing literature was conducted and data an information was draw from a diverse array of sources including scholarly articles, conference proceedings, governmental reports, and statistical databases. In order to access publications and establish a solid theoretical foundation, the KoBSON service, a Serbian consortium for digital libraries, was used. Additional platforms and services included WoS, DOAJ, IEEE, Scopus, JSTOR, arhivX. **Phase 2:** Following the literature review, a theoretical framework was developed to guide the analysis of collected data. The research process also involved the formulation and testing of specific hypotheses related to the aims of the paper. These hypotheses were examined through the developed theoretical framework and ABRDP index, correlating macro-economic values, investments in agriculture, research and development expenditure, and environmental factors with the potential for agricultural business and rural development. The following hypotheses are proposed:

- H_1: Higher macro-economic values of agricultural production index, gross per capita agricultural production index, share in agricultural land use, and agriculture value added positively affect agricultural business and rural development potential.
- H_2: Higher credit to agriculture development and gross domestic value of agriculture positively affect agricultural business and rural development potential.
- H_3: Higher number of organizations that conduct R&D in agriculture, investments into agriculture, and research and development expenditure, positively affect agricultural business and rural development potential.
- H_4: Higher GDP, GDP per capita, and net salaries growth positively affect agricultural business and rural development potential.
- H_5: Higher temperature change of land and inflation rates negatively affect agricultural business and rural development potential.

Phase 3: The data analysis phase was multifaceted, employing deductive reasoning from the datasets, qualitative analysis through comparison with other studies, and the construction of a basic linear model. This model was developed for exploring potential future directions for sustainable agribusiness practices and understanding the relationship between technological advancements and rural development potential. A novel aspect of this research was the development of the Agricultural Business and Rural Development Potential (ABRDP) index. This index served as a quantitative measure of the impact of various factors on agricultural business and rural development. Indicators such as the agricultural production index, temperature change of land, credit to agriculture development, and GDP were identified and analyzed. The calculation of the ABRDP index, based on coefficients derived from these indicators, provided a unique metric for assessing future trends in the agricultural domain. **Phase 4:** In the final stage, the findings were synthesized to propose recommendations for advancing agribusiness practices in Serbia and beyond. Insights from the literature review, theoretical framework, and ABRDP index analysis were utilized to suggest practical and policy-oriented recommendations.

Theoretical background on Society 5.0, sustainable development, and agribusiness

Rural development in the context of agricultural business encompasses a multi-approach aimed at improving the economic, social, and environmental well-being of rural communities. This development is particularly significant as agriculture remains a primary source of livelihood for a large portion of the global rural population (Jeločnik et al., 2023; Pavlova, 2022). Economically, rural development focuses on diversifying agricultural activities and increasing productivity (Tamsah & Yusriadi, 2022). Socially, rural development initiatives aim to improve the quality of life in rural areas (Khan et al., 2022). This includes ensuring access to essential services like healthcare, education, and connectivity (Ge et al., 2023; Tiwari, 2023). (Empowering local communities, especially women and marginalized groups, through education and skill development is important (Zikargae et al., 2022). These efforts help in creating a more inclusive rural workforce, thereby fostering a sense of community and belonging.

Environmental sustainability is another significant aspect of rural development (Koul et al., 2022). Sustainable agricultural practices such as organic farming, conservation agriculture, and efficient water management are encouraged to preserve natural resources (Wanniarachchi & Sarukkalige, 2022). Such practices help in mitigating the impacts of climate change and maintaining ecological balance, which is vital for the long-term sustainability of rural areas (Bwambale et al., 2022). Infrastructure development is also integral to rural progress (Hussain et al., 2022). Improving transportation networks, storage facilities, and market access enables farmers to reach broader markets (Kaiser & Barstow, 2022). Additionally, access to renewable energy sources can transform rural living, making it more sustainable and less reliant on traditional, often environmentally harmful, energy sources (Rahman et al., 2022).

Innovations are not only reshaping agriculture but also play an important role in promoting rural development (Mahdad et al., 2022; 2Vrabcová & Urbancová, 2023), One of the key technologies in modern agriculture is the Internet of Things (IoT). IoT devices, such as soil sensors and climate monitoring equipment, provide real-time data on environmental conditions. This data enables farmers to make informed decisions about irrigation, fertilization, and pest control, leading to more efficient resource use and higher crop yields (Rehman et al., 2022). Additionally, IoT technologies facilitate precision agriculture, which optimizes field-level management with regard to crop farming (Pallathadka et al., 2023). Artificial Intelligence (AI) and Machine Learning (ML) are also revolutionizing agricultural practices Shaikh et al., 2022). AI-driven analytics can predict weather patterns, analyze crop health, and even automate tasks such as harvesting. This not only increases efficiency but also helps in mitigating risks associated with farming, such as unpredictable weather conditions. AI can also support decision-making processes, improving the overall productivity and sustainability of agricultural systems (Sood et al., 2022).

Drone technology is an innovative tool that transfors agriculture. Drones can be used for a range of tasks, from aerial surveillance of crops to the precise application of pesticides and fertilizers (Rejeb et al., 2022). Blockchain technology holds promise for ensuring transparency and traceability in the agricultural supply chain. It can be used to track the road of produce from farm to consumer, ensuring food safety and quality (Sajja et al., 2023). This increased transparency can lead to better market access for rural farmers and fairer pricing.

In addition, technological advancements can address some of the significant challenges faced by rural areas, such as labor shortages and limited access to markets (Cock et al., 2022). For instance, automated farming equipment can compensate for the lack of agricultural labor (Takeshima, 2024), and e-commerce platforms can connect rural farmers directly with consumers, bypassing traditional, often less efficient, supply chains (Liu et al., 2023).

The development of advanced biotechnologies include genetically modified crops that are more resistant to pests and diseases, require fewer chemical inputs, and can withstand extreme weather conditions (Das et al., 2023). Additionally, advancements in gene editing, such as CRISPR technology, offer the potential to rapidly develop crops with desired traits, such as improved nutritional value or reduced need for water and fertilizers (Aman Mohammadi et al., 2023). These technologies not only increase crop yields but also help in conserving biodiversity and adapting to climate change.

Another area of innovation is in the field of robotics and automation (Pearson et al., 2022). Autonomous tractors, drones, and robotic harvesters are becoming increasingly sophisticated and capable of performing complex agricultural tasks. These technologies can significantly reduce labor costs and increase precision in farming operations For example, robotic systems can be programmed to selectively harvest ripe fruits, thereby reducing waste and improving the quality of produce.

Vertical farming and urban agriculture are also emerging as innovative approaches in agricultural business (Lubna et al., 2022; Siregar et al., 2022). They require less land and water than traditional agriculture and can reduce the carbon footprint associated with transporting food into urban areas. This approach is particularly promising for growing high-value crops like herbs and leafy greens in urban settings (Jeager et al., 2022).

The future of agricultural business is likely to be shaped by a diverse innovations. From biotechnology and robotics to AI, blockchain, and renewable energy, these advancements hold the potential to transform agricultural practices, making them more efficient, sustainable, and profitable.

Results

Based on the analysed literature, the framework for agricultural business and rural development potential is outlined through a dozen of indicators. These indicators don't necessarily confirm causation when it comes to agricultural business development, but provides a significant insight into future potential trends in the agricultural domain. The Agricultural Business and Rural Development (ABRDP) indicators are presented in Table 1. The base year was 2018 for indicators where applicable.

Table 1. Agricultural Business and Rural Development Potential (ABRDP) indicators

Indicator	Label	2018	2019	2020	2021	2022	2023
Agricultural production index	API	107.59	107.75	110.88	104.28	98.31	N/A
Gross per capita agricultural production index	GPAP	108.81	109.46	113.29	107.44	102.35	N/A
Share in agricultural land use (%)	SALU	39.61	39.56	41.41	41.44	42.05	N/A
Temperature change of land (°C)	TCL	2.317	2.087	1.816	1.594	1.938	N/A
Credit to agriculture development (millions of euros)	CTAG	2794.46	2668.61	2943.23	3583.02	3869.87	N/A
GDP (billions of euros)	GDP	44.07	45.90	46.42	54.90	55.30	56.84
GDP per capita (euros)	GDPC	6309	6610	6727	8031	8297	9831
Net salaries growth (%)	NETS	4.5	8.5	3.7	8.8	9.64	13.76
Inflation rates (%)	INFL	1.96	1.90	1.58	4.09	11.98	7.6

Indicator	Label	2018	2019	2020	2021	2022	2023
Gross domestic value – Agriculture (%)	GDVAG	1.9	2.2	2.0	2.1	2.3	2.2
Organizations that conduct R&D in agriculture	RDAG	33	33	32	32	33	33
Country investment into agriculture (in millions of euros)	CIAG	2794.46	2668.61	2943.23	3583.02	3869.87	N/A
Research and development expenditure (% of GDP)	RDE	0.92	0.89	0.91	0.99	1.01	1.03
Agriculture value added (% of GDP)	AGVD	6.34	5.95	6.34	6.29	6.46	6.88 est.

Sources: (FAO, 2024; RZSS, 2024; The World Bank, 2024)

Currently, there are no indicators regarding biotechnology application, AI technology application, drone application, IoT solutions, and blockchain solutions in Serbia's agriculture. Therefore, the ABRDP index doesn't include these as there is no empirical data over time on these indicators. However, the suggestions and guidelines are indeed considering the advanced agricultural technology applications and these are appropriately noted.

The values from Table 1. are converted to coefficients for easier calculation of the Agricultural Business and Rural Development Potential (ABRDP) indicators. Where there was no data (N/A) the coefficient was taken from the year before. The other coefficients are calculated on a compared-to-max-value ratio. More precisely, the largest/most favorable values are converted into 100, while the others are proportionally less.

Table 2. Coefficients for the Agricultural Business and Rural Development Potential (ABRDP) index

Coefficients	Label	2018	2019	2020	2021	2022	2023
Agricultural production index	API	97.03	97.18	110.88	94.05	98.31	98.31
Gross per capita agricultural production coefficient	GPAP	96.05	96.62	100	94.84	90.34	90.34
Share in agricultural land usage coefficient	SALU	94.20	94.08	98.48	98.55	100	100
Temperature change of land coefficient	TCL	54.64	69.07	86.07	100	78.41	78.41

Coefficients	Label	2018	2019	2020	2021	2022	2023
Credit to agriculture development coefficient	CTAG	72.21	68.96	76.07	92.61	100	100
GDP coefficient	GDP	77.53	80.75	81.67	96.59	97.29	100
GDP per capita coefficient	GDPC	64.17	67.24	68.43	81.69	84.40	100
Net salaries growth coefficient	NETS	32.7	61.77	26.89	63.95	70.06	100
Inflation rates coefficient	INFL	75.95	79.74	100	1.00	1.00	1.00
Gross domestic value – Agriculture coefficient	GDVAG	82.61	95.65	86.86	91.30	100	100
Organizations that conduct R&D in agriculture coefficient	RDAG	100	100	96.97	96.97	100	100
Country investment into agriculture coefficient	CIAG	72.21	68.96	76.07	92.61	100	100
Research and development expenditure coefficient	RDE	91.09	88.11	90.10	98.02	100	100
Agriculture value added coefficient	AGVD	98.45	92.39	98.46	97.67	100	100

Sources: Authors

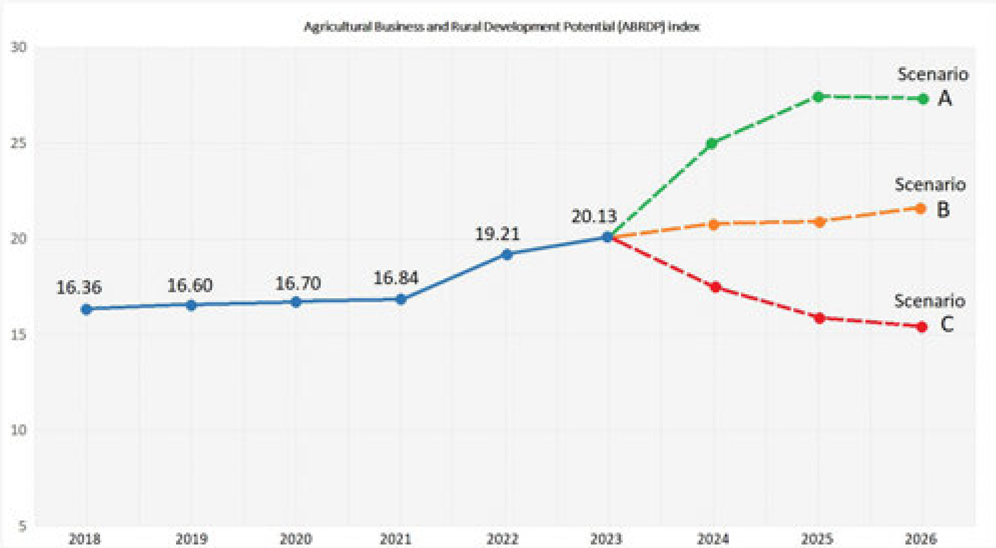
The Agricultural Business and Rural Development Potential (ABRDP) index calculation is based on the following equation:

ABRDP = [(API+GPAP+SALU+AGVD)*25+ (CTAG+GDVAG)*15+ +(RDAG+CIAG+RDE)*20+ (GDP+GDPC+NETS)*10- (TCL+INFL)*20]/1000

The ABRDP index is calculated based on the assumption of linear influences of the analyzed indicators. The ABRDP index is not addressing causation, but rather provides a basis for discussion and indication for future trends in this domain. Based on the equation and the coefficients from Table 2. the following ABRDP indexes are calculated: $ABRDP_{2018}$=16.36; $ABRDP_{2019}$=16.60; $ABRDP_{2020}$=16.70; $ABRDP_{2021}$=16.84; $ABRDP_{2022}$=19.21; $ABRDP_{2023}$=20.13.

Future trends based on the calculated ABRDP indexes are presented on Figure 1.

Figure1. ABRDP values and potential future outcomes (scenarios)



Sources: Authors

From 2018 to 2023, there is an observed increase in the ABRDP index, suggesting that factors influencing agricultural business and rural development are improving. Specifically, the index rises from 16.36 in 2018 to 20.13 in 2023. This growth trajectory is indicative of positive developments in the agricultural sector. This can further be positively influenced through the integration of advanced technologies and sustainable practices aligned with Society 5.0 principles, as discussed in the document. The graph projects three future scenarios:

Scenario A (green line) is the most optimistic, where the ABRDP index continues to rise sharply after 2023. This scenario would likely result from the successful optimization of renewable water sources, the application of new technologies and innovations in the agriculture sector, supportive government policies, improved standards of living, increased GDP, and reduced poverty risk.

Scenario B (orange line) represents a more conservative forecast, with the ABRDP index showing a plateau after 2023. This scenario might reflect a situation where economic and social indicators experience little to no change due to factors such as global economic crises, indicating a stagnation in the rate of sustainable development within the agricultural sector.

Scenario C (red line) is the pessimistic forecast, where the ABRDP index starts to decline after 2023. This could be the result of negative factors such as overexploitation of natural resources, ineffective water management, and the absence of strategic solutions for reversing unsustainable agribusiness processes, leading to a decrease in GDP.

The graph serves as a visual representation of the potential outcomes for agricultural business and rural development, dependent on how various economic, environmental, and social indicators evolve in the context of Society 5.0's impact on the agricultural sector.

Discussion

Data analytics can provide insights into optimal planting times, soil health, and crop selection based on current production and yield data. This leads to better-informed decisions that can increase crop productivity. The transition from traditional farming practices to precision agriculture, utilizing IoT devices, allows for more efficient use of resources like water and fertilizers, tailored to the specific needs of different crop areas, thereby improving yields and reducing environmental impact. The economic realities of rural farming, such as market access and farmer incomes, are significantly impacted by digital platforms. E-commerce enables direct farmer-to-consumer sales, potentially increasing profits and reducing the dependency on middlemen. Current levels of resource use and environmental impact can be mitigated through sustainable practices. The adoption of organic farming and renewable energy sources reduces the carbon footprint and promotes the sustainable use of natural resources.

The introduction of automation and robotics in agriculture can lead to economic growth in rural areas by increasing efficiency and productivity. This can create new jobs in technology maintenance and management, contributing to the local economy. Smart governance can facilitate the development of modern infrastructure in rural areas. Policies that encourage investment in transportation and storage facilities can improve market access for farmers, thereby improving the overall agricultural value chain. The social dynamics of rural areas, including employment rates and community involvement in agriculture, are closely linked to education and skills development. Providing advanced training and education in modern agricultural techniques can empower local communities, leading to increased participation and innovation in agriculture. Practices that promote environmental sustainability in agriculture also have a positive impact on the social well-being of rural communities. Sustainable farming practices ensure long-term food security and preserve the natural resources that these communities depend on. The development of infrastructure directly influences economic growth in rural areas. Improved roads, better storage facilities, and access to markets facilitate the movement of goods and services, making agriculture more profitable and sustainable.

Advancements in technology and sustainable practices not only improve agricultural productivity but also have far-reaching implications for economic growth, environmental sustainability, and the social well-being of rural communities. These interactions highlight the transformative potential of integrating modern technologies into the agricultural sector within the broader framework of Society 5.0.

Based on the analysed literature and calculated ABRDP index, the hypotheses are assessed as follows:

- H_1: Higher macro-economic values of agricultural production index, gross per capita agricultural production index, share in agricultural land use, and agriculture value added positively affect agricultural business and rural development potential **is failed to be rejected.**
- H_2: Higher credit to agriculture development and gross domestic value of agriculture positively affect agricultural business and rural development potential **is failed to be rejected.**
- H_3: Higher number of organizations that conduct R&D in agriculture, investments into agriculture, and research and development expenditure, positively affect agricultural business and rural development potential **is failed to be rejected.**
- H_4: Higher GDP, GDP per capita, and net salaries growth positively affect agricultural business and rural development potential **is failed to be rejected.**
- H_5: Higher temperature change of land and inflation rates negatively affect agricultural business and rural development potential **is failed to be rejected.**

Based on the analysed literature about the integration of Society 5.0 innovations in agricultural business and their impact on rural development, here are suggestions and guidelines to improve both sectors:

- Implement precision agriculture that encourages the adoption of IoT, AI, and GPS technology to optimize resource use and increase crop yields.
- Develop infrastructure to support the use of drones, autonomous tractors, and robotic harvesters to reduce labor costs and improve efficiency.
- Encourage practices that minimize environmental impact, such as organic farming and conservation agriculture.
- Support the transition to sustainable energy sources like solar, wind, and biomass to power agricultural operations.
- Leverage big data to make informed decisions regarding crop selection, pest control, and weather predictions.
- Use climate data and predictive modeling to prepare for and mitigate the impacts of climate change on agriculture.
- Create and support online platforms for farmers to directly sell their produce, reducing reliance on middlemen.
- Develop financial products tailored to the agricultural sector to help farmers invest in new technologies and practices.
- Provide educational programs and workshops on the latest agricultural technologies and practices.

- Ensure that rural populations have the skills to utilize digital tools and platforms effectively.
- Build and maintain roads, and invest in storage facilities to reduce post-harvest losses.
- Invest in broadband infrastructure to ensure rural areas have reliable internet access.
- Foster partnerships between academic institutions, tech companies, and agricultural businesses to drive innovation.
- Allocate resources to research on crop improvement, sustainable practices, and climate adaptation strategies.
- Craft policies that support sustainable farming, technology adoption, and rural development.
- Encourage collaboration between government entities and private companies to fund and implement rural development projects.

By implementing these strategies and actions, rural development and agricultural business can be significantly improved, aligning with the principles of Society 5.0. These suggestions aim to create a sustainable, efficient, and inclusive agricultural sector that supports the broader goals of economic growth, environmental sustainability, and social well-being in rural communities.

Conclusion

The exploration of Society 5.0's impact on agricultural business and innovation provides a comprehensive understanding of how advanced technologies and sustainable practices are pivotal in reshaping rural development. This study elucidates the transformative potential that lies in the integration of cyberspace and physical space, with a particular focus on the agricultural sector. This shift is not only essential for addressing pressing global challenges such as food security and climate change but also aligns with the overarching goals of Society 5.0 to balance economic advancement with social welfare.

The findings from this research underscore the importance of innovations. Moreover, the study introduces the Agricultural Business and Rural Development Potential (ABRDP) index as a tool for assessing future trends and potential outcomes, highlighting a positive trajectory for agricultural development under the influence of Society 5.0.

Future studies could delve deeper into the social implications of integrating advanced technologies in agriculture, particularly in terms of labor dynamics and rural-urban migration patterns. Additionally, there is a need for more empirical research on the scalability of innovative farming practices and their economic viability across different regions and farming systems. Investigating the role of policy and governance in facilitating or hindering the transition to a Society 5.0-aligned agricultural model could also provide valuable insights. Lastly, exploring the potential of emerging technologies not extensively covered in this study, such as nanotechnology and advanced genetic engineering, could uncover new opportunities for improving agricultural productivity and sustainability.

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Conflict of interests

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VALUE ASSESSMENT OF FRUIT ORCHARDS BASED ON THE COSTS OF ESTABLISHMENT

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A B S T R A C T

The necessity for value assessment of fruit orchards (an orchard as a whole and/or individual fruit trees grown therein) arises in instances of the damage or destruction of orchards caused by climatic factors, intentional harm, expropriation, the construction of public facilities at the orchard site (such as highways, railways, power lines, etc.), changes in ownership, and expert mediation in various legal disputes. The value assessment of orchards based on the total costs of establishment involves determining all expenditures incurred from the very establishment of the orchard until its full development, id est until reaching such productivity that the value of production exceeds the incurred production costs and the annual annuity payment. The theoretical-methodological procedure for assessing the value of fruit orchards based on the total costs of establishment, or their cultivation value, is illustrated using a peach orchard as an example.

Introduction

The value assessment of fruit orchards ranks among the most challenging and complex undertakings in fruit production, as it often requires considering a large number of different factors. The assessor, typically an experienced expert, must possess a thorough understanding of the biological characteristics and economic dynamics of fruit production. The knowledge of biological characteristics of fruit production is necessary due to significant differences between fruit crops according to ecological conditions, cultivation intensity, orchard conditions at different stages of its lifespan,

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etc. Understanding the economic dynamics of fruit production is essential due to variations in required investment funds for establishing an orchard, market prices of individual fruit crops and cultivars, and the proximity and connectivity of the orchard to consumer centers (Sredojević & Jovanović, 1998; Milić & Lukač Bulatović, 2017).

Concrete data for assessing the value of a fruit tree are often lacking, requiring the assessor to rely on personal observations and acquired experience. The biological valuation of a single fruit tree can be conducted by an agricultural expert specializing in fruit growing, whereas the economic valuation can be performed by agricultural economists or economists based on previous analyses.

The following methods are applied to assess the value of fruit trees according to their life stage:

1. the value assessment of fruit trees in the investment period (the establishment and care of young fruit trees),
2. the value assessment of fruit trees before reaching half of their average lifespan (the period of growing productivity),
3. the value assessment of fruit trees at half of their average lifespan (the period of full productivity) and
4. the value assessment of fruit trees after reaching half of their average lifespan (the period of declining productivity).

The value assessment of fruit trees based on the total costs of establishment (the investment period) or their cultivation value entails determining all expenditures incurred from the very establishment of the orchard until reaching the full productivity of fruit trees. If subjected to compound interest, such expenditures are reduced by the discounted values of expected yields in the period under consideration (Sredojević & Jovanović, 1998). Introducing intercrops among young orchard trees during cultivation renders the aforementioned value assessment method more complex. The complexity arises from the allocation of production costs between the fruit orchard and the intercrops cultivated therein.

The value assessment of fruit orchards based on their yield value is also applied to evaluate the economic efficiency of the orchard by comparing its yield and cultivation (acquisition) values (Milić et al., 2005). In addition to these values, there is also the capital value, which, alongside other methods such as the internal rate of return, the payback period of invested funds, etc., is utilized to determine the economic effectiveness of the orchard.

When assessing the value of an orchard, depreciation (the annual write-off of the total investment value of the orchard as an asset) must be taken into account because an orchard, as a perennial plantation, falls uder fixed assets. The lifespan (or the production period) of an orchard is calculated from the year in which a profit is realized (when the production value exceeds the production costs) until the year in which the production value decreases to the level of total production costs. The depreciation period of an orchard varies depending on the fruit crop, rootstock, cultivation form, etc.

This paper presents a theoretical-methodological procedure for assessing the value of fruit orchards based on the total expenditures incurred from the very establishment of the orchard until its full development, i.e. until reaching such productivity that the value of production exceeds the incurred production costs and the annual annuity payment ((Production Value (V_p) – Production Costs (T_p) = Profit)). The value determination of fruit orchards based on the total costs of their establishment is illustrated herein using a peach orchard as an example.

Materials and methods

The cultivation or acquisition value of a fruit orchard represents the sum of all expenditures incurred from its establishment until reaching the regular annual cropping, the value of which exceeds the annual costs. The cultivation value of an orchard is calculated in the course of assessing the economic effectiveness of its establishment and utilization. As an indicator, it is compared to the yield value of the orchard.

The total amount of monetary investments during the orchard establishment period, reduced by the market value of the yields obtained during this period, constitutes the value of the orchard at the beginning of its utilization:

$$V_0 = u_0 + (u_1 + u_2 + \cdots + u_{m-1} + u_m) - (v_1 + v_2 + \cdots + v_{m-1} + v_m)$$

V_0 - the total amount of investments in the establishment of the orchard, or the value of the orchard at the beginning of the utilization period;

u_0 - one-time investments (costs) incurred during the establishment period (clearing, cleaning, land preparation for planting, procurement of seedlings, planting, fence installation, etc.);

$u_1, u_2 \dots u_m$ - the costs of fertilization, care, and protection of the orchard in individual years of its establishment;

$v_1, v_2 \dots v_m$ - the market value of yields in individual years of the orchard establishment.

During cultivation, fruit orchards require sigificant financial investments and are commonly financed through borrowed funds (loans) (Sredojević, 1998) For this reason, it is necessary to calculate interest on the determined amount of total investments at a specified interest rate for m years (Sredojević & Jovanović, 1998; Milić & Lukač Bulatović, 2017).

By applying the compound interest calculation, the total amount of investments in establishing the orchard, increased by the corresponding amount of interest, is determined by discounting to the ultimate moment of interest accrual (at the end of the m year) as follows:

$$V_0 = u_0 \times r^m + (u_1 \times r^{m-1} + u_2 \times r^{m-2} + \cdots + u_{m-1} + u_m) - (v_2 r^{m-2} + v_3 \times r^{m-3} + \cdots + v_{m-1} \times r + v_m)$$

where:

r - denotes the interest factor (1+i)

i - denotes the interest rate

The present theoretical-methodological procedure for the value assessment of orchards based on the costs of their establishment or cultivation value is illustrated herein using a peach orchard as an example. The costs accounted are those related to an investment peach orchard project in the Bačka region (the Autonomous Province of Vojvodina, the northern part of Serbia) and are presented per unit capacity (per hectare).

Results with discussions

When assessing the value of fruit orchards, especially their productivity, it is necessary to consider not only the current condition of the orchard but also environmental conditions, fruit crops and cultivars, rootstocks, general care, and everything else that may affect the current and prospective yields and the longevity of the fruit trees. For example, if the most suitable rootstock is not selected for establishing the orchard, the lifespan of the tree will be shorter and the expected yield per tree will be lower, thus reducing the value of the tree compared to the case of optimal selection (Vukoje & Milić, 2009; Milić & Lukač Bulatović, 2017). In principle, it is easier to assess the value of young trees that have not yet borne fruit than those in production. With young trees, investment expenditures and orchard care costs during establishment are more or less the same for the same cultivation form, the same level of intensity, the same fruit crop, and so forth, allowing for a precise and adequate assessment to be conducted.

In assessing the value of fruit trees not yet in production, the investment period encompasses the time from the establishment of the orchard to the full development of the fruit trees, or until reaching such productivity that the value of production exceeds the incurred production costs and the annual annuity payment. In this assessment, it is necessary to determine the investment expenditures and maintenance (care) costs of the orchard during the cultivation period as accurately as possible.

Understanding the investment period is essential for calculating annual depreciation, which is charged against the fruit production costs.

The cultivation value of an orchard is also calculated during the assessment of the economic effectiveness of its establishment and utilization. In this case, in addition to calculating the investments in establishing the orchard, it is necessary to calculate the investments in replacing the worn-out machinery during the period of orchard utilization (Sredojević & Jovanović, 1998). This is achieved by discounting the planned future investments in replacing the worn-out machinery to the final moment of the orchard establishment period, or the beginning of its exploitation.

The investment expenditures and maintenance costs during orchard establishment comprise the following items: material costs (costs of seedlings, basic fertilizers, markers, and various auxiliary materials), variable costs of machinery (fuel and lubricants, maintenance costs, the functional depreciation of used machinery), fixed costs of machinery and equipment, labor costs (temporary and permanent workers), and costs of outsourced services.

On balance, the key elements of assessing the cultivation (acquisition) value of an orchard are as follows:

1. The amount of investment required for establishing the orchard up to the completion of planting – including land preparation for planting (costs of fertilization, deep plowing, and other preparatory activities), procurement of seedlings, poles, wires, planting, and all associated costs, orchard area landscaping (construction of roads, installation of fencing, and other related activities), irrigation systems, etc.
2. The costs of regular maintenance and care of the orchard annually – including the costs of fertilization, soil cultivation, pruning, pest and disease control, general orchard care, and harvesting and transportation costs in years of initial low yield. In addition to direct costs, which vary depending on the fruit crop, cultivation form, and production conditions, the assessor must also consider administrative costs, insurance, etc. When assessing the amount of investment and all costs related to tree cultivation annually, the method of calculation based on market prices is applied. The market prices at the time of assessment are used for calculating materials and services, whereas human labor is valued according to the qualification structure of individual work operations.
3. By summing up the aforementioned assessment elements, the total value of the orchard is calculated, which, when divided by the number of fruit trees per unit area, provides the estimated value of a single fruit tree. If the entire orchard or individual fruit trees already produce initial low yield, the value of such yield is subtracted from the total value of the orchard.

A recapitulation of the costs incurred in establishing a peach orchard is presented in Table 1.

Although significant investments per unit capacity are required for establishing a peach orchard, such investments find justification in the relatively long and profitable period of full orchard productivity, which can last (depending on the cultivar, rootstock, soil, and climate) 15 to 25 years (Gangwar et al., 2008; Lukač Bulatović, 2014).

Table 1. A recapitulation of the total costs of establishing a peach orchard

Period of exploitation: 15 years Planting density: (4,5 x 3.5 m) (approximately 630 trees/ha) Areas: 1 ha		
Year (m)	Description of costs	Iznos (EUR/ha)
0	Costs of land preparation for establishing the orchard[4]	1,200.0
	Costs of planting[5]	2,100.0
	Costs of fence installation[6]	1,650.0
	Costs of drip irrigation system installation[7]	2,700.0
	Other costs[8]	300.0
	Total investments in the zero year	7,950.0
	Discount factor ($1{,}08^{m}$)	1.2597
	Discounted investments in the zero year	**10,014.6**
1.	Costs of care in the first year[9]	960.0
	Discount factor ($1{,}08^{m}$)	1.1664
	Discounted investments in the first year	**1,119.7**
2.	Costs of care in the second year[10]	1,050.0
	Discount factor ($1{,}08^{m}$)	1.0800
	Discounted investments in the second year	**1,134.0**
3.	Costs of care in the third year[11]	1,280.0
	Value of initial low yield in the third year[12]	138.0
	Discount factor ($1{,}08^{m}$)	2.0000
	Discounted value of initial low yield in the third year	138.0
	Discounted investments in the third year (reduced by the value of initial low yield)	**1,142.0**
	Total amount of investment	11,102.0
	Discounted investments (0-3)	**13,410.3**

Source: Author's calculations

4 Costs of terrain leveling, fertilization (the procurement, delivery, and spreading of organic (30 t/ha) and mineral fertilizers (700 kg/ha)), deep plowing (50-60 cm deep) , harrowing (2x)

5 Costs of purchasing seedlings and planting (site marking, digging holes, the preparation and planting of seedlings, watering)

6 Costs of purchasing poles and wire, and costs of fence installation

7 Costs of constructing a drip irrigation system (well drilling, the procurement of pump and irrigation systems)

8 Costs of road and path maintenance, filling empty spaces, protection and others

9 Harrowing (6x), plowing, the spreading of nitrogen fertilizers (300 kg/ha), protection (3x), watering

10 The same as in the first year with the addition of pruning (6 working days)

11 The same as in the first and second years with the addition of harvesting (4 working days)

12 Reduced by harvesting costs

According to the tabular calculation of investments for eastablishing a peach orchard (the investment expenses and costs of care and mainenance of the orchard) in the specified cultivation system, for m = 3 and i = 0.08, the amounts are as follows:

the initial investment in the zero year.. $u_0 =$ EUR 7,950.00

the investment in the first year of establishing the orchard............ $u_1 =$ EUR 960.00

the investment in the second year of establishing the orchard........ $u_2 =$ EUR 1,050.00

the investment in the third year of establishing the orchard........... $u_3 =$ EUR 1,280.00

the value of initial low yield in the third year of establishing

the orchard.. $v_3 =$ EUR 138.00

$$V_0 = (7{,}950 \times 1.08^3 + 960 \times 1.08^2 + 1{,}050 \times 1.08 + 1{,}280) - 138$$

$$V_0 = \text{EUR } 13{,}410{,}3 \text{ (per hectare)}$$

$V_0 \approx$ EUR 21.3 (per tree)

When calculating the value of an orchard, if the average annual costs of establishing the orchard are utilized, denoted as $u_1 = u_2 = u_3 = \cdots = u_1 = u,$ and the average annual orchard revenues, denoted as $v_1 = v_2 = v_3 = \cdots = v_1 = v$, then the total investment amount, increased by the calculated amount of intercalary interest (Sredojević & Jovanović, 1998), can be computed as follows:

$$V_0 = u_0 \times r^m + \text{u} \frac{r^{m-1}}{r-1} - \text{v} \frac{r^h - 1}{r-1}$$

where:

u = average annual costs (expenditures),

v = average annual revenues,

m = the number of years of the orchard establishment,

h = the number of yield years in the orchard establishment period (the number of years of initial low yield).

In such determination of total investment amounts, it is assumed that both revenues and expenditures occur at the end of the year.

The total amounts of investment in the orchard establishment represent the initial value of these assets, i.e. the value of the orchard at the beginning of the period of their utilization. This value is known as the cultivation value of the orchard. It serves as the basis for depreciating the investment assets, which will gradually be allocated, during the period of utilization, to the obtained yields in the form of established annual depreciation costs. Upon commercializing the achieved yields, the assets invested in their production will be multiplied.

Comparable to all other basic assets in agriculture, orchards also undergo depreciation. The calculation of orchard depreciation consists of two parts: determining the basis for depreciation and allocating the basis to individual production processes or cycles, or to time periods during which the asset is utilized (Milić & Lukač Bulatović, 2017). However, in agriculture, it is common for a basic asset to be constructed or established over several years, which is a constant occurrence in the establishment of perennial plantings. Determining the basis for depreciation in perennial plantings would not pose a greater difficulty if it were not known that the resources invested in establishing the plantation would be tied up for a longer period and that perennial plantings would begin to yield at some point during the establishment period (albeit in small quantities, but with a certain volume and value).

The perennial plantings considered basic assets in agriculture encompass productive orchard areas, grapevine areas, plantings for wind protection, erosion control, and sand fixation, and industrial plantings such as hop plantations and forests (Milić & Lukač Bulatović, 2017). This implies that young, newly established orchards, grapevines, and hop plantations do not possess the characteristics of basic assets because additional investments are made until they begin bearing fruit (the care of the plantation in the first, second, and third year, the installation of supports, etc.), significantly increasing their initial value. Therefore, newly established plantings are deemed ongoing investments until they start yielding fruit.

One of the methods for assessing fruit orchards based on their acquisition or cultivation value (the bases for depreciation) is the following procedure (Milić & Lukač Bulatović, 2017):

$$V = (A + B + C) x\ f\ x\, d - E$$

where

V = the value of the orchard (trees),

A = the costs of orchard establishment including planting,

B = the costs of annual mantenance and care of the orchard,

C = the intercalary interest for investment,

f = the correction factor according to the condition of the orchard for potential yield and market value relative to the structure of fruit crops and cultivars,

d = the discount factor (infaltion rate),

E= the production value in the assessment year, reduced by the harvest costs (the initial low-yield value).

The correction factor of the orchard general condition at the moment of assessment is used to draw conclusions about its potential production. Based on the growth of fruit trees, balance of cultivation form, health condition, etc., the estimated value of fruit trees can be adjusted downwards or upwards. Accordingly, if the growth of fruit trees is better, and the prospect of earlier entry into the bearing period and achieving high yields is more favorable, or if the orchard as a whole is in better condition, then their estimated value should be higher and vice versa. For example, the investment costs for establishing 1 hectare of peach orchard, using the inclined palmette cultivation form, may be equal to or even lower than those for establishing 1 hectare of plum orchard of the same cultivation form (Milić & Lukač Bulatović, 2017). However, the nominal value of 1 hectare of young peach orchard is certainly higher than that of plum, and a single tree of an early pear cultivar near consumer centers is certainly nominally more valuable than a tree of the "Kaluđerka" cultivar, even though their determined investment value will be the same through calculation. Therefore, the correction factor comprises multiple elements, which need to be individually constructed and calculated in each specific case.

The costs of establishing perennial orchards significantly depend on the fruit crop cultivated and the planned level of orchard intensity (Lukač Bulatović, 2013, 2014; Badiu at al., 2015; Lukač Bulatović at al., 2017). The costs of planting and caring for one hectare of intensive peach orchard amount to HRK73,000 (Ivić, 2004). The approximate costs of establishing and maintaining one hectare of high-intensity pear orchard during the investment period amount to USD17,500 (Keserović, 2004). The costs of establishing one hectare of apple orchard are as follows: EUR5,000 for extensive planting, EUR10,000 for semi-intensive planting, EUR20,000 for modern dense planting without irrigation and drainage, and EUR30,000 for modern dense planting with irrigation and drainage (Mišić, 2003). The total investment value of an intensive quince orchard is 3,630 EUR/ha (Milić et al., 2010). The required investment for intensive grape cultivation amounts to approximately 30,000 EUR/ha (Sredojević et al., 2015). The initial cost of investment in litchi plantation was estimated to be ₹ (Indian Rupee) 32,157.43 per hundred plants - Kayastha at al,, 2022. In the structure of total orchard establishment costs, the largest share is attributed to planting costs: the costs of purchasing seedlings, marking the planting sites, digging pits, preparing seedlings for planting, and irrigation (Milić et al., 2010; Kawalpreet & Jatinder, 2016). Orchard maintenance costs are lower in the initial years of establishment, but significantly increase with the orchard's age (Raghav & Srivastava, 2015; Manpreet at al., 2016; Kawalpreet & Jatinder, 2018: Łakomiak & Zhichkin, 2020).

In investments in fruit growing and agriculture in general, the amount of investment and the length of the investment period are significantly influenced by biological processes, technical and technological execution capabilities, and the duration of individual tasks. Therefore, in the process of investing in orchard establishment, the conditions for initial orchard fruiting and investment activation are not simultaneously created. Specifically, the time of initial fruiting varies according to the orchard type, with noticeable differences within the same type of orchard relative to individual cultivars. Additionally, periods of varying intensity with increasing, peak, and declining yields occur during the exploitation of orchards. These are often conditioned by agricultural work processes based on cultural, technical-technological, and economic foundations.

Conclusions

There is often a practical need for the value assessment of an orchard as a whole and/or individual fruit trees grown therein, arising in instances of the damage or destruction of the orchard caused by extreme weather events, intentional harm, expropriation, the construction of public facilities at the orchard site, changes in ownership, inheritance division, and expert mediation in various legal disputes.

Different methods are applied to assess the value of fruit orchards according to their life stage, the most frequent of which is based on their acquisition (cultivation) and yiled values. In principle, it is easier to assess the value of young orchards that have not yet borne fruit than those in production. In young orchards, investment expenditures and orchard care costs during establishment are more or less the same for the same cultivation form, the same level of intensity, the same fruit crop, etc.

The value assessment of orchards based on the total costs of establishment involves determining all expenditures incurred from the very establishment of the orchard until its full development, i.e. until reaching such productivity that the value of production exceeds the incurred production costs and the annual annuity payment ((Production Value (V_p) – Production Costs (T_p) = Profit)). The cultivation value of an orchard is calculated in the course of assessing the economic effectiveness of its establishment and utilization. As an indicator, it is compared to the yield value of the orchard.

The costs of establishing fruit orchards depend on a number of factors such as the area and type of orchards, cultivation system, rootstock, cultivar, duration of the establishment period, dynamics of orchard establishment, distribution of investments over the years of orchard establishment, level of the calculated interest rate, and timing of achieving initial low yields.

The cultivation value of an orchard represents its initial value, serving as the basis for the orchard depreciation. The depreciation period of an orchard varies depending on the fruit crop, rootstock, cultivation form, etc.

The value assessment of fruit orchards based on the total costs of their establishment is of paramout importance to resolving numerous issues in practice, particularly under economic operation conditions exclusively guided by market principles.

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Conflict of interests

The authors declare no conflict of interest.

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MULTI-CRITERIA MEASUREMENT OF AGRI-ENVIRONMENTAL PERFORMANCE IN EUROPEAN UNION COUNTRIES

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A B S T R A C T

The purpose of the paper is to assess the agri-environmental situation in the European Union at the national level. To realize that goal, a multi-criteria analysis of indicators from the official European database was used. The results of the ranking show that Portugal, Estonia, and Ireland are at the top according to agri-environmental performance, while the worst ranked countries are Malta, the Netherlands, Slovenia, and Cyprus. The common agricultural policy of the European Union must be designed to improve the position of certain countries, based on the experience and sustainable agricultural practices of the leading countries in this area, considering the obtained research results. This study can contribute to the creators of agri-environmental policies in the preparation of the future strategy of the agricultural development of the European Union countries.

Introduction

As part of the assessment of the sustainable development of society, environmental and agricultural sustainability have a special place. The sustainability of agriculture relies

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heavily on environmental sustainability (Mukherjee, 2022). In fact, agriculture is an activity, which, unlike others, depends significantly on natural and climatic factors. But, at the same time, it exerts a significant impact on the environment (negative externalities), bearing in mind the reliance on land as a basic natural resource in agricultural production. According to the latest data from the World Bank (2021), agricultural land makes up 40.76% of the total land of the European Union. Lal (2009) argues that ecosystem degradation due to inadequate agricultural practices can be devastating to all of humanity. The following trends are characteristic of agriculture: (i) increasing use of pesticides that pollutes the soil, (ii) accelerated conversion of forest land into agricultural land, which affects soil erosion, (iii) large emissions of ammonia, and (iv) agricultural intensification. All this calls into question the possibility of agricultural development in the future and disrupts the entire ecosystem to a certain extent. That is why Volkov et al. (2020) in the study emphasize that agricultural performance must always be viewed together with environmental indicators. Their study showed that the newer member states of the European Union achieve better agri-environmental performance compared to the members that joined earlier.

Although it does not have a significant contribution to the gross domestic product, agriculture is important because it ensures food security and poverty reduction; affects the satisfaction of basic human needs, as well as human health (considering food quality and the impact of agricultural activities and practices on natural resources and the environment) (Renner et al., 2020; Streimikiene, & Mikalauskiene, 2023). In addition, it is expected that this sector will gain importance, bearing in mind the forecast of further increase in food prices. Agriculture must provide enough food for the growing population, but without harming the quality of the environment (water, soil, air, etc.), which is the idea of sustainable development of this economic activity (Skaf et al., 2019). The increasing number of studies on this topic testifies to the significant interest of the scientific community in the problem of sustainability, quantifying the sustainable development of agriculture, as well as the impact of the agricultural sector on the environment (Talukder, Blay-Palmer, & Hipel, 2020; Streimikiene, & Mikalauskiene, 2023). Therefore, our determination is to investigate the achieved level of development of agri-environmental performance in the countries of the European Union. This economic integration directs significant resources to agriculture, its protection from foreign competition, as well as for strengthening the position of farmers. Also, the Common Agricultural Policy of the European Union influences the greening of the agricultural sector and the reduction of negative effects on the environment (Rudnicki et al., 2023), especially due to high energy consumption and high greenhouse gas emissions (Cheba et al., 2022). All reforms of the European Union's Common Agricultural Policy had measures to prevent negative effects of agricultural production on the environment (Salvan et al., 2022). Considering the amount of energy consumed by agriculture, it is necessary to reduce consumption due to at least two reasons: (i) high energy dependence of European countries, and (ii) negative consequences on environmental pollution.

In recent years, global society has faced economic, energy, political and health crises. This also influenced the transformation of agricultural practices to minimize the negative impact on the environment (Cheba et al., 2022). Namiotko et al. (2022) point out that the deterioration of agri-environmental indicators is one of the important aspects of these crises, so in their work they apply TOPSIS, EDAS and SAW methods of multi-criteria analysis for European countries to find and overcome this situation. With this objective in mind, they analyse seven agri-environmental indicators: ammonia emissions from agriculture, areas of intensive agriculture, average organic carbon content in arable land, surface water quality, groundwater quality, the farmland birds index, and the favourable conservation status of agricultural habitats. Marković et al. (2023) state that intensive irrigation, the use of chemicals and the disruption of biodiversity due to monoculture production are the key issues of concern. That is why the evaluation of environmental sustainability of agriculture is important. Multi-criteria decision making is particularly prevalent in the field of sustainable development (Bartzas, & Komnitsas, 2020; Castillo-Díaz et al., 2023), bearing in mind the multidimensionality of the research problem and the complexity of data aggregation. Observing agri-environmental performance using multi-criteria decision-making methods has been the preoccupation of researchers, especially since 2016 (Gürlük, & Uzel, 2016; Gómez-Limón, Arriaza, & Guerrero-Baena, 2020; Cicciù, Schramm, & Schramm, 2022). Most of this research apply criteria such as enhancing or protecting biodiversity, improving habitat diversity, minimizing soil erosion, promoting soil fertility, improving soil and water quality, reducing water extraction, optimizing energy balance, maximizing the economic value of agricultural production, increasing the efficiency of fertilizer and pesticide use, and/or reducing total agricultural emissions. Recent research used the following techniques: Principal Component Analysis, Data Development Analysis, and the DEXiPM (Cicciù, Schramm, & Schramm, 2022). In this paper, the authors opted for the MOORA (Multi-Objective Optimization by Ratio Analysis) method, which until now (according to the literature review) has not been used in the ranking of European Union countries according to agri-environmental status, and it is ideal for conflicting criteria that exist in this case. In addition to the highlighted originality of the study, the justification for the research lies in the fact that there is still no unified view of the coverage of agri-environmental indicators that would constitute a single, composite index. The basic research question of this paper is: Which countries of the European Union represent leaders in terms of agri-environmental performance, and which, on the other hand, should significantly improve their prospects for the realization of ecologically acceptable agriculture?

The study consists of several standard parts. After the introduction, the analysis material (indicators, data sources, definitions) is presented in detail, the weighting method is described, as well as the data aggregation tool (section Materials and methods). Then, the research results are presented in tabular and graphical form. In this unified section (Results and Discussion), an effort will be made to review and evaluate the current situation in the countries of the European Union based on the obtained composite indicators of agri-environmental performance. In the last section (Conclusions), final considerations and limitations of the research will be stated, and recommendations to other authors for future research on this topic will be highlighted.

Materials and methods

Multi-criteria decision-making implies several stages. The first step in creating a composite index is the choice of indicators. Carefully selected indicators are essential for the later decision-making by sustainable development policy makers (Krstić, Milenović, & Rađenović, 2021). The authors selected seven indicators from the database of the European Commission (Eurostat), from the segment related to agri-environmental indicators. These are the attributes that will be used in the multi-criteria model. The choice was conditioned by the level of observation (national level), the availability of data, as well as their relevance (significance) based on a thorough review of the literature. Thus, the following indicators of agri-environmental performance were reached (European Commission, 2024):

1. *Area under organic farming (percentage of the total used agricultural land),*
2. *Final energy consumption by agriculture/forestry (per hectare of utilised agricultural area),*
3. *Permanent grassland (percentage of the total used agricultural land),*
4. *Energy productivity (EUR per kilogram of oil equivalent),*
5. *Ammonia emissions from agriculture (kilograms per hectare),*
6. *Greenhouse gas emissions from agriculture (in percentage), and*
7. *Estimated soil loss by water erosion (tonnes per hectare).*

Table 1 provides a description of the indicators, the unit of measure for each of them, as well as information on the year to which the data refer (the most recent data according to the Eurostat database).

Table 1. Display and description of the indicators/criteria used in the model

Criteria	**Year (last available year)**	**Unit of measurement**	**Description**
Area under organic farming (C1)	(2021), except for Greece and Austria (2020)	%	Areas under organic production (crop and livestock production) calculated as a percentage of the total used agricultural land
Final energy consumption by agriculture/forestry (C2)	(2022)	consumption per hectare	Final energy consumption by agriculture/ forestry per hectare of utilized agricultural area, which represents the sum of all types of energy supplied to the agricultural sector
Permanent grassland (C3)	(2016)	%	The share of permanent grasslands in the total used agricultural area

Criteria	Year (last available year)	Unit of measurement	Description
Energy productivity (C4)	(2022)	EUR per kilogram	It is calculated as the amount of economic production (in euros) per unit of gross available energy
Ammonia emissions from agriculture (C5)	(2021)	kg per hectare	Agriculture is the sector that predominantly emits ammonia and thus affects air pollution. This indicator measures the amount of ammonia emissions from agriculture per hectare of the total used area under agriculture
Greenhouse gas emissions from agriculture (C6)	(2022)	%	Percentage of emissions coming from agricultural activities
Estimated soil loss by water erosion (C7)	(2016)	tonnes per hectare	Estimated soil erosion caused by water, expressed in tons per hectare. Both agricultural areas and natural grassland are included in the calculation of this indicator

Source: Authors' representation based on European Commission definitions, 2024

Three indicators are revenue-type criteria (*Area under organic farming, Permanent grassland,* and *Energy productivity*), while the remaining four indicators are cost-related criteria (*Final energy consumption by agriculture/forestry, Ammonia emissions from agriculture, Greenhouse gas emissions from agriculture,* and *Estimated soil loss by water erosion*).

Before building the composite index, it is necessary to define the method of determining the weighting coefficients. As a method of weighting, the method of equal weighting coefficients was applied in the paper. Based on the existing shortcomings of subjective methods, the paper uses the method of equal weighting coefficients, which gives equal relative importance to each indicator (when creating a composite index). In this way, the subjectivity of decision-makers and the possible favouring of some indicators were avoided, and on the other hand, the task was significantly simplified, bearing in mind the different preferences of stakeholders (interested parties) at the macro or micro level (Hagerty, & Land, 2007).

In aggregating data, the authors chose one of the newer multi-criteria methods that has not been applied in the assessment of agri-environmental sustainability - the MOORA (Multi-Objective Optimization based on Ratio Analysis) method. The MOORA method is selected due to its ability to normalize and compare criteria that may have different units of measurement, making it particularly suitable for complex decision-making scenarios (Brauers, & Zavadskas, 2006). Additionally, the MOORA method does not require complex mathematical models, allowing decision-makers to easily apply it without extensive computational resources (Stanujkic et al., 2012). In the process of obtaining the value of the composite index, the authors followed the steps described below and manually arrived at the final results. Scientists use this tool when it is necessary to reduce various conflicting indicators to a single measure and to rank alternatives (Filipe, & Caleiro, 2020). By simultaneous optimization of several criteria, an aggregate indicator is obtained, in this case, the index of agri-environmental performance of the countries of the European Union. The MOORA method usually involves the following procedures for calculating the composite index and ranking the alternatives (Brauers, & Zavadskas, 2006; Gadakh, Shinde, & Khemnar., 2013; Madić, Radovanović, & Petković, 2015; Marjanović, Rađenović, & Marković, 2019):

Step 1. Creating a decision matrix $X_S = [x_{ij}] X_S = [x_{ij}]$,

where:

x_{ij} – the value of the alternative i according to the criterion j,

$i = 1, 2, \ldots, m$ (number of alternatives) and $j = 1, 2, \ldots, n$ (number of criteria).

Step 2. Determining the normalized decision matrix, where x^*_{ij} are normalized values:

$$x^*_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

Step 3. Optimization of the multi-criteria problem, where the normalized values of the revenue criteria (multiplied by the weighting coefficients) are added, while the normalized values of the cost criteria (multiplied by the weighting coefficients) are subtracted:

$$y_{ij} = \sum_{j=1}^{g} w_j x^*_{ij} - \sum_{j=g+1}^{n-g} w_j x^*_{ij}$$

where:

g (number of revenue criteria), n-g (number of cost criteria), and w_j - the weight coefficients. The values of the normalized decision matrix are multiplied by the weighted coefficients to form a preference-normalized decision matrix. In this paper equal weighting approach has been applied as one of the objective approaches. This approach is commonly applied in situations where input from the decision-maker is unavailable or when insufficient information exists to determine the relative importance of criteria (Jahan et al., 2012). Equal weighting assumes that all criteria hold equal importance, eliminating the need for subjective judgments or complex weighting schemes, which can sometimes introduce bias. The equal weights can be calculated using the following equation:

$$w_j = \frac{1}{n}$$

where n is the number of criteria. Therefore, in the following analysis each indicator will have a weight coefficient of 0.142857. In other words, the sum of the weighted values is equal to the one.

Step 4. Ranking of the alternatives (in descending order of value), with the best being the one with the highest value y_{ij}. The value of the composite index can be both positive and negative, depending on whether revenue or cost criteria dominate. Unlike methods that generate results on a specific scale (such as from 0 to 1), the MOORA method produces results that depend on the specific data and context of the decision problem. The range of results is influenced by the number of criteria, the distribution of the data, and the weighting factors. While the results are typically within the [-1, 1] interval, the MOORA method can produce scores that vary beyond this range (Stanujkic et al., 2012). Therefore, the scores within the specific context of the decision-making problem should be analysed.

Results and Discussions

First, Table 2 shows the descriptive statistics of the selected indicators. One of the indispensable indicators in the evaluation of the environmental performance of agriculture is organic production. The percentage of areas under organic production is the highest in Austria, while the lowest is in Malta. The data argue that the highest energy consumption per hectare was recorded in the Netherlands' agriculture, while the lowest consumption was in Bulgaria. The latest available data shows that the percentage of permanent grassland is highest in Ireland, while it is almost non-existent in Malta. They are particularly important from the standpoint of biodiversity conservation. Ireland achieves the highest energy productivity, while Bulgaria achieves the lowest. When looking at ammonia emissions from agriculture, the worst situation is in Malta, while farmers in Latvia realise the lowest ammonia emissions. At the level of the European Union, according to data for 2021, over 90% of ammonia emissions on average originate from agriculture (European Commission, 2024), and this percentage is the highest in Ireland (99.2%), while the lowest is in Germany (82%), as the most industrialized country in the European Union. One of the leading causes of climate change, i.e. of global warming is ammonia emissions, so this indicator is almost always used in assessing the impact of agriculture on the environment (Shakoor et al., 2021). These emissions are caused by the production of methane and nitrogen oxides, and uncontrolled application of fertilizers, which may affect the sustainability of agricultural production in the future (Marković et al., 2023). Greenhouse gas emissions from agriculture are the highest in Ireland, while they are the lowest in Malta. Finally, inadequate water management practices in agriculture cause a significant reduction in soil quality and soil erosion. It is one of the most common types of soil degradation in the European Union, so it is a common element when looking at agri-environmental performance (Panagos et al., 2020; European Commission, 2024). Estimated soil loss by water erosion is most present in Slovenia, while the Netherlands shows the most favourable value.

The results of descriptive statistics indicate that the highest average deviations from the mean value are for the indicator *Final energy consumption by agriculture/forestry per hectare of utilized agricultural area*, so at the same time there are also the biggest differences between the countries of the European Union when it comes to the same indicator.

Table 2. Descriptive data statistics

Criteria	Maximum	Minimum	Mean	Std. deviation	Coefficient of variation
Area under organic farming	25.69	0.61	10.57	6.58	62.25
Final energy consumption by agriculture/forestry per hectare of utilised agricultural area	1627.00	38.49	275.24	399.44	145.12
Permanent grassland	90.60	0.00	31.09	19.25	61.92
Energy productivity	26.77	2.53	8.65	4.92	56.88
Ammonia emissions from agriculture	120.40	6.80	25.44	23.10	90.80
Greenhouse gas emissions from agriculture	35.30	3.30	12.10	6.96	57.52
Estimated soil loss by water erosion	14.80	0.30	3.29	3.29	100.00

Source: Calculation of authors based on European Commission data, 2024

Table 3 shows the ranking of the countries of the European Union and the values of the composite indices calculated using the MOORA method. Portugal, Estonia, and Ireland stand out at the top of the list, as countries that, according to the results of the research, achieve the best agri-environmental results. On the other hand, Malta has the weakest agri-environmental performance. Along with Malta, the Netherlands, Slovenia, and Cyprus achieve rather poor results in this regard. Fourteen countries of the European Union have positive values of the aggregate indices (left side of Table 3), while in the remaining thirteen countries, cost criteria dominate over revenue ones (right side of Table 3), which results in negative values of the obtained indices.

Table 3. Values of composite indices of agri-environmental performance and ranking of European Union countries

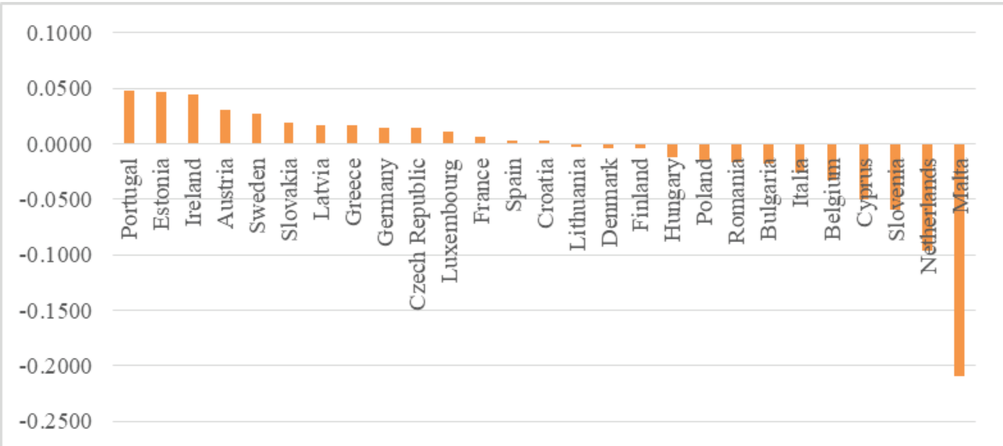
Country	Composite index	Rank	Country	Composite index	Rank
Portugal	0.0479	1	Lithuania	-0.0031	15
Estonia	0.0473	2	Denmark	-0.0036	16
Ireland	0.0448	3	Finland	-0.0044	17
Austria	0.0309	4	Hungary	-0.0118	18
Sweden	0.0267	5	Poland	-0.0154	19
Slovakia	0.0195	6	Romania	-0.0165	20
Latvia	0.0168	7	Bulgaria	-0.0178	21
Greece	0.0163	8	Italia	-0.0254	22
Germany	0.0146	9	Belgium	-0.0323	23
Czech Republic	0.0146	10	Cyprus	-0.0497	24

Country	Composite index	Rank	Country	Composite index	Rank
Luxembourg	0.0114	11	Slovenia	-0.0593	25
France	0.0061	12	Netherlands	-0.0964	26
Spain	0.0034	13	Malta	-0.2091	27
Croatia	0.0032	14			

Source: Calculation of authors based on European Commission data, 2024

Figure 1 shows the performance index values by country. It is concluded that there are no big differences between the countries of the European Union when looking at the calculated aggregate indicator of agri-environmental performance. This stems from the fact that there are certain countries that are very well positioned according to some indicators, while according to other indicators they have poor results at the level of the European Union. For example, Austria is the leader in terms of areas under organic production, while it is at the very bottom when it comes to the indicator related to soil erosion. Similarly, although Malta is the worst ranked country, it shows the best values for permanent grassland and greenhouse gas emissions. Furthermore, Ireland is at the top in all indicators except for area under organic production and greenhouse gas emissions.

Figure 1. Composite indices of agri-environmental indicators in European Union countries

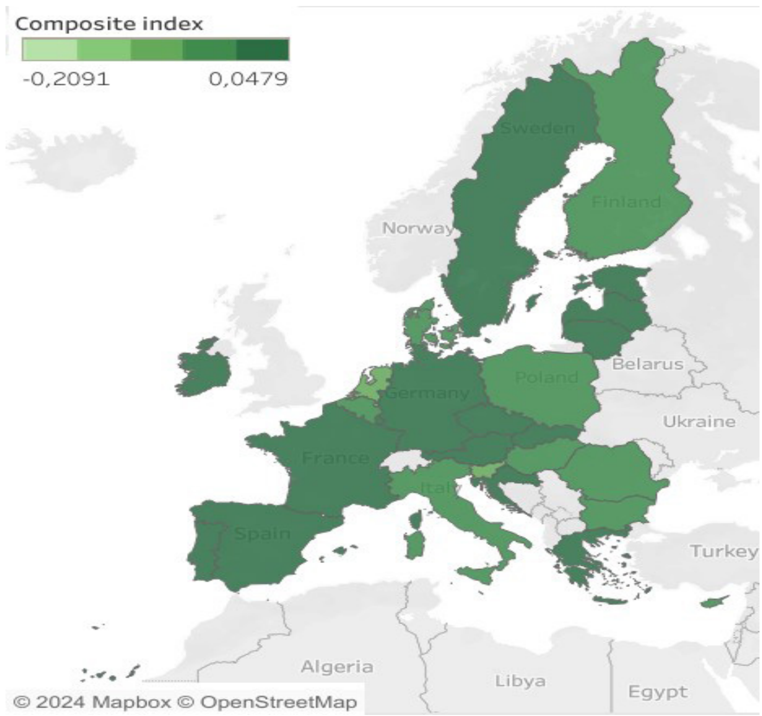


Source: Authors' calculations

In order to improve the placement of certain countries and improve agri-environmental sustainability at the level of the European Union, it is necessary to insist on the concept of organic agriculture and the transition to a circular model of agricultural production. Organic agriculture has been proven as the basic form of sustainable agriculture (Marković et al., 2023). It is one of the ways to ensure high-quality, healthy food, the production of which will have minimal negative effects on the environment due to reduced use of pesticides, herbicides, fertilizers (Rouyendegh, & Savalan, 2022). In this way, soil fertility and biodiversity will be preserved, and farmers can earn solid incomes, bearing in mind the high price of organic products. Another way to build ecological agriculture can be the application of modern circular solutions (Silvestri et al., 2022), primarily in waste management from agriculture (Lombardi, & Todella, 2023). Circular models in agriculture are aimed at reducing the consumption of energy and other resources, as well as reducing waste and negative emissions, which affects many agri-environmental indicators and can lead to the fulfilment of the goals of the 2030 Agenda (Castillo-Díaz et al., 2023). Raising awareness of the strong cause-and-effect relationships between agriculture and the environment and their joint impact on the quality of life of people in every sense must be a priority (Šebek, 2020).

Finally, in Figure 2, the position of the countries of the European Union is clearly illustrated through the maps. Countries with a better state of agri-environmental performance have a darker colour, in contrast to the worse ones, which are assigned a lighter shade.

Figure 2. Graphical presentation of the composite indices' values of agri-environmental indicators of the European Union countries



Source: Authors' calculations. The map was generated using Tableau Public 2023.1

Conclusions

The study formed (developed) a model (framework) for evaluating agri-environmental performance at the national level. In this way, it is easy to follow the movement of the obtained composite index over time and compare performance indices among different countries. Accordingly, policy makers can take appropriate decisions. The results of the research represent an added value for the future definition of practices, programs, and redesign of the Common Agrarian Policy of this economic integration. Emphasis must be placed on the use of environmentally friendly technologies and the use of renewable resources to preserve natural capital and slow down climate change. Research limitations are determined by the choice of indicators, the choice of multi-criteria decision-making methods, as well as the availability of data. Authors of future research could have a modified set of agri-environmental performance indicators (compared to those proposed by the authors), apply other method of analysis, as well as use updated data as soon as they are available in the database used in this study. Thus, this study can be used for comparison with results obtained in some other way. It is necessary for official databases to be supplemented with indicators of biodiversity, as well as consumption and pollution of water due to agricultural production.

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Conflict of interests

The authors declare no conflict of interest.

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Appendix

Table A1. Normalized decision matrix

	C1	C2	C3	C4	C5	C6	C7
Belgium	0.1163	0.2320	0.1868	0.1403	0.2541	0.1164	0.0668
Bulgaria	0.0266	0.0155	0.1360	0.0491	0.0429	0.1399	0.1378
Czech Republic	0.2417	0.0698	0.1444	0.0915	0.0988	0.0984	0.1086
Denmark	0.1800	0.0856	0.0455	0.3448	0.1288	0.3602	0.0209
Germany	0.1500	0.0883	0.1487	0.2067	0.1440	0.0956	0.0752
Estonia	0.3570	0.0394	0.1619	0.0814	0.0520	0.1566	0.0209
Ireland	0.0311	0.0291	0.4793	0.5200	0.1610	0.4891	0.0376
Greece	0.1577	0.0204	0.2159	0.1616	0.0616	0.1344	0.2047
Spain	0.1677	0.0427	0.1735	0.1799	0.1062	0.1566	0.1921
France	0.1503	0.0605	0.1635	0.1997	0.0994	0.2148	0.0961
Croatia	0.1284	0.0661	0.2058	0.1305	0.1000	0.1302	0.1462
Italia	0.2616	0.0905	0.1360	0.2154	0.1395	0.1011	0.4595
Cyprus	0.0999	0.1380	0.0063	0.1706	0.2632	0.0776	0.1462
Latvia	0.2384	0.0394	0.1735	0.1078	0.0384	0.2951	0.0292
Lithuania	0.1385	0.0174	0.1391	0.1140	0.0700	0.2923	0.0334
Luxembourg	0.0807	0.0846	0.2719	0.2856	0.2400	0.0914	0.1420
Hungary	0.0903	0.0473	0.0783	0.1047	0.0785	0.1427	0.0877
Malta	0.0095	0.6347	0.0000	0.0835	0.6800	0.0457	0.1963
Netherlands	0.0656	0.6537	0.2148	0.1913	0.3264	0.1538	0.0125
Austria	0.3993	0.0790	0.2492	0.2065	0.1327	0.1344	0.2924
Poland	0.0587	0.0939	0.1164	0.1024	0.1084	0.1205	0.0627
Portugal	0.3001	0.0404	0.2725	0.1659	0.0740	0.1593	0.1295
Romania	0.0687	0.0176	0.1799	0.1171	0.0610	0.2272	0.1754
Slovenia	0.1680	0.0620	0.3090	0.1406	0.2016	0.1510	0.6182
Slovakia	0.2090	0.0269	0.1471	0.1049	0.0666	0.0720	0.1587
Finland	0.2246	0.1241	0.0063	0.1239	0.0678	0.1773	0.0167
Sweden	0.3139	0.0870	0.0794	0.1970	0.0830	0.1912	0.0418

Table A2. Preference-normalized decision matrix

	C1	C2	C3	C4	C5	C6	C7
Weights	*0.1429*	*0.1429*	*0.1429*	*0.1429*	*0.1429*	*0.1429*	*0.1429*
Belgium	0.0166	0.0331	0.0267	0.0200	0.0363	0.0166	0.0095
Bulgaria	0.0038	0.0022	0.0194	0.0070	0.0061	0.0200	0.0197
Czech Republic	0.0345	0.0100	0.0206	0.0131	0.0141	0.0141	0.0155
Denmark	0.0257	0.0122	0.0065	0.0493	0.0184	0.0515	0.0030
Germany	0.0214	0.0126	0.0212	0.0295	0.0206	0.0137	0.0107
Estonia	0.0510	0.0056	0.0231	0.0116	0.0074	0.0224	0.0030
Ireland	0.0044	0.0042	0.0685	0.0743	0.0230	0.0699	0.0054
Greece	0.0225	0.0029	0.0308	0.0231	0.0088	0.0192	0.0292
Spain	0.0240	0.0061	0.0248	0.0257	0.0152	0.0224	0.0274
France	0.0215	0.0086	0.0234	0.0285	0.0142	0.0307	0.0137
Croatia	0.0183	0.0094	0.0294	0.0186	0.0143	0.0186	0.0209
Italia	0.0374	0.0129	0.0194	0.0308	0.0199	0.0144	0.0656
Cyprus	0.0143	0.0197	0.0009	0.0244	0.0376	0.0111	0.0209
Latvia	0.0341	0.0056	0.0248	0.0154	0.0055	0.0422	0.0042
Lithuania	0.0198	0.0025	0.0199	0.0163	0.0100	0.0418	0.0048
Luxembourg	0.0115	0.0121	0.0388	0.0408	0.0343	0.0131	0.0203
Hungary	0.0129	0.0068	0.0112	0.0150	0.0112	0.0204	0.0125
Malta	0.0014	0.0907	0.0000	0.0119	0.0971	0.0065	0.0280
Netherlands	0.0094	0.0934	0.0307	0.0273	0.0466	0.0220	0.0018
Austria	0.0570	0.0113	0.0356	0.0295	0.0190	0.0192	0.0418
Poland	0.0084	0.0134	0.0166	0.0146	0.0155	0.0172	0.0090
Portugal	0.0429	0.0058	0.0389	0.0237	0.0106	0.0228	0.0185
Romania	0.0098	0.0025	0.0257	0.0167	0.0087	0.0325	0.0251
Slovenia	0.0240	0.0089	0.0441	0.0201	0.0288	0.0216	0.0883
Slovakia	0.0299	0.0038	0.0210	0.0150	0.0095	0.0103	0.0227
Finland	0.0321	0.0177	0.0009	0.0177	0.0097	0.0253	0.0024
Sweden	0.0448	0.0124	0.0113	0.0281	0.0119	0.0273	0.0060

Table A3. Calculation of MOORA score

Country	Sum of normalized criteria values		MOORA score (difference)
	Revenue criteria	Cost criteria	
Belgium	0.0633	0.0956	-0.0323
Bulgaria	0.0302	0.0480	-0.0178
Czech Republic	0.0682	0.0537	0.0146
Denmark	0.0815	0.0851	-0.0036
Germany	0.0722	0.0576	0.0146
Estonia	0.0858	0.0384	0.0473
Ireland	0.1472	0.1024	0.0448
Greece	0.0765	0.0601	0.0163
Spain	0.0744	0.0711	0.0034
France	0.0734	0.0672	0.0061
Croatia	0.0664	0.0632	0.0032
Italia	0.0876	0.1130	-0.0254
Cyprus	0.0395	0.0893	-0.0497
Latvia	0.0742	0.0574	0.0168
Lithuania	0.0559	0.0590	-0.0031
Luxembourg	0.0912	0.0797	0.0114
Hungary	0.0390	0.0509	-0.0118
Malta	0.0133	0.2224	-0.2091
Netherlands	0.0674	0.1638	-0.0964
Austria	0.1221	0.0912	0.0309
Poland	0.0396	0.0551	-0.0154
Portugal	0.1055	0.0576	0.0479
Romania	0.0522	0.0687	-0.0165
Slovenia	0.0882	0.1475	-0.0593
Slovakia	0.0659	0.0463	0.0195
Finland	0.0507	0.0551	-0.0044
Sweden	0.0843	0.0576	0.0267

AGRICULTURAL INPUTS USE FOR SUSTAINABLE DEVELOPMENT: THE INNOVATIVE COUNTRIES AND THE REPUBLIC OF SERBIA

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A B S T R A C T

Bearing in mind the increasingly pronounced world challenges such as the growth of population on the world, climate changes and pandemics, there is an increasing emphasis on healthy and safe food, as well as environmental protection. Organic production achieves the best ecological advantages compared to all other agricultural production methods. However, its application is limited due to lower yields, which requires increasing productivity. The aim of the paper is to differentiate between conventional and organic inputs (resources) and their impact on agricultural production, economic and sustainable development. Ordinary Least Square (OLS) panel regression did not show a significant difference between conventional and organic inputs for agricultural production, where it is only important to increase the amount of inputs for higher production, while the increase in total factor productivity of inputs has a positive impact on the economic and sustainable development of the observed countries.

Introduction

Bearing in mind the increasingly pronounced climate changes, as well as the expected increase in the population to 9.7 billion by 2050, which would put additional pressure

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on agricultural land due to the increased demand for food, the impact and development of agriculture in accordance with the goals of sustainable development is increasingly pronounced (Arora, 2019). At the same time, the smart agriculture is one of the most important challenges for solving many problems of the agricultural sector, in terms of productivity, impact on the environment, food safety and sustainability (Kamilaris & Prenafeta-Boldú, 2018; Durkalić et al., 2019).

Organic agriculture excludes the use of chemical fertilizers, pesticides, but also genetically modified organisms, minimizing air, soil and water pollution, and optimizing health (Bengtsson et al., 2005, Scialabba & Müller-Lindenlauf, 2010). Organic agriculture is used as an indicator of sustainable agricultural development (Tomaš Simin et al., 2019). Organic production refers to sustainable agriculture with different environmental and health approaches, in conrast with conventional farming system that has degraded resources essential to agricultural production (Milić et al., 2022). Organic agriculture has low yields and productivity. However, organic agriculture has better results than conventional agriculture, because it provides important environmental benefits, such as stopping the use of harmful chemical inputs and their spread in the environment (Gomiero et al., 2011). Organic waste to energy conversion technologies have been successful in solving global challenges such as fossil fuel dependence, optimization of production costs, waste management, emission control and sustainable production (Stephen & Periyasamy, 2018; Pantović et al., 2023). Life cycle assessment (LCA) is the most commonly used method for environmental impact assessment. LCA was established to assess the problems of resource depletion, environmental and health impacts. Principle of LCA is the optimal relationship between inputs (resources) and outputs. Although organic agriculture generally emits less pollutants per unit of land occupied than conventional agriculture, it can also have higher impacts per unit of product (land occupation) due to lower yields per unit area (Van Der Werf et al., 2020; Andrei et al., 2023).

The productivity of organic agriculture depends on whether and to what extent it will be competitive with conventional agriculture. Some research shows that organic yields of certain crops are on average around 80% of conventional yields (De Ponti et al., 2012). There is much disagreement about what percentage of population can be fed by transforming the world's agriculture to organic methods. Considering productivity estimates in organic production, it is about half of the current world population (Connor, 2018). Some analyzes show that organic yields are lower than conventional ones by around 20% (De Pascale et al., 2017; Fowler et al., 2022).

Food quality and safety is one of the main challenges in developing and developed countries. Developed countries have problems with a high percentage of obesity, while developing countries face undernourishment. These challenges can be overcome with organic farming. A large percentage of organic producers come from developing countries. Food safety is a major concern in developed countries, while for developing countries it is food security. Organic agriculture can simultaneously contribute to the supply of food for the population, as well as to the reduction of the harmful effects of conventional agriculture on the environment. It is also promising since it can contribute to a significant increase in yields in developing countries. Even, organic agriculture has the potential to achieve higher yields than conventional agriculture in developing countries (Schoonbeek et al., 2013). The profitability potentional of organic agriculture is often significantly more successful than conventional agriculture in developing countries (Te Pas & Rees, 2014), which is mainly due to lower labor costs and cheaper organic manure. Lower production costs and higher net yield and profit, with ability of drought tolerance of certain organic crops, there is a possibility for higher profit in organic agriculture than in conventional agriculture (Shrestha et al., 2014).

Table 1. Significance of organic agricultural land by country, 2021

Country	**Organic area, in ha**	**Country**	**Organic producers**
Australia	35.687.799,00	India	1.599.010,00
Argentina	4.074.804,30	Uganda	404.246,00
France	2.776.553,93	Ethiopia	218.175,00
China	2.753.700,00	Tanzania	148.607,00
Uruguay	2.741.845,06	Peru	117.398,00

Source: Fibl Statistics, 2021

The largest number of organic producers come from developing countries (India, Uganda, etc.), although this is not the case in terms of the area of organic land (Table 1). This leads to the conclusion about the pronounced fragmentation of organic area in developing countries, as one of limitations in increasing the productivity of organic crops.

With the aim of sustainable agricultural development, innovative approaches and models such as organic agriculture, bioeconomy and circular economy in agriculture, conservation agriculture, precision agriculture, etc., are becoming more and more important. Organic agriculture contributes the most to the ecological goal of sustainable development, but it has lower yields than conventional agriculture. For the future development of organic agriculture important emphasis is on the increasing its productivity. Good combinations of organic and conventional methods, as well as other innovative agricultural systems (Reganold & Wachter, 2016), can greatly contribute to sustainable productivity in global agriculture (Meemken & Qaim, 2018). The integrated agricultural systems are a possible solution to the continuous increase in demand for food production, especially for small farmers with limited resources (Dar et al., 2018, p. 112), because the integral agriculture does not have such rigorous standards as organic, but still has stricter requirements than conventional. Organic agriculture, however, achieves significantly better environmental effects than integral and conventional agriculture (Pacini et al., 2003).

Given that agriculture improves productivity relatively quickly, the cost of doing so is high and is reflected in the excessive consumption of resources. The circular economy is therefore described as a very effective way towards the sustainable development of agriculture (Jun & Xiang, 2011). Given the importance of biomass, energy production technology, biofuels and materials from waste biomass within the circular economy and bioeconomy, it is important to make maximum use of the potential of agricultural waste (Rekleitis et al., 2020). The transition from a linear to a circular economy in the agri-food domain requires innovative business models (Donner et al., 2020; Melović, 2022).

Also, it is necessary to introduce approaches that, increase the productivity of inputs in addition to their ecological significance. In that sense, agriculture 4.0, which can reconcile both environmental and economic goals, refers to the use of artificial intelligence (AI), drones, Internet of Things (IoT), etc. in agriculture, thereby influencing increases in yields and reductions in costs, as well as the use of inputs and resources such as water, fertilizers and fuel. To grow food and meet the world's needs, agriculture need innovative solutions to produce in an ecologically, economically and socially sustainable manner (Yahya, 2018). Precision agriculture involves the use of information technology to improve the quality of products and production as a whole, so the use of wireless sensors and tools for agricultural management can lead to more efficient and environmentally oriented agriculture (Jawad et al., 2017), which can effectively manage resources. Precision agriculture can improve productivity and profits on farms, through better management of farm inputs, while leading to improved environmental quality (Tokekar et al., 2016).

The subject of the paper is the review of the used agricultural inputs and their importance for agricultural production, while the aim of the paper is to show the difference between organically used agricultural inputs and their contribution to the economic and sustainable development, in relation to conventionally used inputs, as well as the importance of productivity in their use. In line with this, the hypotheses were put forward:

H1: Countries with better agricultural indicators are characterized by a higher inputs use.

H2: Organic agriculture and inputs, which is in line with ecological standards, unlike conventional ones, can contribute to economic and sustainable development.

H3: The increase in efficiency and total factor productivity of inputs leads to economic and sustainable development.

Materials and methods

The research was conducted for the period 1999-2019, on the sample of the Republic of Serbia and ten the most innovative countries (WIPO, 2020): Switzerland, Sweden, USA, UK, Netherlands, Denmark, Finland, Singapore, Germany and Republic of Korea. Table 2 shows the variables used for the research.

Table 2. Definition of research variables

Label	Definition	Source
Dependent variables		
Ag_out	Agriculture output	USDA, 2020.
HDI	Human Development Index	UNDP, 2020.

Label	Definition	Source
GDP_pc	Gross domestic product per capita (GDP per capita)	World Bank, 2020.
Agricultural independent variables		
Ag_mac	Use of agricultural machinery	USDA, 2020.
Ag_fer	The use of mineral fertilizers - t	USDA, 2020.
Ag_land	Agricultural land	USDA, 2020.
Ag_labo	Labor force in agriculture	USDA, 2020.
Livesto	Livestock balance	USDA, 2020.
Feed	Livestock feed	USDA, 2020.
Org_area	Organic area	FiBL Statistics, 2020.
Org_liv	Organic livestock	Eurostat, 2020.
TFP	Total Factor Productivity	USDA, 2020.
Control variables		
Ino	Innovativeness – Dummy variable (Republic of Serbia vs. the most innovative countries)	Authors' research.
GERD	Expenditure on research and development (% of GDP)	World Bank, 2020.
Cred	Domestic credit to the private sector (% of GDP)	World Bank, 2020.

Source: Authors' research

The following research equations examined the impact and importance of agricultural inputs for agricultural production, economic and sustainable development of the observed countries:

$$Ag\_outi,t = \alpha + \beta 1AGRICULTUREi,t + \beta 2Inoi,t + \beta 3GERDi,t + \beta 4credi,t + \varepsilon i,t \quad (1)$$

$$GDP\_pci,t = \alpha + \beta 1AGRICULTUREi,t + \beta 2Inoi,t + \beta 3GERDi,t + \beta 4credi,t + \varepsilon i,t \quad (2)$$

$$HDIi,t = \alpha + \beta 1AGRICULTUREi,t + \beta 2Inoi,t + \beta 3GERDi,t + \beta 4credi,t + \varepsilon i,t \quad (3)$$

where agriculture refers to Ag_mac, Ag_fer, Ag_land, Ag_labo, Livesto, Feed, Org_area, Org_liv, TFP country i in the year t.

OLS panel regression was used to test the fitted equations. A random effect based on the Hausman test was used. Research models are set based on the multicollinearity of variables. Eviews was used for the research.

Based on the multicollinearity of the variables, the agricultural variables were separated into different models, where control variables were also used in addition to them, i.e., innovation that distinguishes the Republic of Serbia from highly innovative countries, GERD, considering that they lead to the emergence innovation, as well as domestic credit to the private sector that are significant from the aspect of financing the introduction of innovation and business in agriculture.

Results

In the following two tables (Table 3 and Table 4), the impact of agricultural inputs on agricultural production was examined. Research results presented in different research models, which determined based on multicollinearity of variables and represent combinations of agricultural inputs with control variables.

Table 3. The impact of agricultural inputs on agricultural production in the Republic of Serbia and the most innovative countries - model 1 - 4

Label	**Dependent variable Ag_out**			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Intercept	**-14780665.55 (-2.32)	-1519822.53 (-0.35)	1818759.96 (0.22)	10995397.13 (0.20)
Ag_mac	***44.56 (29.88)			
Ag_fer		***10.85 (46.86)		
Ag_land			***368.41 (10.63)	
Ag_labo				***-8459.55 (-2.86)
GERD	**1974397.66 (1.90)	*1573594.62 (1.47)	**1200235.09 (1.95)	-1204084.83 (-0.79)
Cred	19334.67 (1.13)	**35967.97 (1.99)	**21978.28 (2.22)	4467.62 (0.22)
Ino	8260624.12 (1.19)	-2568250.65 (-0.50)	*15377258.18 (1.76)	28836082.04 (0.51)
Adjusted R^2	0.67	0.90	0.08	0.31
F-statistic	***88.09	***409.93	***4.54	**2.38

Source: Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

Table 4. The impact of agricultural inputs on agricultural production in the Republic of Serbia and the most innovative countries - model 5 - 8

Label	**Dependent variable Ag_out**			
	Model 5	**Model 6**	**Model 7**	**Model 8**
Intercept	-283589.65 (-0.08)	-2398893.97 (-0.56)	4487010.16 (0.11)	***4739394.75 (2.79)
Livesto	***2007.70 (55.66)			
Feed		***0.29 (41.26)		
Org_area			***19.30 (12.35)	
Org_liv				***0.08 (3.44)
GERD	903386.04 (0.97)	833539.57 (0.94)	479487.81 (0.49)	-128370.13 (-0.46)
Cred	9292.14 (0.58)	***41981.93 (2.84)	-11164.95 (-0.55)	-5090.02 (-1.46)

Label	Dependent variable Ag_out			
	Model 5	Model 6	Model 7	Model 8
Ino	-4551387.70 (-1.04)	-649087.98 (-0.13)	23184305.58 (0.53)	***8130326.41 (4.32)
Adjusted R^2	0.91	0.64	0.49	0.03
F-statistic	***418.51	***76.53	***35.94	*1.62

Source: Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

All examined models in Table 3 and Table 4 were statistically significant, and the inputs used in agriculture (agricultural machinery, fertilizers, agricultural land, livestock, livestock feed, organic area and organically raised livestock, represents respectively Models 1-3 and 5-8) had a positive and statistically significant impact on agricultural production, except the labor force (Model 4), which had a negative impact. This conclusion was imposed considering that a larger quantity of observed inputs led to higher agricultural production, i.e. output. This was not the case with the labor force, considering labor productivity as an important component, which meant that it is important to increase labor productivity by using digital technologies and agricultural methods. The following two tables (Table 5 and Table 6) examined the impact of all these inputs on the economic development of the observed countries.

Table 5. The impact of agricultural inputs on economic development of the Republic of Serbia and the most innovative countries - models 1 - 4

Label	Dependent variable GDP_pc			
	Model 1	Model 2	Model 3	Model 4
Intercept	-4466.94 (-0.38)	-6601.56 (-0.56)	-6627.48 (-0.55)	951.67 (0.11)
Ag_mac	**-0.01 (-2.28)			
Ag_fer		-0.01 (-0.51)		
Ag_land			*-0.09 (-1.58)	
Ag_labo				***-8.45 (-3.18)
GERD	***6000.88 (3.31)	***6039.37 (3.25)	***6180.93 (3.32)	***3990.29 (2.41)
Cred	***224.79 (7.59)	***215.25 (7.10)	***221.27 (7.27)	***211.61 (7.52)
Ino	8602.56 (0.67)	8166.79 (0.63)	8551.87 (0.65)	10997.38 (1.20)
Adjusted R^2	0.35	0.33	0.34	0.38
F-statistic	***23.48	***22.45	***22.61	***30.37

Source: Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

Table 6. The impact of agricultural inputs on economic development of the Republic of Serbia and the most innovative countries - models 5 - 8

Label	**Dependent variable GDP_pc**			
	Model 5	**Model 6**	**Model 7**	**Model 8**
Intercept	-6636.77 (-0.56)	-6348.13 (-0.53)	-6961.84 (-0.54)	-9895.60 (-1.29)
Livesto	*-0.16 (-1.42)			
Feed		*-0.01 (-1.89)		
Org_area			***0.01 (4.75)	
Org_liv				***0.01 (2.63)
GERD	***6274.06 (3.41)	***6155.95 (3.28)	***6652.70 (4.62)	***6653.00 (2.84)
Cred	***221.11 (7.35)	***222.46 (7.25)	***203.66 (6.10)	***259.00 (7.56)
Ino	8799.74 (0.68)	9291.92 (0.71)	2351.12 (0.17)	9550.71 (1.02)
Adjusted R^2	0.34	0.34	0.41	0.50
F-statistic	***22.39	***23.09	***29.16	***25.75

Source: Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

All models and variables (except chemical fertilizers) shown in Table 5 and Table 6 were statistically significant. Agriculture inputs had a statistically negative impact on economic development, except the organic area and organically raised livestock, where this impact was positive. The following two tables (Table 7 and Table 8) examined the impact of all these inputs on the sustainable development of the observed countries.

Table 7. The impact of agricultural inputs on sustainable development of the Republic of Serbia and the most innovative countries - models 1 - 4

Label	**Dependent variable HDI**			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Intercept	***0.74 (34.04)	***0.72 (33.74)	***0.74 (33.98)	***0.75 (38.39)
Ag_mac	*-0.01 (-1.71)			
Ag_fer		-0.01 (-0.76)		
Ag_land			*-0.01 (-1.33)	
Ag_labo				***-0.01 (-4.13)
GERD	***0.03 (7.03)	***0.03 (6.22)	***0.03 (6.94)	***0.02 (5.11)

Label	Dependent variable HDI			
	Model 1	Model 2	Model 3	Model 4
Cred	***0.00 (5.72)	***0.00 (5.48)	***0.00 (5.55)	***0.00 (5.80)
Ino	**0.05 (1.96)	***0.06 (2.52)	**0.05 (1.97)	***0.07 (3.11)
Adjusted R^2	0.44	0.43	0.44	***0.47
F-statistic	***34.36	***33.71	***34.11	***44.30

Source: Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

Table 8. The impact of agricultural inputs on sustainable development of the Republic of Serbia and the most innovative countries - models 5 - 8

Label	Dependent variable HDI			
	Model 5	Model 6	Model 7	Model 8
Intercept	***0.74 (34.08)	***0.74 (34.13)	***0.75 (41.49)	***0.77 (79.24)
Livesto	-0.01 (-1.01)			
Feed		-0.01 (-1.20)		
Org_area			***0.01 (4.27)	
Org_liv				***0.01 (8.33)
GERD	***0.03 (7.04)	***0.03 (6.89)	***0.03 (9.00)	***0.01 (2.67)
Cred	***0.00 (5.54)	***0.01 (5.49)	***0.01 (4.16)	***0.01 (4.31)
Ino	**0.05 (1.97)	**0.05 (1.99)	**0.05 (2.26)	***0.09 (6.59)
Adjusted R^2	0.44	0.44	0.53	0.71
F-statistic	***33.71	***34.08	***46.50	***63.95

Source: Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

In the case of sustainable development, all the models shown in Table 7 and Table 8 were statistically significant. In this case, again, agriculture inputs had a statistical negative impact, except organic area and organically raised livestock, which had a statistically positive impact on sustainable development. Among the control variables it was important to point out innovation, i.e. that innovative countries had a positive impact, which should be a guideline for the Republic of Serbia. That is why it is important to introduce innovative approaches in agriculture, such as organic agriculture. However, the introduction of these approaches, must have been accompanied by an increase in input productivity.

Table 9. Importance of agricultural productivity for economic and sustainable development of the Republic of Serbia and the most innovative countries

Label	Dependent variable BDP_pc	Dependent variable HDI
	Model 1	Model 2
Intercept	-6855.26 (-0.57)	***0.74 (38.50)
TFP	**13211.99 (1.99)	**0.03 (2.26)
GERD	***6312.44 (3.34)	***0.03 (6.92)
Cred	***213.37 (6.96)	***0.01 (5.35)
Ino	7096.27 (0.54)	**0.05 (2.17)
Adjusted R^2	0.34	0.46
F-statistic	***23.07	***36.20

Source: Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

Both models shown in Table 9 were statistically significant and in both models the productivity of inputs used in agriculture had a statistically positive impact on economic and sustainable development. Control variables had a positive impact both on the economy and sustainable development, which meant that allocation for research and development, innovation, and financing of farmers is very important. The growth of inputs can lead to an increase in agricultural production, while their productivity in use is much more important for economic and sustainable development.

Discussions

In today's world with a growing population, it is very important to ensure the sustainability of agriculture and production. That is why it is necessary to increase productivity, which can be achieved by introducing modern technologies that increase production with a smaller amount of use of resources and inputs. Improved total factor productivity (TFP) can be achieved by adopting innovations (Steensland & Zeigler, 2021). Technical changes are important determinant of productivity growth in agriculture (Bustos et al., 2016).

The use of chemical inputs in agriculture is not only dangerous for human health, but also affects the ecological balance. Bio-fertilizer can act as a very good alternative, which leads to the sustainable development of agriculture (Mahanty, et al., 2016). It is important to motivate farmers to use organic fertilizers as an alternative to chemical fertilizers (Lu & Xie, 2018), due to its negative impact. The production and use of renewable energy for the operation of some types of agricultural machinery should be promoted, where possible, which can replace the use of fossil fuel energy and cause a minimal negative impact on the environment (Ridzuan et al., 2020). In order to achieve the sustainable development of the Republic of Serbia, it is important to use renewable energy sources more intensively and increase energy efficiency in all sectors, including agriculture, in order to reduce the use of non-renewable energy sources, environmental pollution and greenhouse gas emissions (Bošković et al., 2019).

Sustainable agriculture, which is in line with the Green Deal, includes different models, such as precision and organic agriculture. Organic model reduces pesticides and fertilizers (Poponi et al., 2021), in line with ecological goals. But, due to the limited yields of organic production, precision agriculture is being developed that better meet both the economic and ecological goals of sustainable development. Smart agriculture is fully in line with sustainable development, because, with the help of smart technologies, resources and inputs are optimally used in production, which increases productivity. This further reduces production costs. Also with reduces of inputs use, impact on the environment is also reduced.

The intensification of agricultural production has led to excessive use of non-renewable resources and a negative impact on the environment, which is considered unacceptable today. Namely, this obvious contradiction between the need to improve agricultural productivity for food security reasons and the urgent prevention of nature degradation due to the necessity of environmental restoration must be overcome (Lemaire et al., 2014). Regarding to negative impact of agriculture inputs, reducing the intensity of the use of natural raw materials and their rational use is necessary, as well as the introduction of modern technology and mechanization in agriculture in accordance with precision agriculture, which affects the increase in productivity while simultaneously preserving the environment. Innovative multipurpose agricultural machines are extremely important, in order to simplify and speed up the production process, with the reduction of the negative impact on the environment by agricultural activities (Bortolini et al., 2014). Emphasis should be placed on the possibility of automatic operation of agricultural machines and automatic navigation systems of agricultural machines, as a technology within precision agriculture (Li et al., 2019). Efforts to design and develop agricultural machinery, in this context, are preoccupied with numerous questions about initial costs, crop yields, and more (Banerjee & Punekar, 2020).

The main limitations of introducing precision agriculture are that its introduction is mostly expensive and unsuitable for small farms. Accordingly, financial measures and incentives for its adoption, as well as education in terms of promotion, are recommended (Ammann et al., 2022). Federal conservation programs can stimulate the adoption of precision agriculture. Productivity vary within fields suggesting conservation programs could be targeted to marginal field (Meng et al., 2022).

Developed countries have more intensive agricultural production than developing countries, which has a negative impact on the environment. Therefore, the effective use of chemical inputs is very important, such as fertilizers, pesticides, etc. Although they have strategies to reduce pollution and chemical fertilizers, they are still not implemented effectively. These countries use more fossil fuels and consume more resources than developing countries (Papież et al., 2022). That is why new technologies and agricultural mechanization should be adopted that enable efficient agriculture and higher productivity, as well as the energy transition between fossil energy and electricity (Vogt et al., 2021).

Excessive use of chemical fertilizers, fossil fuels, and other agricultural inputs are more intensive in developed countries with better agricultural indicators, which have an impact on higher yields and agricultural production. Given that negative impact of conventional inputs on the environment and environmental pollution, it is important to improve them in terms of increasing productivity, but also greater application of organic inputs and the use of renewable energy sources, in accordance with the preservation of the environment and sustainable development. That's why productivity should be increased along with environmental protection and conservation. Conventional inputs in agriculture negatively affect economic and sustainable development. That is why innovative solutions in agriculture and the introduction of modern technologies are needed, which will increase their productivity. The same applies to the use of chemical fertilizers, which can be replaced by organic ones that do not pollute the environment (Dimitrijević, 2023).

Low-input agriculture, precision agriculture and organic farming affects sustainable development. Organic production is based on the rational use of renewable resources and environmental protection (Bajagić et al., 2022). Today, the ecological dimension is increasingly taken into account when talking about the use of conventional inputs, such as fertilizers and others. There is a link between input use and yield growth, as well as economic development, increasing GDP per capita and decreasing agricultural labor. Agricultural productivity has a special role in these structural changes. Countries should not be based on avoiding fertilizers and conventional inputs for ecological reasons, but on the application of modern inputs that are in line with the green revolution and increasing agricultural productivity in line with structural changes. These complementary inputs can be of particular importance for increasing yields in economies with low agricultural productivity and a large share of the agricultural labor force (McArthur & McCord, 2017).

Conclusions

The size of population on the world and the limited supply of energy represent major challenges for modern society. Therefore it is necessary to develop an agricultural methods that will be more energy efficient. Organic agriculture is able to significantly contribute to food production, without harmful impact on the environment and people. This type of agriculture can be applied more simply on small farms, as well as in developing countries, where the chances for the development of organic production are much greater due to the unavailability of expensive inputs for other types of agriculture. On the other hand, precision agriculture is a better option for large farms, bearing in mind the costs of its introduction, but also the economic and ecological benefits of its introduction.

The organic agricultural system is directed towards the protection of the human health and environment, while the conventional agricultural system degrades the environment. Although organic farming is an environmentally very sustainable option, it should also be economically viable for the farmers. Conventional agriculture is more economically viable compared to organic agriculture. At the same time, many consumers are not able to pay a higher price for organic products, which is why in the future the relationship between economic and environmental sustainability should be balanced as best as possible. That is why organic methods should be developed in the direction of increasing productivity and yield, because they are significantly different from all other agricultural production methods in terms of ecological characteristics.

The limitation of the work is that there is no record of the application of other innovative agricultural methods and inputs in production, which is why the research is based only on organic production. It is precisely the development of such databases, as well as the comparison of other innovative methods of production with organic, that are recommended for future research.

This research proved the research hypotheses, i.e. developed countries have better agricultural indicators and characterized by a higher input use, too. However, it is mostly the conventional inputs that have a negative impact on economic and sustainable development. Therefore, it is important to replace them with organic inputs and increase agricultural productivity, that have a positive impact on economic and sustainable development.

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Conflict of interests

The authors declare no conflict of interest.

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RURAL AREAS MANAGEMENT AND STRATEGIC DEVELOPMENT CHALLENGES WITH EMPHASIS ON SUSTAINABLE ISLAND DEVELOPMENT

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ABSTRACT

The main constraint of strategic development and management of rural areas is rooted in resource management and insufficient holistic approach to all available resources and its interdependence. Management of such areas involves thorough planning on all levels and management of changes to achieve the best competitive advantage possible. In this paper, the focus is on the strategic management of the destination (Croatian islands), the concept of sustainable development of rural areas on Croatian islands, level of permanent education of local population on the concept of sustainable development and existence of even distribution of opportunities that can enable local community to achieve socio-economic benefit. The primary survey is conducted in the observed area in 2019. The total sample of respondents is 243.

Introduction

Although it was first mentioned in the 19th century, the concept of sustainable development and its definition has not been fully explained nor grasped since the time it is composed of two contradictory concepts that identify static (sustainability) and dynamic (development). Therefore, it is not surprising that different viewpoints on sustainable development are found in the scientific and professional literature. Development and sustainability have repeatedly acquired new meanings, hence requiring new analytical techniques, planning objectives and effective governance and management (Connell,

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2018:111). Author Sharpley (2000:3) highlights that development and sustainability could be in opposition, where each could produce different effects. Contrary to such thinking, numerous economic theorists, as stated by Črnjar and Črnjar (2009:81), believe that development is necessary and “refers to the concept of the order of resources, while sustainability expresses the principle of the permanent survival of resources. Research related to sustainable development is dynamic and changing in accordance with the obtained research results and their practical confirmation in space. In one of his publications author Klarin (2018:72) has given an overview of international activities, reports, conferences related to the concept of sustainable development from 1969 until the late 2010s clearly showing the dynamic in this field. As stated, from its development, the concept has been adapting to the contemporary requirements of a complex global environment, but the underlying principles and goals, as well as the problems of their implementation, remained almost unchanged. Since the introduction of the concept, many international conferences, congresses, summits and meetings have been held, resulting in various declarations, reports, resolutions, conventions and agreements mentioning different issues and much needed sustainability in all areas of human behavior and activity. There is a continuous emergence of new ideas that enable improvements in sustainable development research respecting economic models (circular economy - CE, green economy - ZE and bio economy - BE) and sustainability models (development, maintaining the existing state and slowing down development). Viewed from the perspective of sustainable development policy, all three concepts are the subject of political discussions at the level of the European Union (EU) with the New Action Plan for the Circular Economy (EC, 2020), the green goals and objectives of economic policy (EC, 2020) and the European Bio-Economy Strategy from 2012 and 2018 (Kulušić, 2021). The Green Economy concept was initiated by the United Nations (UNECE, 2011), and is also found in the OECD Green Growth Strategy (OECD, 2011).

Adding in the narrative of sustainable development islands and their challenges, we get an even more layered and complex issues that must be addressed from multiple levels. As Connell (2023) commented in his recent work “progress toward sustainability in islands and island states is hampered by multiple challenges, including limited and threatened biodiversity, migration, resource deficits, shortages of skilled human resources, lack of capital, weak governance and management, inadequate data (and problems of interpretation), social divisions, and simultaneous quests for modernity (and superior incomes) and conservation”.

Each island community has unique geographical features, a unique history, culture and socio-economic position (De Clercq et al. 2019:5). Therefore, every normative act, which seeks to impose solutions in the field of sustainable development and the use of clean energy, should be viewed as a framework to which the island community can adapt. To be able to purposefully consider the issues connected to much needed development, it is necessary to look at all the peculiarities that make up the island as destination. As author Munier (2005:37) detects that assessment of progress towards sustainable development should be based on an explicit set of categories or an organizational framework that links vision and goals with indicators and assessment criteria, which clearly points to the importance of strategy and strategic thinking that will be holistically understood and considered by a greater number of local stakeholders, which is not always properly addressed.

The development programs for islands were developed with the basic intention of encouraging local communities to take the initiative to make their destination more attractive and competitive, while respecting environmental protection standards, sustainable development principles and circular economy principles. The development of sustainable rural areas has become a priority of national policies and/or strategies in many countries. The programs should be aligned with various supporting documents, declarations, laws and agendas such as Agenda 2030 on global level, Declaration on Smart Islands, Political Declaration on Clean Energy on EU Islands, Resolution of the European Parliament on the Special Situation of Islands (2015/3014(RSP)), Barcelona Convention on Integral Management of the Mediterranean Coastal Area (UNEP/MAP, 2011) and the European Green Deal (Fetting, 2020) on EU level. The national development strategy, sectoral and multi-sectoral strategies and spatial planning documents (national level). There are also ample regulations, such as EU Regulation 1698/2005, which supports rural development through the European Agricultural Fund for Rural Development (EAFRD), which indicates that special provisions should apply ‘to mitigate the specific constraints and structural problems in farming and forestry activities and in adding value to agricultural and forestry products as a result of remoteness, insularity or distant location and of the dependency of the rural economy on a limited number of agricultural products, and to promote a robust rural development policy (EC, 2006). Besides mentioned regulations there is a considerable number of research that talks about the problems, stratification and challenges of island areas, the sustainable development of their future (Moncada et al., 2009) and various rural development program assessment methods such as SCEPTICAL method (Moutinho, 2000) or SEA approach (Strategic environmental assessment) that integrates sustainability issues into policies, plans and programs promoting the participation of different stakeholders including the communities (Polido et al., 2014; Spaziante and Murano, 2009). Throughout the entire recent history of the strategic thinking of the island’s development, first purely economic, then sustainable and most recently circular, it has its starting point in the “top-down” approach. Despite numerous scientific and professional research, published books and articles, development documents do not sufficiently respect the specificity of each island as a separate unit which is crucial for its own, unique development but due to size of islands, this type of segmentation might not produce much desired effect.

In the case of Croatia, there have been several attempts to form the island’s development through various regional plans, for example, into formed regions according to the geographical division into: North Adriatic, Central Adriatic and South Adriatic or according to island groups: Kvarner Islands, Zadar and Šibenik Archipelago, Dalmatian and South Dalmatian. The islands make up about 6% of the Croatian mainland, which is the second largest archipelago in the Mediterranean (Vidučić, 2007:42). In the case of Croatia, the Law on Islands (NN, 116/18, 73/20, 70/21) defines the term insularity as: "a set of geographical, social, historical, economic and ecological peculiarities resulting from being completely surrounded by the sea".

The chronology of the problem of balanced development of the Croatian islands has its own historical, cultural, demographic and social characteristics. The strategic discussion resulting from the National Island Development Program (1997) treat the Croatian islands as a single entity, which they certainly are not. The absence of a differentiated approach to island development has led to inequality in the level of development between individual islands and island groups, which is confirmed by numerous indicators. With the adoption of several strategic documents on rural development and also the Tourism Development Strategy of the Republic of Croatia until 2020 (Official Gazette 55/13), the position was accepted that "development should be based on the improvement of environmental protection, preservation of the quality of natural resources and responsible and sustainable management", which amnestied the existing condition, but also limited development, such as tourism development, for those islands that managed it responsibly and sustainably. Without an overall umbrella strategy, current problems and limitations related to the sustainable development of island destinations can only be partially solved. Namely, all initiatives that come from the "bottom-up" approach are primarily the result of the interests of the local community, and only then of the general interest.

The topic of sustainable development of islands began to occupy Croatian scientists in the early nineties of the last century, and the works Radnić and Mikačić (Tourism and sustainable development of Croatian islands, 1994), Mikačić (Tourism as a function of sustainable development of Croatian islands, 1996) and Starc (Sustainable development, tourism and evaluation of investment ventures, 1996). Critical elements of a successful participatory planning process in protected areas that are under significant pressure from visitors were analyzed in recent years by Pivčević, Mikulić and Krešić (Mitigating the Pressures: The Role of Participatory Planning in Protected Area Management, 2021).

Within this paper, the issue of strategic management of an island with an emphasis on sustainable development will be viewed from a several different points of view that can allow a wider understanding and more in-depth approach that will include all crucial stakeholders who can help approach the complex issue of island development that will be in line with much needed sustainable development.

Materials and methods

A questionnaire was used as a research instrument. The research was conducted on a selected sample in the period from February to October 2019, and the interviewed respondents were tourism workers (direct employment in tourism), representatives of local (regional) self-government and residents of the island connected with tourism (indirect employment in tourism).

The questionnaire was created in the form of statements, and the respondents were asked to express their views on the elements of the development strategy of the island, the development of the island destination, the concept sustainable development and the way of implementation and responsibility with the aim of research and formation of views on strategic guidelines for the sustainable development of tourist destinations on inhabited islands in the Republic of Croatia. The collected data were systematized according to the socio-demographic characteristics of the sample (respondents) and systematically statistically processed and analysed with the appropriate computer program (SPSS Statistics 24).

In this paper, the classification of islands according to permanent population as a measure of survival and development was approached. The first group A includes islands with more than 5,000 inhabitants. These are islands with developed infrastructure, they are well connected to the mainland, they have their own tourist tradition and acceptable development plans structured with a "bottom-up" approach. The second group B consists of islands with a permanent population of 1,001 to 5,000 inhabitants. They are smaller in area than the islands from group A, but have reached a high level of tourism development, have a solid infrastructure and a connection with the mainland. The third group C consists of islands with a permanent population of 100 to 1,000. In terms of tourism, these are marginal islands with a solid tourist perspective, but inadequate infrastructure. The last group of islands D consists of islands where up to 100 inhabitants live permanently. They are inferior in terms of tourism, without adequate infrastructure, weak connections with the mainland and an uncertain tourist perspective.

Results and discussion

In the empirical part of the research, to analyze the collected data, the methods of descriptive and inferential statistics, analysis of variance, correlation analysis, examination of the connection of variables with the Chi-square test and the relevance of the sample with the T-test were used.

A highly structured questionnaire was used as a research instrument. The research was conducted in the period from February to October 2019, and the respondents were tourism workers, representatives of local and regional self-government, and residents of the island connected with tourism. The questionnaire consisted of statements and relevant dimensions of sustainable island development identified based on a review of the relevant literature. The collected data were analyzed using the SPSS Statistics 24 program. According to the 2011 census, there were fifty inhabited islands in the Republic of Croatia. The groups of islands are classified in relation to the number of permanently settled population into 4 groups as shown in table 1 together with the number of respondents per island.

Table 1. Frequency and distribution of the sample of respondents according to island category

ISLAND CATEGORY		F	%	Number	Respondent/island	Respondent/islands (50)
A	Over 5.000 inhabitants	123	50,6	9	13,67	2,46
B	1.000 - 5.000 inhb.	67	27,6	8	8,38	1,34
C	100 do 1.000 inhb.	43	17,7	18	2,39	0,86
D	Less than 100 inhb.	10	4,1	15	0,67	0,20
Σ		**243**	**100**	**50**	**4,86**	**4,86**

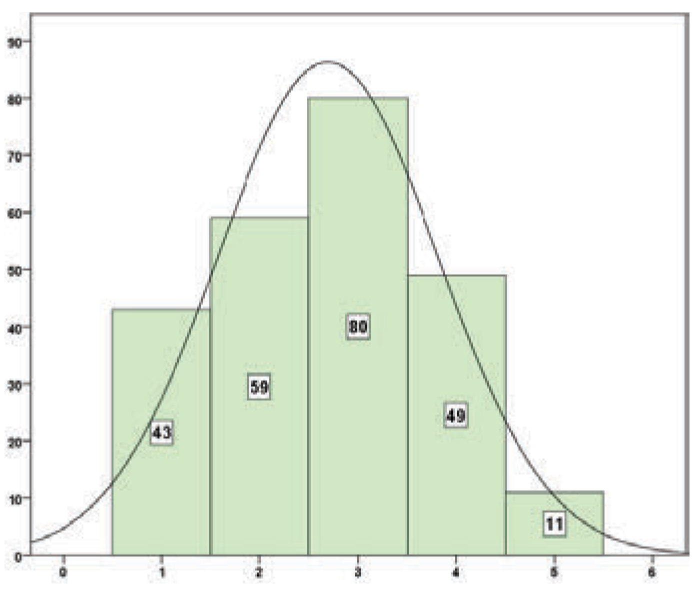
Source: author's processing in Ms Excel according to data from the questionnaire

The total sample of respondents (n=243) amounts to 0.2% of the island's population, which would not be representative if the opinion of all the island's residents were examined. However, the research was conducted on a target group of experts in the sustainable development of island tourist destinations. Out of the total number, 45.3% of respondents are male, and 54.7% are female. More than half of the respondents (52.3%) have higher education. 26.7% of respondents have a secondary vocational education. The majority of respondents belong to the age group of 30 to 50 years (58%), 22.2% of respondents are over 50 years old, and 19.8% are under 30 years old. According to the role of the respondents on the island, 37.9% are tourist workers, 32.9% are representatives of local self-government and 29.2% are prominent residents of the island (reputable people from the field of culture, chroniclers, people with extensive experience in tourism.). As part of this paper, the results for the four claims will be presented using suitable methods.

Respondents were asked to grade the statements from 1 to 5 in such a way that: score "1" is "I do not agree - it is incorrect", score "2" is "mostly disagree - mostly incorrect", score "3" is "I neither agree nor disagree - it is neither true nor false", score "4" is "mostly agree - mostly true" and score "5" is " I absolutely agree - it is completely correct".

In the statement "There is an organized and satisfactory system of financing sustainable development on the islands", respondents mostly or completely agree that there is an organized and satisfactory system of financing sustainable development on the islands. This statement also represents the HI research hypothesis. In contrast, the null-hypothesis H0 was determined, according to which the respondents' answers were distributed evenly.

Table 2. Frequency and distribution of responses to this statement

STATEMENT		F	%	HISTOGRAM OF THE RESPONSE ON THE STATEMENT
score	1	43	17,7	
	2	59	24,3	
	3	**80**	**32,9**	
	4	49	20,2	
	5	11	4,5	
	Σ	**242**	**99,6**	
	invalid	1	0,4	
$\bar{X}$		2,6942		
Median		3		
SD		1,11826		
Variance σ^2		1,251		
Skewness		0,052		
Kurtosis		-0,801		
Range		4		
Σ		652		
Percentile	25	2		
	50	3		
	75	*4*		

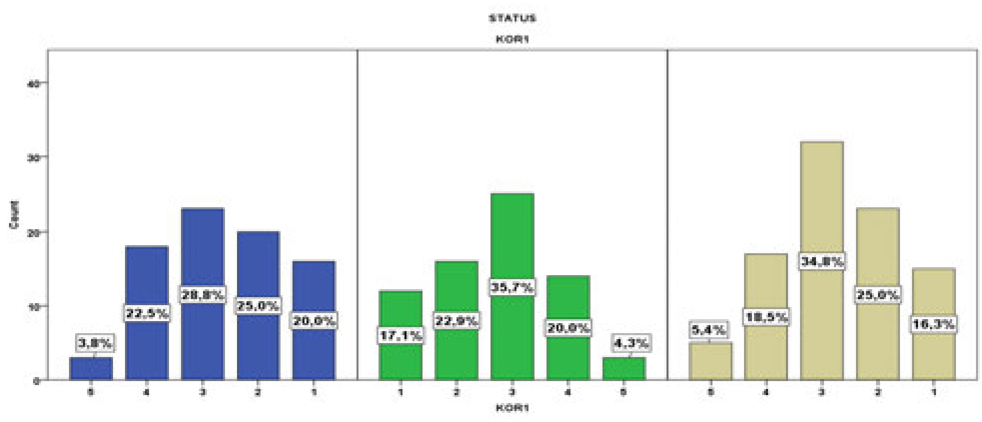
Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

From the previous table, it can be seen how the respondents determined themselves according to the set Statement 20 in the range of grades from 1 to 5. Forty-three respondents (17.7%) do not agree with the statement, and 59 of them (24.3%) mostly agree. does not agree. 32.9% of respondents are neutral. For the most part, 49 respondents (20.2%) agree with the statement, while only 11 of them (4.5%) agree completely. The attached histogram clearly shows how the ratings follow a Gaussian distribution. The Skewness measure of asymmetry is very weak but positive at 0.052, which indicates a weak shift towards lower grades. The Kurtosis curve flattening measure has a value of -0.801, which indicates pronounced platykurticity, which is reflected in the grouping of results around the arithmetic mean. Respondents evaluated the observed statement with an average score of 2.6942 with a standard deviation of 1.11826 and a variance of 1.251.

The following table analyzes the responses to this statement according to the respondent's occupation. In principle, the HI research hypothesis is put forward, which claims that there is a significant difference in evaluation between individual categories of respondents. In contrast, the null hypothesis H0 was determined, according to which there is an evenness of evaluation of all categories.

Table 3. Analysis of the answers to the statement according to the respondent's occupation

A representative of local government	a respectable resident of the island	A tourism worker



SCORE	1	2	3	4	5	$\overline{X}$	N	SD
A representative of local government	16	20	23	18	3	**2,65**	80	1,148
A respectable resident of the island	12	16	25	14	3	2,71	70	1,105
A tourism worker	15	23	32	17	5	**2,72**	92	1,113
Σ	**43**	**59**	**80**	**49**	**11**	**2,69**	**242**	**1,118**
COEFFICIENTS	**VALUE**		**df**		table χ^2 for 5% sign.			
Pearson χ^2	1,752		8		15,507			
the likelihood ratio	1,759		8		$\chi^2<\chi^2$ table 5% sign. **H_0 accepted**			
Phi	0,085							
Cramer's V	0,060		Eta η	0,028				
Contingency Coefficient C	0,085		η^2	0,001				

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

Analyzing the average marks assigned by the respondents, it is evident that there are no significant differences between them in accepting this statement, which speaks of the uniformity of attitudes. This is additionally confirmed by the result of the χ2 test, which indicates that with a risk level of 5%, the null hypothesis H0 can be accepted, and it can be concluded that the respondents do not differ from each other when evaluating this statement. Cramer's V as a measure of symmetry has a minimal effect, and η2 as the association measure has a negligible value. The following table analyzes the answers to this statement according to the respondent's profile, the category of the island and the perception of the tourism development of the island destination.

Table 4. Analysis of responses to the statement according to the profile of respondents, island category and perception of tourist development of the island destination

RESPONDENT PROFILE			ISLAND CATEGORY		
EDUCATION	$\bar{X}$	**N**	**POPULATION**	$\bar{X}$	**N**
PhD	**4,00**	2	Over 5.000 inhabitants (A)	**2,95**	123
MSc	2,73	11	1.001 - 5.000 inhb.(B)	2,58	66
Masters Degree	**2,53**	127	100 do 1.000 inhb.(C)	**2,19**	43
Bachelor Degree	3,32	38	Less than 100 inhb.(D)	2,50	10
Secondary education	2,61	64			
Σ	**2,69**	**242**	**Σ**	**2,69**	**242**
Pearson χ^2 =**30,499;** df = 16;			Pearson χ^2 = **54,141**; df = 12		
table χ2 za 5% sign. =26,296			table χ2 for 5% sign. = 21,026		
$\chi^2 > \chi^2$ table for 5% sign. **Prihvaća se H_1**			$\chi^2 > \chi^2$ table for 5% sign. **Acccepted H_1**		
EXPERIENCE	$\bar{X}$	**N**	**DEVELOPMENT PERCEPTION**	$\bar{X}$	**N**
< 30 years	**2,85**	48	Inferior	**2,29**	17
30 - 50 years	2,66	140	Promising	2,38	95
> 50 years	**2,63**	54	Developed	**2,98**	130
Σ	**2,69**	**242**	**Σ**	**2,69**	**242**
Pearson χ^2=**23,914**; df =8			Pearson χ^2=**30,365**; df =8		
Table χ2 for 5% sign. =15,507			table χ2 for 5% sign. =15,507		
$\chi^2 > \chi^2$ table for 5% sign. **Accepted H_1**			$\chi^2 > \chi^2$ table for 5% sign. **Accepted H_1**		

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

In order to confirm the results obtained by the Chi-square test, an ANOVA analysis of variance is additionally performed.

Table 5. Analysis of the variance of the Statement in relation to the characteristics of the respondents and the category of island groups

ANOVA		SUM OF SQUARES	DF	MS	F	F BORDER FOR 5% SIGN.
* occupation of the respondent	between groups	0,234	2	0,117	0,093	2,239
	within the group	301,138	239	1,260		**2,09**
	Σ	301,372	241			
* development perception	between groups	22,554	2	11,277	**9,666**	2,239
	within the group	278,818	239	1,167		2,09
	Σ	301,372	241			

ANOVA		SUM OF SQUARES	DF	MS	F	F BORDER FOR 5% SIGN.
* respondent's education	between groups	22,092	4	5,523	**4,687**	4,237
	within the group	279,280	237	1,178		1,46
	Σ	301,372	241			
* respondent's experience	between groups	1,579	2	0,789	0,625	2,239
	within the group	299,793	239	1,254		**2,09**
	Σ	301,372	241			
* island group	between groups	20,532	3	6,844	**5,800**	3,238
	within the group	280,840	238	1,180		1,07
	Σ	301,372	241			

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

The result of the variance analysis is a prominent F-ratio, a value that represents a general indicator of the existence of statistically significant differences between the examined groups. The analysis of variance, except for the attribute education (shaded), confirmed the results of the conducted Chi-square tests, and an additional analysis using the T-test method is performed.

Table 6. Results of the T-test according to the experience of the respondents

STATEMENT: THERE IS AN ORGANIZED AND SATISFACTORY FINANCING SYSTEM FOR SUSTAINABLE DEVELOPMENT ON THE ISLANDS									
Category	**Pairs**	**N**	$\bar{X}$	**SD**	**F**	**t**	**df**	**Critical t**	**difference** $\bar{x}$
Experience	Older	194	2,65	1,100	0,390	1,107	240	**1,97**	0,1995
	younger	48	2,85	1,185		1,059	68	**2,00**	0,1995

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

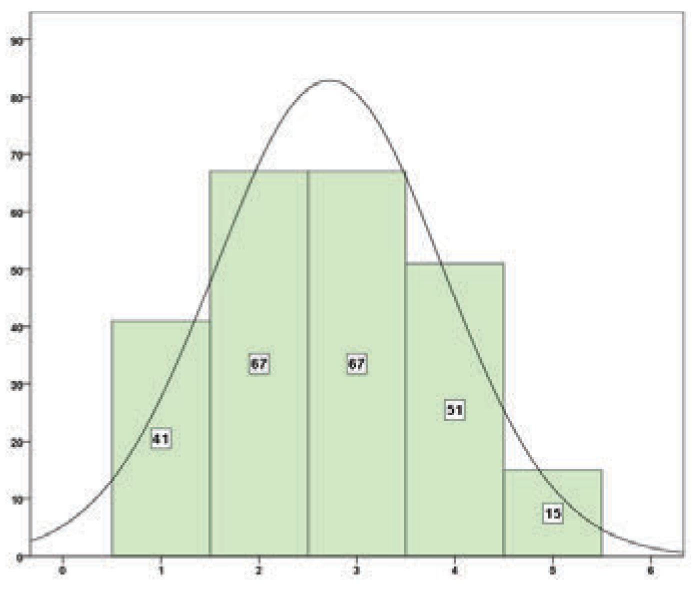
From the data in the previous table, it can be concluded that there is no statistically significant difference in the rating of this statement in relation to the experience of the respondents. This is confirmed by the results of the T-test considering that the calculated t is not greater than the limit value t for a certain degree of freedom, and the values of the differences of the arithmetic means are small. This also accepts the null hypothesis H0 about the homogeneity of the observed sets. This also accepts the null hypothesis H0 about the homogeneity of the observed sets. According to the calculated average values, the set statement resulted in a good rating (2.6942) and the respondents took a neutral position. The surveyed respondents know about island conditions and it is concluded that they are not too convinced that there is an organized and satisfactory system of financing sustainable development on the islands. In support of such a claim, the following can be stated:

- The distribution of the assigned grades according to the respondents' profession ranged from 2.65 for local government representatives to 2.72 for tourism workers. The distribution is even, which was confirmed by the Chi-square test and analysis of variance.
- The distribution of assigned grades according to the level of education of the respondents ranged from 2.53 for respondents with a university degree to 4.00 for those with a PhD. The distribution is not even, which was confirmed by the Chi-square test and analysis of variance.
- The distribution of the assigned marks according to the respondents' experience in tourism ranged from 2.63 for the most experienced respondents to 2.85 for those under 30 years of age. The analysis showed that the distribution is even, although it was not confirmed by the Chi-square test, but homogeneity is indicated by the analysis of variance and the additional T-test.
- The distribution of the assigned scores according to the perception of the tourism development of the island destination from which the respondents come ranged from 2.29 for tourist inferior destinations to 2.98 for tourist developed destinations. The distribution is not even, which was confirmed by the Chi-square test and analysis of variance.
- The distribution of the assigned grades according to the category of the island from which the respondents come ranged from 2.19 for islands of category C to 2.95 for islands of category A. The distribution is not even, which was confirmed by the Chi-square test and analysis of variance.

In the distribution of answers according to the category of respondents, there is an evenness in relation to the occupation and experience of the respondents.

In the next statement (Education of the local population on the concept of sustainable development is carried out permanently), the respondents mostly or completely agree that the education of the local population on the concept of sustainable development is carried out permanently on the islands. This statement also represents the HI research hypothesis. In contrast, the null-hypothesis H0 was determined, according to which the respondents' answers were distributed evenly. The following table presents the frequency and distribution of respondents' responses to this statement.

Table 7. Frequency and distribution of responses to this statement

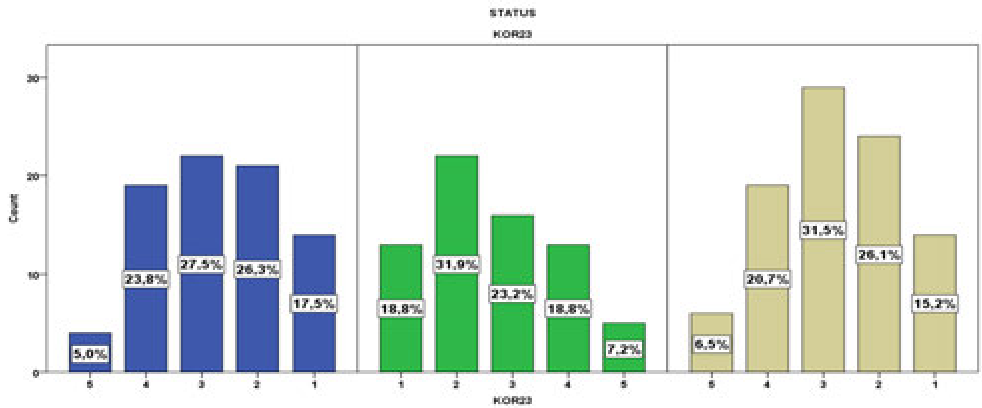
STATEMENT		F	%	HISTOGRAM OF THE RESPONSE ON THE STATEMENT
score	1	41	16,9	
	2	**67**	**27,6**	
	3	**67**	**27,6**	
	4	51	21,0	
	5	15	6,2	
	Σ	**241**	**99,2**	
	invalid	2	0,8	
$\bar{X}$		2,7178		
Median		3		
SD		1,15977		
Variance σ²		1,345		
Skewness		0,147		
Kurtosis		-0,865		
Range		4		
Σ		655		
Percentile	25	2		
	50	3		
	75	4		

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

From the previous table, it can be seen how the respondents decided according to the set statement in the range of grades from 1 to 5. Forty-one respondents (16.9%) do not agree at all with the statement, and 67 of them (27.6%) mostly disagree. 27.6% of respondents are neutral. For the most part, 51 respondents (21%) agree with the statement, while only 15 of them (6.2%) agree completely. The attached histogram clearly shows how the ratings follow a Gauss distribution. The Skewness measure of asymmetry is weak and positive at 0.147, which indicates a weak shift towards lower grades. The Kurtosis curve flattening measure has a value of -0.865, which indicates weak platykurticity, which is reflected in the grouping of results around the arithmetic mean. Respondents evaluated the observed statement with an average score of 2.7178 with a standard deviation of 1.15977 and a variance of 1.345. The following table analyzes the responses to this statement according to the respondent's occupation. In principle, the HI research hypothesis is put forward, which claims that there is a significant difference in evaluation between individual categories of respondents. In contrast, the null hypothesis H0 was determined, according to which there is an evenness of evaluation of all categories.

Table 8. Analysis of the answers to the statement according to the respondent's occupation

A representative of local government	A respectable resident of the island	A tourism worker



SCORE	**1**	**2**	**3**	**4**	**5**	$\bar{X}$	**N**	**SD**
A representative of local government	14	21	22	19	4	2,73	80	1,158
A respectable resident of the island	13	22	16	13	5	2,64	69	1,200
A tourism worker	14	24	29	19	6	2,77	92	1,140
Σ	**41**	**67**	**67**	**51**	**15**	**2,72**	**241**	**1,160**
COEFFICIENTS	**VALUE**		**df**		table χ^2 for 5% sign.			
Pearson χ^2	2,652		8		15,507			
the likelihood ratio	2,656		8		$\chi^2<\chi^2$ table 5% sign **Accepted H_0.**			
Phi	0,105							
Cramer's V	0,074		Eta η	0,047				
Contingency Coefficient C	0,104		η^2	0,002				

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

Analyzing the average marks assigned by the respondents, it is evident that there are no significant differences between them in accepting this statement, which speaks of the uniformity of attitudes. This is additionally confirmed by the result of the χ2 test, which indicates that with a risk level of 5%, the null hypothesis H0 can be accepted, and it can be concluded that the respondents do not differ from each other when evaluating this statement. Cramer's V as a measure of symmetry has a minimal effect, and η2 as the association measure has a negligible value.

The following table analyzes the answers to this statement according to the respondent's profile, the category of the island and the perception of the tourism development of the island destination.

Table 9. Analysis of responses to the statement according to the profile of respondents, island category and perception of tourist development of the island destination

RESPONDENT PROFILE			ISLAND CATEGORY		
EDUCATION	$\bar{X}$	N	**POPULATION**	$\bar{X}$	N
PhD	**4,00**	2	Over 5.000 inhabitants (A)	**2,85**	123
MSc	**2,45**	11	1.001 - 5.000 inhb.(B)	2,62	65
Masters Degree	2,61	127	100 do 1.000 inhb.(C)	**2,49**	43
Bachelor Degree	3,21	38	Less than 100 inhb.(D)	2,80	10
Secondary education	2,65	63			
Σ	**2,72**	**241**	**Σ**	**2,72**	**241**
Pearson χ^2 = **32,985;** df = 16;			Pearson χ^2 = 5,753; df = 12		
table $\chi2$ for 5% sign. =26,296			table $\chi2$ for 5% sign. = **21,026**		
$\chi^2 > \chi^2$ table for 5% sign. **Accepted H_1**			$\chi^2 < \chi^2$ table for 5% sign. **Accepted H_0**		
EXPERIENCE	$\bar{X}$	N	**DEVELOPMENT PERCEPTION**	$\bar{X}$	N
< 30 years	**2,98**	48	Inferior	2,65	17
30 - 50 years	**2,62**	140	Promising	**2,46**	95
> 50 years	2,74	53	Developed	**2,91**	129
Σ	**2,72**	**241**	**Σ**	**2,72**	**241**
Pearson χ^2=11,627; df =8			Pearson χ^2=**16,013**; df =8		
table $\chi2$ for 5% sign. =**15,507**			table $\chi2$ for 5% sign. =15,507		
$\chi^2 < \chi^2$ table for 5% sign. **Accepted H_0**			$\chi^2 > \chi^2$ table for 5% sign. **Accepted H_1**		

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

In order to confirm the results obtained by the Chi-square test, an ANOVA analysis of variance is additionally performed.

Table 10. Analysis of the variance of the Statement in relation to the characteristics of the respondents and the category of island groups

ANOVA		SUM OF SQUARES	DF	MS	F	F BORDER FOR 5% SIGN.
* occupation of the respondent	between groups	0,715	2	0,357	0,264	2,239
	within the group	322,099	238	1,353		**2,09**
	Σ	322,813	240			

ANOVA		SUM OF SQUARES	DF	MS	F	F BORDER FOR 5% SIGN.
* development perception	between groups	11,248	2	5,624	**4,296**	2,239
	within the group	311,565	238	1,309		2,09
	Σ	322,813	240			
* respondent's education	between groups	15,138	4	3,784	**2,903**	4,237
	within the group	307,675	236	1,304		1,46
	Σ	322,813	240			
* respondent's experience	between groups	4,597	2	2,298	1,179	2,239
	within the group	318,217	238	1,337		**2,09**
	Σ	322,813	240			
* island group	between groups	5,019	3	1,673	1,248	3,238
	within the group	317,794	237	1,341		**1,37**
	Σ	322,813	240			

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

The result of the variance analysis is a prominent F-ratio, a value that represents a general indicator of the existence of statistically significant differences between the examined groups. Analysis of variance confirmed the results of the conducted Chi-square tests.

According to the calculated average values, the set statement resulted in a good rating (2.7178) and the respondents took a neutral position. The surveyed respondents are knowledgeable about island conditions and it is concluded that they are not too convinced that there is an organized and satisfactory system of financing sustainable development on the islands. In support of such a claim, the following can be stated:

- The distribution of the assigned grades according to the occupation of the respondents ranged from 2.64 for prominent residents of the island to 2.77 for tourism workers. The distribution is even, which was confirmed by the Chi-square test and analysis of variance.
- The distribution of the assigned grades according to the level of education of the respondents ranged from 2.45 for respondents with a master's degree to 4.0 for those with a doctorate in science. The distribution is not even, which was confirmed by the Chi-square test and analysis of variance.
- The distribution of the assigned marks according to the respondents' experience in tourism ranged from 2.62 for medium-experienced respondents to 2.98 for those under 30 years of age. Distribution is uniform by Chi-square test and analysis of variance.

- The distribution of the assigned scores according to the perception of the tourism development of the island destination from which the respondents come ranged from 2.46 for promising tourist destinations to 2.91 for developed tourist destinations. The distribution is not even, which was confirmed by the Chi-square test and the analysis of variance.
- The distribution of the assigned grades according to the category of the island from which the respondents come ranged from 2.49 for islands of category C to 2.85 for islands of category A. The distribution is even, which was confirmed by the Chi-square test and analysis of variance.

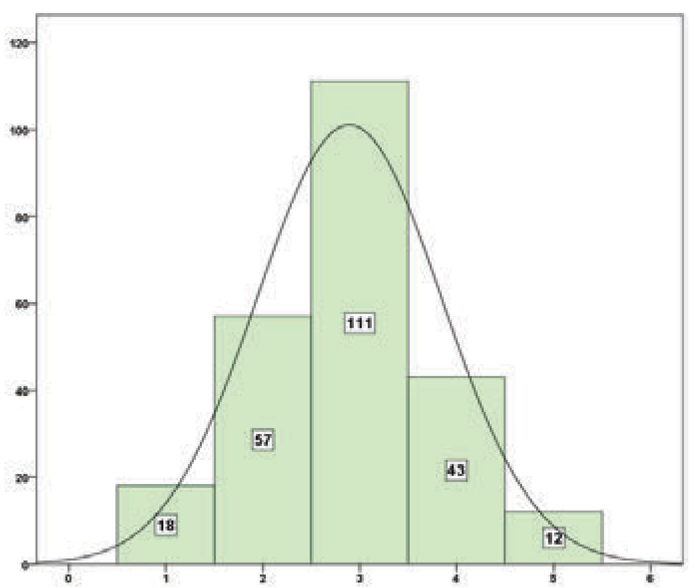
In the distribution of answers according to the category of the respondents, there is an evenness in relation to the profession and experience of the respondents and the category of the island.

In the next statement (Opportunities that can achieve socio-economic benefit are evenly distributed), the respondents mostly or completely agree that opportunities that can achieve socio-economic well-being are evenly distributed. This statement also represents the HI research hypothesis. In contrast, the null-hypothesis H0 was determined, according to which the respondents' answers were distributed evenly.

The following table presents the frequency and distribution of respondents' responses to this statement.

Table 11. Frequency and distribution of responses to this statement

STATEMENT		F	%	HISTOGRAM OF THE RESPONSE ON THE STATEMENT
score	1	18	7,4	
	2	57	23,5	
	3	**111**	**45,7**	
	4	43	17,7	
	5	12	4,9	
	Σ	**241**	**99,2**	
	invalid	2	0,8	
$\bar{X}$		2,8921		
Median		3		
SD		0,95130		
Variance σ^2		0,0905		
Skewness		0,042		
Kurtosis		-0,072		
Range		4		
Σ		697		
Percentile	2	2		
	3	3		
	3	3		



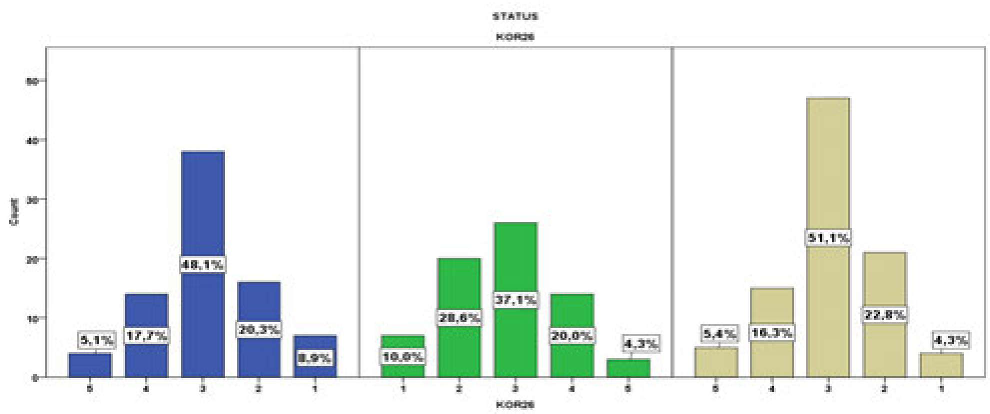
Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

From the previous table, it can be seen how the respondents decided according to the set statement in the range of grades from 1 to 5. Eighteen respondents (7.4%) do not agree at all with the statement, and 57 of them (23.5%) mostly disagree. agrees. 45.7% of respondents are neutral. Forty-three respondents mostly agree with the statement (17.7%), while only 12 of them (4.9%) agree completely. The attached histogram clearly shows how the ratings follow a Gauss distribution. The Skewness measure of asymmetry is very weak but positive at 0.042, which indicates a weak shift towards lower grades. The Kurtosis curve flattening measure has a value of -0.072, which indicates weak platykurticity, which is reflected in the grouping of results around the arithmetic mean. Respondents evaluated the observed statement with an average score of 2.8921 with a standard deviation of 0.95130 and a variance of 0.0905.

The following table analyzes the answers to the set statement according to the respondent's occupation. In principle, the HI research hypothesis is put forward, which claims that there is a significant difference in evaluation between individual categories of respondents. In contrast, the null hypothesis H0 was determined, according to which there is an evenness of evaluation of all categories.

Table 12. Analysis of the answers to the statement according to the respondent's occupation

A representative of local government	A respectable resident of the island	A tourism worker



SCORE	1	2	3	4	5	$\overline{X}$	N	SD
A representative of local government	7	16	38	14	4	2,90	79	0,969
A respectable resident of the island	7	20	26	14	3	2,80	70	1,016
A tourism worker	4	21	47	15	5	2,96	92	0,888
Σ	**18**	**57**	**111**	**43**	**12**	**2,89**	**241**	**0,951**

COEFFICIENTS	VALUE	df		table χ^2 for 5% sign.
Pearson χ^2	5,331	8		15,507
the likelihood ratio	5,518	8		$\chi^2<\chi^2$ table 5% sign. **H_0 accepted**
Phi	0,149			
Cramer's V	0,105	Eta η	0,067	
Contingency Coefficient C	0,147	η^2	0,005	

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

Analyzing the average marks assigned by the respondents, it is evident that there are no significant differences among them in the acceptance of this statement, which speaks of the uniformity of attitudes. This is additionally confirmed by the result of the χ2 test, which indicates that with a risk level of 5%, the null hypothesis H0 can be accepted and it can be concluded that the respondents do not differ from each other when evaluating the statement. Cramer's V as a measure of symmetry has a weak effect, and η2 as the association measure has a negligible value.

The following table analyzes the answers to this statement according to the respondent's profile, the category of the island and the perception of the tourism development of the island destination.

Table 13. Analysis of responses to the statement according to the profile of respondents, island category and perception of tourist development of the island destination

RESPONDENT PROFILE			ISLAND CATEGORY		
EDUCATION	$\bar{X}$	N	**POPULATION**	$\bar{X}$	N
PhD	**3,50**	2	Over 5.000 inhabitants (A)	**3,03**	122
MSc	3,18	11	1.001 - 5.000 inhb.(B)	2,76	66
Masters Degree	2,80	126	100 do 1.000 inhb.(C)	**2,72**	43
Bachelor Degree	3,26	38	Less than 100 inhb.(D)	2,80	10
Secondary education	**2,78**	64			
Σ	**2,89**	**241**	**Σ**	**2,89**	**241**
Pearson χ^2 =22,560**;** df = 16;			Pearson χ^2 = 18,840; df = 12		
table χ2 for 5% sign. =**26,296**			table χ2 for 5% sign. = **21,026**		
$\chi^2<\chi^2$ table for 5% sign. **Accepted H_0**			$\chi^2<\chi^2$ table for 5% sign. **Accepted H_0**		
EXPERIENCE	$\bar{X}$	N	**DEVELOPMENT PERCEPTION**	$\bar{X}$	N
< 30 years	**3,04**	48	Inferior	2,59	17
30 - 50 years	2,86	140	Promising	**2,75**	95
> 50 years	**2,85**	53	Developed	**3,04**	129
Σ	**2,89**	**241**	**Σ**	**2,89**	**241**
Pearson χ^2=12,432; df =8			Pearson χ^2=13,811; df =8		
table χ2 for 5% sign. =**15,507**			table χ2 for 5% sign. =**15,507**		
$\chi^2<\chi^2$ table for 5% sign. **Accepted H_0**			$\chi^2<\chi^2$ table for 5% sign. **Accepted H_0**		

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

In order to confirm the results obtained by the Chi-square test, an ANOVA analysis of variance is additionally performed.

Table 14. Analysis of the variance of the Statement in relation to the characteristics of the respondents and the category of island groups

ANOVA		SUM OF SQUARES	DF	MS	F	F BORDER FOR 5% SIGN.
* occupation of the respondent	between groups	0,979	2	0,490	0,539	2,239
	within the group	216,216	238	0,908		2,09
	Σ	217,195	240			
* development perception	between groups	6,334	2	3,167	**3,575**	2,239
	within the group	210,861	238	0,886		2,09
	Σ	217,195	240			
* respondent's education	between groups	8,713	4	2,178	**2,446**	4,236
	within the group	208,482	236	0,883		1,46
	Σ	217,195	240			
* respondent's experience	between groups	1,343	2	0,672	0,740	2,239
	within the group	215,852	238	0,907		**2,09**
	Σ	217,195	240			
* island group	between groups	4,954	3	1,651	1,844	3,237
	within the group	212,241	237	0,896		**2,00**
	Σ	217,195	240			

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

The result of the variance analysis is a prominent F-ratio, a value that represents a general indicator of the existence of statistically significant differences between the examined groups. The analysis of variance, except for the attributes education and perception (shaded), confirmed the results of the conducted Chi-square tests, and for dubious results, an additional analysis is performed using the T-test method.

Table 15. Results of the T-test according to the experience of the respondents

STATEMENT: OPPORTUNITIES THAT CAN ACHIEVE SOCIO-ECONOMIC BENEFIT ARE EVENLY DISTRIBUTED									
Category	**Pairs**	**N**	$\bar{X}$	**SD**	**F**	**t**	**df**	**Critical t**	**Difference** $\bar{x}$
Education	Higher	139	2,84	0,878	2,729	0,952	238	**1,97**	0,1187
	Lower	101	2,96	1,048		0,956	191	**1,97**	0,1187
Perception	Undeveloped	112	2,72	0,951	0,355	**2,599**	239	1,97	0,3155
	Developed	129	3,04	0,930		**2,595**	233	1,97	0,3155

Source: author's processing in IBM SPSS Statistics 24 according to data obtained from the questionnaire

From the data in the previous table, it can be concluded that there is no statistically significant difference in the assessment of this statement in relation to the education of the respondents. This is confirmed by the results of the T-test considering that the calculated t is not greater than the limit value t for a certain degree of freedom, and the values of the differences of the arithmetic means are small. This also accepts the null hypothesis H0 about the homogeneity of the observed sets. However, in the case of perception attributes, the calculated t is greater than the limit value t for a certain degree of freedom, and the value of the difference of the arithmetic means is expressed. This also accepts the proposed research hypothesis HI about the inhomogeneity of the observed sets. According to the calculated average values, the set statement resulted in a good rating (2.8921) and the respondents took a neutral position. The surveyed respondents are connoisseurs of the island's conditions and it is concluded that they are not too convinced that the opportunities that can realize the socio-economic well-being of the island community are evenly distributed. In support of such a claim, the following can be stated:

- The distribution of the assigned grades according to the occupation of the respondents ranged from 2.80 for prominent residents of the island to 2.90 for representatives of local self-government. The distribution is even, which was confirmed by the Chi-square test and analysis of variance.
- The distribution of the assigned grades according to the level of education of the respondents ranged from 2.76 for respondents with a high school diploma to 3.50 for those with a doctorate in science. The distribution is even, which was confirmed by the Chi-square test, but not by the analysis of variance, and a T-test was performed, which confirmed the evenness.
- The distribution of the assigned marks according to the respondents' experience in tourism ranged from 2.85 for the most experienced respondents to 3.04 for those under 30 years of age. The distribution is even, which was confirmed by the Chi-square test and analysis of variance.
- The distribution of the assigned marks according to the perception of the tourist development of the island destination from which the respondents come ranged from 2.75 for promising tourist destinations to 3.04 for developed tourist

destinations. The distribution is not even though it is not confirmed by Chi-square test, but it is confirmed by analysis of variance and T-test.

- The distribution of the assigned grades according to the category of the island from which the respondents come ranged from 2.72 for islands of category C to 3.03 for islands of category A. The distribution is even, which was confirmed by the Chi-square test and analysis of variance.

In the distribution of answers according to the category of respondents, there is an unevenness in relation to the perception of development.

Conclusion

The problems in strategic planning of rural development are significant and involve numerous interest groups with different interests, goals and values. For this reason, it is necessary to build a joint Strategy for the sustainable development of the rural area, which will be designed and implemented and monitored from the level of each local community on the islands, which are significantly different from each other. Although the subregional approach to the development of the islands remains only declarative in nature, since such an approach also faces the peculiarities of individual islands, but also due to the absence of a development policy that would respect these peculiarities, this work contributes to an important discourse in that area. The concept of sustainability in rural areas is becoming and will remain an important segment of every rural area. Sustainability cannot be based only on narrow principles of environmental protection, but as sustainability goals that extend to the preservation of the landscape and natural habitat, local culture and the identity of the local community, and the development and encouragement of support, understanding and awareness of decision-makers and other stakeholders responsible for long-term development of rural areas (Krajinović et al., 2011). Sustainable rural development is a complex concept, especially in the European Union and the modern economy, and form the point of view of the economic policy holder. The economic development of the Republic of Croatia is characterised by imbalances, inherent in the development of rural and urban areas. The results of the analyses of economic indicators indicate a significant lag in the development of rural areas compared to urban areas. Tourism activities in the area of rural development in the Republic of Croatia are important for the segment of diversification of rural economy and economic revival of rural areas (Tolić et al., 2019). The guidelines for the sustainable development of a rural area imply the harmonization of goals and interests of all stakeholders and assume a compromise management at all levels relevant to its sustainable development. Sustainable development can be defined as the relationship between economic and ecological systems that must be in ecological balance. In conclusion, the issue of strategic management of an island with an emphasis on sustainable development should continue to be explored and approached more in-depth from a spatial, ecological, cultural, socio-demographic and regulatory point of view.

Conflict of interests

The authors declare no conflict of interest.

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GENDER PERSPECTIVES OF TWIN TRANSITION IN AGRICULTURE AND FOOD SECTOR COMPANIES: EMPIRICAL EVIDENCE FROM SERBIA

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A B S T R A C T

This paper investigates the gender perspectives in the twin transition of companies in Serbia's agriculture and food sector, focusing on their adoption of information and communication technologies (ICT) and green/ environmental activities. Using primary data from computer-assisted telephone interviews, a comprehensive survey was conducted among sector companies. Statistical analysis included descriptive statistics and non-parametric tests to compare differences between groups. The results highlight the significant impact of gender diversity on digitalisation adoption. However, disparities emerge in the green transition, particularly in waste reduction through recycling, raw material reuse, and supplier selection based on environmental criteria. No gender-specific differences were found in reducing harmful emissions or using eco-friendly packaging. This study enhances understanding of gender dynamics in the agri-food sector's twin transformation and highlights how gender perspectives influence digital and environmental practices. The findings inform policymakers and businesses on promoting gender-sensitive strategies for sustainable development and economic growth in Serbia and beyond.

Introduction

The "twin transition" concept originates from the European Green Deal and highlights the intertwined nature of digital and green transitions (European Commission, 2019).

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Even though the digital and green transformations are interconnected, their dynamics and characteristics are different. The green transition requires a strong political and societal push driven by the public interest. On the other hand, the digital transformation is primarily market-driven. Advances in digital technologies have created enormous opportunities for innovative businesses, but this has often exploited regulatory gaps and caused inequalities (Brunori, 2022). These two concepts, while distinct, influence each other and are essential for everyone. They highlight the reciprocal relationship between digital advancements and sustainability efforts. Although the twin transition began within the European Union (EU), it has global relevance, reflecting the need for countries worldwide to address both digital and sustainable development simultaneously (Morten, 2023).

The twin transition in companies is a significant step towards integrating sustainability and technological advancements into their operations and strategies. The digital transformation plays a crucial role in promoting green technology innovation within companies (Xue et al., 2022; Zhang et al., 2022; Chen & Hao, 2022; Sun & Guo, 2022). Moreover, the integration of environmental responsibility into digital transformation efforts can lead to more cost-effective and efficient green innovation, satisfying both internal and external stakeholders (Sun & He, 2023). There is also a positive impact of digital transformation on total factor productivity, especially in heavily polluting enterprises, by increasing green technology innovation and corporate social responsibility (Su et al., 2023).

In the twin transition, agriculture and food processing are crucial sectors, identified alongside energy and mobility as key areas requiring profound transformation to achieve sustainability goals (European Environment Agency, 2021). The Farm to Fork strategy emphasizes this necessity by highlighting the significant contributions of agricultural systems to greenhouse gases, biodiversity loss, pollution, and water scarcity, as well as the food system's vital role in human well-being (Brunori, 2022). The twin transition in agriculture involves simultaneous changes in both production and consumption that can facilitate a shift towards sustainability and diversification in the agrifood system (Magrini et al., 2018).

The use of digital technologies in agriculture contributes to faster integration into the global economy, increases efficiency, promotes innovation and identifies new ways to improve supply chain management (Deichmann, Goyal & Mishra, 2016; Radić et al., 2022). The digitalisation of agriculture has been instrumental in improving agricultural productivity, promoting sustainable development, and achieving sustainability goals (Zhou et al., 2022; Zhong & Qi, 2022). Additionally, the transformation of agriculture from traditional to digital, ecological and intelligent practices can reduce resource wastage and environmental pressure, ultimately enhancing overall factor productivity in green agriculture (Hong et al., 2023). Improved management practises, higher productivity, lower costs, minimised environmental impact and improved product quality can be achieved through the introduction of digital innovations (Bolfe et al., 2020). Digital agriculture not only enhances agricultural productivity, but also addresses food security, climate protection, and resource management (Nasirahmadi & Hensel, 2022). Although digitalisation in agriculture has a transformative impact across the agro-food systems, there are different challenges in establishing data systems and technologies. These include data ownership and control, development of technologies and data security (Rotz, et al., 2019).

In the context of the twin transition in the agri-food sector, gender dynamics play an important role in shaping agricultural productivity, sustainability and adaptation to climate change. Understanding the intersection of gender and these transformations is critical to promoting gender equality, improving agricultural outcomes and fostering inclusive development. The participation of women in agriculture is recognised as a key factor in increasing agricultural productivity and sustainability. Studies have shown that if women had equal access to productive resources as men, they could significantly increase yields on their farms, highlighting the potential for gender equality to drive agricultural productivity gains (Doss, 2017). The inclusion of women in agri-food value chains can help reduce the gender gap and empower women through measures such as equal payment, maternity rights and female-specific training (Malanski et al., 2022). Furthermore, addressing gender dimensions in agriculture is essential for enabling communities to effectively adapt to climate change, as traditional gender analyses may not fully capture the norms and roles that underlie gender dynamics in specific socio-cultural contexts (Jost et al., 2015).

Agriculture stands as a cornerstone of the Serbian economy, constituting a significant sector that contributes approximately 7.5% to gross value added (GVA) and employs 15% of the labour force during the period from 2015 to 2020. When combined with the food, beverage, and tobacco industries, agriculture collectively represents approximately 19% of total exports (Ministry of Agriculture, Forestry and Water Management, 2022). The agri-food sector has been identified as a priority in the Smart Specialisation Strategy of the Republic of Serbia, focusing on key areas such as high-tech agriculture, value-added food products, and sustainable food production chains (Ministry of Education, Science and Technological Development, 2020). The agri-food sector in Serbia is undergoing a transformation driven by digitalisation and green transition initiatives. Digital technologies, such as digital marketing, online sales, and search engine optimization, are significantly impacting the performance of companies in the agricultural sector in Serbia (Mihailović et al., 2024). This can be observed especially in the autonomous province of Vojvodina, where digital technologies are being adopted in agriculture, leading to higher productivity and the establishment of the digital agricultural sector (Vukadinović et al., 2022). Despite recognising ICT as crucial for the sustainable development of agriculture, Serbia still lags behind EU countries, mainly due to limited financial resources and insufficient educational background of agricultural producers (Jurjević et al., 2019). Environmental responsibility is increasingly recognized as crucial within Serbian agri-food companies. Recent research conducted in the Serbian economy indicates that companies in the agri-food sector demonstrate above-average commitment to environmental orientation and strategy (Milić, 2021). This underscores the need to further develop environmental practices within these companies to better align with societal expectations and enhance sustainability efforts.

While the Serbian agri-food sector is undergoing a significant transformation driven by digitalisation and green initiatives, it remains unclear to what extent this transformation includes a gender perspective. Unequal access to resources and opportunities between men and women in agriculture is a significant barrier to achieving comprehensive sustainability and productivity goals. In addition, the insufficient involvement of women in digital and green initiatives hinders the potential to maximize the growth and sustainability of the sector.

The literature exploring technological transformation from a gendered perspective is notably sparse, especially in specific workplace contexts. Previous studies highlight that men adopt new agricultural production technologies at higher rates and more quickly than women (Ragasa, 2012). These gender differences are evident across a wide range of technologies, from basic agricultural tools to advanced digital agriculture technologies and ICT (Peterman et al., 2014). Despite these disparities, the impact of management structures in agricultural companies on ICT adoption remains under researched. This gap in the literature prevents a comprehensive understanding of how technological advances intersect with gender roles and inequalities, influencing agricultural productivity, sustainability efforts and adaptation strategies. Addressing this gap is important for advancing gender equality, improving agricultural outcomes and fostering inclusive development within the digital and green transitions.

The main objective of this study is to examine the gender perspectives related to the twin transition of enterprises in the agriculture and food sector in the Republic of Serbia, with a focus on the adoption of ICT and engagement in green/environmentally friendly activities. Specifically, the paper aims to determine whether there are significant differences between agri-food companies with women in their management structures and those managed exclusively by men in the key dimensions of the twin transition.

Materials and methods

In line with the main objective of the study, observed companies in the agri-food sector were categorised into two groups depending on whether they have women in management positions. The first group consists of companies that have women in management, while the second group consists of companies whose management is made up exclusively of men.

The level of ICT adoption was assessed by surveying organisations on their use of tools such as Enterprise Resource Planning (ERP) software, Customer Relationship Management (CRM) software, cloud service and the Internet of Things (IoT). The variable for the use of ICT was created based on the data collected. It ranges from 0 to 4, depending on how many of these technologies a company uses (0 – uses none of these four technologies; 4 – uses all four technologies).

In order to assess the use of renewable energy sources, the companies surveyed were asked whether they use any of the following energy sources: solar panels (or cells), biomass (including wood and waste), biogas plants, heat pumps (geothermal energy). The variable for the use of renewable energy sources ranges from 0 to 3, depending on whether a company uses none, one or more of these energy sources (0 – uses none of these energy sources; 3 – uses three of them). It should be noted that none of the companies surveyed use all four renewable energy sources.

Using a five-point Likert scale (1 - not at all; 2 - little; 3 - somewhat; 4 - to a large extent; 5 - to a great extent), the companies assessed the extent of progress in processes related to the more efficient use of energy and resources. They assessed the extent to which they have made progress in the following processes in the last three years: (1) reducing emissions of harmful gases/substances, (2) reducing waste by recycling and returning raw materials to the production chains, (3) using environmentally friendly or smart packaging and (4) selecting suppliers according to environmental criteria.

Following the main objective of the study and the definition of the variables, three research questions (RQ) are posed:

RQ1: Are there differences in the use of ICT between companies run by women and those run by men?

RQ2: Are there differences in the use of renewable energy sources between companies run by women and those run by men?

RQ3: Are there differences between women-led and men-led companies in the extent of progress in processes related to more efficient use of energy and resources?

The statistical analysis included descriptive statistics and non-parametric tests to compare the differences between two groups: companies that have women in management and companies whose management consists exclusively of men.

Sample description

The population for the sample selection includes all active companies in Serbia that have submitted the financial report for 2020 and whose main activity corresponds to the agriculture and food sector. The agriculture and food sector includes the following economic activities according to the Statistical Classification of Economic Activities in the European Community (NACE Rev. 2): crop and animal production and related activities (01), manufacture of food products (10) and manufacture of beverages (11) (Eurostat, 2008). Enterprises with fewer than 5 employees were excluded from the population due to their oversimplified management structures, so that the population thus defined consisted of 3,008 enterprises.

Stratified random sampling was chosen as the sampling method because it ensures that each subgroup of the population is adequately represented in the sample. The stratification was based on the two-digit economic activity of NACE Rev. 2 and took into account the regions (Vojvodina, Belgrade, South and East Serbia, Šumadija and West Serbia) and company sizes (5-20, 21-50, 51-250 and 251-500 employees). The survey sample (gross sample) consisted of 639 companies from the agricultural and food sector.

The number of companies that took part in the survey consists of 446 (69.8% sample fulfilment) companies from the agricultural and food sector. The survey was conducted using the CATI (Computer Assisted Telephone Interviewing) method and the survey period was set from June to July 2022. *Table 1* shows the structure of the population for sample selection, the gross sample size and the final (net) sample size by NACE Rev. 2 two-digit economic activity.

Table 1. The population for the sample selection, gross sample size and net sample size

NACE 2-dig	Activity	Population	Gross sample	Net sample
01	Crop and animal production and related activities	575	396	261
10	Manufacture of food products	2302	225	170
11	Manufacture of beverages	131	18	15
Total	Agriculture & Food	3008	639	446

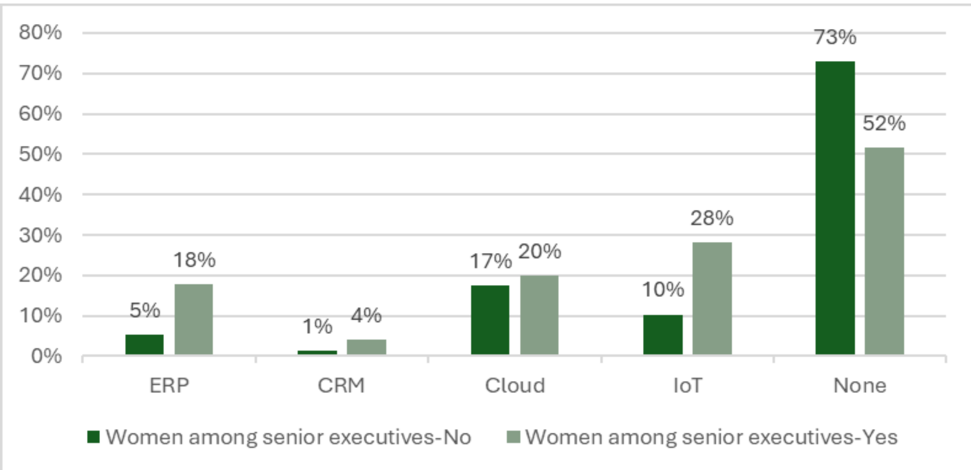
Source: Author's research

Regarding the regional distribution of the final (net) sample, 52% of the companies are from Vojvodina, 15% from Belgrade, 15% from South and East Serbia and 15% from Šumadija and West Serbia. Of the companies included in the final sample, 37% have between 5-20 employees, 29% between 21-50 employees, 29% between 51-250 employees and 5% between 251-500 employees.

Results and discussion

Figure 1 shows the percentage of surveyed companies that use ICT, including ERP software, CRM software, cloud service and the IoT. A comparison of ICT use in companies run by women and men shows that companies with women in management use ICT to a greater extent than companies whose management consists exclusively of men. Specifically, 18% of companies managed by women use ERP, while only 5% of companies managed by men use this software. The same is true for CRM software, cloud service and IoT. Despite these findings, a significant proportion of surveyed companies, comprising 73% led by men and 52% led by women, reported not using any of these technologies. This disparity in ICT adoption between male and female-led companies highlights potential differences in managerial strategies and priorities concerning technological investments.

Figure 1. The use of ICT tools



Source: Author's research

Table 2 contains descriptive statistics for companies that have women in management positions and for companies that do not have women in management positions for variables: ICT adoption, Use of renewable energy sources, Reduction of emissions of harmful gases / substances, Reduction of waste through recycling, Use of environmentally friendly or smart packaging, and Selection of suppliers based on environmental criteria.

Table 2. Descriptive statistics with the Shapiro-Wilk test of normality

Twin transition	Women among senior executives	N	Mean	Std. Deviation	Shapiro-Wilk	
					Statistic	Sig.
ICT adoption	No	155	0.34	0.63	0.59	0.00
	Yes	291	0.70	0.87	0.76	0.00
Use of renewable energy sources	No	155	0.15	0.41	0.41	0.00
	Yes	291	0.26	0.56	0.51	0.00
Reduction of emissions of harmful gases / substances	No	155	2.85	1.19	0.90	0.00
	Yes	291	2.90	1.35	0.89	0.00
Reduction of waste through recycling	No	155	3.03	1.12	0.92	0.00
	Yes	291	3.33	1.37	0.88	0.00
Use of environmentally friendly or smart packaging	No	155	2.26	1.26	0.85	0.00
	Yes	291	2.53	1.43	0.85	0.00
Selection of suppliers based on environmental criteria	No	155	2.17	1.17	0.84	0.00
	Yes	291	2.58	1.35	0.87	0.00

Source: Author's research

The Shapiro-Wilk test for normality is significant for each of the subsamples ($p<0.01$), which means that the data are not normally distributed. Since the normality assumption is necessary for parametric tests, the non-parametric Mann-Whitney test is used to determine whether there are significant differences between companies managed by women and those managed by men with regard to the application of these six criteria (*Table 3*).

Table 3. Mann-Whitney Test

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
ICT adoption	17314.50	29404.50	-4.60	0.00
Use of renewable energy sources	20852.00	32942.00	-1.95	0.05
Reduction of emissions of harmful gases / substances	22012.50	34102.50	-0.43	0.67
Reduction of waste through recycling	19092.50	31182.50	-2.74	0.01
Use of environmentally friendly or smart packaging	20458.50	32548.50	-1.67	0.09

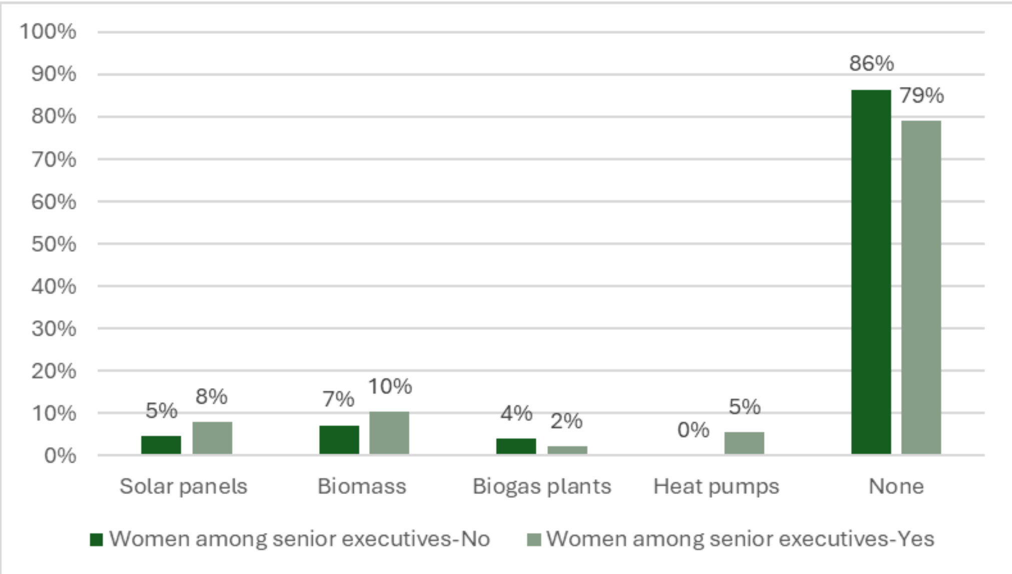
	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Selection of suppliers based on environmental criteria	18653.00	30743.00	-3.11	0.00

Source: Author's research

The result of the Mann-Whitney test is significant ($p<0.05$) for the variable ICT adoption, which means that companies with women in management use ICT to a greater extent (M=0.70) than companies whose managers are only men (M=0.34). While the previous literature often suggests that women entrepreneurs in the agri-food sector tend to implement fewer IoT technologies (Ragasa 2012; Peterman et al., 2014), these results reveal the opposite trend in Serbia. The presence of women in management structures within agri-food companies increases the likelihood of adopting ICT technologies. This finding suggests that gender-inclusive management practices can significantly enhance technological adoption and integration, challenging conventional narratives and underscoring the critical impact of women's leadership in driving technological advancement.

Figure 2 shows the percentage of companies that use renewable energy sources such as solar panels (or cells), biomass (including wood and waste), biogas plants and heat pumps (geothermal). As with ICT, the companies are categorised into two groups depending on whether they have women in management positions.

Figure 2. The use of renewable energy sources



Source: Author's research

A comparison of the use of renewable energies in companies shows that companies with women in management make greater use of solar panels, biomass and heat pumps than companies whose management consists exclusively of men. The opposite is only true for biogas plants: 4% of male-managed companies compared to 2% of female-managed companies stated that they use this renewable energy source. However, most of the companies surveyed stated that they do not use any of the renewable energy sources mentioned: 86% of male-managed companies and 79% of female-managed companies stated this.

The result of the Mann-Whitney test is significant (p=0.05) for the variable Use of renewable energy sources (*Table 3*), which means that companies with women in management use renewable energy sources to a greater extent (M=0.56) than companies whose managers are only men (M=0.41) (*Table 2*). This finding, similar to the results observed with ICT adoption, underscores the positive impact of gender diversity in leadership on sustainable practices within agri-food companies. The increased use of renewable energy sources by companies led by women suggests that gender-inclusive management not only fosters technological adoption but also promotes greater environmental responsibility.

Respondents rated various statements on a five-point Likert scale about the extent of progress in processes related to the more efficient use of energy and resources in their companies. *Table 4* shows the percentage structure of the respondents' assessments (1 - not at all; 2 - little; 3 - somewhat; 4 - to a large extent; 5 - to a great extent).

Table 4. The percentage structure of the respondents' assessments

Progress in processes related to the more efficient use of energy and resources	Women among senior executives	1	2	3	4	5	Significant progress (4+5)
Reduction of emissions of harmful gases / substances	No	18%	17%	33%	25%	7%	32%
	Yes	24%	12%	28%	23%	13%	36%
Reduction of waste through recycling	No	9%	25%	30%	26%	10%	36%
	Yes	16%	10%	24%	25%	25%	50%
Use of environmentally friendly or smart packaging	No	36%	28%	17%	12%	7%	19%
	Yes	37%	13%	22%	16%	12%	28%
Selection of suppliers based on environmental criteria	No	37%	28%	23%	6%	6%	12%
	Yes	32%	15%	27%	16%	10%	26%

Source: Author's research

The findings indicate that in the past three years, a higher proportion of companies led by women have reported significant advancements in processes aimed at enhancing energy and resource efficiency. Specifically, 36% of women-led companies, compared to 32% of men-led companies, noted substantial progress in reducing emissions of harmful gases and materials. The same applies to reducing waste through recycling and returning raw materials to the production chain (50% of women-led companies compared to 36% of men-led companies), using environmentally friendly or smart packaging (28% of women-led companies compared to 19% of men-led companies) and selecting suppliers according to environmental criteria (26% of women-led companies compared to 12% of men-led companies).

The Mann-Whitney test is used to determine whether there are statistically significant differences in mean values between two groups in terms of the extent of progress in processes related to the more efficient use of energy and resources. The results of the test are significant ($p<0.05$) for the reduction of waste through recycling and the selection of suppliers based on environmental criteria (*Table 3*). Companies with women in management (M=3.33) advanced in the past three years to a larger extent in reducing waste through recycling than companies whose managers are only men (M=3.03). In addition, in the past three years women-led companies (M=2.58) made a larger progress in selecting suppliers based on environmental criteria than men-led companies (M=2.17) (*Table 2*). On the other hand, statistical differences between women-led and men-led companies were not found ($p>0.05$) in terms of the extent of progress in reducing emissions of harmful gases/substances or in the use of environmentally friendly or smart packaging (*Table 3*).

These results suggest that while women-led companies are particularly effective in implementing practices that promote waste reduction and environmentally conscious supplier selection, both women-led and men-led companies need to increase their focus on reducing harmful emissions and adopting environmentally friendly packaging solutions. The significant advancements by companies with women in their management structures in certain sustainability practices highlight the potential for gender-inclusive leadership to drive broader environmental initiatives within the agri-food sector.

Conclusion

This study has explored the interconnected dynamics between gender diversity, technology adoption and sustainability practices within the agri-food sector. It highlights the significant role of gender diversity in the adoption of ICT and sustainability practices in agri-food companies in Serbia. The presence of women in leadership positions within this sector positively influences the dynamics of the twin transition. Companies led by women demonstrate more robust utilisation of ICT tools and stronger commitment to sustainable practices compared to those led exclusively by men.

A study of 446 companies from the agricultural and food sector in Serbia concluded that companies run by women are more committed to the introduction of ICT and environmental sustainability than companies run exclusively by men. In particular, the statistical analysis showed that companies with women in management positions use ICT tools such as ERP, CRM software, cloud services and IoT to a greater extent than companies whose managers are only men. In terms of the green transition, there are statistically significant results between male and female-led companies in reducing waste through recycling and in selecting suppliers according to environmental criteria. On the other hand, no statistical differences were found between the two groups of companies in terms of the extent of progress in reducing emissions of harmful gases/substances or in the use of environmentally friendly or smart packaging.

The findings not only highlight the enhanced performance of women-led companies in these areas but also emphasise the importance of gender-inclusive management structures for fostering technological innovation and sustainability. The research findings have important implications for both business leaders and policymakers. Promoting gender diversity in leadership positions can enhance companies' technological capabilities and sustainability performance. By actively promoting gender diversity, companies can improve their competitiveness, operational efficiency and reputation among stakeholders.

The research suggests policy instruments that support women's leadership and measures that aim to reduce barriers to female leadership in the agri-food sector. Policymakers can use these findings to advocate for initiatives that promote inclusive growth and create a favourable business environment.

While the study provides valuable insights into the relationship between gender diversity, ICT adoption and sustainability practices, further research is needed to examine additional factors influencing this dynamic. Future studies can build on these findings to investigate the mechanisms through which gender diversity enhances ICT use and sustainability efforts, as well as explore the long-term impacts of these practices on agricultural productivity and inclusive development. Additionally, research could delve deeper into the organisational mechanisms and leadership strategies that promote greater ICT adoption and sustainability performance in women-led firms and track the long-term impact of gender diversity on business performance and societal contributions within the agri-food sector.

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Conflict of interests

The authors declare no conflict of interest.

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EXPLORING THE CRAFT BEER EXPERIENCE IN SERBIA: THE CONSUMER PERSPECTIVE

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ABSTRACT

One of the main things driving the growth of culinary, or more accurately, beverage tourism, is the "beer revolution," or the proliferation of craft beer production. Investigating the reasons and perceptions of tourists about the beer tourism experience is vital in the lack of comparable studies. The purpose of this study is to add to the extremely little that is currently known about Serbia's beer tourism industry. Authors specifically looked at the factors that affect craft beer experience and customer loyalty among craft breweries' consumers. Considering that consumers of craft beer have different motivations, it was discovered that craft beer experience has a positive but the lowest impact on perceived quality.

Introduction

The most frequent motives of travel for tourists are the search for enjoyable experiences, entertainment, and new discoveries. They appreciate relaxation, stress-

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free opportunities, and have a growing interest in local gastronomy and high-quality food and beverages (Bujdosó & Szűcs, 2012, Popescu et al., 2019). Beer, as a widely consumed global drink, has excellent potential for attracting tourists; however, beer tourism is not sufficiently developed in Serbia (Kalenjuk, 2014). Plummer et al. (2005) define beer tourism as “visiting breweries, beer festivals, and beer shows for which beer tasting and experiencing the attributes of the beer region are the main motivating factors for visitors” (p. 449). It can be said that beer related events increase opportunities for developing tourism destinations and play a key role in promoting the region as well as creating loyalty to food and beer (Mason & Piggiaro, 2012). Carvalho et al. (2018) state that beer tourism is intended for beer drinkers who are looking for new tastes, while Bujdosó & Szűcs (2012) express that beer drinkers and other tourists are often interested in “visiting breweries and other beer-related attractions” (p. 105). According to some data today in Serbia, beer began to be made in the 5th-6th centuries by the Slavic and Celtic tribes that immigrated. Beer consumption per capita, as far as European countries are concerned, is in the Czech Republic with 143 l of beer per year, Germany with 106 l, Austria with 105 l, Poland with 98 l of beer per year, and Lithuania with 92 l of beer per year. In 2018, Serbia ranked 43rd in the world with 5.56 million hectoliters produced (Andrei & Darvasi,2012; Gajić et al., 2021).

The “beer revolution”, or the expansion of the manufacture of craft beers, belongs to the major factors affecting the development of gastronomic, or more precisely, beverage tourism (Krogmann et al., 2020, p. 37), or as said by Kraftchick et al. (2014), beer tourism. Compared to other sectors, there is a clear deficit in studies devoted to investigating craft breweries as well as beer tourism routes that would connect breweries as elements of tourism facilities (Alonso, 2011; Krogmann et al., 2020). According to Flack (1997), there has been a development within the sector in the form of blending craft brewing with hospitality and tourism, which leads to the need for an active approach.

In the absence of similar research, it is necessary to investigate the motives and impressions of visitors about the beer tourism experience. This paper aims to contribute to the very limited existing knowledge regarding the beer tourism sector in Serbia. The purpose of this paper is to examine the role of craft beer in tourism, focusing on the visitor experience. The components that influence satisfaction with craft beer and lead to great loyalty among visitors to craft breweries were examined in particular.

Literature review

Creating attractive gastronomic experiences in a certain destination can positively influence tourism and have a significant impact on various sectors (Mora et al., 2021). Visiting a tourist destination represents a unique and differentiated experience when some gastronomic experiences are combined with others, such as wine tourism (Haven-Tang & Jones, 2005) or beer tourism. Beer tourism is often based around beer festivals, walking tours, and beer tastings, with the addition of visits to specific breweries and first-hand interactions with master brewers (Brown & Getz, 2005; Yeoman &

McMahon-Beattie, 2016). According to Plummer et al. (2005), during a three-year research, on a total sample of 2,136 respondents, the author states that it is necessary to create beer routes, such as wine routes, because beer tourism is recognized as a local product and has the potential to interest tourists. The experience of beer tourism can be influenced by numerous dimensions. In terms of gastronomic experience, the following three dimensions were respected: first, processing, color, or texture were evaluated; secondly, the atmosphere and possibility of interaction with employees, as well as the physical environment, were considered; and thirdly, individual factors such as the feeling in the restaurant or the time spent tasting were observed (Taar, 2014; Mora et al., 2021). Allowing for the above, in order to research the experience in beer tourism, five hypotheses were defined in the paper.

According to Bitner (1992), servicescape implies a built physical environment where servicescape components affect the internal cognitive, emotional states, which contribute to the socialization of customers and employees in their roles, behaviors, and relationships. The components of servicescape that Pizam and Tasci (2019) distinguished are the sensory (hedonic) component, the functional component, the social component, the natural component, the cultural component, and the hospitality culture component. The servicescape encompasses the tangible aspects of service setting (Pizam & Tasci, 2019). Manis et al. (2020) suggest that the servicescape elements have a significant impact on satisfaction. Intangible aspects are necessary, as stated by Schmitt (2003), to offer a holistic experience resulting from the interaction of a set of intangible experiences. The social component of the servicescape includes "social density, context, and displayed emotions of people in the servicescape" (Pizam & Tasci, 2019, p. 28). Schmitt (1999), within the components of experience and the context of the social environment, singles out senses, feels, acts, and relates. In accordance with the above, the overall social atmosphere, along with the physical, can significantly affect perceived quality in the context of beer tourism. Thus, the first hypotheses about the components that leads to the perceived quality of craft beers and breweries are the following:

H1: The Servicescape positively influences Perceived quality

H2: The Socialscape positively influences Perceived quality

Perceived quality differs from objective quality because it involves a thorough evaluation of the product and an appreciation of specific product attributes (Zeithaml, 1998). Perceived quality is defined as "the consumers' judgment about an entity's overall excellence or superiority" (Snoj et al., 2004, p. 159). The benefits of products/services are measured through the perceived level of quality, which is often concentrated in the value of the price (Snoj et al., 2004). The third hypothesis states that value for money is determined based on perceived quality:

H3: Perceived quality positively influences Value for money

Positive experience, in terms of getting sufficient value for money, is positively related to satisfaction. Homburg and Giering (2001) find that satisfaction is linked to service evaluation and tourist experience. Satisfaction is also defined as “an evaluation of emotion” (Hunt, 1977, p. 459). Although good products/services are the basis of satisfaction and loyalty, Roberts and Sparks (2006) state that value for money is important to visitors, which leads to the fourth hypothesis:

H4: Value for money positively influences Satisfaction

As stated by Mason and Paggiaro (2012), “satisfaction is a partly affective and partly cognitive evaluation of the consumption experience” (p. 1331). According to Oliver (1997), satisfaction is considered to be a consumer’s evaluation of goods and services. The outcome of this is a subjective assessment of whether the selected goods or services meet or exceed consumer expectations. The definition of loyalty can be explained as repeat purchasing behavior, and it is characterized in terms of repeat purchases and word-of-mouth recommendations (Lee et al., 2006). Oliver and Burke (1999) estimated that the achievement of loyalty depends on customer satisfaction, which is influenced by expectations. They suggested that there is a significant satisfactory correlation between consumers and their future intentions. Camargo et al. (2012) indicate that authenticity is very important for the success of product quality as well as consumer loyalty. They emphasize the importance of the sensory quality of food and beverages in achieving greater production and marketing. Baker and Crompton (2000), as well as Chen and Huang (2019), point to the positive influence of gastronomic satisfaction on loyalty, which can also be applied to the beer experience. The last hypothesis is the following:

H5: Satisfaction positively influences Loyalty

Metholodology

The primary instrument for data collection was a structured questionnaire designed to gather quantitative data on the factors that influence guests’ experience and loyalty towards breweries. The questionnaire consisted of two sections: the first section collected information on the socio-demographics of brewery guests, while the second section consisted of closed-ended questions with a 7-point Likert scale related to various factors discussed in the section above. The former section was developed by adapting concepts from previous research in tourism, consumer behavior, and brand loyalty. Servicescape was measured through seven statements adapted from Bitner (1992), such as The smells in the brewery are pleasant and The lighting in the brewery is pleasant. The socialscape or social component of the environment was measured using five statements adapted from Pizam and Tasci (2019), e.g. The crowd level is comfortable and Employees are friendly. Perceived quality consisted of three statements proposed by Francioni et al. (2022), while to measure value for money, three statements were adapted from Sweeney and Soutar (2001). To measure satisfaction, two statements were adapted from Füller et al. (2011) and one from Mora et al. (2021). Loyalty was measured using two statements from Kim et al. (2010) and one statement from Füller et al. (2011).

To ensure only valid respondents were approached, a pre-screening question (e.g., “Have you visited a brewery?”) was asked before inviting potential participants to take part in the survey. The online questionnaire was distributed via email and social media platforms, while the print version was distributed in person at breweries and brewery events. The responses from the printed questionnaires were manually entered into the same database used for the online responses to ensure consistency in the data analysis. Over a three-month period from March to May 2024, a total of 198 responses were collected, with 103 valid cases being used for data analysis.

The data were analyzed using IBM-SPSS statistics software version 25.0 and SmartPLS version 4.1.0.4. Descriptive statistics were used to summarize the demographic profile of brewery visitors, while partial least squares structural equation modeling (PLS-SEM) was used to test the theoretical model and the defined hypotheses, following the procedure presented by Seočanac (2024).

Results

The sample consisted predominantly of male respondents (72.82%), with 27.18% of participants being female. The majority of respondents were between 26 and 35 years old (27.18%) and between 36 and 45 years old (26.21%). Educational attainment was evenly distributed, with the largest groups having a faculty degree (27.18%) or a master’s degree (26.21%). The income distribution shows that a significant proportion of respondents (42.72%) earn more than EUR 1,000 per month.

Table 1. Respondent profile

Variable	Description	Frequency	Percentage
Gender	Male	75	72.82
	Female	28	27.18
Age	18–25	18	17.48
	26–35	28	27.18
	36–45	27	26.21
	46–55	23	22.33
	56+	7	6.80
Education level	High school	24	23.30
	Faculty	28	27.18
	Master	27	26.21
	PhD	24	23.30
Monthly income (EUR)	<300	6	5.83
	301–500	7	6.80
	501–700	9	8.74
	701–1,000	23	22.33
	>1,000	44	42.72
	No answer	14	13.59

Source: Authors

The results presented in Table 2 show that the constructs used in the study are reliable and exhibit good convergent validity, thereby supporting the robustness of the measurement model. First, the standardized loadings of the indicators have a minimum value of 0.708 (Hair et al., 2011). Additionally, both Cronbach's alpha and the composite reliability values are greater than 0.7 and less than 0.95, while the average variance shared between the variable and its individual indicators exceeds 0.5 (Hair et al., 2019).

Table 2. Construct reliability and validity

Constructs	Indicators	Indicator loadings	Cronbach's alpha	rho_a	CR	AVE
Servicescape	SERV_1	0.818	0.919	0.920	0.935	0.675
	SERV_2	0.877				
	SERV_3	0.828				
	SERV_4	0.822				
	SERV_5	0.813				
	SERV_6	0.814				
	SERV_7	0.774				
Socialscape	SOCIAL_1	0.743	0.898	0.908	0.925	0.713
	SOCIAL_2	0.898				
	SOCIAL_3	0.869				
	SOCIAL_4	0.887				
	SOCIAL_5	0.816				
Perceived quality	PQ_1	0.889	0.812	0.818	0.888	0.726
	PQ_2	0.824				
	PQ_3	0.843				
Value for money	VFM_1	0.931	0.898	0.899	0.936	0.831
	VFM_2	0.910				
	VFM_3	0.893				
Satisfaction	SATISF_1	0.890	0.869	0.869	0.920	0.792
	SATISF_2	0.902				
	SATISF_3	0.879				
Loyalty	LOYALTY_1	0.938	0.898	0.927	0.936	0.830
	LOYALTY_2	0.946				
	LOYALTY_3	0.847				

Source: Authors

To assess discriminant validity, the heterotrait-monotrait (HTMT) criterion was used, as recommended by Sarstedt et al. (2022). Table 3 shows that there are no issues with discriminant validity for any of the variables, except for loyalty and satisfaction. All variables have values less than 0.85, with socialscape and servicescape having values less than 0.9, which is acceptable for conceptually similar constructs (Henseler, 2015). However, the variables satisfaction and loyalty have values slightly above the upper limit of 0.9. After additionally checking the Fornell-Larcker criterion and the cross-loading values for these two variables, which indicated no problems, and considering that the HTMT values were only slightly above the upper limit for conceptually similar constructs, it was decided to confirm the discriminant validity of all variables.

Table 3. Discriminant validity (HTMT)

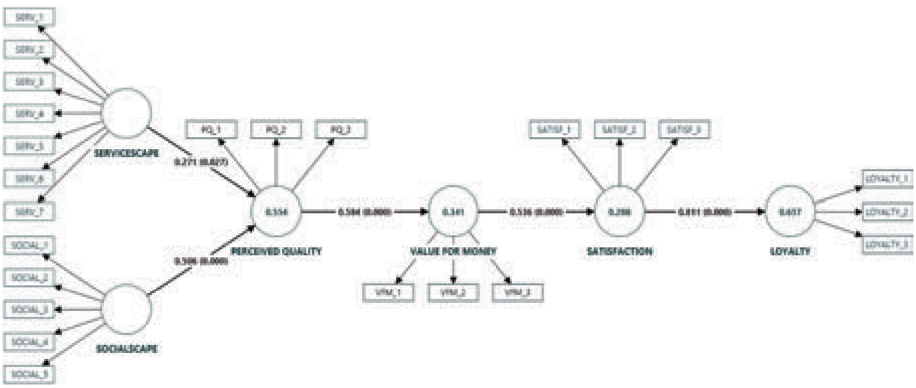
	SERV	SOCIAL	PQ	VFM	SATISF	LOYALTY
SERV						
SOCIAL	0.889					
PQ	0.786	0.841				
VFM	0.552	0.664	0.678			
SATISF	0.723	0.837	0.734	0.605		
LOYALTY	0.648	0.786	0.732	0.509	0.903	

Abbreviations: Servicescape (SERV), Socialscape (SOCIAL), Perceived quality (PQ), Value for money (VFM), Satisfaction (SATISF).

Source: Authors

After ensuring that the measurement model demonstrated good reliability and validity, as indicated by high factor loadings, acceptable Cronbach's alpha values, composite reliability values and good convergent and discriminant validity, the structural model was estimated. The structural model in PLS-SEM (Figure 1) illustrates the relationships between various constructs in our study. The model proposes that servicescape and socialscape have a direct influence on perceived quality, which in turn influences value for money. Value for money then influences satisfaction, and finally satisfaction influences loyalty. This relationship chain shows a progression that leads from environmental factors (servicescape and socialscape) to perceived benefits (perceived quality and value for money) to emotional outcomes (satisfaction) and finally to behavioral intentions (loyalty). The path coefficients (*ß*) in the model indicate the strength and direction of these relationships, while the R^2 values explain the proportion of variance in the dependent variables and thus provide an insight into the explanatory power of the model. According to Hair et al. (2011), "R^2 values of 0.75, 0.50, or 0.25 for endogenous latent variables in the structural model can, as a rule of thumb, be described as substantial, moderate, or weak, respectively" (p. 147). The effect sizes (f^2) reveal the influence of each predictor construct on its respective endogenous construct and emphasize the small (0.02–0.15), medium (0.15–0.35) or large (above 0.35) effect (Cohen, 1988).

Figure 1. Structural model



Source: Authors

The structural model in PLS-SEM was assessed using the path coefficients (*ß*), the t-values (*T*), the *p*-values (*p*), the coefficient of determination (R^2) and the effect size (f^2). The results are summarized in Table 4. Servicescape has a positive and significant impact on perceived quality (*ß* = 0.271, $p = 0.027$), with a small effect size, and the model explains 55.4% of the variance in perceived quality. Socialscape also has a positive and significant impact on perceived quality (*ß* = 0.506, $p < 0.001$), with a larger effect size compared to servicescape, which further supports the robustness of the model for perceived quality. Perceived quality has a significant effect on value for money (*ß* = 0.584, $p < 0.001$), with a large effect size, and the model explains 34.1% of the variance in value for money. Value for money has a positive and significant effect on satisfaction (*ß* = 0.536, $p < 0.001$), with a large effect size, explaining 28.8% of the variance in satisfaction. Satisfaction shows a very strong and significant impact on loyalty (*ß* = 0.811, $p < 0.001$), with the highest effect size among the relationships examined, and the model explains 65.7% of the variance in loyalty.

In summary, all hypothesized paths are supported, indicating that the constructs in the model are well connected and the overall model exhibits good explanatory power. Servicescape and socialscape have a positive effect on perceived quality, which in turn influences value for money. Value for money has a positive effect on satisfaction, which ultimately leads to higher loyalty. The R^2 values indicate that the model explains a substantial amount of the variance in the dependent variables, especially for loyalty. The effect sizes demonstrate the strength of the individual relationships within the model, ranging from small to large effect.

Table 4. Structural model assessment: hypotheses testing

Path	ß	T	*p*	Support	R²	f²
H1: Servicescape -> Perceived quality	0.271	1.925	0.027	Supported	0.554	0.055
H2: Socialscape -> Perceived quality	0.506	3.806	0.000	Supported		0.190
H3: Perceived quality -> Value for money	0.584	8.945	0.000	Supported	0.341	0.517
H4: Value for money -> Satisfaction	0.536	6.578	0.000	Supported	0.288	0.404
H5: Satisfaction -> Loyalty	0.811	24.101	0.000	Supported	0.657	1.915

Source: Authors

Discussion

The study reveals the overall experience of craft beer that can serve as success criteria for creating a unique gastronomic experience in the Republic of Serbia and other destinations. It was found that beer experience has a positive but the lowest impact on perceived quality, which is confirmed by previous research, bearing in mind that craft beer consumers have specific characteristics and motives based on whether or not they had ever experienced craft beer (Kraftchick et al., 2014; Aquilani et al., 2015; Gómez-Corona et al., 2016; Betancur et al., 2020). Therefore, the study emphasizes the need to evaluate the craft beer experience taking into account the socialscape and value for money, all in terms of satisfaction and loyalty. Consequently, based on the conducted findings, two implications emerge. First, the study corresponds to the findings of previous research studies of the craft beer market, that perceived quality and value for money are very important to craft beer consumers within the servicescape and social landscape, since consumers vary significantly in and react differently to the perception of the value of a brand (Orth et al., 2004). Second, value for money, together with perceived quality, affects consumer satisfaction and loyalty konzumenata (Howat & Assaker, 2013; Donadini & Porretta, 2017), highlighting the new consumption trend in order to satisfy the new needs and preferences of beer consumers (Aquilani et al., 2015). The results that indicate that servicescape and socialscape influence the perceived quality of consumers, additionally confirm the need for further strategies for the development of loyalty and satisfaction.

In addition to the above, the study identified characteristics specific to the researched region that affect satisfaction and locality. With consumers of craft beer in the Republic of Serbia, attributes such as the decision to consume craft beer and the level of satisfaction have a positive effect on the spread of positive thoughts about craft beer and repeated consumption. However, perceived quality may also depend on the region in which it is measured. The natural and cultural component of the researched environment is the most affected by this, since it, in contrast to the social component, cannot be built in a short period of time. This is in line with Hassler and Kohler's (2014) argument that some parts of the environment (such as social) can adapt to change while natural and cultural must evolve and grow over time.

Conclusions

The research confirms the existence of a clear correlation between social scape and servicescape and their impact on satisfaction and loyalty through value for money. Experiences with the consumption of craft beer should be developed and marketed, considering that they can positively influence the perceived quality and satisfaction and loyalty of the entire community. Therefore, it is important to regulate the further direction and strategy of developing the quality of craft beer.

This study has certain limitations because of the sample that was employed, the small number of questionaires that were conducted, and the confined location in which they were conducted.

As this topic covers various aspects: Market trends, consumer preferences, economic aspects, impact on the local community, regulations and laws, sustainability and environmental aspects as well as cultural and social impacts. Each of these areas offers room for further analysis and research that will help to improve knowledge and practices related to craft beer production. The beer festivals organized in our country are the only way to promote this type of beer, which proves to be insufficient. In addition, great attention should be paid to environmental sustainability and reducing the ecological footprint through recycling and efficient use of resources. As craft breweries are constantly working to innovate production techniques and ingredients, educating consumers about the different styles of beer and the quality of beer will also be key to further growth. There is no question that the craft beer industry in the Republic of Serbia has great potential for further growth and development, overcoming the existing challenges and taking advantage of the new opportunities that are increasingly available on the market.

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Conflict of interests

The authors declare no conflict of interest.

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THE IMPACT OF RAKIJA CULTURAL HERITAGE AND RAKIJA MARKETING ON THE CONSUMER PURCHASING DECISIONS

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A B S T R A C T

This is the first study on the tradition and cultural heritage of the rakija market based on consumer behavior analysis. The primary objective is to investigate the impact of cultural tradition on consumer behavior regarding the purchase of rakija, the national alcoholic beverage of Serbia. The secondary objective of this research is to measure the magnitude to which the marketing program of distilleries influences consumers' purchases of rakija. The research data were collected in Serbia from December 2023 to March 2024 utilizing a survey approach. Electronic data collection was carried out through an online questionnaire. The study sample comprised 608 valid respondents (n=608) who were chosen randomly. Traditional cultural heritage affects the purchase of rakija; however, the UNESCO recognition of šljivovica as part of its intangible heritage list does not. Moreover, the marketing program of distilleries affects the purchase of rakija. However, the effect sizes of these phenomena are insignificant.

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Introduction

In this study, we aim to answer the following questions: Are cultural tradition and marketing important factors in consumers' decision to purchase traditional alcoholic beverages? Who takes precedence in the purchase of traditional alcoholic beverages, marketing or cultural traditions? How significant are these variables, and how much do they influence the purchasing decisions of rakija consumers? Does the recognition of rakija by UNESCO as part of intangible cultural heritage also have an impact on purchasing decisions?

To the best of our knowledge, no previous research has explored this aspect of influence on purchasing decisions and quantities purchased by consumers of alcoholic beverages in Serbia. This study fills the identified gap in academic research, which is the main contribution of this work. Following the introduction, we will present findings from the literature to establish our research hypotheses. We will then present the results of our survey titled "Consumer attitudes about rakija." Through inferential statistical analysis, particularly regression analysis, we have obtained results that confirm two hypotheses and refute one. The paper concludes with a summary and suggests potential future avenues of research.

Literature Review

Rakija, also referred to as rakia or schnapps, is a spirit-based beverage that holds significant cultural and traditional value in Serbia (Nikićević, 2021). Specifically, šljivovica, a plum spirit or plum brandy, is widely recognized as a national Serbian beverage. However, other types of fruit spirits are also commonly distilled. The consumption of rakija is intimately intertwined with the daily lives of people residing in Serbian villages (Kerewsky-Halpern, 1984). Unlike wine, which is primarily associated with religious ceremonies, rakija is endowed with unique attributes that hold significant cultural value. The sentiment expressed by the Serbian people is that rakija is an integral part of their existence because it is consumed during pivotal life events such as birth, marriage, and death. Recently, the UNESCO World Heritage List expanded to include Serbian plum rakija šljivovica. This traditional plum brandy was recognized as intangible cultural heritage by UNESCO under the name "Social practices and knowledge related to the production and use of traditional plum brandy – šljivovica" at the end of 2022 (UNESCO, 2022).

In 2023, 953 producers of rakija were registered in Serbia, according to data obtained from the Ministry of Agriculture (BBC News na srpskom, 2023). Approximately 50 million liters of rakija are estimated to be produced in Serbia, with approximately 80% of the market operating illegally (Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia, 2020). Despite the significant number of registered distilleries, the export of spirits from Serbia remains relatively low, with only 2.823 million liters of spirits valued at $14.5 million being exported. In contrast, the value of imported strong alcoholic beverages into Serbia surpasses the aforementioned export value, amounting to 3.442 liters of strong alcoholic beverages valued at $15.5 million (Info Press, 2020). Rakija was primarily exported to neighboring countries such as Montenegro and Bosnia. In contrast to rakija, the French cognac, with which Serbian distilleries prefer to compare their products, exhibits a pronounced inclination toward exportation. In 2016, an overwhelming majority (over 97%) of this particular beverage was consumed on an international scale, with its distribution spanning 159 countries (Carew et al., 2017). In contemporary times, despite Serbia's prominent position as one of the leading plum producers globally, the exportation of Serbian plums and plum-derived products remains inconsequential (Matković, 2015). Consequently, it is unsurprising that the acreage dedicated to plum cultivation in Serbia has been experiencing a decline (Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia, 2019).

Despite the presence of a thousand officially recognized distilleries and a multitude of pot stills operated by small-scale producers, the rakija industry in Serbia is not financially lucrative, and only a limited number of brands are available on the market (Adžić, 2021). Furthermore, Adžić (2021) posits that the primary challenge in the marketing of rakija is the establishment of unrealistically high prices beyond the purchasing power of consumers, resulting from an unfounded belief that rakija is on par with the highest quality of strong alcoholic beverages. Distilleries face challenges in selling their products despite their belief in their quality. The chemical and sensory analyses carried out by Mrvčić et al. (2021) emphasized that there are rakija derived from traditional production methods that lack sufficient understanding of production technologies and fail to maintain adequate control over fermentation and distillation processes. To establish a strong position in the market, it is essential for the product to demonstrate high quality (Adžić, 2023). However, a mere 25.96% of the 104 distillers surveyed adhered to modern and scientifically accepted processes in rakija production (Adžić et al., 2023). The research findings also indicate that only 3.85% of distillers in the Serbian rakija industry effectively utilize all four elements of the marketing mix in their business operations, indicating a lack of mastery of marketing strategies. Interestingly, those distillers who have successfully implemented these strategies have managed to command higher prices for their products. Based on the rakija price list provided by a prominent distributor in the Serbian market (*SUPERNOVA • Import and Distribution of Wine, Spirits and Equipment*, 2024), the average price of rakija stands at 6,180 RSD (approximately $57), with a 95% confidence interval ranging from 2,586.78 to 9,772.88. The median price of rakija is reported to be 2,832 RSD (approximately $26), with a price range spanning from 1,320 to 70,488 RSD.

Drinking has been linked to a conventional way of life among individuals of varying genders and age groups and is commonly viewed as a source of pleasure and relaxation. Despite individuals possessing a certain perception of their health identity in relation to alcohol consumption, the consumption of alcohol in diverse social contexts has resulted in the emergence of distinct and conflicting drinking identities. Certain social events or gatherings are associated with higher levels of alcohol consumption than others are.

Typically, occasions that involve drinking with other adults tend to necessitate greater alcohol consumption, as individuals strive to be included in social groups (Gregory-Smith & Manika, 2017). Social norms exert a significant influence on consumer behavior (Melnyk et al., 2022). The impact of social and cultural norms on behavior that is deemed acceptable remains consistent across different times and cultural contexts. However, it is noteworthy that the influence of norms on behavior that is considered unacceptable has intensified over time, particularly in societies characterized by a focus on survival and adherence to traditional values. There are two main rationales behind the consumption of alcohol (Pettigrew & Charters, 2010). First, it serves as a means of celebration, fostering stronger social bonds within a community. Second, it enables individuals to express their social status and position through their choice and consumption of beverages. Local brands are deemed more suitable for consumption at home due to their affordability and less prestigious image.

Subsequent studies on classical conditioning should focus on comprehending the domains in which the principles of classical conditioning are applicable in practical contexts, thereby enhancing its external validity. The concept of involvement has gained significant attention in consumer behavior research (Rahman & Reynolds, 2015). Involvement refers to an individual's perception of the relevance of a consumption object, which is based on their inherent needs, values, and interests. When consumers perceive a product as addressing or corresponding to something of substantial value or fundamental importance in their lives, they become "inolved" with the product. The level of involvement a consumer has with a product influences their decision-making processes, leading to variations among individuals. In light of the diminishing significance of national borders and the erosion of traditional cultural boundaries, the inclination of consumers toward specific alcoholic beverages seems to be less influenced by longstanding regional customs and more by the increasing acceptance of cultural transformation (Smith & Mitry, 2007).

The contemporary marketing philosophy is centered on the concept of value; however, the existing marketing theory that elucidates value from the consumer's perspective is restricted (Tanrikulu, 2021). The theory of consumption value is a marketing theory that offers a profound understanding of the driving forces behind consumers' consumption behavior through consumption values. While personal-based values are instrumental in establishing a connection between the motivation for purchasing and the personal values of consumers, the supplementary value (such as expositional, religious, cultural, etc.) that is contingent upon the particular nature of the product under investigation is equally significant. Rakija is a culturally endorsed national alcoholic drink in Serbia that should have a major effect on its consumption and sales. Therefore, we established the following hypotheses for further statistical analysis:

H1: Traditional cultural heritage significantly affects the purchase of rakija.

H2: The UNESCO recognition of šljivovica as part of its intangible heritage list significantly affects the purchase of rakija.

The dominant alcoholic brands in the current market have cultivated strong consumer loyalty through years of reputation building (Gordon, 2003). In addition to these major brands, there are niche products available to cater to the preferences of connoisseurs. Consumers today have a wide range of brands from which to choose, catering to various tastes and budgets. However, consumers may face difficulty in distinguishing between brands, making the power of persuasion through promotion a significant influence on their choices. As a result, a complex and sophisticated consumer marketing industry has emerged. Under the broader category of marketing costs, two key components can be identified. First, there are costs associated with brand development, encompassing product marketing activities such as advertising, promotion, public relations, and other paid-for initiatives aimed at influencing demand. Second, there are costs related to channel management, which involves selling and distribution. This category encompasses the entire infrastructure required to drive products through the distribution chain and reach consumers. The alcoholic beverage industry commonly distinguishes between two channels known as on-premises and off-premises trades (Gordon, 2003). The on-premises trade involves consumption in establishments such as pubs, hotels, and restaurants, while the off-premises trade pertains to retail outlets such as supermarkets and other stores. Successful international drink marketers possess channel capabilities that enable them to bring a diverse portfolio of brands to the market, each with a distinct positioning. These marketers effectively execute the brand message at the point of sale.

Gaining insight into consumer preferences is crucial for the development of a prosperous product (Palma et al., 2018). However, it is important to acknowledge that preferences vary among individuals. Sociodemographic characteristics exhibit limited correlation with preferences. Instead, the recommendations provided by friends and critics hold significant value for the majority of consumers. Surprisingly, a higher alcohol concentration does not carry a negative perception. Discounts effectively capture the attention of most consumers. Furthermore, the impact of price on the probability of choice is generally negative, albeit occasionally uncertain (Palma et al., 2018). The Vodka consumer attitude and purchasing behaviors study (Prentice & Handsjuk, 2016) aimed to examine the relationships between various marketing factors and the purchasing behavior and brand preference of Vodka in the Australian market. The factors under investigation included branding, country of origin, packaging, and social media. The findings of this study suggest that marketers should allocate additional resources to establishing a strong brand image, enhancing brand awareness, and fostering positive brand perceptions. The results indicate that branding significantly influences consumers' attitudes toward Vodka, their brand preference, and their frequency of purchase.

Verdonk et al. (2017) proposed a theoretical framework for understanding the factors that influence the purchasing preferences of sparkling wine, particularly that of champagne. It posits that personal taste, guidance from trusted sources such as family, friends, and wine salespersons, expert reviews, brand image and reputation, country or region of origin, price, consumption occasion, the nature of the company at the occasion, and gift purchasing all play significant roles in shaping consumer choices in this domain. By examining these various dimensions, this model aims to provide a comprehensive understanding of the complex decision-making process involved in the selection of sparkling wine products. The findings from a focus group study revealed that convenience played a crucial role in the wine purchasing behavior of participants, with price serving as a key guiding factor (Weightman et al., 2019). Price is a significant factor for consumers in determining the quality of a product and is considered one of the primary drivers of purchase decisions. Hlédik and Harsányi (2019) recognized three significant contexts for alcohol buying, namely, everyday consumption, special occasions, and gifts.

The beverage industry offers consumers an extensive selection of choices compared to many other fast-moving consumer goods categories (Gordon, 2003). Consumers today rely heavily on brands when making choices, as brands provide reassurance regarding the origin and quality of products, ultimately guaranteeing satisfaction. Consequently, the brand itself often becomes the primary basis for consumers to choose one product over another. Alcohol pricing is widely recognized as a potential mechanism influencing levels of alcohol consumption. In light of the expenditure survey conducted by Lu et al. (2017), an average price was calculated assuming that 86 percent of the expenditure was derived from promotional items and 14 percent from nonpromotional items. This average price was subsequently utilized in the computation of expenditure from these models. It is noteworthy that the introduction of a promotion invariably results in increased purchasing of alcohol for the specific product in question, both in terms of units purchased and expenditure.

Advertising plays a significant role in the marketing of alcoholic beverages, exerting a formidable influence on a diverse range of consumers across multiple locations (Frank Amoateng & Kofi Poku, 2012). Since 1971, there has been a significant surge of over 400% in total expenditures on alcoholic beverage advertising in the United States (Wilcox et al., 2015). The advent of new media platforms, such as social networking sites, has significantly transformed the media landscape (Moraes et al., 2014). Word-of-mouth/mouse (WOM) continues to be the most influential promotional tool, with recommendations from acquaintances or influencers serving as a potent marketing weapon (Kaikati & Kaikati, 2004). Currently, social networks have emerged as the prevailing means of communication in the field of alcoholic beverage marketing (Atkinson et al., 2021). These platforms have facilitated a multitude of communication practices that allow for interactions between multiple individuals, thereby leading to a substantial rise in the exposure of young individuals to pro-alcohol consumption messages. Consequently, the boundaries between content generated by alcohol brands, nightclubs, and consumers have become increasingly indistinct. Our objective is to assess the effectiveness of marketing programs and distilleries activities in Serbia in relation to sales outcomes, considering factors such as branding, distribution, pricing, and promotional efforts.

H3: The marketing program of distilleries significantly affects the purchase of rakija.

Materials and methods

The primary objective of this study is to investigate the impact of cultural tradition on consumer behavior regarding the purchase of rakija, the national alcoholic beverage of Serbia. To achieve this objective, a research scale approach was utilized. The brand preference scale employed in the aforementioned Prentice and Handsjuk (2016) study was modified for this research to ascertain the preference for rakija due to its traditional cultural heritage. The newly modified RPS was labeled the Rakija Preference Scale (the RPS scale is shown in Table 1). The purpose of the new scale is to test H1: Traditional cultural heritage significantly affects the purchase of rakija. The UNESCO Pride Scale, labeled UP, consists of three questions and was specifically designed for this study (scale UP in Table 1). The purpose of this scale is to examine the H2 hypothesis: The UNESCO recognition of šljivovica as part of its intangible heritage list significantly affects the purchase of rakija.

The secondary objective of this research is to measure the magnitude to which the marketing program of distilleries influences consumers' purchases of rakija. For this purpose, the marketing scale, referred to as the MKT, was developed. It comprises six Likert-type questions. According to Gordon (2003), three variables are associated with product marketing activities: brand, advertising, and price. The other three variables are related to channel management, with a focus on two off-premises activities and one on-premises activity carried out by distilleries. The purpose of this scale is to assess H3: The marketing activities of distilleries significantly affect the purchase of rakija.

Table 1. Research scales

RPS	**Rakija preference scale** *(Cronbach's Alpha = .879)*
RPS1	I would choose this rakija over any other available alcoholic beverages
RPS2	I am willing to recommend others to purchase rakija
RPS3	I intend to purchase rakija in the future
UP	**UNESCO pride scale** (*Cronbach's Alpha = .835*)
UP1	I am proud that rakija is our national drink
UP2	Rakija is a very important part of our culture
UP3	I am proud that šljivovica has been protected by UNESCO
MKT	**Marketing scale** (*Cronbach's Alpha = .648*)
MKT1	The brand is important to me when choosing rakija
MKT2	Advertising has a lot of influence on the choice of rakija that I drink
MKT3	I buy rakija in specialized stores
MKT4	If I don't find the rakija I want to buy, I will leave the store
MKT5	I choose bars that pour my favorite rakija
MKT6	What matters to me is the price of rakija

The study data were gathered in Serbia between December 2023 and March 2024 through a survey method. A random selection was made for the research sample to ensure a representative group of participants. The survey was carried out anonymously, and participation was voluntary. A total of 620 people completed the online questionnaire entitled Consumer attitudes about rakija. Twelve underage respondents were automatically excluded, resulting in a valid sample of 608 ($n = 608$). Data collection was performed electronically using a questionnaire created with Google Forms. Prior to taking part in the study, all participants provided their consent for the use of the collected data for academic purposes in the development of a scientific paper. Participant attitudes and opinions were assessed on a scale from one to seven, where one indicated complete disagreement and seven indicated complete agreement. Descriptive statistics and parametric methods were employed in the data analysis, which was conducted using SmarPLS version 4.1, JASP version 0.18.3, and SPSS version 25.

Results

In the sample, the number of female participants exceeded that of male participants, with 328 female participants or 54% compared to 279 male participants or 46%. The average age of the participants, ranging from 18 to 77 years, was 42.45 years, with a median of 44. The majority of the participants (490 or 81%) were employed. In addition, a significant majority of the participants (476 or 79%) had a college degree. The vast majority of the participants lived in urban areas (522 or 86%). Therefore, it was expected that only 15% or 90 participants would be engaged in agriculture. Of the 608 participants, 93 or 15.30% did not consume alcohol. Since the focus of the study was on the attitudes of rakija users, we thanked this group of participants and did not ask further questions. Among the remaining 515 participants, 120 or 23.30% did not consume rakija, so they were not asked about their attitudes toward rakija. However, as nonconsumers may buy a bottle of rakija as a gift, they were asked questions about prices and the quantity of rakija purchased. Of this group of participants, 363 or 71% buy rakija, while 148 or 29% do not. Finally, the final number of rakija users decreased from 608 to 395 participants. Among these rakija users, 56 or 14.18% of the participants did not like rakija as a drink even though they consumed it.

The mean monthly consumption of rakija among the participants was 0.58 liters ($SD = 0.965$), while the average consumption of other brandies was 0.20 liters per month ($SD = 0.356$). A total of 19.7% of rakija users preferred other strong alcoholic beverages to rakija. Moreover, the respondents consumed an average of 2.98 liters of beer monthly ($SD = 6.095$) and 1.23 liters of wine ($SD = 2.063$). Approximately one-third of the rakija drinkers preferred beer to rakija, accounting for 35.2%, while nearly half of the rakija consumers preferred wine to rakija, representing 48.4%. In comparison to fruits from which respondents most prefer to drink rakija, plum stands out at 41.8%. In second place was quince at 16.2%, followed closely by apricot at 15.4%. The fourth and fifth most common fruits were pears (10.4%) and grapes (4.3%), while the remaining 11.9% of respondents preferred one of the other 32 fruits offered in the survey questionnaire.

The vast majority of rakija users, 93.7% of all respondents, or 370 out of 395, preferred homemade rakija. Approximately half of the participants, 170 or 43%, distilled and consumed their own rakija. A little over a quarter of the respondents, 113 or 28.6%, purchase rakija from retail stores. Consequently, only 106 or 26.8% of the participants had a favorite brand of rakija, while almost three-quarters of the respondents, 289 or 73.2%, did not have a favorite brand. On average, rakija users who recognized brands bought their last bottle of rakija 6 months ago, with a median of 2 months. The highest frequency of individual brand names in response to the question "What is your favorite brand of rakija?" is five ($n = 129$), indicating that no brand stands out. The broader group of rakija users ($n = 393$) purchased their last bottle of rakija 10 months ago, with the same median of 2 months as in the narrower group of branded rakija users. On average, alcohol beverage consumers buy 7.36 liters of rakija annually ($Mdn = 3$), while they receive 7.41 liters of the same beverage as a gift ($Mdn = 5$).

Participants were surveyed regarding the context in which they purchase rakija. Responses were rated on a scale ranging from one to seven. Two final results had mean scores that surpassed the average, while one result fell below it. The mean score for the variable gift was the highest at 5.22, followed closely by the variable special occasions at 5.18. Interestingly, the variable everyday consumption had the lowest mean score of 2.64. Quality is of great importance to rakija users, who rate it at 4.63 out of 5, while they rate the quality of rakija on the Serbian market notably lower at 3.74 out of 5. According to a survey conducted among 490 alcoholic beverage consumers, it is believed that the average fair price for a bottle of rakija in retail should be 1,518 RSD ($Mdn = 1200, SD = 1995.732$). On average, respondents would not purchase rakija if it was priced below 884 RSD ($Mdn = 700, SD = 808.212$) due to concerns about its quality. However, the maximum average price at which respondents would not be willing to pay for rakija is 3,495 RSD ($Mdn = 2500, SD = 3494.866$).

Finally, we will highlight the most interesting comments from the participants that we asked to provide in the last, open-ended question of the survey. One respondent insists that "tradition should be preserved," while another believes that "all of our rakija are strong, or pungent, other strong alcoholic beverages have alcohol but are easier to drink." One participant claims that "rakija is much better and healthier than any other alcoholic drink, it is natural, especially if we make it ourselves," while another participant has a completely opposite view that "rakija is so rarely good that I almost always refuse it on every occasion." Two participants in this survey have very similar attitudes toward homemade and industrial rakija. The first stated, "I prefer homemade rakija and usually consume it in restaurants. I buy rakija as a gift, most often from trips," while the second stated, "I always buy rakija at the market, homemade, from the same people when it is for me (home, guests, etc.). I occasionally buy branded rakija in stores for gifts, but for my own consumption, only homemade rakija." Also interesting is the critical attitude of this participant:

> *You are pushing brands and stories about them, and I do not believe in them, and generally, people do not believe. I buy rakija from well-known domestic producers (peasants), usually after tasting. I produce part of the rakija*

> *when there is time for it. Industrial rakija repels me, and I often do not trust small producers who have expanded and branded production because by standardizing and technological processes they lose authenticity, the rakija becomes too standardized in taste, industrially "fine" and seems processed.*

Common method bias can occur when the same measurement method is used to evaluate both the independent and dependent variables. The negative effects of common method bias are especially noticeable when self-reported data collection methods are employed, particularly in sensitive research areas such as alcohol consumption (Kock et al., 2021). To assess the honesty of respondents, specifically whether they provided automatic responses to Likert-type questions in these self-administered surveys, Harman's single-factor test was conducted. Principal axis factor analysis with a fixed factor to one produced a result of 25.187%, indicating that a single factor explains 25.187% of the variance in the data, which is below the 50% threshold (Aguirre-Urreta & Hu, 2019). This discovery implies the absence of common method bias. Furthermore, the reliability of all the scales for further statistical analysis was confirmed by the Cronbach's alpha values exceeding .06 (Ahdika, 2017), as presented in Table 1.

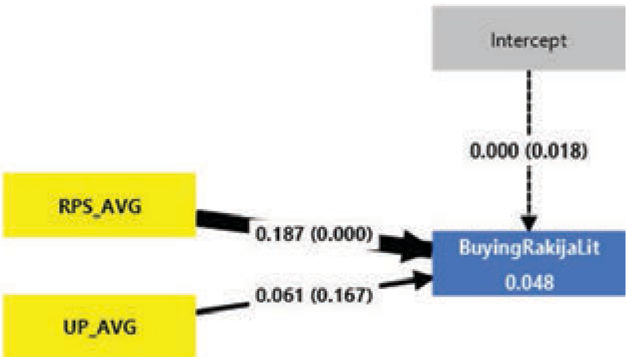
The mean score for all scales utilized in this study was computed. The UNESCO pride scale (UP_AVG) recorded the highest mean of all scales, 6.23 ($SD = 1.159$), which was very close to the maximum score of seven. The rakija preference scale (RPS_AVG) also achieved an above-average result, with a mean score of 4.74 ($SD = 1.692$). The mean score of the marketing scale (MKT_AVG) was 3.49 ($SD = 1.104$), which falls close to the middle of the scale.

A series of independent-samples t tests were conducted to compare the mean scores of all computed scales between rakija consumers who like rakija ($n = 338$) and rakija consumers who dislike it ($n = 56$). A design consisting of two groups with sample sizes of 338 and 56 can detect a medium effect size ($d = .50$) with a power of at least $1 - \beta = .933$, assuming an error rate of $\alpha = .05$ (two-sided). None of the tests revealed statistical significance at the .05 level, i.e., for UP_AVG $t(392) = -0.370, p = .711$, for RSP_AVG $t(392) = 0.683, p = .495$, or for MKT_AVG $t(392) = -0.370, p = .675$

However, the results of a series of independent-samples t tests conducted to compare the mean scores of all computed scales between the group of participants who purchased rakija ($n = 306$) and the group of participants who did not purchase rakija ($n = 89$) were quite different. A design consisting of two groups with sample sizes of 306 and 89 can detect a medium effect size ($d = .50$) with a power of at least $1 - \beta = .985$, assuming an error rate of $\alpha = .05$ (two-sided). We are more likely to miss (power less than 50%) effect sizes less than $d = .237$. The Brown-Forsythe test of equality of variances was not statistically significant for any of the dependent variables. The t test was significant for the composite average results of the UNESCO pride scale (UP_AVG) $t(393) = 1.976, p = .049$. The effect size of the mean difference of 0.275 was small, $d = .238$. The composite average results of the rakija preference scale (RPS_AVG) also yielded a significant t test $t(393) = 5.370, p < .001$. The effect size of the mean difference of 1.057 was between medium and large, $d = .670$. Finally, the t test was also significant for the composite average results of the marketing scale (MKT_AVG) $t(393) = 4.460, p < .001$. The effect size of the mean difference of 0.579 was medium, $d = .537$. On average, the participants who purchased rakija had more positive attitudes toward tradition and marketing than did those who did not purchase it; these differences in attitudes were statistically significant.

As the test results for the UP_AVG scale are borderline values and as we have specific data on the purchase of brandy products in the sample, we will move on to further analysis. By conducting multiple regression analysis, we test the complex relationships between variables, specifically the impact of multiple factors on the dependent variable, which is the quantity of rakija purchases in liters. Additionally, regression analysis enables the simultaneous testing of multiple hypotheses and the estimation of the influence of each independent variable while controlling for others.

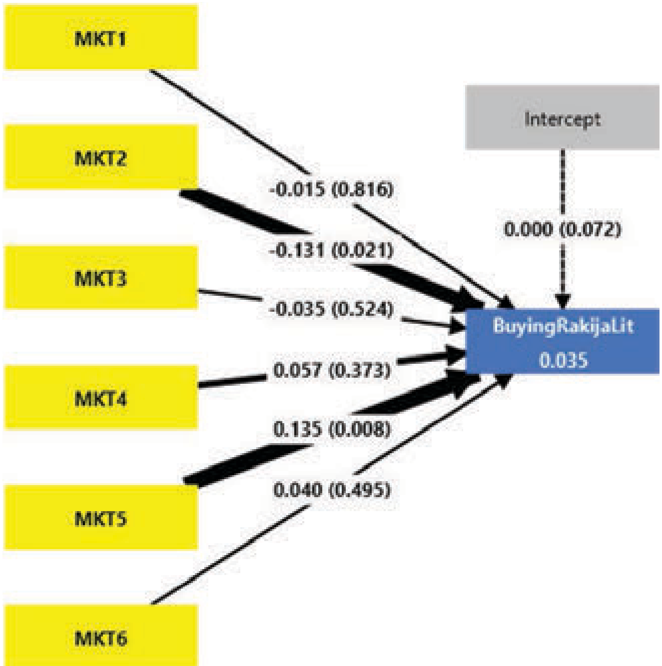
Figure 1. Graphical representation of regression analysis examining the impact of cultural tradition on the purchase of rakija



Multiple regression analysis was conducted to evaluate how well the heritage and origin measures predicted rakija sales (Figure 1). The predictors consisted of the aggregated and averaged values derived from the Rakija preference scale (RPS_AVG) and the UNESCO pride scale (UP_AVG), while the criterion variable was the rakija purchase quantity in liters (BuyingRakijaLit). Given that the significance of the Breusch–Pagan test was less than .001, the regression analysis in SmartPLS 4 was conducted by opting for heteroscedasticity consistent (HC4) standard errors, as suggested by Hayes and Cai (2007). Scatterplots demonstrated linear relationships, indicating that the assumption of linearity was not violated. The Durbin-Watson statistic was used to analyze the residuals. The results were within the acceptable range of 1.50 – 2.50, signifying the absence of autocorrelation in the residuals (Turner, 2020). Moreover, the variance inflation factor (VIF) for each predictor was found to be below the threshold of 5, alleviating any concerns regarding multicollinearity (Hair et al., 2019).

The linear combination of heritage and origin measures was significantly related to the rakija purchase quantity $R^2 = .048, F(2,388) = 9.674, p < .001$. The effect size is fairly poor, and approximately 5% of the variance in rakija sales in the sample can be accounted for by the linear combination of heritage and origin measures. Only the partial correlation between rakija preference and rakija sales was statistically significant, although the size of the associated effect of .187 was small according to Cohen's criteria (Cohen, 1988). Overall, cultural tradition had a tiny positive effect on purchase of rakija. However, only the variable RPS_AVG, which indicates the preference for rakija based on its heritage and origin of Serbian rakija, achieved statistical significance, while the variable UP-AVG, which represents the recent recognition of that heritage and origin of Serbian rakija by an international organization, did not. Therefore, hypothesis H1 (*Traditional cultural heritage significantly affects the purchase of rakija*) is supported, but hypothesis H2 (*the UNESCO recognition of šljivovica as part of its intangible heritage list significantly affects the purchase of rakija*) is rejected.

Figure 2. Graphical representation of regression analysis examining the impact of marketing on the purchase of rakija

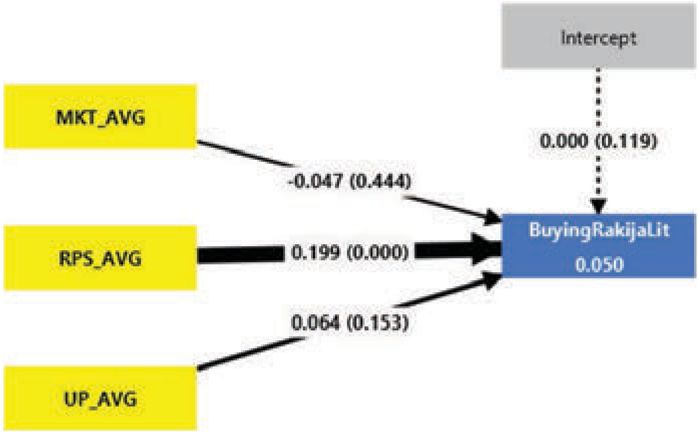


In the multiple regression analysis (see Figure 2), we evaluated the influence of six independent variables ("The brand is important to me when choosing rakija, Advertising has a lot of influence on the choice of rakija that I drink, I buy rakija in specialized stores, If I don't find the rakija I want to buy I will leave the store, I choose bars that pour my favorite rakija, and What matters to me is the price of rakija) on the dependent variable, How many liters of rakija do you buy per year? In SmartPLS 4, regression analysis was performed with the selection of heteroscedasticity consistent (HC4) standard errors due to the statistical significance of the Breusch–Pagan test. Scatterplots revealed linear trends. Additionally, the Durbin-Watson statistic of 2.017 indicated the absence of autocorrelation in the residuals, confirming the independence of the errors. Additionally, the VIF was computed for each predictor, revealing that all the VIF values were below 1.5. This discovery eliminates any worries about multicollinearity among the predictors.

The overall multiple regression was statistically significant ($R^2 = .035, F(6,384) = 2.332, p < .001$). In terms of model fit, the data fit the model poorly. The marketing activities of distillers accounted for only 3.5% of the purchases of rakija. We found that only two of the six independent variables had a statistically significant effect on the purchase of rakija. Advertising (MKT2) had a significant but negative effect, indicating that more advertising activities will decrease the purchase of rakija. The impact of on-premises marketing activities, specifically rakija bars (MKT5), on the purchase of rakija was substantial and held the highest level of influence, although the associated effect size was small. Overall, marketing had a slight positive effect on the purchase of rakija; however, it was solely the on-premises marketing activities that contributed to this outcome. As a result, hypothesis H3 (*The marketing activities of distilleries significantly affect the purchase of rakija*) is accepted.

We were ultimately interested in measuring the effect of all dependent variables together on the purchase of rakija. Analyses and necessary actions were conducted to ensure compliance with the assumptions of normality, linearity, multicollinearity, and homoscedasticity. Multiple regression was used to predict rakija purchases based on the composite average results of the marketing scale (MKT_AVG), rakija preference scale (RPS_AVG) and UNESCO pride scale (UP_AVG). The model was significant, $R^2 = .050, F(3,387) = 6.790, p < .001$, indicating that at least one predictor significantly affects the purchase of rakija (Figure 3). With this combination of influences, only the preference for rakija yielded a statistically significant outcome, despite the small effect size of the beta coefficient at .199. Furthermore, the coefficient of determination, reflecting the collective impact of all independent variables on the dependent variable, is deemed insignificant at .050.

Figure 3. Graphical representation of regression analysis on the influence of all dependent variables on the purchase of sales



Discussions

The statistical findings are very clear; the first and third hypotheses are confirmed, while the second hypothesis is refuted. Traditional cultural heritage affects the purchase of rakija; however, the UNESCO recognition of šljivovica as part of its intangible heritage list does not. Moreover, the marketing program of distilleries affects the purchase of rakija. The influence of tradition embodied in cultural heritage on the sales of national alcoholic beverages deeply rooted in customs is not surprising. Neither is it surprising that marketing affects the sales of brandy products. What is surprising, however, are their minor effects. Nevertheless, our data also unveil the reasons why...

All of our respondents are extremely proud that rakija has been recognized by UNESCO. However, rakija is already a culturally accepted national drink, and this new recognition from an international organization is simply a reaffirmation of its status. This recognition has not influenced changes in old cultural patterns and therefore has not affected consumption. However, in regard to purchasing rakija for personal consumption, the data unequivocally show that rakija is rarely bought for personal consumption. It is mostly purchased as a gift or for special occasions. Additionally, as distilling rakija is a popular hobby in Serbia, the amount received by respondents as gifts without payment exceeds the amount purchased.

Previous analyses have shown that the main issues with rakija are low quality and high prices (Adžić, 2021; Mrvčić et al., 2021). In this study, participants clearly emphasized that the quality of rakija is extremely important to them but also that the quality of rakija in the domestic market does not meet their perception of satisfactory quality. Since almost half of the participants in the sample also made rakija for their own needs, it is clear to them that the highest quality fruit is not used as a raw material for rakija. This fruit is used for further sale, while lower quality fruit is used for rakija production.

Rakija brands on the market are advertised as being made from the best fruit, which is simply not true, as it is not economically feasible. Therefore, only one-fourth of the participants tend toward brands, and no rakija brand stands out in the market. In the words of one participant, “I do not believe in brands and generally, people do not believe.” It is not surprising that 9 out of 10 participants preferred domestic rakija. The majority of participants enjoyed drinking šljivovica.

Local brands of questionable quality, which have not evolved from the commodity brand, communicate with consumers using messages that they significantly do not believe. While price was not significant in the statistical tests, the price of rakija is certainly a determinant of quality (Weightman et al., 2019), and rakija consumers do not have trust in this price. The average price that observers consider fair is not within the 95% confidence interval of the specialized distributor’s prices. Furthermore, the average price of rakija at distributors is nearly twice as high as the maximum price that consumers advise producers. The respondents themselves claimed that “I buy branded rakija in stores occasionally for gifts, but for my own consumption only homemade,” or “I prefer homemade rakija (but) I buy (branded) rakija as a gift, most often from trips.”

The act of giving a bottle of alcoholic beverage is also part of cultural heritage, which is why we interpret that price is not important when making a purchase. Rakija is bought as a gift or for important family occasions, not for personal consumption. Due to the custom of presenting the gift in front of others, there is also a presence of rakija with multiple packages, golden flakes in the drink, and protective packaging made of noble wood on the market. From the marketing programs of manufacturers, only on-premises actions are important, which is also the message to marketing practitioners from this research on which direction to direct their marketing actions. Of course, since only 3.8% of distilleries carry out comprehensive marketing activities in the market (Adžić et al., 2023), it is not surprising that the marketing effect size is only 3.5% in this research. Simply put, what is not there is not seen. Social networks and WOM, which Serbian distilleries have not mastered, are the focus of successful marketing campaigns for alcoholic beverages (eg. Fireball whisky, see Andry, 2021), while the marketing of competition from numerous brands of alcoholic beverages surely occupies a large part of the market share.

In summary, in the majority of cases, Serbs love their rakija and will proudly continue the tradition of consuming it, but they will not buy it. They will distill rakija themselves or with friends and thus carry on the tradition of their ancestors. Like in any traditional society, they find it difficult to accept changes. To them, new rakija brands are novelties that they do not believe in and are not yet ready to accept.

Conclusion

This is the first study on the tradition and cultural heritage of the rakija market based on consumer behavior analysis after UNESCO recognized Serbian rakija šljivovica as an intangible cultural heritage, which is the greatest contribution of this research.

Traditional cultural heritage influences the purchase of rakija; however, the inclusion of šljivovica in UNESCO's intangible heritage list does not have an impact. Additionally, the marketing strategies implemented by distillers also exert a certain degree of influence on the purchase decisions related to rakija. With this study, we also contribute to the limited literature that examines rakija marketing.

We acknowledge the limitations inherent in our study. Specifically, our research solely focuses on rakija and does not provide a comparative analysis with other strong alcoholic beverages. Moreover, this study is limited by the geographical scope of Serbia, which limits its generalizability to other countries. A research design that encompasses a broader spectrum of beverages and markets would undoubtedly stimulate further interest. Consequently, these aforementioned research gaps present opportunities for future research.

Conflict of interests

The authors declare no conflict of interest.

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ECONOMIC ASPECTS OF DIGITALIZATION IN SERBIAN AGRICULTURE: FARMERS' ATTITUDES

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ABSTRACT

One of the ways to achieve economic, environmental, and social sustainability in agriculture is to introduce digitalization in the production process or its digital transformation. The primary research objective in this paper is to obtain empirical knowledge about the various economic aspects of investing in digitalization in Serbian agriculture. The research relies on interviews conducted in the period April-October 2023 using a semi-structured questionnaire, covering a sample of 53 agricultural holdings on the entire territory of Serbia. The results show that the interviewed farm managers do not show a high degree of satisfaction with the achieved level of digitalization on the farms they manage. Nevertheless, based on the analysis of economic parameters of investment in digital solutions (return on investment period, perceived benefits, costs, investment limitations, financial support), the largest percentage of respondents (56.6%) intends to intensify investments in digitalization on their farm in the next period.

Introduction

Agriculture 4.0 represents the fourth agricultural revolution, involving the use of digital technology and becoming an important factor in economic growth and the creation of more resilient, sustainable and environmentally responsible agriculture (Kljajić et al., 2016; Pogorelskaia & Várallyai, 2020; Javaid et al., 2022). What is more, information and communication technologies (acronym ICTs), when applied in agriculture, have an impact on the country as a whole (Sinitsa et al., 2021). Digital technologies rely on the

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use of electronics, robotics, drones, computing devices, genetic engineering and imply intensive use of ICTs and other already existing technologies, such as telephones, television, radio and satellites (Javaid et al., 2022). In general, smart farming is a new trend of services to agricultural producers using digital platforms and integrated ICTs, which reduces production costs and losses, increases productivity and profitability, and boosts competitiveness and farmers' living standard (Jurjević et al., 2019; Latif Virk et al., 2020; Pogorelskaia & Várallyai, 2020; Javaid et al., 2022; Tankosić et al., 2024).

Serbia has very favourable conditions for the development of various types of agricultural products, and the need for digitalization, innovation, modern agro technical solutions and ICTs in agriculture is extremely high (Jurjević et al., 2019; ITU & FAO, 2020). On the other hand, a significant limitation on the road to modernization and digitalization of agriculture lies in fragmented domestic agriculture. Namely, farmers are mostly owners of family farms, most often small-scale farms, with numerous unfavourable structural, production and financial characteristics (Paraušić, Roljević Nikolić & Subić, 2019; FAO, 2020; Paraušić, Subić & Roljević Nikolić, 2021; Jurjević et al., 2022; Kovljenić et al., 2023).

Due to above, innovations and good digitalization practices in Serbian agriculture are not so common (Kljajić, Paraušić & Rodić, 2016; Jurjević et al., 2019; Subić, Kljajić & Jeločnik, 2017; FAO, 2020; ITU & FAO, 2020; Kovljenić et al., 2023). The authors' empirical research shows that agricultural producers have a hard time deciding on the implementation of digital solutions, both because of the high costs of purchasing various digital systems, devices, and equipment, as well as because they do not have enough information about the advantages of their application. A small number of farmers is aware and know what digitalization is and how much it can boost the process of agricultural production. What is more, a large number of farmers are sceptical about innovations if they deviate from production tradition and embedded cultural and social norms.

The research subject in this paper are the views of agricultural farm managers in Serbia on the economic dimension of sustainability of investments in digitalization of agricultural production and business processes. Their perceptions regarding the benefits and costs of digitalization, the limitations they face in this process, as well as their views on the profitability of investments (return on investment period) and financial support (incentives) for these investments are examined. The authors indirectly assess the extent of economic sustainability of investments in digitalization in agriculture through a question about the intensity in which the respondents intend to invest in digitalization on their farms in the coming period.

The research objectives are to obtain empirical knowledge and better understand the economic aspects of digital agriculture (acronym DA) in Serbia, as well as test the possibility and feasibility of undertaking larger and more extensive research in the coming period (Payne & Payne, 2004; Babbie, 2008). The knowledge will be useful both to the scientific community and to farmers and agrarian policy makers. Also, the results will be useful as policy makers to plan future support, both to suppliers of agricultural techniques and ICTs and to their users, i.e. agricultural producers.

Materials and methods

Research on the economic aspects of DA sustainability covered the territory of the Republic of Serbia in the period April-October 2023. It examined the views of farm managers, i.e. *"persons responsible for the daily making and implementation of farm-related production and financial decisions"* (Statistical Office of the Republic of Serbia, 2019). The authors got the managers' contact data (phone numbers, email addresses) from the "Ruma Farmers' Association", which gathers farmers from all over Serbia.

A simple random sample included 53 respondents, and the conditions for participation in the research were as follows: (a) the respondent is a manager of an agricultural holding registered either in the Register of Agricultural Holdings or in the Business Registers Agency; (b) one or more business and production digitalization solutions are applied on the farm managed by the respondent. Respondents (agricultural managers) were from 19 areas on the territory of the Republic of Serbia, which makes the sample representative from a territorial point of view.

Qualitative research was conducted using the interview method and using a semi-structured interview (Kallio et al., 2016). In order to examine the respondents' views on sustainability of investment in business digitalization, a number of questions were designed, and for the purposes of this paper and the analysis of the economic sustainability of investment in business digitalization, only one set of questions (relevant to the subject research) was analysed. The questions were formulated based on an extensive literature review (presented in the introduction of the paper), as well as on the authors' perceptions and experiences related to the research area. Respondents gave some answers in free form, while in some questions they could circle an answer or scale an item on a Likert scale.

The questions in the semi-structured questionnaire, relevant to the subject of the paper, can be grouped into three groups: (1) the first part of the questionnaire included general questions related to the farm (name and seat; business form; number of persons on the farm involved in agricultural production; dominant production line on the farm; number of hectares cultivated on the farm); (b) the second part of the questionnaire asked the respondents to describe the current practice of business digitalization (which DA solutions they use, in which processes, in what percentage, etc.); (c) the third part of the questionnaire included the following questions to assess the economic sustainability of investing in DA solutions: what benefits does the application of DA solutions brings; what costs do you incur when introducing DA solutions; what are the biggest limitations for greater application of DA solutions; in what period can you expect a return on investment in DA solutions; evaluation of the financial support of the line ministry and local authorities for greater application of digitalization in agriculture; assessment of the degree of personal activity (agility) in finding different support programs (EU support, national support programs and the like) for financing investments in DA solutions (self-evaluation); plans for the intensity of future investments in digitalization in relation to the current situation (Scheme 1).

Some respondents were interviewed by telephone, with a conversation lasting 45 to 60 minutes. From other respondents, the answers were collected directly, through direct conversation with the producers. In data collection and analysis, the authors had an objective and unbiased attitude (Payne & Payne, 2004). All answers were summarized, analysed and presented in the form of research results, in tables and graphs. The qualitative content analysis method was used to analyse the responses received in free form (Kuckartz, 2019).

Results and discussion

The research results are presented through the description of the sample structure, and then through the respondents' views on the current application of DA on the farm, as well as the economic sustainability of investing in various digitalization solutions on the farm.

Sample description

The sample includes 53 respondents (agricultural managers on agricultural farms) from 19 areas on the territory of Republic of Serbia (South Banat, North Banat, South Bačka, Central Bačka, North Bačka, West Bačka, Srem, Belgrade, Danube, Pomoravlje, Šumadija, Kolubara, Mačva, Zlatibor, Nišava, Jablanica, Rasina, Raška and Pčinja districts).

All agricultural holdings are registered in the appropriate registers (Register of Agricultural Holdings, Business Registers Agency). According to the legal form, 44 agricultural holdings (83%) are family agricultural holdings, and 7 (13.2%) are companies. The sample includes one entrepreneur, as well as one agricultural cooperative.

According to the surface of land they cultivate (ownership + lease), the largest number of farms own 5-20 ha of land (20 of them or 37.7%). 18 farms (34%) are small holdings (up to 5 ha) and 9 farms (17%) are holdings from 20 ha to 100 ha. A total of 6 farms (11.3%) cultivate 100 ha and more.

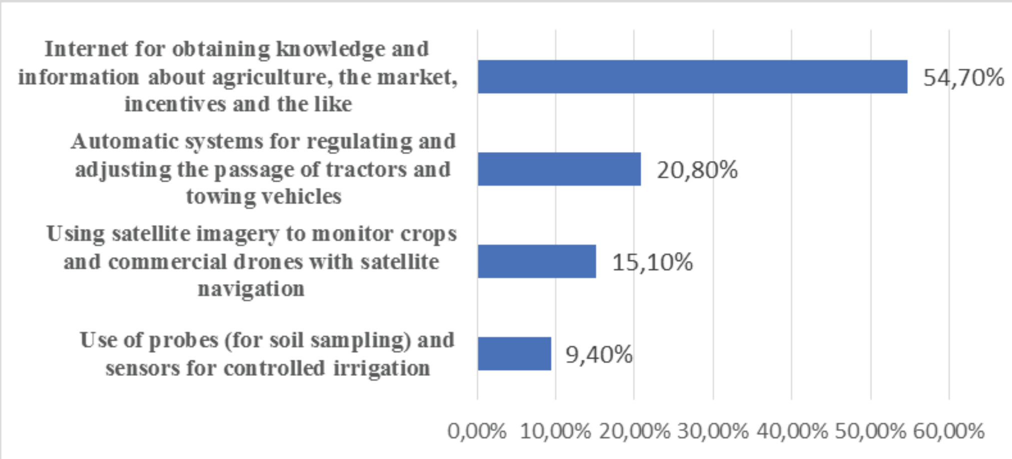
On the largest number of farms (34 of them or 64.2%), up to two people are engaged in the production process, and from 3-5 people on 16 farms or 30.2%.

The largest number of farms (34%) has mixed agricultural production. Crop farming is the dominant type of production in 32.1% of farms, fruit growing and/or viticulture is the dominant type of production in 18.9% of farms, and 15.1% of farms in the sample are predominantly engaged in livestock production.

Application of agricultural digitalization solutions: views of interviewed agricultural managers

The interviewed agricultural managers on the farm apply different digitalization solutions in the process of agricultural production and business. Figure 1 shows digitalization solutions used in absolute numbers and as a percentage. Figure 1 shows that, of the total number of respondents, the largest share (55%) use the Internet in their production to collect information and news about agriculture, the market, incentives and the like. A significantly smaller number of interviewed managers declare that they use some of the more advanced digitalization solutions in their business and production processes (automatic systems for regulating and adjusting the passage of tractors and towing vehicles; satellite images and commercial drones to monitor crops; probes and sensors for soil sampling and irrigation control).

Figure 1. Digital agriculture solutions that agricultural managers use on their farms, answer structure

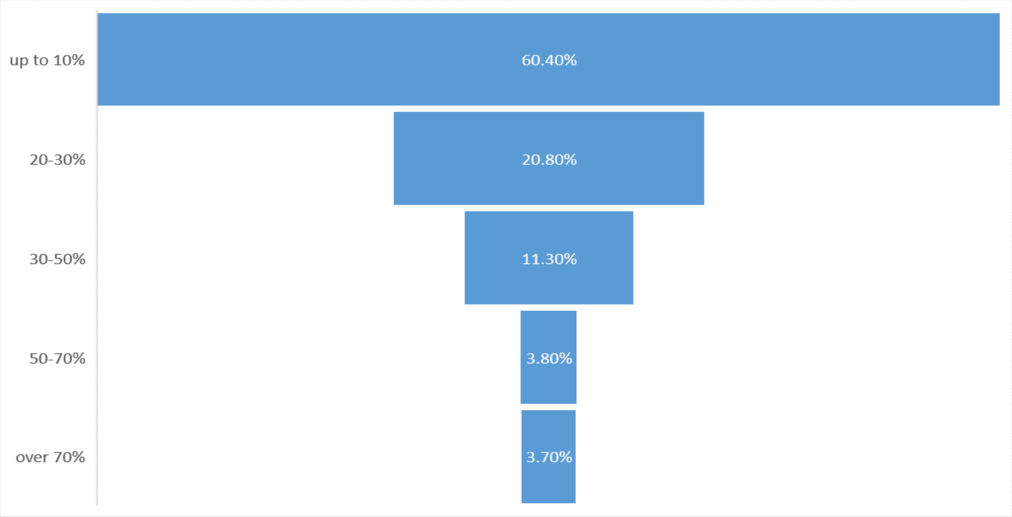


Source: Authors' presentation based on respondents' answers

Khanal & Mishra (2016) state that the Internet is one of the best digitalization options for small agricultural enterprises to collect information related to production and new markets, product sales, e-commerce, communication and social networking, etc. Our producers' practice correlates with this statement. Using the example of small-scale farmers in the USA, Khanal & Mishra (2016, p. 553) indicate that the financial performance (total household income, off-farm income, gross cash income) of small farm business households was higher in the group of farmers who used the Internet, compared to the control group (small-scale farmers who did not use the Internet).

60.4% of respondents have replaced work and production processes by digital agriculture solutions up to 10%. 20.8% of respondents have replaced production processes by digital agriculture solutions from 20-30%, 11.3% of respondents replaced them from 30-50%, while other respondents (7.6%) apply DA solutions in their work and production processes 50- 70% or over 70% (Figure 2).

Figure 2. Replacement of business and production processes in agriculture with digitalization solutions: percentage of responses



Source: Authors' presentation based on respondents' answers

The interviewed agricultural managers emphasize that they mainly apply digitalization solutions in the following business and production processes: (a) soil cultivation, sowing, fertilizing, irrigation and crop protection (dominantly in agriculture and vegetable growing); (b) heating and automatic regulation of ventilation in greenhouses; (c) monitoring of the production process (measurement and supervision); (d) marketing and sales of products; (e) information on the market and subsidies and incentives.

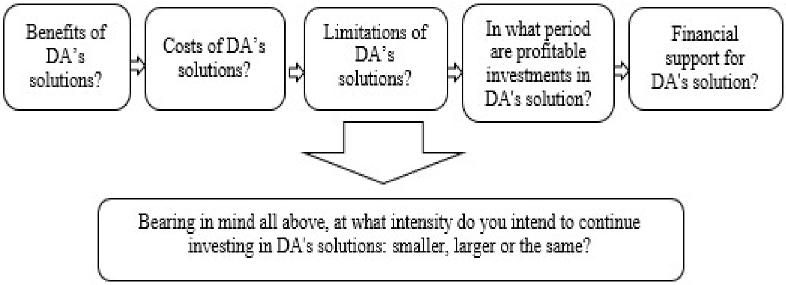
About a third of the respondents (more precisely 35.8%) develop digital solutions by themselves or in cooperation with one of the family members, 30.2% of respondents purchase solutions on the market, while 34% of them combine these two possibilities.

Finally, respondents were asked how they would evaluate the application of digitalization solutions on their agricultural holdings, in relation to the desired state. The following 1-5 response scale was offered: (1) I am not satisfied; (5) I am extremely highly satisfied. The average rating is only 2.5, which indicates that the surveyed managers do not show a high degree of satisfaction with the achieved level of digitalization on the farm. As many as 47.2% of agricultural managers rated 1 or 2, while 52.8% of respondents gave ratings from 3 to 5. The obtained results indicate a pronounced polarity on this issue. At the same time, the average rating of managers' satisfaction with the achieved degree of farm digitalization was not significantly different between the group of 16 large farms, which cultivate 20 and more hectares (average rating 2.7) and the group of 37 small and medium-sized farms that cultivate up to 20 ha (average rating 2.6).

Economic sustainability of investments in digitalization solutions on the farm: views of interviewed agricultural managers

The analysis of the economic sustainability of investments in digitalization on the farm was analysed using a set of questions presented in Figure 3.

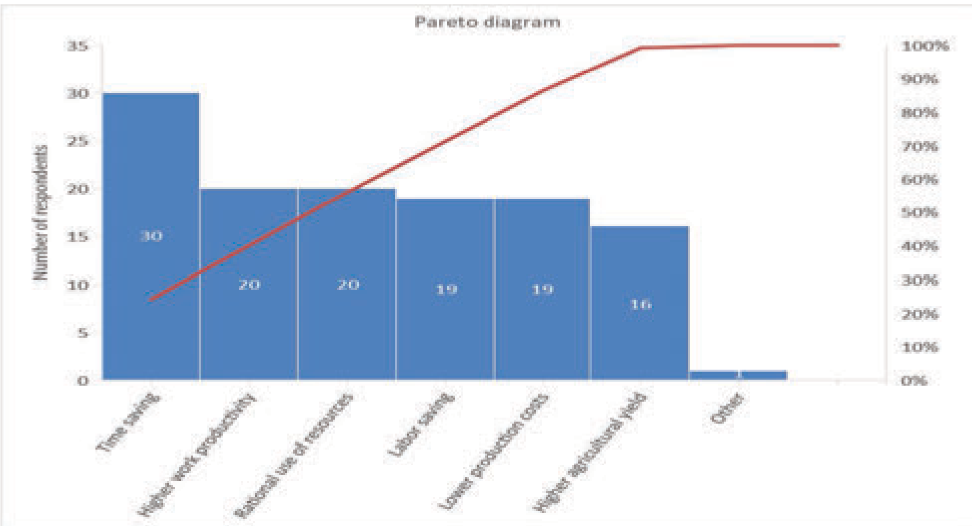
Figure 3. Guide with major issues to be discussed in in-depth interviews with farm managers



Source: Authors' presentation.

When asked what benefits business and production digitalization on the farm brings, the respondents pointed to benefits presented in Figure 4, be they the only benefits or in combination with a set of other benefits. Based on Figure 4, Pareto analysis is useful and indicative due to 80% of the results suggest five main benefits of the digitalization on the agricultural farm (time saving, higher work productivity, rational use of resources, labour saving, and lower production costs).

Figure 4. Benefits of digitalization on the agricultural farm, number and percentage of responses

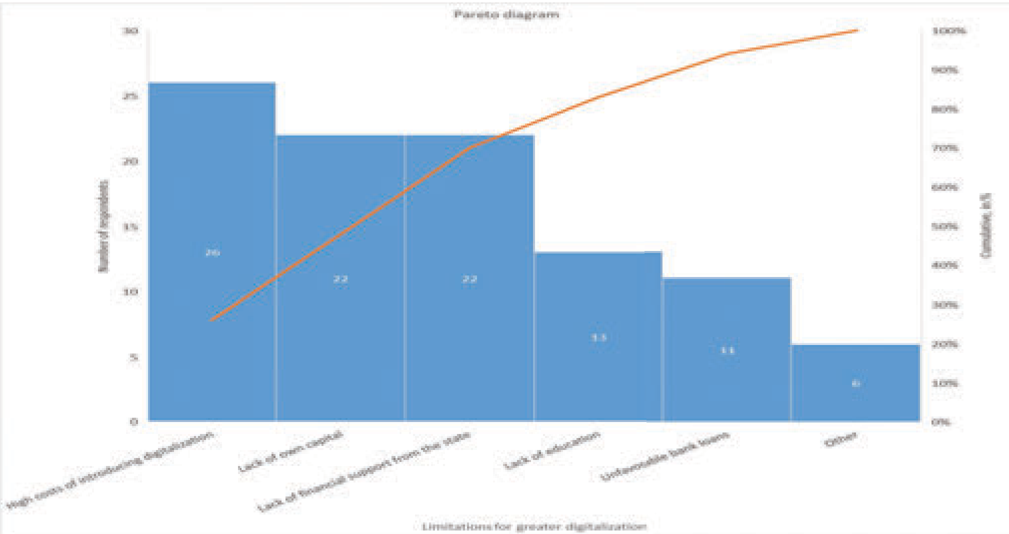


Source: Authors' presentation based on respondents' answers

As for costs that arise when introducing digital agriculture on the farm, respondents mentioned high costs, mainly for: (a) procurement of machinery, equipment, devices, applications; (b) installation of equipment, implementation and maintenance of digital systems; (c) Internet, as well as (d) training to master techniques of managing digitalization devices.

Respondents stated the biggest limitations for greater digitalization on the farm giving answers shown in Figure 4. Respondents pointed to the presented limitations either as the only limitations or in combination with other types of limitations. Based on Figure 5, Pareto analysis is useful and indicative due to 80% of the results suggest four main limitations for greater digitalization on the agricultural farm (high costs of introducing digitalization, lack of own capital, unfavourable bank loans, and lack of financial support from the state).

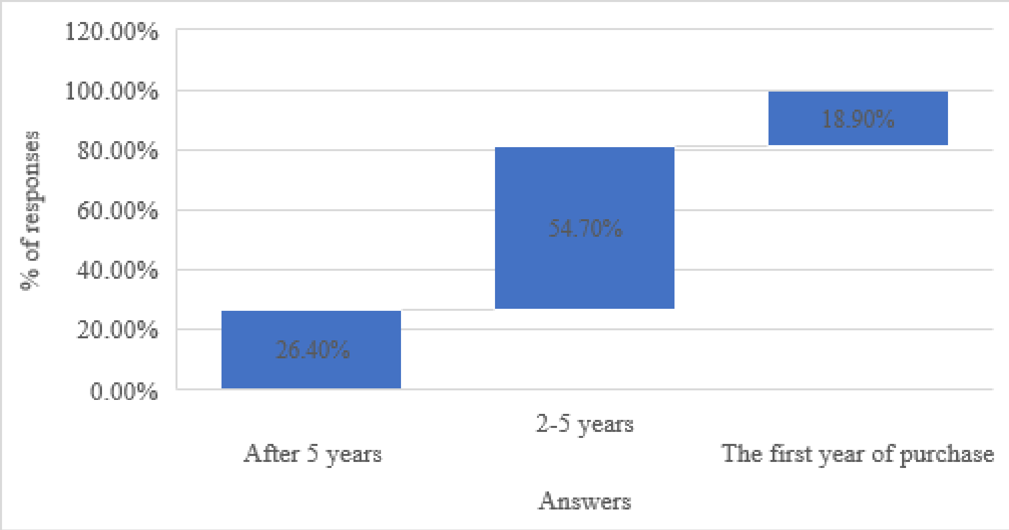
Figure 5. The biggest limitations for greater agricultural digitalization: number and percentage of responses



Source: Authors' presentation based on respondents' answers

For more than half of respondents (54.7%) investment in digitalization is profitable in a period of 2-5 years, for 26.4% of respondents the invested funds return after five years, and for almost 20% of them (18.9%) investment in business digitalization is profitable already in the first year (Figure 6).

Figure 6. Return period of invested funds: percentage of responses

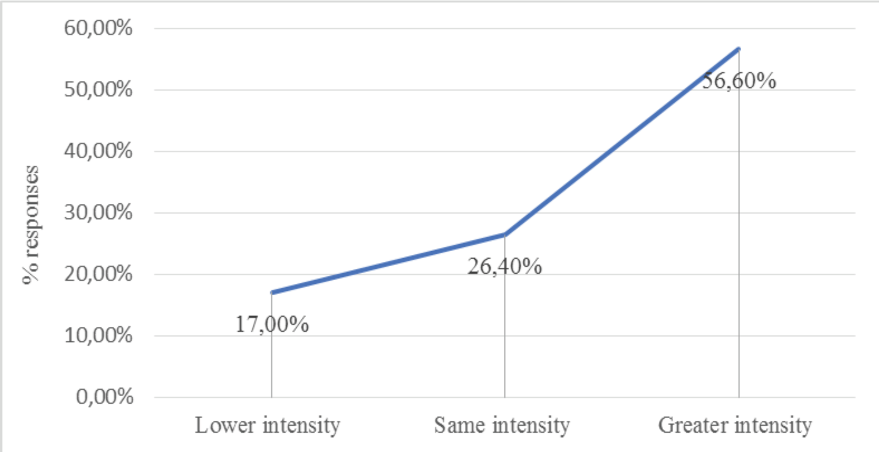


Source: Authors' presentation based on respondents' answers

Respondents evaluated financial support from the relevant ministry and local authorities for greater business and production digitalization giving answers from 1 (not satisfied) to 5 (extremely highly satisfied). As many as 69.8% of respondents rated 1 (not satisfied) or 2 (slightly satisfied), so it can be concluded that farmers are mostly dissatisfied with this type of assistance. Regarding their own activity in finding different support programs (EU support, national support programs, etc.) to finance investments in business and production digitalization, the respondents were divided: 43.4% of them declared that they were not active or were only slightly active, compared to 56.6 % who consider themselves to be moderately to extremely highly active.

In accordance with all the previous answers, and bearing in mind the degree to which investments in digitalization on the farm are economically justified and sustainable, the interviewed agricultural managers declared how intensively they intend to continue with the application of digital solutions on the farm in the future. The results show that more than half of the surveyed agricultural managers (56.6) plan more intensive investments in digitalization in the coming period. 26.4% of them will not change the intensity of investment when it comes to digitalization, while 17% of them will not invest in digitalization or will invest less, due to the low economic sustainability of these investments (Figure 7).

Figure 7. Expected intensity of digitalization on the farm in accordance with the interviewed managers' perceptions about the economic sustainability of investment, % of responses



Source: Authors' presentation based on respondents' answers

The obtained results correspond largely with the results of other authors dealing with this issue. Thus, Latif Virk et al. (2020) and Kernecker et al. (2020) indicate that, today, in general, farmers (in all countries of the world) hesitate to adopt new technologies and digitalize their farms, both because of the high costs they incur in this process, and because of the unavailability of the Internet or the lack of appropriate knowledge and skills. When it comes to digitalization research in Serbian agriculture, the limitations for greater digitalization that authors identified in this research are almost identical to the limitations already established by other authors (Jurjević et al., 2019; ITU & FAO, 2020; Kovljenić et al., 2023). Thus, Jurjević et al. (2019) indicate that insufficient knowledge and education of farmers, along with their low financial strength, are the main reasons that hinder greater digitalization of domestic agriculture, which is why Serbia lags significantly behind the EU countries in this segment. As the reasons for the low rate of adoption of innovations and subsequent technologies in Serbian agriculture, the ITU & FAO (2020) report emphasizes high costs of acquiring appropriate equipment, with state subsidies being of crucial importance for the adoption of new technologies. Also, based on the research of 46 agricultural farms on the territory of Vojvodina, a group of authors (Kovljenić et al., 2023, p. 583) indicates that "*digital technology is still not used enough on farms in AP Vojvodina, and the main limiting factors are financial resources, education and lack of different types of training*".

Digitalization is a very powerful tool for efficient use of resources and their management in agriculture (Latif Virk et al. 2020). Its positive impact on the sustainability of agriculture is undeniable, and the goals of modernization and technological and digital transformation of Serbian agriculture cannot be achieved in the short term (Jurjević et al., 2019). In order for the farmer to become familiar with the importance of digitalization and start using it, it is important to engage many state and non-governmental organizations, as well as every individual in promoting new technologies. It is very important that agricultural producers prepare and accept digitalization by mastering new ICT skills and abilities (Pogorelskaia & Várallyai, 2020), and it is also important to adapt digitalization software for use by agricultural producers. In addition, the line ministry's intervention should include surveys, experiments and cost analysis of digital production, in order to increase farmers' confidence for further and more intensive digitalization (ITU & FAO, 2020). Finally, creating an enabling environment for the transition of agricultural systems towards greater automation and digitalization implies multiple and coherent actions, including legislation and the adoption of appropriate regulations, infrastructure, institutional arrangements, education and training, as well as research and development (FAO, 2022).

Although the answers obtained by the interview have a high degree of validity and relevance, the biggest research limitation lies in the subjectivity of respondents' views, which is, after all, a peculiarity of most social research, which is difficult to avoid (Shipman, 2014).

The research represents a valuable basis for further and more extensive scientific and empirical research. The next steps could certainly be to upgrade the obtained results and examine the environmental and social dimensions of sustainability of agricultural digitalization. Also, it would be useful to analyse the quality and availability of training and education programs for farmers, which is extremely important for their business, as well as any other training in the new digital age.

Conclusions

With the primary goal of gaining empirical knowledge about the economic aspects of digitalization on agricultural farms in Serbia, the authors interviewed 53 agricultural producers (managers), using a semi-structured questionnaire. The survey resulted in the following conclusions: (a) the largest number of farms have land holdings of 1-5 ha, on which they apply some digital solutions, engage in mixed agricultural production and have one employee on their farm; (b) from digital solutions in agriculture, the largest percentage of producers use the Internet (to obtain knowledge and information about agriculture, the market, incentives, etc.); a significantly smaller number of interviewed managers declare that they use some of the more advanced digital solutions in their business and production processes; (c) 60.4% of respondents replaced work and production processes by digital solutions only up to 10%, while the smallest number of respondents replaced their work processes with digital solutions 50-70%; (d) the largest number of producers apply digital solutions during soil cultivation, sowing, fertilizing, irrigation and crop protection, mostly in farming and vegetable growing.

The economic aspects of digitalization of Serbian agriculture, based on the results of the interviews, indicate the following: (a) as for the greatest benefits of digitalization, the interviewees cited time savings, followed by higher labour productivity, lower production costs, labour savings, rational use of resources, higher yields and other;

(b) the highest digitalization costs relate to the procurement of machinery, equipment, devices, applications; then implementation and maintenance of digital systems; as well as training to master digital devices; (c) the biggest limitations for greater digitalization are high investments, as well as the lack of own capital and financial support from the state; (d) farmers are relatively satisfied with their own activity in finding different support programs for financing digitalization investments; at the same time, they are very dissatisfied with the financial support provided for these purposes by relevant ministries and local authorities; (e) the largest percentage of agricultural managers (55%) manage to return the funds invested in the digitalization of agriculture within a period of 2 to 5 years.

The general conclusion is that digitalization is applied in the agricultural sector of Serbia, but in a careful, questioning, modest way, with a tendency to intensify in the coming period. The “digital age” can be used to the maximum in the agricultural sector, by introducing advanced digital solutions, which will improve certain stages of the agricultural production cycle, improve sustainability and profitability of production, while simultaneously ensuring a sufficient amount of quality agricultural products and preserving the environment.

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Conflict of interests

The authors declare no conflict of interest.

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ARTIFICIAL INTELLIGENCE IN AGRICULTURE: THE IMPACT ON LABOR PRODUCTIVITY

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JEL: *O32, O33, O52, Q16, Q55*

A B S T R A C T

The last few years have seen the artificial intelligence technologies' potential to radically transform many industries, including agriculture, by optimizing the use of resources, increasing productivity, work efficiency, and resistance to climate change. The basic research question here is the degree of connection between the level of productivity in agriculture, on the one hand, and the degree of acceptance of AI technologies and a number of agriculture-related economic indicators, on the other hand. For this purpose, an empirical data analysis was carried out for EU 27 member countries. The results of the analysis show a moderately strong positive relationship between the level of the Labor Productivity in Agriculture and the AI Readiness Index score. Also, there is a statistically significant, but slightly less pronounced, positive relationship between the level of the Labor Productivity in Agriculture and GDP per capita and Agriculture, Forestry, and Fishing, Value Added (current US$) in Millions.

Introduction

The last few years have witnessed a very rapid development in the field of Artificial Intelligence (AI). AI technologies have the potential to radically transform various industries, including agriculture, as well as the functioning of the public sector. These technologies can be labeled as "game-changer" technologies, because in addition to improving existing business models and processes, they can lead to disruptive innovations, i.e. radical changes in the usual business models and business rules in

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an industry. Different definitions of artificial intelligence can be found in literature, depending on the approach to this broad and complex field, which is constantly developing. In particular, this is the definition offered by the expert group of the European Commission: „Artificial intelligence (AI) refers to systems that show reasonable, intelligent behavior based on the analysis of their environment and make decisions – with a certain degree of autonomy – to achieve specific goals“ (2020–2025 Strategy for the Development of Artificial Intelligence in the Republic of Serbia, p. 5).

AI encompasses a variety of technologies, including machine learning, deep learning, computer vision and shape recognition, as well as robotics. The essence of machine learning is algorithms based on learning from data, not on explicit programming. Deep learning, as a subset of machine learning, uses multi-layer neural networks to analyze complex data sets, achieving high accuracy in tasks such as image and speech recognition. Computer vision uses machine learning and deep learning techniques and allows computers to interpret visual data from the world, facilitating applications related to object recognition and motion tracking.

AI technologies have “general purpose” characteristics, i.e. they are generic in nature, much like electricity or railroads, or like the steam engine once was. This indicates that the application of these technologies “permeates all areas of the economy and society and introduces revolutionary changes in many of them” (2020–2025 Strategy for the Development of Artificial Intelligence in the Republic of Serbia, p. 5). Particularly suitable areas of AI application are transport, energy, telecommunications, medicine, agriculture and a wide range of public services (Ibid., p. 6).

AI offers numerous opportunities to improve agricultural production, optimize resources, and improve the efficiency of agricultural operations (Nguyen, et. al., 2020; Javaid, et. al., 2023; Mishra, et.al., 2024; Stamenković et al., 2024). The application of AI technologies allows farmers to make decisions based on relevant information, increase yields, reduce costs, and better respond to challenges such as climate change. Also, AI in agriculture has “the potential to feed a continuously growing global population and still contribute to achieving the UN’s Sustainable Development Goals (SDGs)” (Ryan et.al., 2023).

In addition to the above, the integration of AI in agriculture can lead to the development of new business models and services (Cavazza et al., 2023). For example, AI-based platforms can offer subscription-based services for crop monitoring and management, providing farmers with relevant recommendations and real-time data. This can attract tech-savvy entrepreneurs and investors, further boosting the agricultural economy. In addition, AI can facilitate better supply chain management, reduce waste and improve the efficiency of agricultural markets. These economic benefits highlight the potential of AI to transform agriculture into a more profitable and sustainable industry. The introduction of AI technologies not only increases productivity, but also makes agriculture more sustainable and resistant to future challenges (Dolgikh, Mulesa, 2021).

Bearing in mind the previously stated views and observations, the question arises as to how the impact of AI technologies on increasing labor productivity in agriculture can be seen (and measured), taking into account the macro level, i.e. state level? This was the core research question in this paper.

It is generally accepted that the basic indicator of the readiness of countries to accept and apply AI is the AI Readiness Index. It is a composite index that includes 39 indicators, divided into three groups: government indicators (12 indicators), technology sector indicators (15 indicators), and data and infrastructure indicators (12 indicators) (Government AI Readiness Index 2023).

The paper analyzes the connection of labor productivity in agriculture with the AI readiness index, as well as with a series of economic indicators at the macro level. The research is focused on EU member states. The derived conclusions are then connected to the situation in Serbia, where basic comparisons of trends in the AI readiness index were made for Serbia and several EU member states with similar geographic and demographic characteristics. Based on the obtained empirical results, concluding comments are given.

Literature review

AI with all its technologies, has significant potential to improve and modernize agriculture, providing advanced tools to increase efficiency and productivity in this sector. Eli-Chukwu (2019) provides a comprehensive overview of AI applications in agriculture, highlighting the various techniques and technologies used to optimize agricultural processes. This author indicates that the application of AI in agriculture brings numerous benefits, including improving yields, optimizing resources and reducing costs. Subeesh and Mehta (2021) point out that AI and IoT can revolutionize agriculture by automating tasks such as irrigation, pesticide application and crop monitoring. Their research shows that these technologies enable precise management of resources, thereby reducing operating costs and increasing production efficiency.

As explained in the study (Dharmaraj, Vijayanand, 2018), the direct application of AI or machine intelligence in the agriculture sector clearly indicates changes in the way agriculture is practiced today. AI-based agriculture solutions allow farmers to be more efficient with less investment of time and resources, improving quality and providing a quick go-to-market strategy. The integration of cognitive computing in agriculture enables systems to mimic human thought processes, making decisions that improve crop yields, manage resources more efficiently and reduce the need for manual labor.

Machine learning technologies bring benefits to agriculture in the area of crop management, livestock management, water management and soil management (Liakos, et al., 2018). A similar overview of the application of machine learning in agriculture can be found in the paper written by Benos, L., Tagarakis, A. C., Dolias, G., Berruto, R., Kateris, D., & Bochtis, D. (2021).

Radun, Dokić and Gantner (2021) explore the specific application of AI in livestock, emphasizing the AI contribution to precise livestock production. Using AI technologies, such as sensors and algorithms for data analysis, it is possible to monitor livestock health, optimize nutrition and improve reproductive processes, all of which contribute to sustainable and efficient milk and meat production.

Kovljenic et al. (2023) provide insight into the application of these technologies on farms in AP Vojvodina, where digital tools contributed to improving productivity and farm management. Their research shows that the use of digital technologies can help accurately monitor crops, predict yields and optimize the use of fertilizers and pesticides.

Rudrawar (2024) emphasizes the potential of AI in terms of transforming the agricultural sector through the introduction of innovative solutions that can improve all aspects of food production. His work explores how AI can contribute to more efficient management of agricultural operations, reducing waste and improving product quality. Also, Rudrawar emphasizes the importance of cooperation between researchers, technologists and farmers for the successful implementation of AI technologies. Ben Ayed and Hanana (2021) focus on improving the food and agriculture sector through AI, while Zha (2020) explores the application of AI in agriculture, providing a comprehensive overview of current achievements and future perspectives.

Talaviya et al. (2020) explore the application of AI to optimize irrigation and pesticide and herbicide application, pointing to opportunities to improve efficiency and reduce negative environmental impacts. On the other hand, Mladenović, I. and Mladenović, S.S. (2023) analyze the contribution of the agricultural sector to the economic growth of the EU 27 countries, emphasizing the importance of innovation and state incentives.

The application of AI in agriculture includes several innovative methods that transform traditional agricultural practices (Adewusi et al., 2024). AI is used in precision agriculture, where it processes data from various sources, such as weather conditions, soil quality and crop health, to create real insight into the condition (Kostić, 2021). This enables precise interventions, optimization of resource use and increased crop yields.

Finally, Mihailović, Radosavljević and Popović (2023) focus on the role of smart gardens in urban environments. Their research shows that smart gardens, which use AI to optimize plant growing conditions, can significantly contribute to sustainable food production in cities. These technologies make it possible to grow fresh vegetables and fruits all year round, reduce the need to transport food and improve access to fresh food in urban areas.

The above papers provide an overview of the current state and potential of AI application in agriculture. Highlighting the diverse applications of AI, from automating tasks to optimizing production processes, they highlight the key benefits the technology brings to the agricultural sector. With innovative solutions and collaboration among different actors, AI has the potential to significantly improve the efficiency, sustainability and productivity of agricultural practices around the world.

Current AI trends in the agricultural market

As pointed out in the introductory part, AI includes modern technologies that have a disruptive significance and a strong influence on the transformation of entire industrial branches. This also applies to the agricultural sector. It is no exaggeration to say that AI has the potential to revolutionize agricultural processes and activities. The main goal of these changes is to increase productivity and efficiency in the agricultural sector.

The latest research indicates that the application of AI in agriculture is on the rise, with an average global growth rate of 24.5% in the last decade (AI in Agriculture Statistics, 2024). In 2022, the global value of AI in agriculture market was US$ 1.2 billion and expected to reach US$ 10.2 billion in 2032. The aforementioned research indicates the most important components of the AI in agriculture market, shown in table 1.

Table 1. Market Share of AI Components in Agriculture

Component	Market Share (%)
Software	45.2
Hardware	24.5
Service	18
AI-as-a-Service	12.3

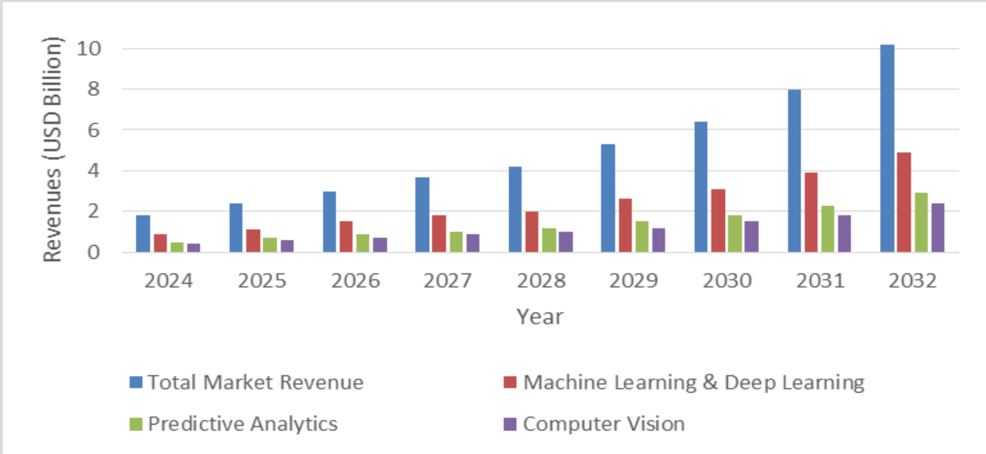
Source: AI in Agriculture Statistics: Transforming Farming Practices for Enhanced Efficiency and Sustainability

Table 1 clearly shows that software dominates the market with a share of 45.2%, which highlights the key role of software solutions in the transformation of agricultural practices. Software applications in agriculture enable big data analysis, resource optimization and process automation, leading to increased efficiency and productivity. Data-driven AI methods are becoming increasingly popular due to their high efficiency, especially with the advent of large-scale datasets and high-performance computing units (Su et al., 2023). Hardware is also significant, with a share of 24.5%, indicating the importance of physical infrastructure supporting AI implementations. This segment includes sensors, drones and robotic systems that collect data and perform physical tasks on farms. Services have a share of 18.0%, indicating a high demand for professional services that help in the adoption of AI technologies. Consulting services, training and implementation support play a key role in enabling farmers to use AI technologies effectively. Finally, AI-as-a-service, with a share of 12.3%, reflects the growing popularity of cloud-based AI solutions that offer scalability and affordability for agricultural enterprises. These solutions allow farmers to use advanced AI tools without the need for large initial investments in infrastructure.

Based on the previously presented data, key areas of investment and development in the agricultural sector can be identified. Understanding the market share of various AI components helps decision makers, researchers and investors recognize trends and opportunities to improve the efficiency and sustainability of agricultural production.

Figure 1 shows the growth projection of AI in Agriculture Market Revenue in 2024–2032. The total market value is shown in detail, divided according to the representation of certain technologies: machine and deep learning, predictive analytics, and computer recognition of shapes and patterns.

Figure 1. Projected Growth of AI in Agriculture Market Revenue (2024–2032)



Source: AI in Agriculture Statistics: Transforming Farming Practices for Enhanced Efficiency and Sustainability

As seen in the previous graph, total market revenues are expected to grow drastically, highlighting the growing economic impact of AI in improving the efficiency and sustainability of agriculture. The data presented depicts a significant jump in Total Market Revenue from $1.8 billion in 2024 to $10.2 billion in 2032, which clearly indicates increasing investment and innovation in this sector. Revenues from machine and deep learning, predictive analytics, and computer vision are projected to grow significantly, contributing to overall market growth and providing additional opportunities to improve agricultural practices.

Empirical analysis

Data and methodology

In the introductory part of the paper, we pointed out that the main research question in this paper is the discovery of the degree of connection between the level of labor productivity in agriculture and the degree of acceptance of AI technologies by the governments, as well as a series of economic indicators important for the agricultural field. For this purpose, an empirical data analysis was carried out, where parametric correlation and regression analysis techniques were applied. The analysis was conducted for 27 member countries of the European Union (EU). The following indicators are included in the analysis: *Labor Productivity in Agriculture (EUR/FTE)*, a variable that is presented as a dependent variable in the regression model, as well as the following indicators as independent predictor variables:

Rural Development Financial Contribution to Restructuring and Modernization (%), AI Readiness Index, Network Readiness Index, GDP per capita (current US$), Agriculture, Forestry, and Fishing, Value Added (current US$) in Millions, and *Agriculture, Forestry, and Fishing, Value Added (% of GDP).* The data were taken from official databases and reports of institutions that monitor the above indicators: data on *Labor Productivity in Agriculture (EUR/FTE)* and *Rural Development Financial Contribution to Restructuring and Modernization (%)* were taken from the report of the European Commission – Directorate-General for Agriculture and Rural Development; data on AI Readiness Index from Oxford Insights Reports (Government AI Readiness Index); data on the *Network Readiness Index* from regular annual reports on this index prepared by the Portulans Institute, University of Oxford and Saïd Business School; data on other indicators were taken from the World Bank databases (World Bank indicators and Open Data).

The data refer to the year 2022. The analysis was carried out using the IBM SPSS software package and the R programming language.

Results

As we previously pointed out, according to the subject and goal of the research, as well as the type and nature of the observed data, parametric techniques of correlation and regression analysis were applied in the analysis. First, a correlation analysis of the observed variables was conducted. The results are shown in Table 2 and Table 2a.

Table 2. Correlation – Pearson correlation coefficients (2022)

	LPA	**RDF**	**AIRI**	**NRI**	**GDP p. c.**	**AFF v. a.**	**AFF % GDP**
LPA	1.000	-0.127	0.703	0.762	0.583	0.412	-0.556
RDF	-0.127	1.000	-0.098	-0.100	-0.041	-0.266	0.135
AIRI	0.703	-0.098	1.000	0.892	0.472	0.372	-0.523
NRI	0.762	-0.100	0.892	1.000	0.575	0.219	-0.665
GDP p. c.	0.583	-0.041	0.472	0.575	1.000	-0.018	-0.676
AFF v. a.	0.412	-0.266	0.372	0.219	-0.018	1.000	-0.095
AFF % GDP	-0.556	0.135	-0.523	-0.665	-0.676	-0.095	1.000

Source: Authors' calculations

Table 2a. Correlation – Pearson correlation coefficients – Sig. (p value) (2022)

	LPA	**RDF**	**AIRI**	**NRI**	**GDP p. c.**	**AFF v. a.**	**AFF % GDP**
LPA		0.264	0.000	0.000	0.001	0.016	0.001
RDF	0.264		0.313	0.311	0.420	0.090	0.252
AIRI	0.000	0.313		0.000	0.007	0.028	0.003
NRI	0.000	0.311	0.000		0.001	0.137	0.000
GDP p. c.	0.001	0.420	0.007	0.001		0.464	0.000
AFF v. a.	0.016	0.090	0.028	0.137	0.464		0.320
AFF % GDP	0.001	0.252	0.003	0.000	0.000	0.320	

Source: Authors' calculations

Key:

LPA – Labour Productivity in Agriculture (EUR/FTE)

RDF – Rural Development Financial Contribution to Restructuring and Modernization (%)

AIRI – AI Readiness Index

NRI – Network Readiness Index

GDP p. c. – GDP per capita (current US $)

AFF v. a. – Agriculture, Forestry, and Fishing, value added (current US$) in millions

AFF % GDP – Agriculture, Forestry, and Fishing, value added (% of GDP)

Based on the data in Table 2 and Table 2a moderate and strong correlation between the variable *Labor Productivity in Agriculture* and other variables can be observed. It is mainly a positive correlation, with the exception of the correlation between *Labor Productivity in Agriculture* and *Agriculture, Forestry, and Fishing, Value Added (% of GDP),* where a statistically significant negative correlation coefficient was recorded (-0.556, p=0.001), as well as correlation between *Labor Productivity in Agriculture* and the indicator *Rural Development Financial Contribution to Restructuring and Modernization (%)*, where a negative correlation was recorded (-0.127), which is not statistically significant (Sig. p=0.264).

Based on the correlation analysis, a regression analysis was carried out, where three linear regression models were applied (Soldić-Aleksić, J, 2018):

Model 1: LPA was regressed on all other indicators:

LPA = -91582.14 + 5431.38 RDF – 377.23 AIRI + 1940.18 NRI + 0.251 GDP p. c. + 0.517 AFF v. a. + 1053.81 AFF % GDP

Model 1 is characterized by the following global statistics: coefficient of determination $R^2 = 0.699$; Std. Error of the Estimate = 13633.97 (in comparison with Std. Deviation of LPA = 21808.17) and ANOVA test (F = 7.754, df = 6, 20, Sig. = 0.000) which indicate the statistical significance of the obtained model. However, a more detailed analysis shows the following: the t test indicates the statistical significance of the regression coefficients only for the indicators of NRI and AFF v. a. (Sig. for the predictors are respectively: 0.878, 0.668, 0.054, 0.095, 0.033, and 0.772). Also, high multicollinearity of indicators AIRI and NRI, as well as AFF v. a. and AFF % GDP was observed (VIF values are respectively: 6.127, 7.151, 1.384, and 2.454). Therefore, we excluded the NRI and AFF % GDP indicators from Model 1.

Model 2: LPA was regressed on the following indicators: RDF, AIRI, GDP p. c. and AFF v. a.

LPA = -64852.72 + 131.49 RDF + 1203.81 AIRI + 0.321 GDP p. c. + 0.411 AFF v. a.

The resulting Model 2 has the following global features: coefficient of determination R^2 = 0.631; Std. Error of the Estimate = 14392.60 (in comparison with Std. Deviation of LPA = 21808.17) and the ANOVA test (F = 9.424, df = 4, 22, Sig. = 0.000) which indicate the statistical significance of the obtained model. In model 2, multicollinearity is not present (VIF values for predictors RDF, AIRI, GDP p. c. and AFF v. a. are respectively: 1.079, 1.582, 1.366, and 1.314). The t test that checks the statistical significance of regression coefficients in Model 2 shows that regression coefficients with the variables AIRI and GDP p. c. are statistically significant (Sig. for the predictors are: 0.997, 0.017, 0.017, and 0.090, respectively). Also, the standardized regression coefficients (Beta coefficients) in this model for the predictors RDF, AIRI, GDP p. c., and AFF v. a. are the following: 0.000, 0.421, 0.389, and 0.263 respectively. It is obvious that the RDF indicator can be excluded from Model 2.

Model 3: LPA was regressed on the following indicators: AIRI, GDP p. c. i AFF v. a.

LPA = -64833.49 + 1203.86 AIRI + 0.321 GDP p. c. + 0.411 AFF v. a.

The coefficient of determination remained the same as in Model 2 (R^2 = 0.631); Std. Error of Estimate is slightly lower compared to Model 2 and amounts to 14076.25; The ANOVA test shows that the obtained model is statistically significant: F = 13.136, df = 3, 23, Sig. = 0.000. The VIF values for the predictors are respectively: 1.580, 1.362 and 1.229, indicating no multicollinearity. Based on the values of the correlation coefficients (0.703, 0.583, and 0.412) and the values of the Beta regression coefficients (0.421, 0.389, and 0.263) for the predictors in this model, it can be concluded about the strongest influence of the AI Readiness index on the observed dependent variable LPA *– Labor Productivity in Agriculture (EUR /FTE)*.

Since these are three models that have the features of a nested model, the ANOVA test was applied for their comparison. The results of ANOVA analysis are: ANOVA (Model 2, Model 1): p = 0.1305; ANOVA (Model 3, Model 2): p = 0.9972. Also, in order to compare the above three models, the Akaike Information Criterion (AIC) values were calculated for each model: AIC (Model 1) = 598.6171; AIC (Model 2) = 600.1146; AIC (Model 3) = 598.1146 (Kabacoff, 2015, p. 202). The obtained results clearly indicate the advantages of Model 3 compared to Model 1 and Model 2.

Table 3 shows the summary results obtained for the previous three regression models.

Table 3. Summary Results – main models' statistics

Statistics	Model 1	Model 2	Model 3
R^2	0.699	0.631	0.631
Std. Error of the Estimate	13633.97	14392.60	14076.25
ANOVA test	F = 7.754, df = 6, 20, Sig. = 0.000	F = 9.424, df = 4, 22, Sig. = 0.000	F = 13.136, df = 3, 23, Sig. = 0.000.
Multicollinearity (VIF)	expressed (1.099; 6.127; 7.151; 2.004; 1.384; 2.454)	not expressed (1.079; 1.582; 1.366; 1.314)	not expressed (1.580; 1.362; 1.229)

Statistics	Model 1	Model 2	Model 3
Model comparisons: ANOVA test		ANOVA (Model 2, Model 1): p = 0.1305	ANOVA (Model 3, Model 2): p = 0.9972
AIC*	598.6171	600.1146	598.1146

*Akaike Information Criterion

Source: Authors' calculations

Based on the results of the empirical analysis, it can be concluded that there is a strong connection between the level of the *AI Readiness Index* and the *Labor Productivity in Agriculture*. Furthermore, the relationship, i.e. the influence of the *GDP per capita* indicator and the *Agriculture, Forestry, and Fishing, Value Added (current US$) in Millions* indicator on the variable *Labor Productivity in Agriculture* is somewhat weaker.

The position of Serbia

Bearing in mind the results of the previous data analysis, which revealed a significant connection between the level of the AI readiness index and productivity in the agricultural sector, below is a presentation of the trend in the value of this index for Serbia and five EU member states that we singled out due to certain geographic and/or demographic similarities with Serbia.

First of all, let us point out that in terms of most of the indicators included in the previous analysis, with the exception of the indicator *Agriculture, Forestry, and Fishing, Value Added (% of GDP)*, Serbia lags behind the average of EU countries (Table 4).

Table 4. Values of the analyzed indicators for Serbia and EU countries – average (2023)

	AIRI	NRI	GDP p. c.	AFF v. a.	AFF %GDP
Serbia	55.57	51.68	11361.00	3935.74	5.20
EU average	65.87	63.85	42248.34	11448.67	2.11

Source: Oxford Insights, Portulans Institute, World Bank official reports and authors' calculations

Key:

AIRI – AI Readiness Index

NRI – Network Readiness Index

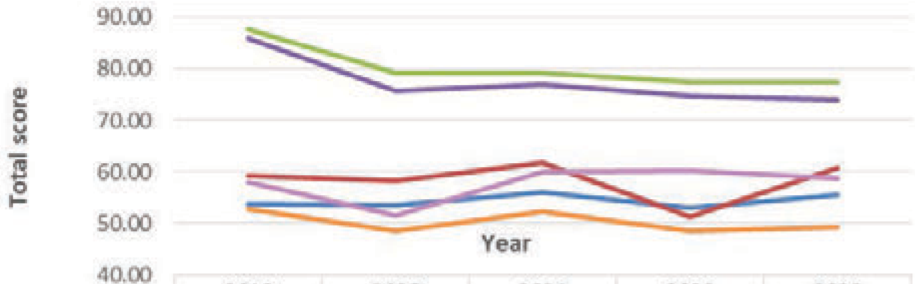
GDP p. c. – GDP per capita (current US $)

AFF v. a. – Agriculture, Forestry, and Fishing, Value Added (current US$) in Millions

AFF % GDP - Agriculture, Forestry, and Fishing, Value Added (% of GDP)

The values of the AI Readiness Index in 2019–2023 highlight the changing picture of readiness for the application of AI among European countries such as Slovakia, Finland, Denmark, Bulgaria, Croatia, and Serbia (Government AI Readiness Index Reports for 2019, 2020, 2021, 2022, and 2023).

Figure 2. Comparative Analysis of AI Readiness Scores (2019–2023)



	2019	2020	2021	2022	2023
Serbia	53.64	53.43	55.98	52.96	55.57
Slovakia	59.23	58.16	61.62	51.23	60.73
Finland	87.72	79.24	79.23	77.59	77.37
Denmark	86.01	75.62	76.96	74.79	73.91
Bulgaria	58.06	51.42	60.07	60.33	58.64
Croatia	52.73	48.62	52.30	48.59	49.34

Source: Authors' calculations based on data from multiple Oxford Insights reports

Based on the data for the year 2023, it is evident that Serbia lags behind the value of the AI Readiness Index compared to the average of EU countries by more than 10 points (Table 4). Figure 2 reveals trends in the movement of the AI readiness index for Serbia and several selected EU countries. Also, it is noted that Serbia shows a gradual improvement in its readiness to accept AI technologies, increasing its AI score from 53.64 in 2019 to 55.57 in 2023. A similar tendency can be observed for Slovakia and Bulgaria. It is interesting to note a marked drop in the AI index for Finland and Denmark in 2023 compared to 2019: for Finland, the AI index in 2023 is lower compared to 2019 by over 10 points, and for Denmark by more than 12 points. Despite the decline, Finland and Denmark remain leaders among EU countries. Monitoring the movement of the AI index is especially important for countries like Serbia that are trying to catch up with more advanced countries. By learning from the successful strategies of leading countries, Serbia can improve its adoption of AI technologies and use AI technologies to drive economic growth and innovation in agriculture and other key sectors.

Conclusion

In this paper, we considered the connection between labor productivity in the agricultural sector and the general development and applicability of AI at the macro level. The results of the empirical analysis for EU countries show a strong connection between the *Labor Productivity in Agriculture* and the *AI Readiness Index* at the national level. It is interesting that this connection is more pronounced compared to the connection of the *GDP Per Capita* indicator and indicator *Agriculture, Forestry, and Fishing, Value Added (current US$) in Millions,* with the variable *Labor Productivity in Agriculture*. The obtained result unequivocally indicates the importance of improving the entire AI ecosystem at the national level (three important AI pillars: government pillar, technology sector pillar and data and infrastructure pillar), which generally leads to conditions for increasing productivity in the agricultural sector.

Moderate growth of the AI index in the last five years is evident in Serbia. However, Serbia still lags behind the average value of the AI index in EU countries, which indicates the need for further investments in digital infrastructure, AI research and development, and reform policies to accelerate the adoption of AI technologies.

As AI technologies continue to develop, their application in agriculture is likely to expand, offering even greater opportunities to improve agricultural outcomes and contribute to the broader goal of sustainable development. The insights provided here are intended to help define a strategy that will support the integration of AI in agriculture, ensuring a sustainable and prosperous future for the Serbian agricultural sector.

Conflict of interests

The authors declare no conflict of interest

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ENHANCING AGRICULTURAL PROGRESS VIA SUSTAINABLE PRODUCTION AND CONSUMPTION

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A B S T R A C T

The paper's main aim is to discuss the importance of reducing environmental impact, conserving biodiversity, and addressing socio-economic concerns within the context of agriculture. The research methodology involves a comprehensive review of existing literature, and data analysis to address the following research questions: By emphasizing the interdependence of ecological, social, and economic factors, the paper provides insights into holistic approaches to sustainable agriculture. The paper contributes to the field by offering practical recommendations and policy implications for policymakers, practitioners, and stakeholders involved in agriculture. It highlights the importance of collaborative efforts among various stakeholders to foster innovation, promote knowledge sharing, and drive systemic change towards a more sustainable food system. Through its interdisciplinary approach, the paper bridges gaps in understanding and offers pathways for achieving agricultural progress while safeguarding the environment and ensuring food security for future generations.

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Introduction

In both academic and public discourse concerning global development, the pursuit of sustainable agricultural practices is regarded as a fundamental imperative. The nexus between sustainable production and consumption in agriculture not only fosters environmental resilience, thereby further boosting socio-economic progress (Polcyn, 2023). Based on the United Nations Sustainable Development Goals (SDG), particularly SDG 12 (Responsible Consumption and Production) (2015), this paradigm emphasizes the necessity to harmonize agricultural activities with ecological integrity and social equity. In the context of the European Union (EU), a highly influential advocate of sustainable development agendas, concerted efforts have been made to redefine agricultural practices in alignment with sustainability imperatives. Romania, as one of the EU's agrarian constituents (Feher, 2020), provides an illustrative case study in which the interplay of policy frameworks, socio-economic dynamics, and environmental exigencies influences the trajectory of agricultural sustainability. The evolution of the agricultural sector has resulted in substantial changes to inputs and investments, along with unprecedented shifts in trend evolution, which have collectively led to significant alterations in agricultural patterns, as previously asserted by Andrei et al. (2022).

This article aims to enhance understanding of the multifaceted dimensions of enhancing agricultural progress via sustainable production and consumption, with a specific focus on the EU context and the intricate landscape of Romanian agriculture. Sustainable agriculture seeks to address the challenges of food security, environmental degradation, and socio-economic disparities. At its core lies the principle of ensuring the longevity of agricultural systems by minimizing negative environmental impacts, optimizing resource utilization, and enhancing resilience to external shocks (Leoveanu-Soare, 2020). SDG 12 represents the global commitment towards fostering sustainable patterns of consumption and production, with a particular emphasis on the agricultural sector. By promoting resource efficiency, reducing food waste, and fostering equitable access to land and resources, SDG 12 underscores the pivotal role of agriculture in achieving broader sustainability objectives (Frone &Frone, 2020). The radical transformation of national agricultural systems influenced by the convergence with European agricultural standards and directives, as argued by Dragoi et al. (2016), results in substantial changes in the agri-food markets, impacting the structure and dynamics of food trade and, consequently, affecting food safety.

Within the EU framework, sustainable agriculture has emerged as a cornerstone of the European Green Deal, a comprehensive policy agenda aimed at transitioning towards a carbon-neutral, circular economy. The Farm to Fork Strategy (2020), a flagship initiative under the European Green Deal, outlines ambitious targets for reducing greenhouse gas emissions, promoting organic farming, and enhancing biodiversity conservation within the agricultural sector. Through regulatory measures, financial incentives, and knowledge-sharing initiatives, the EU seeks to empower farmers and stakeholders to embrace sustainable practices while ensuring the resilience and competitiveness of European agriculture on the global stage. The forthcoming section presents a detailed examination of the existing body of literature, followed by an in-depth analysis of Sustainable Development Goal 12 (SDG 12) as it pertains to Romania, utilizing data sourced from Eurostat (2024). The section culminates with conclusions that synthesize the findings and insights discussed.

The aim of this paper is to examine the various aspects of enhancing agricultural development through sustainable production and consumption. Specific focus will be given to the EU context and the complex agricultural environment of Romania. One of the primary objectives of this study is to examine the current state of sustainable farming practices in Romania in the context of SDG 12. Additionally, the study utilizes data from Eurostat to evaluate Romania's performance in critical sustainability metrics. Furthermore, it aims to offer constructive recommendations to stakeholders, practitioners, and policymakers to enhance sustainable agricultural practices. Lastly, it highlights the agricultural sector's potential for supply chain management and sustainable intensification in Romania.

Literature Review

Mouratiadou (2021) defines sustainable intensification (SI) as a means of increasing agricultural productivity while simultaneously reducing negative environmental impacts, a concept that has gained considerable traction in the literature and among policymakers. The concept of sustainable intensification (SI) encompasses a variety of strategies, including the optimisation of input utilization, the adoption of advanced technologies and the enhancement of crop management practices. As Smith et al. (2020) state, the integration of sustainable production and consumption practices in agriculture has two main objectives: firstly, to increase productivity and secondly, to minimize environmental impacts. Beltran-Peña et al. (2020) argue that the dual emphasis on productivity and sustainability is what has attracted global attention to SI. In the view of MacLaren et al. (2022), the key components of SI include enhancing resource use efficiency, improving soil health, and reducing reliance on synthetic inputs. It is crucial to recognise that successful implementation of SI requires context-specific solutions that are tailored to the specific local conditions and needs.

Sustainable supply chain management (SSCM)(Nayal et al., 2021) in agriculture involves optimizing the entire food production process, from farm to table. SSCM practices include reducing waste, enhancing resource efficiency, and maintaining ethical standards throughout the supply chain. Sharma et al. (2021) highlight that integrating sustainability into supply chain operations is driven by consumer demand and regulatory pressures.

In the context of Romania, the pursuit of Sustainable Development Goal (SDG) 12 - Responsible Consumption and Production, within the agricultural sector, is paramount for achieving broader sustainability objectives (Government of Romania, 2020). The alignment of Romania's agricultural practices with SDG 12 embodies a commitment to enhancing resource efficiency, reducing environmental degradation, and fostering equitable access to agricultural resources (Firoiu et al., 2019). The legacy of centralized planning, land fragmentation, and limited access to modern technologies has historically hindered the transition towards sustainable agricultural production and consumption patterns. However, recent policy initiatives and strategic interventions have sought to address these challenges and align Romania's agricultural sector with the principles outlined in SDG 12. Mensah et al. (2023) contend that current targets set out in the Sustainable Development Goal 12 (SDG12) for monitoring sustainable food consumption are inadequate and argued that more robust policy indicators and a comprehensive definition of sustainable food consumption are required. Tseng et al. (2016) highlight that SCP in emerging markets involves novel methods, practices, and opportunities to address environmental issues through various approaches, including firms, supply chain networks, and government regulations. This is evident in the growth patterns of countries with varying economic statuses, reflecting diverse strategies and innovations tailored to their specific contexts.

As Tukker et al. (2010) argue, sustainable consumption and production (SCP) refer to a global effort to improve living conditions without exhausting resources or damaging biogeochemical systems. This concept aligns closely with the trends observed in the EGGS, where the increasing GVA indicates a shift towards more sustainable economic activities. Furthermore, Singh and Singh (2017) suggest that traditional agriculture is a climate-smart approach for sustainable food production, addressing environmental problems like climate change and increasing population. The National Strategy for Sustainable Development (NSSD) serves as a foundational framework for integrating sustainability principles into Romania's agricultural policies and practices (Government of Romania, 2020). Encompassing diverse sectors, including agriculture, the NSSD emphasizes the importance of promoting resource efficiency, reducing waste, and enhancing the resilience of agricultural systems to climate change impacts. By incorporating SDG 12 targets into its strategic vision, Romania demonstrates a commitment to fostering responsible consumption and production patterns within its agricultural sector. Moreover, Romania's National Rural Development Program (NRDP), supported by EU funding, plays a pivotal role in promoting sustainable agricultural practices across rural communities (Ministry of Agriculture and Rural Development, 2014). Through targeted investments in infrastructure, technology transfer, and capacity-building initiatives, the NRDP seeks to enhance the competitiveness and sustainability of Romania's agricultural sector while advancing SDG 12 objectives. By fostering the adoption of agroecological practices, organic farming methods, and efficient resource management techniques, the NRDP contributes to reducing environmental footprints and promoting responsible consumption patterns among farmers and stakeholders.

Despite significant progress, several challenges hinder the widespread adoption of sustainable agricultural practices. These include limited access to financial resources, lack of supportive policies, and inadequate infrastructure. Addressing these barriers requires providing financial incentives, investing in research and development, and developing policies that support sustainable agriculture. Additionally, enhancing farmer education and community involvement is crucial in promoting sustainable practices (Pe'er et al., 2020). As Dragoi (2016) notes, the limitations of the traditional linear economic system have prompted the development of new, contemporary economic models, which are frequently hybrids in nature and have played a significant role in transforming conventional production and consumption relationships.Future research should focus on refining the definitions and metrics of sustainable intensification, exploring regional variations, and developing comprehensive models that integrate economic, environmental, and social dimensions of sustainability. The integration of digital technologies and data analytics in agriculture, known as digital agriculture, presents promising opportunities for optimizing resource use and improving decision-making processes (Tian et al., 2021).

Data and Methods

The analysis of sustainable production and consumption is based on an investigation of the relevant indicators, namely the circular material use rate (CMR), the raw material consumption (RMC) and the gross value added (GVA) by the environmental goods and services sector (EGSS) available in Eurostat, (2024). The data set covers the period from 2019 to 2022 and is analyzed both for the EU as a whole and for individual member states from 2019 to 2022. The data were visualized and analyzed with the objective of identifying trends, comparing performances and highlighting significant changes in raw material consumption over the specified period. The countries are also analyzed in terms of their absolute volumes and trends over the specified period.

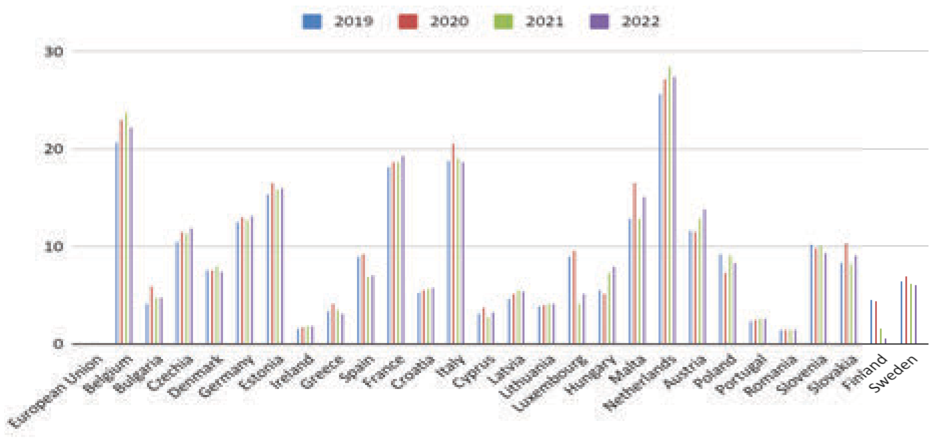
Analysis of SDG-12 in Romania and European Union

This section conducts a comprehensive analysis of the European Union Eurostat data to evaluate whether Romania is adhering to the criteria established under Sustainable Development Goal 12 (SDG 12). This evaluation involves a thorough examination of three indicators provided by Eurostat, which are essential in assessing Romania's progress towards sustainable consumption and production patterns. Through this analysis, the section aims to determine the extent of Romania's alignment with the SDG 12 targets and identify areas requiring further improvement.Firstly, the circular material use rate (see Fig. 1) is an important indicator of how efficiently a country is using its materials. It measures the proportion of material consumption that is recycled and reused in the production cycle rather than being wasted. A higher CMR means that more waste is being converted back into usable materials, reducing the need for new raw materials and lessening the environmental impact. Romania's results are relatively low compared to other countries, indicating a lower CMR. This suggests that a smaller share of material recovered is fed back into Romania's economy relative to its overall material use. The figure indicates that the EU average is higher than that of Romania. This means that on average, EU countries recycle and reuse a larger proportion of their waste materials compared to Romania. Since Romania's CMR is lower, it implies that the country relies more heavily on primary raw materials, which typically involve higher environmental costs due to extraction, processing, and transportation.

Moreover, a lower CMR can also have economic implications, as it might mean that Romania is not fully capitalizing on potential savings from using secondary materials. The information could be used by policymakers in Romania to identify opportunities for improving waste management systems, encouraging recycling, and supporting the circular economy through incentives for using recycled materials in production.

The figure shows that Romania has significant room for improvement in increasing its CMR. Efforts to enhance the recycling infrastructure, waste management policies, and incentives for using recycled materials could potentially increase Romania's CMR, bringing both environmental and economic benefits. Additionally, keeping track of trends over time would be critical to evaluate the effectiveness of any measures taken to improve the CMR.

Figure 1. Circular material use rate in EU



Source: Eurostat, 2024

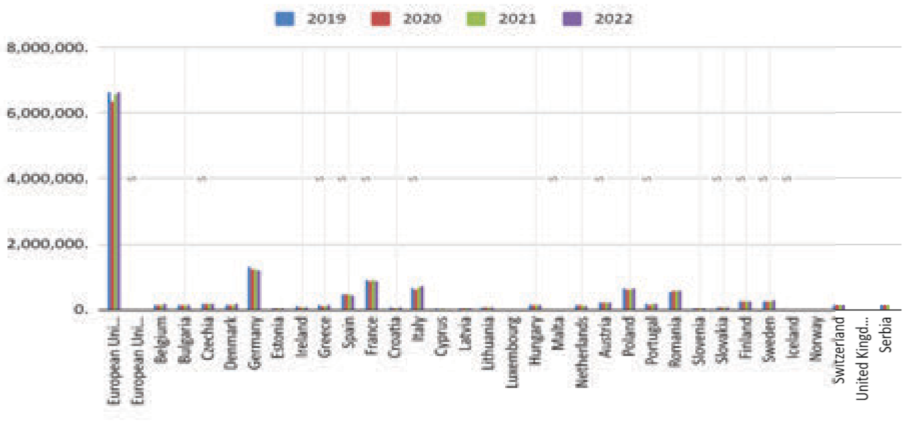
The first figure highlights a discernible pattern of slight fluctuations in the CMU rate for the EU from 2019 to 2022. This indicates that there is a relatively stable trend in the rate, which does not undergo significant upward or downward shifts. This stability suggests the existence of established practices in recycling and the reuse of materials throughout the Union. The analysis of the rates of recycling and reuse across the EU reveals a mixed picture of progress and challenges. Those countries which perform well, such as the Netherlands and Belgium, can be regarded as exemplars, demonstrating effective strategies which other countries might wish to emulate. The substantial enhancements observed in Italy and Estonia illustrates that targeted policies and investments in infrastructure can yield favorable outcomes. Nevertheless, the poor performance of countries such as Romania and Bulgaria highlights the necessity for bespoke strategies that address the specific obstacles to the adoption of a circular economy.

The Netherlands records the highest CMU rate among EU countries on a consistent basis, which demonstrates a strong commitment to the principles of a circular economy. Furthermore, Belgium also merits mention as a high-performing country, having consistently maintained a robust CMU rate over time. The relatively high CMU rates observed in Luxembourg and France reflect the effectiveness of their recycling and material reuse strategies. Italy and Estonia have demonstrated significant improvements in their CMU rates.

The notable increase observed in Italy between 2019 and 2022 suggests an enhancement in circular economy practices, which is likely driven by improved policies and infrastructure. Estonia has displayed a rising trend, particularly evident in 2022, indicating an increasing effectiveness in recycling and material reuse. Germany, Spain, and France have demonstrated a relatively stable CMU rate with slight fluctuations, reflecting a consistent implementation of circular economy practices and a robust recycling culture. In contrast, Romania and Bulgaria have the lowest CMU rates among EU countries, indicating a limited capacity for recycling and material reuse. Portugal and Finland also exhibit lower CMU rates in comparison to the EU average, highlighting an urgent need for strengthened circular economy policies and practices.

Analyzing the raw material consumption (RMC), for various countries and the European Union as a whole, Romania is placed midway on the chart, suggesting that its material footprint is neither at the high end nor the low end among the countries listed. Romania's RMC is below the value for the entire European Union, indicating that Romania's consumption induces less global material extraction than the EU average. Higher values on the chart imply greater demand for material extraction globally, which can be associated with higher environmental impact due to resource extraction processes. Romania's value suggests a moderate level of induced global extraction. Understanding Romania's RMC is essential for making policy decisions related to sustainable consumption and production, aiming to reduce the environmental impact of its material demand. The figure 2 provides a snapshot of Romania's demand for global material resources, offering insight into the environmental impact of its consumption patterns and can help inform strategies for more sustainable resource use.

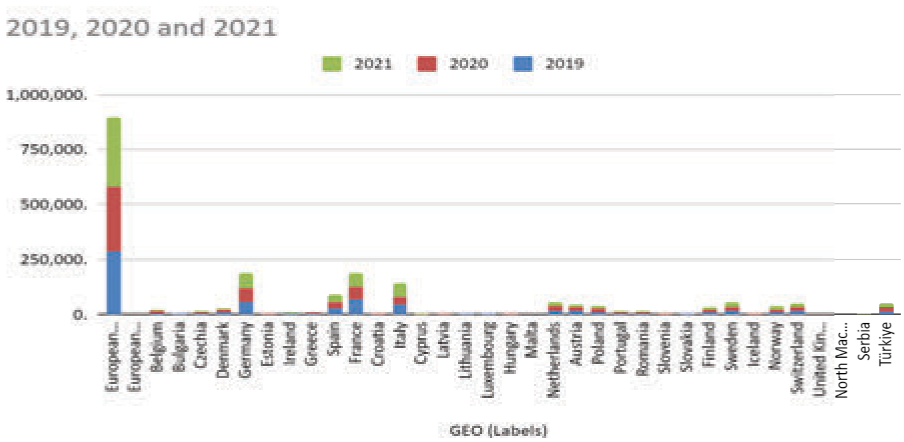
Figure 2. Raw material consumption in EU



Source: Eurostat, 2024

The data presented in Fig. 3 presents the gross value added (GVA) of the environmental goods and services sector (EGSS) in diverse EU countries, with a particular emphasis on its impact on the gross domestic product (GDP). The analysis of raw material consumption in the EU from 2019 to 2022 identifies notable discrepancies among member states. While the overall trend for the EU demonstrates stability, individual countries exhibit varying levels of consumption, reflecting differences in industrial activities and economic development. In comparison to the raw material consumption of individual member states, that of the EU is particularly high, this reflects the aggregate demand of all member countries. The overall trend appears to be relatively stable, with minor fluctuations between 2019 and 2022.

Figure 3. The gross value added (GVA) by the environmental goods and services sector (EGSS)



Source: Eurostat, 2024

The majority of countries, including major developed economies such as Germany, France, and the United Kingdom, demonstrate a stable pattern of raw material consumption from 2019 to 2022. This stability underscores the presence of well-established industrial practices and consistent economic activities. Countries with significant industrial bases, such as Germany, France, and the United Kingdom, naturally consume more raw materials, which highlights the correlation between industrial activity and raw material demand. Romania's results are among the shorter ones on the chart, suggesting that the environmental goods and services sector contributes a smaller share of its GDP compared to many other countries listed. The European Union's average GVA by EGSS is indicated on the chart. Romania is below this average, indicating that, proportionally, the country's economy is less involved in producing environmental goods and services than the EU on average. Considering the relevance of SDG 12 Romania's lower GVA by EGGS could suggest that there is potential for growth in sustainable consumption and production, as well as in building resilient and sustainable infrastructure. The chart provides an insight into where Romania stands in the context of the European Green Deal and its alignment with the EU's sustainability priorities. Romania may have opportunities to expand its EGGS to contribute to sustainable industrialisation and innovation. For Romania, this data can inform policy-making to enhance investment in the EGGS, potentially leading to greater economic diversification and moving towards sustainable practices that align with EU priorities. The data suggests that Romania, while currently having a smaller EGSS contribution to GDP compared to other countries, may look towards policy and investment in this sector to drive sustainable economic growth and meet EU sustainability goals.

The overall trend across the majority of countries and the EU is an increase in gross value added (GVA) from 2019 through to 2021. This growth serves to underscore the expanding importance of the environmental sector, driven by heightened awareness, policy initiatives, and increased investments in sustainability. The sector's resilience, even during the challenging period of the Coronavirus Disease 2019 (Covid-19) pandemic, serves to highlight both its robustness and its potential as a future source of economic growth. In terms of individual countries, Germany, France and Italy are the principal contributors to the EGSS GVA. These countries demonstrate a persistent upward trajectory over the three-year period, indicating robust sectoral expansion. This growth can be attributed to the existence of substantial industrial bases, the implementation of comprehensive environmental policies, and the allocation of significant investments in sustainable technologies.

It is notable that countries such as Spain, the Netherlands and Sweden also make a moderate contribution to the GVA. Although their total GVA is less than that of the top contributors, they exhibit a similar upward trajectory, indicative of a gradual and consistent advancement within the sector. It seems probable that these countries will benefit from targeted policies and investments designed to strengthen their environmental sectors.

It is observed that countries with smaller economies or those with less developed environmental sectors, such as Malta, Luxembourg, and Cyprus, demonstrate relatively low GVA figures. Notwithstanding their comparatively minor contributions, these countries demonstrate growth from 2019 to 2021, indicating positive development. This suggests that even countries with smaller economies are recognising and investing in the potential of the EGGS. Some countries, such as Finland and Romania, exhibit slight fluctuations, with 2020 GVA values marginally higher than those in 2021. These anomalies could be due to specific economic conditions, policy changes, or external factors affecting the sector during those years.

Discussion

The study's findings shed important light on Romania's sustainable agricultural situation and how it relates to SDG 12. The examination of the rate of circular material usage, consumption of raw materials, and the GDP contribution of the environmental products and services industry reveals sectors that have made success as well as those that still require work. Firstly, Romania’s lower percentage of circular material use suggests that improved waste management programs and recycling incentives are required. To maximize material efficiency, policymakers ought to concentrate on advancing the circular economy and enhancing recycling infrastructure. Secondly, a balanced approach to material demand is suggested by Romania’s low raw material usage. To lessen the negative effects of resource extraction on the environment, more sustainable methods and technologies must be used. Thirdly, the environmental products and services sector’s comparatively small GDP contribution suggests that there is untapped development potential in sustainable businesses. Investing more in this area can promote sustainable growth and economic diversification.

A complex strategy including financial incentives, regulatory assistance, technology uptake, and stakeholder participation is needed to address these issues. The amalgamation of digital technology and data analytics offers auspicious prospects for enhancing resource allocation and refining agricultural decision-making procedures. Creating complete models that incorporate the social, environmental, and economic aspects of sustainability should be the main goal of future study. Tailoring solutions to local conditions and demands will also need investigating regional variances and improving sustainability indicators.Romania may join the international effort to balance economic activity with ecological preservation and social inclusion by promoting a culture of sustainable production and consumption. In order to provide a successful and long-lasting legacy for future generations, the nation’s agriculture sector has the potential to become a beacon of development, emulating the transformational power of sustainable practices.

Conclusion

In the quest for sustainable development, Romania’s journey through agricultural enhancement reflects both its rich potential and the challenges it faces in an ever-evolving global landscape. The insights gathered from a comprehensive analysis of the country’s circular material use rate, raw material consumption, and contribution of the environmental goods and services sector to its GDP provide a valuable framework for understanding the intricate interplay of environmental responsibility and economic progress.

In its pursuit of economic growth and environmental stewardship, Romania has reached a pivotal crossroad where the implementation of strategic policies and investment in sustainable practices have become not just options but necessities for achieving long-term resilience. Guided by the European Green Deal and the Sustainable Development Goals, the country’s future trajectory is becoming increasingly clear: aligning sustainability at the core of agricultural practices, promoting technological adoption and innovation, and integrating a circular economy that prioritizes resource conservation and minimizes waste.

The journey ahead for Romania is promising yet challenging, requiring concerted efforts from policymakers, stakeholders, and communities. It demands a transformative approach to agriculture that prioritizes not only productivity but also the well-being of the environment and society. By fostering a culture of sustainable production and consumption, Romania can secure its place as a leading agrarian force within the European Union, contributing to a global movement that seeks to harmonize economic activity with ecological preservation and social inclusivity.

The article has outlined that although Romania's current performance in certain sustainable metrics may not be the most notable, the country presents a multitude of potential for growth. The lessons learned and the strategies outlined herein should serve as a catalyst for action, inspiring innovation, collaboration, and a steadfast commitment to a future where economic success and environmental stewardship are not mutually exclusive. As the world marches towards the 2030 Agenda for Sustainable Development, Romania's agricultural sector can serve as a model for progress, exemplifying the transformative power of sustainable practices to ensure a prosperous and enduring legacy for generations to come.

Conflict of interests

The authors declare no conflict of interest.

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INHERITANCE AS A BASIS FOR THE ACQUISITION OF OWNERSHIP RIGHTS OVER REAL ESTATE AND AGRICULTURAL LAND BY FOREIGN CITIZENS

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A B S T R A C T

The subject of research in the paper will be the right of foreign citizens to inherit real estate and agricultural land in the Republic of Serbia. By using the methodological-theoretical framework, the aim of the work will be the analysis of the inheritance institute, which represents the basis of acquisition of property rights on real estate and agricultural land by foreign citizens. The era of globalization favors the movement of people between countries, but each country determines the availability and scope of rights of foreign nationals according to its interests. Therefore, in order to analyze the research subject, we will use historical, descriptive, normative and content analysis methods. The conclusion will summarize the results of research on inheritance as a basis for acquiring property rights on real estate and agricultural land by foreign citizens.rights over real estate and agricultural land by foreign citizens.

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Introduction

The legal position of foreigners includes the legal regulation by which each country regulates the availability and enjoyment of rights to foreign nationals on its territory. At the current level of legal regulation of the legal position of foreigners, the basic approach is that a foreigner (legal or natural person) has fewer rights than domestic citizens and domestic legal entities. For this reason, each country has a special legal regime for foreigners, which is based on its national regulations, as well as on international treaties. It is the right of every state to sovereignly regulate the legal position of foreigners, and how it will be regulated depends on the state's policy towards foreigners, which, we can say, is subject to change, especially due to the state's need for international cooperation and its opening to the world. The legal regime of a certain state that concerns the rights of foreigners includes the possibility of foreigners to enter and stay on its territory, to settle, to work, to enjoy various political and civil rights, to have the right of access before its courts and other state bodies (Petrović, Prica, 2020). The reason why foreign citizens do not have the same legal treatment as domestic citizens when it comes to acquiring property in real estate and other real rights is of a different nature. Sometimes it is about security reasons in the sense that foreigners cannot acquire real estate in the border area. Also, those reasons can be of an economic nature, all with the aim of preventing foreigners from economic activity in industry, trade, etc. or activities that are directly related to real estate or national reasons formulated in a general way like "benefit for the state", state interest" (Kitić, 1987). Economic and social reasons aim to prevent the rise of real estate prices, given that foreigners have greater purchasing power compared to domestic entities. In the long term, this can lead to the displacement of domestic subjects from key economic branches such as agriculture, animal husbandry and tourism (Stanivuković, 2012). These reasons can be analyzed through the prism of economic theory and social dynamics. On the economic side, increased foreign demand for real estate can result in rising real estate prices, making it harder for local residents to afford real estate. This can cause negative effects on the local economy, such as a reduction in local consumption and investment, as more capital is diverted to the real estate sector. These effects can further affect the availability of resources and increase the cost of doing business in sectors such as agriculture and livestock, which can reduce the competitiveness of domestic producers in the market. From a social aspect, the increase in real estate prices can lead to social tensions and inequality, as the rising cost of living can become unbearable for the local population. Also, there may be demographic changes due to migration of the local population in search of more affordable living conditions, which may further weaken local communities and culture. In addition to the above, we must point out that there are justified reasons for the prohibition of foreigners acquiring property on agricultural land (more in Baturan, 2013). "Agricultural land is the basic factor of agricultural production. And agriculture, as an important branch of economic life and development, represents one of the basic levers of our social development. It is an economic branch that realizes a significant trade surplus in economic relations, i.e. in exchange with other countries. In addition, agriculture, and therefore agricultural land as its most important resource, has a decisive influence on the general development of our community, especially in the process of harmonizing economic mechanisms for the realization of certain social goals, first of all, on the implementation of reforms and transition. Agriculture is, therefore, financially the largest and most important potential segment of our European integrations, but the condition for it to really become that is to transform from the former planned, socialist, to market" (Vukićević, Stepić, Savović, 2011).

In order for a foreigner to acquire property, it is necessary that his right to property be recognized as a foreigner, and in order to be an heir, he must enjoy the right of inheritance. Inheritance as a phenomenon, temporally, has existed since the time of man. Before the emergence of states and legally regulated relations in society, it existed as a phenomenon that had, above all, biological and social contents. In the biological sense, we recognize inheritance as the transfer of genetic traits from parents to their offspring. Sociologically speaking, inheritance implies the transfer of social goods of the entire community and the generation that lives in it, to the generations that come after them, including the entire social relations in the community. For the aforementioned reasons, inheritance must be tied to natural laws and viewed as the transfer of all spiritual and material values, which result in the evolutionary development of man as well as the progress and development of the entire community and its culture (Počuča, Krstinić, 2022). When it comes to the right of a foreigner to inherit property on real estate, but also on agricultural land located on the territory of Serbia, it has changed over the decades, from a restrictive position, when a foreigner could not acquire real estate through a legal transaction, to a liberal position, when a foreigner can acquire real estate under certain conditions (Krstinić, Vasiljković, Langović Milićević, 2020).

The aim of the work

The main goal of the work is to analyze and indicate how and under what conditions a foreign citizen can acquire ownership rights over real estate and agricultural land in the Republic of Serbia through inheritance. Also, the aim of the work is to study the position of the foreigner in different time periods, as well as a chronological analysis of the regulations concerning the studied area.

Methodology

In order to accurately and systematically study the defined problematic, it is necessary to use a historical method that will enable an overview of the position of foreign citizens throughout history, as well as the historical aspect of the legal basis of acquisition. The descriptive method will be used in order to thoroughly and studiously analyze the institute of inheritance as a basis for acquiring rights to real estate and agricultural land in the Republic of Serbia. The normative method will be a special focus on the analysis of legal regulations that regulate the studied issue, especially the Law on Inheritance, Law on the basics of ownership relations, the Law on Agricultural Land and other relevant legal regulations concerning the studied topic. Through content analysis, the basic terms that represent the subject of research will be gradually analyzed and analyzed, and the theoretical knowledge will be synthesized into a single unit using relevant bibliographic sources.

The concept and position of a foreigner throughout history

When defining a foreign natural person both in legislation and in theory, it is not determined who is a foreigner, but who is not a citizen. Therefore, the starting point when defining the concept of a foreigner is the concept of a citizen. Thus, in our legislation, in accordance with the Law on the Resolution of Conflicts of Laws with Regulations of Other Countries (Official Gazette of the SFRY, no. 43/82 and 72/82 - corr., Official Gazette of the FRY, no. 46/96 and Official Gazette of the RS, no. 46/06 - a natural person who has foreign and Serbian citizenship is considered a Serbian citizen, and if he has more than one foreign citizenship, he is considered a citizen of the country in which he resides. If a person does not have a residence, he is considered to have the citizenship of the country with which he has the closest relationship (Article 11). According to the Law on Foreigners (Official Gazette of RS, no. 24/18, 31/19), a foreigner is any person who does not have citizenship of the Republic of Serbia. According to the ruling position in the theory and legislation of stateless persons - stateless persons are considered foreigners. We are talking about persons that no country, according to the regulations in force in it, recognizes as its citizens. Such a situation can occur by birth, when a person is born in such circumstances that he does not acquire the citizenship of another country under any law, or if a person loses his citizenship and does not acquire the citizenship of another country. On the other hand, bipatris, dual citizens, who have another citizenship in addition to Serbian, will not be considered as foreign natural persons (Carić, 2006).

Throughout history, the position of foreigners has changed, from their complete denial, non-recognition of any rights, to their equalization with domestic citizens. In the old century, foreigners were considered enemies and had no rights (Krstinić, Vasiljković, 2019). In Greece and Rome, the attitude towards foreigners is softened by the possibility of the foreigner enjoying certain rights based on international treaties or by granting special privileges to some foreigners. In ancient Greece, were there “isopolity” contracts that granted certain civil rights to foreigners of the contracting states, such as the right to acquire ownership of certain things (Panić, 2017). In the Middle Ages, foreigners are unwelcome, but “tolerated”. With international trade come foreigners, who are in fact the carriers of this activity. They mostly stay temporarily, but they also settle permanently and enter into various legal relationships on the domestic territory. However, their legal position is not secure and certain, because it happened that they were expelled, their property was confiscated, and they had to pay special taxes and duties. Different forms of discrimination against foreigners were present, and foreigners could not be heirs, and the property of a deceased foreigner belonged to the feudal lord, if it was located on his territory. On the other hand, there were situations when certain rights of foreigners were recognized and guaranteed by international treaties from the then existing small states, as well as by royal charters. With the bourgeois revolution and its postulates, the attitude towards foreigners also changed significantly. The stranger is no longer an enemy, nor is he unwanted. It is treated as a subject of law, although certain limitations and conditions of certain rights of foreigners are foreseen, including exclusion from their enjoyment. In this period, the phenomenon of favorable treatment of foreigners appears, through so-called capitulations. This was an institute by which citizens of a country enjoyed preferential treatment in a country that accepted capitulations. That special treatment was expressed in the exclusion of those foreigners from domestic jurisdiction, as well as in guaranteeing the enjoyment of certain rights. Capitulations no longer exist today, but the phenomenon of securing a special privileged position for foreigners from a certain country has persisted, and it is achieved through international agreements and comes to the fore in foreign investments, the right to conduct international payments, etc. The appearance of various alliances between states, political, economic, military, as a rule affects the legal position and treatment of citizens and legal entities from states in such an alliance. One of the latest examples is the European Union (Mitrović, Kumpan, 2009).

Historical aspect of the legal basis of the acquisition

Historically, foreigners in Serbia have the right to acquire ownership of immovable property on the basis of legal transactions mortis causa, which has never been fully recognized as a general right. Nevertheless, foreigners acquired ownership rights to real estate in Serbia through legal and testamentary inheritance more easily than through legal transactions inter vivos. The only exception to this rule in our territory was valid until the amendment of the Serbian Civil Code in 1852, when the right to property for foreigners based on legal transactions inter vivos was recognized as a general right. Until 1923, the old system was valid in Yugoslavia from 1852, according to which the right of foreigners to acquire immovable property on the territory of the Kingdom was an absolutely reserved right. According to the Law on budget twelfths for July and August 1923, the right of foreigners to acquire real estate in Yugoslavia becomes a relatively reserved right, because they are given the right to in the so-called in the inner zone they can acquire real estate freely under the condition of factual reciprocity (Bartoš, 1951). On the other hand, the right to property based on legal transactions mortis causa was recognized as a relatively reserved right, which was in fact based on some kind of approval. An important feature of this right was related to the distinction between testamentary and legal inheritance regimes. The approval system that was valid between the two world wars, until the entry into force of the Regulation on control of real estate transactions from 1948 (Official Gazette of the FNRJ, No. 24/48) and related only to the acquisition of property rights to real estate through testamentary inheritance. For foreigners, the acquisition of property rights on immovable property has been recognized internationally as a general right. Since the adoption of this regulation, the acquisition of ownership of immovable property through a will has been put on the same level as legal affairs inter vivos, which means that foreigners were absolutely prohibited from acquiring ownership of immovable property on this basis. Until the change, that is, until the recognition of the right of foreigners to inherit immovable property through a will or law was recognized by the adoption of the Law on the Transfer of Land and Buildings (Official Gazette of the FNRJ No. 19/55) and the Law on Inheritance (Official Gazette of the FNRJ No. 20/55) . According to the provisions of Article 159, paragraphs 2 and 3 of the Law on Inheritance, a foreign citizen could not, on the basis of inheritance, have more agricultural land in the SFRY than a Yugoslav citizen could, and a foreign citizen was entitled to monetary compensation for the agricultural land he could not own..

Acquisition of property rights - legal regulation

In accordance with international agreements, the Constitution of the Republic of Serbia (Official Gazette of the RS, no. 98/06 and 115/21) guarantees to foreign persons all the rights guaranteed by the Constitution and the law, with the exception of the rights that, according to the Constitution and the law, only citizens of the Republic of Serbia have (Article 17). . The aforementioned provision actually means that foreigners are guaranteed all the rights that are not specifically reserved for domestic citizens by the Constitution and laws.

The acquisition of property rights by foreigners represents a property legal relationship with an international element and therefore the Law on the Resolution of Conflicts of Laws with the Regulations of Other Countries ("Official Gazette of the SFRY", no. 43/82 and 72/82 - corrected, "Official Gazette of the FRY" applies ", No. 46/96 and "Official Gazette of RS", No. 46/2006 - other law) in order to determine the applicable law. The provision of Article 18, paragraph 1 of this Law prescribes that for property legal relations the applicable law is the place where the thing is located, which means that Serbian law is applicable. When it comes to the acquisition of property rights through mortis causa legal affairs, it is regulated by internal and international legal sources. The right of foreign persons (individuals and legal entities) to acquire property rights on real estate in the territory of the Republic of Serbia through legal transactions inter vivos and legal transactions mortis causa is regulated by the Law on the Basics of Property Relations. This Law defines in detail the conditions and procedures under which foreign persons can acquire real estate, taking into account the specificities of the legal system of the Republic of Serbia and the need to protect national interests. According to the provision of Article 82a of the aforementioned Law, our country, in terms of acquisition of real estate and other real rights from foreign natural and legal persons, is included in the list of countries in which these rights are relatively reserved rights, that is, foreigners are allowed to acquire real estate if the general conditions are met, without regardless of whether the method of acquisition is by inheritance or legal transaction inter vivos. Natural and legal persons may have ownership rights to residential buildings, apartments, office buildings, business premises, agricultural land and other immovable properties, except for natural resources that are state property (Article 9 of the Law on the Basics of Property Relations). A foreign natural person who does not perform economic activity on the territory of the Republic of Serbia may, under the condition of reciprocity, acquire the right of ownership of an apartment and residential building. Pursuant to the provisions of Article 82b of the Law on the Basics of Ownership Legal Relations, a foreign natural person may, on the territory of the Republic of Serbia, acquire the right of ownership of immovable property by inheritance, as well as domestic citizens, under the condition of reciprocity. A similar provision is contained in the Law on Inheritance (Official Gazette of the RS, no. 46/95, 101/03 - decision of the USSR and 6/15). More specifically, the provision of Article 7 of this Law stipulates that foreign citizens in the Republic of Serbia have, under the condition of reciprocity, the same hereditary position as domestic citizens, unless otherwise determined by an international agreement. Reciprocity in inheritance is regulated by bilateral conventions, that is, agreements with several countries (Babić, 2021). These bilateral conventions and international agreements are important for determining the inheritance-legal position of foreigners because they regulate issues of reciprocity, governing law, testamentary capacity, form of will, jurisdiction in probate matters, measures to protect inheritance, cases of inheritance without heirs, etc. (Carić, 2006). On the other hand, when it comes to the acquisition of ownership rights to agricultural land, the legislator, by provision of Article 1, paragraph 4 of the Law on Agricultural Land (Official Gazette of RS, no. 62/2006, 65/2008 - other law, 41/2009, 112/ 2015, 80/2017 and 95/2018 - other laws stipulated that the owner of agricultural land cannot be a foreign natural or legal person, unless this law stipulates otherwise in accordance with the Stabilization and Association Agreement between the European Communities and their member states , on the one hand, and the Republic of Serbia, on the other hand. However, although this prohibition is explicit, there are ways in which foreign persons can acquire ownership rights on agricultural land. One way is to establish a so-called Special Purpose Vehicle. “Special Purpose Vehicle, by definition, is a company that is established in order to fulfill the narrow, specific, temporary goals of another company, that is, the company that founded it. It is usually used to acquire ownership of a particular asset/part of an asset and facilitate the easier transfer of that asset. Bearing in mind what has been said, foreign natural and legal persons can take advantage of the legal opportunity to establish a company in Serbia, which, regardless of the fact that its founder is a foreigner, will be viewed as a domestic legal entity under Serbian law. Therefore, that company will be able to buy land in Serbia under the same conditions under which all domestic persons can, i.e. they will be able to acquire ownership of agricultural land as well” (Žunić, Medić, 2024). Baturan (2017) confirms that foreigners indirectly acquire large areas of arable land precisely by establishing legal entities in the Republic of Serbia. By purchasing a domestic legal entity that already owns agricultural land, a foreign natural or legal entity establishing ownership of the company automatically establishes ownership of all its assets - including agricultural land. We can say that our legislator allows the above because according to the provisions of Article 3 of the Law on Foreign Trade (Official Gazette of the RS, no. 36/09, 36/11 - other laws, 88/11 and 89/15 - other laws) persons or branches of legal persons that have their headquarters, i.e. that are registered in the Republic of Serbia, are considered domestic persons. So, foreigners can indirectly acquire ownership rights to agricultural land through a domestic legal entity, with the fact that it will be registered to a domestic entity, but essentially it is owned by a foreign entity. That foreigners use this possibility is confirmed by practical data that foreigners in Serbia own about 35,000 ha of agricultural land. And Kuzmanović states that according to the data from 2017 of the Agency for Business Registers, "in Serbia, there are 5,400 foreign legal entities and 7,694 natural persons who have companies here with 100 percent ownership, while on the records of the Republic Institute of Statistics there are 5,302 foreign natural persons and 4,658 legal entities a company with a partial ownership share" (Kuzmanović, 2017). Taking into account that the Republic of Serbia accepted the Stabilization and Association Agreement, it undertook to amend its legislation in accordance with the aforementioned Agreement, and in connection with the acquisition of ownership rights to agricultural land. citizens within four years from the date of entry into force of the Agreement. With the provision of Article 72đ of the Law on Agricultural Land, the legislator specified the conditions under which a citizen of a member state of the European Union can acquire agricultural land. "By adopting the amendments in 2017, our legislator only temporarily prevented the tenants from acquiring ownership rights over agricultural land, which means that nothing has changed in the long term." We are of the opinion that the Republic of Serbia will have to equalize the rights of foreigners, ie citizens of the European Union, with the rights of domestic citizens when it comes to acquiring property rights on real estate, including agricultural land. The question that arises is whether the legislator will do it under the pressure of the European Union or the judicial authorities." (Krstinić, Vasiljković, Langović Milićević, 2020).

Inheritance-legal matter - legal position of foreigners

One of the relevant principles on which the inheritance-legal position of foreigners in the law of the Republic of Serbia is based is the principle of equality or equality in relation to domestic citizens, which is not absolute in nature because it is conditioned by the existence of reciprocity with the foreigner's country. Namely, on the territory of Serbia, a foreign natural person can, under the condition of reciprocity, acquire the right of ownership over immovable property by inheritance, just like a citizen of Serbia (Article 82b of the Law on Establishing Ownership Legal Basis). Formal reciprocity exists when a foreign citizen in our country has the same inheritance rights as domestic citizens, if the country of the foreign citizen recognizes our citizens with the same inheritance rights enjoyed by its citizens (Stanojčić, Vuković, 2021). The disadvantage of this type of reciprocity is that it does not guarantee balance regarding the enjoyment of certain rights. "Material reciprocity exists when there is essential symmetry in the content of the right, its subject and scope, the conditions that are set for the enjoyment of that right" (Stanivuković, Živković, 2013). Reciprocity in inheritance can be contracted if it is established by an international treaty or bilateral government agreement, and in this case it is a question of diplomatic reciprocity. When no contract has been concluded in this sense, Serbia recognizes inheritance rights to foreigners because their country recognizes it to our citizens, then there is de facto reciprocity (Babić, 2021). In practice, there is also a legal type of reciprocity that arises when in a country the availability of certain rights to foreigners is guaranteed in the domestic law and in this way the rights of foreigners in a certain legal area are determined, i.e. the availability of a right to foreigners in the home country (Varadi, Bordoš, Knežević, Pavić, 2007). As an example of the above, we can cite the Law on Inheritance of the Republic of Serbia, which in Article 7 defines that "Foreign citizens in the Republic of Serbia have, under the condition of reciprocity, the same inheritance position as domestic citizens, unless otherwise determined by an international agreement." Also, the Law on the fundamentals of legal property relations, the provision of Article 82b prescribes: "A foreign natural person can, on the territory of the Federal Republic of Yugoslavia, under conditions of reciprocity, acquire the right of ownership of immovable property by inheritance, just like a citizen of the Federal Republic of Yugoslavia." The above actually means that if they are in foreign countries also the rights guaranteed by law to persons who are foreigners in those countries to inherit under the condition of reciprocity, there is legal reciprocity between the Republic of Serbia and the respective foreign countries in the field of inheritance.

A court or other state body before which the question of the existence of reciprocity is raised can request an explanation from the Ministry of Justice (Article 82v, paragraph 2, of the Law on the Establishment of Property Rights). However, these rules do not apply to apatrides (persons without citizenship) because they should have the same inheritance rights, as domestic citizens, because the condition of reciprocity cannot be demanded of them. In practice, the competent authority uses the table on the existence of reciprocity, which is highlighted on the website of the Ministry of Justice (Ministry of Justice). However, the question can be raised whether they are using it correctly, that is, whether they are taking into account which category of tenants and which type of real estate is involved, because e.g. if it is a foreign natural person who does not perform an activity, he cannot be the owner of agricultural land, given that the Law on Agricultural Land is applied, not the Law on the Establishment of Property Rights (Stanković, 2016).

What is obvious from the legal regulation of the inheritance-legal position of foreigners in Serbia, in relation to immovable property, is that the recognition of inheritance rights, under the condition of reciprocity, is only discussed when it comes to natural persons. When it comes to the inheritance rights of legal entities, taking into account that this issue is not explicitly regulated in legal provisions, in theory two positions have been formed. According to the first paragraph, foreign legal entities do not have this right, because it is not expressly provided for. As a confirmation of the above-mentioned point of view, the provisions on conflict norms in bilateral agreements are cited, according to which the real estate inheritance of a citizen of one contracting party, which is located in the territory of the other contracting party and which remains without an heir, belongs to the state in whose territory it is located (Pak, 1989). On the other hand, Jezdić (1982) believes that this right is recognized to foreign legal entities, despite the lack of explicit provisions on this, under the condition of formal reciprocity with justification for the necessity of achieving sovereign equality of states and better international cooperation. However, according to the current legal solution in our country, the first position is represented, which stems from the rule of lex rei sitae, which is contained in both internal and international legal sources that regulate this issue. In addition, we believe that it would be contrary to public order to allow a foreign country to acquire property without an owner, which is located in our territory. Also, if the legislator wanted to recognize this right for a foreign legal entity as well, when formulating this issue in the provision of Article 82b of the Law on the Basics of Ownership Relations, next to the wording “foreign natural person” should also be “foreign legal entity”.

For the inheritance-legal position of foreigners in Serbia, in addition to the principle of equality, the principle of uniqueness, freedom of inheritance and the principle of limitation of the basis of reference to inheritance are also relevant. The principle of uniqueness, i.e. the universality of inheritance means that the rules of legal inheritance are the same, i.e. general, unique, universal regardless of the personal characteristics and qualities of either the testator or the heir, which means that it applies to both domestic citizens and foreigners under the condition of reciprocity , as well as regardless of the type, origin and quality of goods that are part of the legacy. The principle of freedom of bequest applies equally to foreigners and domestic citizens and it is limited in the same way for all categories of testators, by the institution of public order, the right to a necessary portion, etc. The principle of limitation of the basis of reference to inheritance means that for foreigners as well as citizens of the Republic of Serbia, the rule applies that they can acquire immovable property exclusively on the basis of legal and testamentary inheritance (Carić, 2006).

In relation to the inheritance-legal position of foreigners, the availability of some inheritance-legal institutions to foreigners is also important. A foreigner can be the executor of a will, if he is designated by the will of the testator. The provisions of Articles 112 and 113 of the Law on Inheritance do not limit the right of foreigners to be testamentary witnesses in respect of bequeathing property located on the territory of the Republic of Serbia. However, for determining the legal position of foreigners in matters of inheritance, the most relevant is the analysis of the following inheritance rights of foreigners: to dispose of their property in case of death and to be heirs. The right of foreigners to dispose of their property in case of death is their general right. In our law, a foreigner can be a testator based on the law and the will. The right of foreigners to make a will derives from the principle of freedom of bequest. Pursuant to Article 30, paragraph 2 of the Law on the Resolution of Conflicts of Laws with the Regulations of Other Countries in Certain Relationships, testamentary capacity, that is, the capacity to make a will, is determined according to the law of the country whose citizenship the testator had at the time of making the will. Also, the rules on drafting a will are evaluated according to domestic law, that is, when it comes to an inheritance consisting of immovable property in Serbia, a foreigner drafts a will according to valid Serbian regulations. Based on the provisions of Article 79 of the Law on Inheritance, the general conditions for making a will are the age of up to 15 years and the ability to judge, and they apply equally to foreigners and citizens of the Republic of Serbia. We emphasize that Article 92 of the Law on Inheritance expressly specifies that an international bequest, as a special form of will, is valid regardless of the citizenship of the testator. When it comes to legal inheritance, the right of foreigners to be a testator is not limited by anything, except for the regulations that regulate the right of foreigners to acquire immovable property in general.

The right of foreigners to inherit real estate located on the territory of the Republic of Serbia belongs to a group of relatively reserved rights. From the previous analysis, it is evident that it is conditioned by the existence of reciprocity with the foreign country and that it only applies to foreign physical persons.

Conclusion

In our opinion, the current regulations of Serbia that regulate the acquisition of property rights on privately owned immovable property by foreign citizens are insufficiently precise, which indicates the need for more detailed and clearer regulation of this matter. For this reason, we conclude that one of the possible approaches is to retain the principle of reciprocity, with additional specification of the obligation to establish material reciprocity. In this way, domestic citizens would enjoy the same rights in foreign countries as foreign citizens in Serbia. Also, we believe that it is necessary to stipulate that the determination of reciprocity is carried out by the Ministry of Justice, and not by other competent authorities, who would turn to the Ministry of Justice in case of doubt. The form of the act establishing reciprocity should be defined in order to enable the exercise of the right to a legal remedy. Finally, it is necessary to clearly prescribe the basis of acquisition of property rights on all types of immovable property by foreign citizens, in order to eliminate existing doubts and ensure legal certainty in this area.

Of course, there is an alternative solution, which is to omit the determination of reciprocity, but in that case it is necessary to precisely determine through the enumeration system which types of immovable property foreigners cannot acquire ownership of. This would include passing a law that prohibits the acquisition of property rights in certain areas, in order to protect the interests and security of the state, such as border areas or locations near military installations. These restrictions would also apply to foreign countries and international organizations. When it comes to agricultural land, it should be remembered that it is a resource of general interest for the Republic of Serbia. Accordingly, Serbia should maintain a restrictive approach to acquiring ownership rights over agricultural land. However, it is necessary to clearly define the right of acquisition through inheritance and develop mechanisms to prevent abuse of the law through the establishment or purchase of domestic companies by foreign citizens..

Conflict of interests

The authors declare no conflict of interest.

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CONDITIONS OF OBTAINING LOANS FROM THE PERSPECTIVE OF MANAGEMENT OF AGRICULTURAL FARMS AND MEDIUM-SIZED AGRICULTURAL ENTERPRISES, THE EXAMPLE OF THE REPUBLIC OF SERBIA

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A B S T R A C T

A number of factors can affect getting a loan. The aim of the study was to determine the possible influence of the following factors: interest rate, loan repayment term, user participation, VAT lending possibilities, agricultural equipment as a pledge, simplicity of the lending procedure, minimum loan amount, adjustment of repayment and total score in the period 2022-2024 on getting a loan. The application of the t-test revealed that there is a strong influence of all the mentioned factors on obtaining loans in agricultural holdings, that is, in the operations of medium-sized agricultural enterprises. The next conclusions would be that the mentioned factors affect the prediction of the interest rate in the business of agricultural farms ($F=185.24$, $p<0.0005$) but also in the business of medium-sized agricultural companies ($F=106.51$, $p<0.0005$) in the Republic of Serbia.

Introduction

Financial support for agricultural development within the framework of the development of an economy is a permanent measure of state authorities and an essential continuous activity that is carried out through measures adopted by state authorities (Javid et al., 2022).

The measures adopted by the state authorities, which are aimed at the agricultural development of an economy, should be seen as a permanent activity undertaken with the aim of better positioning agriculture within the adopted development directions of the

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region (Helming & Peerlings, 2014; Ansah et al., 2018; Soyeh et al., 2021; Zolea, 2022).

Financial monitoring of development programs that are directed towards agriculture are very different and are aimed at specific segments of agriculture (Perez & Herrerias, 2021; Roa et al., 2022; Ansah et al., 2023; Azumah et al., 2023; Bawuah et al., 2023).

The financing of agricultural production is largely adapted to the form of agricultural production (Strauss et al., 2021; Zhou et al., 2021; Chami et al., 2022; Mazumder & Kabir, 2022; Barba, 2023; Han & Gen, 2023; Angioloni et al., 2023). Very often, issues of agricultural financing are associated with the concept of crediting farmers, which is important in a large number of individual ways of financing agricultural production itself (Sood, et al., 2022; Hasam et al., 2022; Abeysiriwardana et al., 2022; Attílio, 2023; Mulimbi et al., 2023; Waaswa et al., 2024).

Crediting of agricultural production is often linked to the monitoring of innovative approaches in agriculture in a very wide range of activities, from agricultural mechanization, irrigation systems, systems for processing agricultural products, systems for processing bio-waste generated in agriculture, etc. (Uni, 2020; Kish, 2022; Pircher et al., 2022; Bentley et al., 2022; Kotyrlo & Zaytsev, 2023; Alrawashdeh et al., 2023).

The role of lending in agriculture is of particular importance both based on the different forms of ownership of the organization of agricultural production, as well as in relation to the size of the agricultural organization, that is, in relation to the types of loans issued by banks to agriculture (Takagi et al., 2021; Cosby et al., 2022; Javangwe & Takawira, 2022; Geza et al., 2023; Zubair, 2024).

Theoretical background

The framework that regulates credit relations between legal entities at the level of one state is regulated by the umbrella law in this area. In the Republic of Serbia, the umbrella relationship that regulates banking business is regulated on the basis of the current Law on Banks ("Official Gazette of RS", no. 107/2005, 91/2010 and 14/2015).

In addition to the existence of the above-mentioned umbrella law, which regulates issues in the domain of banking operations, state authorities pass other legal solutions and regulations that clarify the aforementioned relations in the functioning of heterogeneous legal entities.

One of the important regulations regarding the regulation of this area is the Regulation on financial support to agricultural holdings through easier access to the use of loans in difficult economic conditions due to the disease covid-19 caused by the virus sars-cov-2 ("Official Gazette of RS", no. 57/2020).

Emphasizing the importance of the aforementioned regulation is reflected in the fact that the state reacts quickly in the field of agriculture in the event of major disruptions in the market, which also happened in the case of the application of other laws that monitored the area of damage reduction from the presence of Sars-cov-2, and which in this case, it directly affected the field of agriculture as one of the most important activities for the normal functioning of the population.

In addition, the very performance of activities through a large number of agricultural holdings, but also through an extremely vital number of medium-sized enterprises that perform the predominant activity in agriculture, is closely related to the establishment of numerous relationships that can be seen primarily as market-regulated relationships, which can be seen in numerous works by authors such as (Kumari & Garg, 2023; Ayanwale, 2004) And above all from the point of view of development.

Agriculture as an important segment of the stability of an economy, primarily from the point of view of ensuring the satisfaction of the population's needs with pre-food products created by agriculture, and later processed by the dominant food industry, relies to a large extent on the existence of numerous banking instruments that follow these activities of the state (Teye & Quarshie, 2022; Burova et al., 2022).

Everyone should point out that the aforementioned activities of the state regarding the development of the agrarian and food sector in an economy are directly connected to the observation of social-credit relations and which essentially follow all phases of the movement of goods and services connected to agricultural holdings and medium-sized agricultural enterprises (Lee, 2019; Shu, 2021), which essentially served as a realistic basis for the authors in the preparation of this study.

Materials and methods

The authors conducted research by applying a survey in 155 agricultural farms and 78 medium-sized agricultural enterprises operating in the territory of the Republic of Serbia. Therefore, the survey was conducted in a total of 233 holders of agricultural activities. The research period was from 01.01.2022 to 01.01.2024.

The goal of the research was to determine the possible impact of the analyzed factors on obtaining loans in agriculture. Factors affecting obtaining a loan were analyzed, namely: interest rate, loan repayment period, participation of the loan beneficiary, possible VAT crediting, lending of agricultural equipment as collateral for obtaining a loan, simplicity of the procedure for obtaining a loan, minimum loan amount, the possibility of adjusting the loan repayment plan as and the total score of the mentioned factors.

The survey was completed by owners of agricultural holdings as well as by owners of medium-sized agricultural enterprises. Participants in the survey were given the opportunity to rate the influence of each of the factors in the interval 1-10, with 1 indicating weak influence and 10 indicating very strong influence.

After collecting data by surveying, statistical processing was performed and a comparison was made of the evaluation of two forms of organizing agricultural production, that is, the evaluation of the owners of agricultural holdings with the evaluation of the owners of medium-sized agricultural enterprises.

After that, the obtained differences were tested using the t-test. In the following, the authors went a step further and predicted the impact of the analyzed factors for agricultural holdings and for medium-sized agricultural enterprises.

Hypotheses

The setting of hypotheses was done in such a way as to determine the existence of the influence of the analyzed factors on obtaining loans in agricultural farms and medium-sized agricultural enterprises.

To that end, the authors put forward the following hypotheses.

H:1 that there are no differences in terms of obtaining loans in relation to the form of organizing agricultural production for 2022.

H:2 that there are no differences in terms of obtaining loans in relation to the form of organizing agricultural production for 2023.

H: 3 that there are no differences in terms of obtaining loans in relation to the form of organizing agricultural production for 2024.

H: 4 that the level of the interest rate cannot be predicted based on the rest of the other factors, that is, the conditions for obtaining loans for the operation of agricultural farms.

H: 5 that the level of the interest rate cannot be predicted based on the rest of the other factors, i.e. the conditions for obtaining loans for the business of medium-sized agricultural enterprises.

Data processing

Statistical data processing and analysis were performed using (Statistical Package of Social Science). In the paper, the t test of independent samples was applied to examine the differences between agricultural farms and medium-sized agricultural enterprises in relation to the analyzed factors, as well as in relation to the values of the total score of all factors affecting obtaining loans.

Regression analysis was applied to predict the level of the interest rate in two forms of organizing agricultural production, that is, for organizing agricultural production in agricultural farms as well as in the organization of agricultural production in medium-sized agricultural enterprises.

A significance threshold of 0.05 was used.

Results

The obtained results covered a three-year research period, i.e. from 2022 to 2024. They refer to showing the difference in terms of lending in two forms of agricultural production organization. The first form is agricultural holdings, and the second form is medium-sized agricultural enterprises in the Republic of Serbia.

The results of the research were done with the analysis of 8 factors, as well as their overall score, which can affect the crediting process in the aforementioned branches of the organization of agricultural production, as well as with the strengthening of the obtained results using the t-test of independent samples.

The results were formed within the framework of two logical units that complement each other, and based on both units; it is possible to form a safe opinion regarding the entire process of agrarian lending.

Formation of established differences in relation to the process of obtaining loans in the period 2022-2024

The results obtained in relation to the formation of established differences in relation to the process of obtaining loans in 2022 are shown in Table 1, which were created by evaluating the value of both forms of agricultural production organization.

Table 1. Differences in conditions for obtaining loans for 2022

Influencing factors on obtaining loans	**Agricultural farms (N=155)**	**Secondary agricultural enterprises (N=78)**	**t**	**p**
	Middle value			
The amount of the interest rate	8.55 ± 0.49	5.57 ± 0.49	43.062	<0.0005*
Loan repayment term	8.59 ± 0.49	6.58 ± 0.49	29.247	<0.0005*
Participation of loan beneficiaries	8.81 ± 0.98	7.38 ± 0.80	11.056	<0.0005*
The possibility of crediting VAT	8.70 ± 0.49	4.79 ± 0.40	66.322	<0.0005*
Lending of equipment as a pledge to secure a loan	3.55 ± 0.49	7.79 ± 0.40	-69.505	<0.0005*
Simplicity of the loan realization procedure	8.81 ± 0.97	6.20 ± 0.40	28.624	<0.0005*
Minimum loan amount	6.25 ± 0.69	8.78 ± 0.41	-34.552	<0.0005*
The possibility of adjusting the loan repayment plan	6.60 ± 0.49	9.34 ± 0.47	-40.575	<0.0005*
Total score	59.89 ± 1.64	56.47 ± 1.24	16.115	<0.0005*

* Statistical significance at the level of 0.05

Source: Authors.

The results obtained in relation to the formation of established differences in relation to the process of obtaining loans in 2023 are shown in Table 2, which were created by evaluating the value of agricultural holdings and medium-sized agricultural enterprises.

Table 2. Differences in terms of obtaining loans for 2023

Influencing factors on obtaining loans	**Agricultural farms (N=155)**	**Secondary agricultural enterprises (N=78)**	**t**	**p**
	Middle value			
The amount of the interest rate	7.10 ± 0.63	4.20 ± 0.76	29.036	<0.0005*
Loan repayment term	6.18 ± 1.66	4.79 ± 0.40	9.858	<0.0005*
Participation of loan beneficiaries	6.96 ± 0.92	6.01 ± 0.91	7.420	<0.0005*
The possibility of crediting VAT	7.55 ± 0.73	3.38 ± 0.48	51.313	<0.0005*
Lending of equipment as a pledge to secure a loan	2.55 ± 0.73	6.19 ± 0.77	-34.874	<0.0005*
Simplicity of the loan realization procedure	7.05 ± 0.74	4.61 ± 0.48	26.358	<0.0005*
Minimum loan amount	4.85 ± 0.65	6.03 ± 1.27	-7.735	<0.0005*
The possibility of adjusting the loan repayment plan	5.15 ± 0.65	7.56 ± 1.06	-18.321	<0.0005*
Total score	47.43 ± 3.48	42.80 ± 2.75	10.220	<0.0005*

* Statistical significance at the level of 0.05

Source: Authors.

The results obtained in relation to the formation of established differences in relation to the process of obtaining loans in 2024 are presented by the author in Table 3, which were created by evaluating the value of agricultural holdings and medium-sized agricultural enterprises.

Table 3. Differences in conditions for obtaining loans for 2024

Influencing factors on obtaining loans	**Agricultural farms (N=155)**	**Secondary agricultural enterprises (N=78)**	**t**	**p**
	Middle value			
The amount of the interest rate	9.00 ± 0.54	6.41 ± 0.49	36.373	<0.0005*
Loan repayment term	6.21 ± 4.06	7.61 ± 0.48	-4.215	<0.0005*
Participation of loan beneficiaries	9.44 ± 0.49	8.62 ± 0.80	8.184	<0.0005*
The possibility of crediting VAT	9.44 ± 0.49	5.38 ± 0.37	61.873	<0.0005*
Lending of equipment as a pledge to secure a loan	4.74 ± 0.70	9.03 ± 0.61	-48.098	<0.0005*
Simplicity of the loan realization procedure	9.60 ± 0.49	7.25 ± 1.16	17.044	<0.0005*
Minimum loan amount	7.19 ± 0.80	9.43 ± 0.49	-22.469	<0.0005*
The possibility of adjusting the loan repayment plan	7.59 ± 0.73	9.78 ± 0.41	-24.367	<0.0005*

Influencing factors on obtaining loans	Agricultural farms (N=155)	Secondary agricultural enterprises (N=78)	t	p
	Middle value			
Total score	63.24 ± 4.93	64.00 ± 2.47	-1.271	0.122

* Statistical significance at the level of 0.05

Source: Authors.

Forecasting the level of the interest rate in relation to the form of organizing agricultural production

The forecast of the interest rate in relation to the form of organization of agricultural production is given in the form of two views, that is, in the view of the forecast of the interest rate in agricultural holdings and after that in the forecast of medium-sized agricultural enterprises.

Table 4. Prediction of interest rates for agricultural holdings

	Beta	t	p
A constant	-	11.904.	<0.0005*
Loan repayment term	-0.028	-1.068	0.286
Participation of loan beneficiaries	0.168	4.397	<0.0005*
The possibility of crediting VAT	0.069	1.809	0.071
Lending of equipment as a subject of loan security	0.274	6.200	<0.0005*
Simplicity of the loan realization procedure	0.106	2.631	0.009*
Minimum loan amount	0.278	6.786	<0.0005*
The possibility of adjusting the repayment plan	0.108	2.433	0.015*

* Statistical significance at the level of 0.05

Source: Authors.

Table 5. Prediction of interest rates for medium-sized agricultural enterprises

	Beta	t	p
A constant	-	3.250.	<0.0001*
Loan repayment term	1.094	10.127	<0.0005*
Participation of loan beneficiaries	-0.463	-6.661	<0.0005*
The possibility of crediting VAT	-0.055	-0.575	0.566
Lending of equipment as a subject of loan security	-0.073	-0.999	0.319
Simplicity of the loan realization procedure	0.168	2.908	0.004*
Minimum loan amount	0.104	1.581	0.115
The possibility of adjusting the repayment plan	0.055	0.978	0.329

* Statistical significance at the level of 0.05

Source: Authors.

Discussion

Based on the results shown in Table 1, it can be seen that for the year 2022, there is a statistically significant difference in relation to the form of agricultural organization in all factors that can affect obtaining loans.

Owners of agricultural holdings value more the interest rate, loan repayment term, participation of the loan beneficiary, the possibility of VAT crediting, the simplicity of the loan implementation procedure and the total score.

Owners of medium-sized agricultural enterprises have a stronger belief in equipment lending as an item that ensures obtaining a loan, then the minimum loan amount, as well as the possibility of adjusting the loan repayment plan.

Based on that, Hypothesis 1 can be safely rejected, that is, there are differences in relation to the analyzed factors and their impact on the process of obtaining loans in the mentioned two forms of organizing agricultural production for 2022. Essentially, the obtained results coincide with the already expressed views of the author (Zelenović et al., 2018).

Based on the results shown in Table 2, it can be seen that for the year 2023, there is a statistically significant difference in all factors affecting the process of obtaining loans in relation to the form of organizing agricultural production.

Owners of agricultural holdings more strongly value the interest rate, loan repayment period, participation of loan beneficiaries, the possibility of VAT crediting, the simplicity of the loan implementation procedure and the total score, while the owners of medium-sized agricultural enterprises more strongly value equipment lending as a loan security item, the minimum loan amount and the possibility adjustments to the loan repayment plan.

Based on that, Hypothesis 2 can be rejected, that is, there are differences in the conditions for obtaining loans in relation to the form of agricultural organization for 2023. The obtained results are compatible with the already published views (Popović et al., 2018) regarding the importance of making valid management decisions in the regular operations of agricultural companies.

Based on the presentation of the results in Table 3, it can be seen that for the year 2024, there is a statistically significant difference in relation to the form of agricultural organization in all the analyzed factors that can affect obtaining a loan, except for the overall score.

Agricultural farms better rate the interest rate, the participation of loan beneficiaries, the possibility of crediting VAT and the simplicity of the loan realization procedure, while medium-sized agricultural companies better rate the term of loan repayment, equipment lending as a subject of loan security, the minimum loan amount and the possibility of adjusting the loan repayment plan. Hypothesis 3 can be rejected, that is, there are differences in the conditions for obtaining loans in relation to the observed form of agricultural production for 2024. The results are also such that they indicate the importance of valuation, primarily financial valuation, which can be seen in the already published views of the author (Radović et al., 2023), which was essentially the focus of this study.

In the research, the authors applied multiple linear regression, that is, whether it is possible to predict based on the loan repayment period, the participation of the loan beneficiary, the possibility of crediting VAT, crediting of equipment as a subject of loan security, the simplicity of the loan implementation procedure, the minimum loan amount and the possibility of adjusting the repayment plan the interest rate for agricultural holdings.

The regression analysis yielded a coefficient of determination of 0.739, on the basis of which it can be seen that the obtained model describes 73.9% of the total variance. The level of the interest rate can be predicted based on the independent variables since the model is statistically significant ($F=185.24$, $p<0.0005$).

Based on the results shown in Table 4, it can be seen that the participation of the loan beneficiary, the lending of equipment as a subject of loan provision, the simplicity of the loan implementation procedure, the minimum loan amount and the possibility of adjusting the loan repayment plan have a significant impact on the prediction of the interest rate. Therefore, it can be seen that hypothesis 4 can be rejected because the obtained results showed that the level of the interest rate can be predicted based on the rest of the set factors, that is, the conditions for obtaining a loan, which is necessary in the business of agricultural farms.

In essence, the results obtained by the authors coincide with those who emphasized the importance of realistic application of internal control in business (Radović et al., 2021; Vitomir et al., 2021.

Based on the application of multiple linear regression to examine whether based on the term of loan repayment, the participation of loan beneficiaries, the possibility of crediting VAT, crediting of equipment as a subject of loan security, the simplicity of the loan realization procedure, the minimum loan amount and the possibility of adjusting the repayment plan to predict the interest rate for medium-sized agricultural enterprises.

The regression analysis yielded a coefficient of determination of 0.767, on the basis of which it can be concluded that the obtained model describes 76.7% of the total variance. The level of the interest rate can be predicted based on the independent variables since the model is statistically significant ($F=106.51$, $p<0.0005$).

Based on the results shown in Table 5, it can be seen that the loan repayment term, the participation of the loan beneficiary and the simplicity of the loan realization procedure have a significant impact on the prediction of the interest rate. Therefore, it can be seen that hypothesis 5 can be rejected because the obtained results showed that the level of the interest rate can be predicted based on the rest of the set factors, that is, the conditions for obtaining a loan, which is necessary in the business of medium-sized agricultural enterprises.

This coincides with the already stated views on the importance of establishing real internal control mechanisms, which was highlighted in works (Novaković et al., 2018; Paor, 2021).

Conclusions

With this study, the authors showed that there is a theoretical and functional significance for all eight factors as well as for the factor of their overall score, which can affect the obtaining of loans in the observation period of 2022-2024.

Therefore, the first conclusion of the authors of the study would be that there is a strong influence of all the mentioned factors on obtaining loans in agricultural business, as well as that there is a statistically significant difference in relation to obtaining loans both in agricultural farms and in the business of medium-sized agricultural enterprises in the Republic of Serbia.

Another conclusion would be that based on the application of multiple linear regression based on the term of loan repayment, the participation of the loan beneficiary, the possibility of crediting VAT, lending agricultural equipment as a subject of loan security, the simplicity of the loan realization procedure, the minimum loan amount and the possibility of adjusting the repayment plan can be to predict the level of the interest rate for agricultural holdings.

The third conclusion would be that based on the previously listed factors, the level of the interest rate in the business of medium-sized agricultural enterprises in the Republic of Serbia can be predicted.

Based on the conclusions presented in the study, the authors point out that there is full justification for this study because they showed the essential existence of the influence of the analysed factors on obtaining loans, both in agricultural farms and in medium-sized agricultural enterprises. In addition, in subsequent research it is possible to continue the presented research by expanding it to analyze other factors as well as to other entities that participate in the organization of agricultural production.

Conflict of Interests

The authors declare no conflicts of interest.

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ANALYSIS OF IMPLEMENTATION OF THE IPARD II PROGRAM IN SERBIA

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A B S T R A C T

In Serbia, high expectations were focused on the IPARD Program, considering that in the entire transition period, there was a greater demand for favorable sources of financing for agriculture and rural development compared to their supply. The purpose of the paper is to analyze the implementation of the IPARD II program in Serbia, in the current period, that is, ending with the end of February 2024. The paper uses the following methods: desk research, method of descriptive statistics, as well as methods of analysis and synthesis. The authors conclude that there was a significant utilization of funds from the IPARD II Program in Serbia, ending on February 29, 2024, but also that less than half of the submitted projects met the set criteria. In order for this method of financing to have the best possible effect in Serbia, better education of the inhabitants of rural areas is needed for writing projects. Also, greater financial resources from the European Union are needed in future support programs.

Introduction

The majority of agricultural entities in Serbia do not make a profit in their production, which especially applies to the family farms. Therefore, these subjects do not have their own accumulation for self-financing of production, so there was a great demand for external sources of financing throughout the entire transition period. The subsidies paid from the agricultural budget were insufficient to meet the needs for favorable sources of financing, and there were high expectations from the pre-accession funds of the

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European Union, and especially from the IPARD II program. This program foresees the first significant financial support of the European Union for the financing of agriculture and rural development in Serbia, in the amount of 175 million euros. When mandatory funds from the "national contribution" are added to these funds, in the amount of 54.9 million euros, it can be concluded that the total budget of the IPARD II program, for the program 2014-2020 period amounts to 229.9 million euros.

The main purpose of the pre-accession programs is to finance the development of agriculture and rural development, but also to prepare candidate countries for membership in the European Union, in order to harmonize the measures of their agricultural policies with the Common Agricultural Policy of the EU after accession (Martinovska-Stojcheska et al., 2021). Some authors (Gluščević et al., 2017; 753) believe that, precisely, the IPARD program is the "first steps in the use of further more generous funds for agriculture and rural development EU".

As some authors point out (Zekić et al., 2016; 171), in order to assess the potential importance of the IPARD program for financing agriculture and rural development in Serbia, it is necessary to analyze the contributions of similar pre-accession financial instruments. in other countries. In this regard, the cited authors state that in the period from 2007 to 2012, the following countries: Croatia 130 million euros, of which the largest part of the funds (39%) was used for investments in agricultural holdings; Macedonia 65 million euros, of which 26% was invested in the development of processing and marketing; Turkey 650 million euros, of which 20% was invested in the development and diversification of farms. A group of authors (Šestović et al., 2017; 516) based on their research concluded that "all three analyzed countries (Croatia, Macedonia and Turkey) have a positive correlation between the two factors: IPARD funds and export of agricultural products". In order to implement this program in Serbia in better way, a group of authors (Martinovska-Stojcheska et al., 2021; 31) states "it is recommended to increase the minimum investment threshold for all measures and to redirect small applicants to national measures".

The special importance of the IPARD program is that it encourages rural development. For this purpose, great effects are also expected from measure 5, which is accredited in Serbia within the IPARD III program (Paraušić & Bekić-Šarić, 2021). According to Ciani (Ciani, 2003; 7), the essence of modern rural development is characterized by: diversification, integration, innovation, product quality and certification, sustainability, pluralism of activities and multifunctionality. There are views in the literature that rural economies need integral rural development. The authors Pejanović and Tica (Pejanović & Tica, 2007; 148) believe that the integration of economic, social, institutional, demographic and ecological aspects of development is necessary for this development concept.

The development of rural tourism is of particular importance for rural development. According to some authors (Todorović & Štetić, 2009; 31-32), this activity is correlated with agriculture and can be, among other things, a factor in the development of agriculture, the market of agricultural products, but also in the overall "developmental tendencies of rural areas". The author Pejanović (Pejanović, 2013; 201) also indicates that this activity contributes to the "complete valorization of the natural and anthropogenic values of the rural area". Rural tourism also affects the diversification of rural economies. According to Bogdanov (Bogdanov, 2007), there are three types of diversification of rural economies, of which, in our opinion, the most common is diversification, which the quoted author calls "flow - diversification". As she explains, this diversification is characterized by the fact that the rural population's primary occupation is in agriculture, and additionally in non-agricultural activities.

When we analyze the possibilities for the development of rural tourism, it can be said that Serbia has quality natural resources (Cvijanović et al., 2016; Đurić et al., 2019). In one research (Radović et al., 2018; 423) it was concluded that "rural tourism entities do not generate adequate profits that would allow them to self-finance their activities, and existing funding modalities are inadequate or insufficient". A group of authors also believes that the IPARD program will provide the missing financial resources for the development of this activity (Jeločnik et al., 2018). In the recent research (Radović et al., 2023; 467), it was concluded that they are needed "greater available financial resources ...as well as better education of the inhabitants of rural areas for writing projects".

The analysis of all the stated positions of the quoted authors confirms our opening position, that in Serbia there are great expectations from the financial support of the European Union, which is realized through the IPARD II program. However, it is clear that, in addition to the above, other ways of financing are also needed. According to some others (Ristić et al., 2021; 1124), these are the agricultural budget, as well as "bank loans adapted to the needs of agricultural and rural economy, as well as securities and similar financial instruments". Certainly, in order to develop agriculture, it is also necessary to harmonize agricultural policy measures with the Common Agricultural Policy of the EU. According to the opinion of a group of authors (Ćurčić et al., 2021; 170) in Serbia, the concept of a new agrarian policy should be aimed at "the complete revival of agriculture, its revitalization, financial consolidation, innovation and affirmation of the intensification of the production framework".

Materials and metods

The purpose of the paper is to analyze the implementation of the IPARD II program in Serbia, in the current period, that is, ending with the end of February 2024. The paper uses the method of descriptive statistics, desk research, as well as the method of analysis and synthesis. The sources of data are the literature that deals with the field related to the subject of research, documentation and reports of competent institutions - the Administration for Agrarian Payments and the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia.

Results with Discussions

In order to analyze the current implementation of the IPARD II Program in Serbia, all important data related to this program have been briefly presented, as well as the basic characteristics and importance for the development of agriculture in Serbia of the pre-accession aid of the European Union that existed before the IPARD II Program.

The pre-accession aid program for the Republic of Serbia - IPARD II Program was adopted by the Decision of the European Commission on January 20, 2015. As part of this financial support, 175 million euros were allocated from the European Union budget for financing agriculture and rural development in Serbia in the 2014-2020 program period. According to the procedure of the European Union, financing is realized according to the principle of co-financing. This means that part of the funding for projects is provided from the IPARD II Program, and part from domestic funds. Regarding the part of the funds that needs to be provided from domestic sources, it is foreseen that the participation of the public sector can be a maximum of 50%, while the rest of the funds must be provided from the funds of the private sector (IPARD II Program).

Let us recall that the European Union, by adopting the Regulation of the European Council no. 1085/2006, on July 17, 2006, established the Instruments for Pre-accession Assistance - IPA, as financial support to potential candidate countries and candidate countries for EU membership. The main goal of the IPA component is to provide financial support to candidate countries.

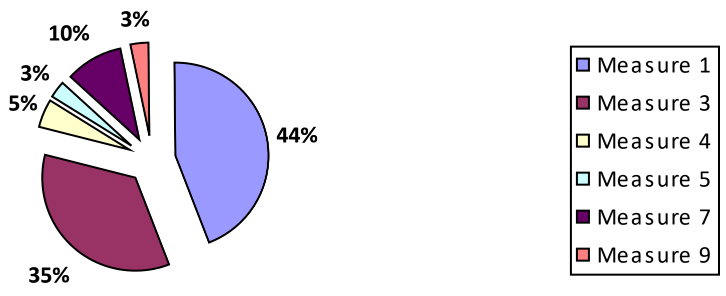
The IPA pre-accession instrument includes five components: (1) support in the process of transition and institution building; (2) support for cross-border cooperation; (3) support for regional development; (4) support for the development of human resources; (5) support for agriculture and rural development (IPARD). Potential candidate states are entitled to financial support based on the first two components, and states that have received candidate status are entitled to financial support based on the 3rd, 4th and 5th components.

The Republic of Serbia, while it was in the status of a potential candidate for membership in the European Union, in the period from 2007 to 2012, was entitled to total financial support in the amount of 1,183.6 million euros, of which 1,113.46 million euros was for support for the transition and strengthening institution and 70.14 million euros based on financial support for cross-border cooperation, that is, for regional development. According to the data of the Ministry for European Integration, in the period from 2007 to 2013, the Republic of Serbia used over 95 percent of the funds available to it based on the IPA funds. The most funds were placed for the reform of the state administration (35.24%), for the development of human resources (18.12%), for environmental protection and energy (12.32%), for competitiveness (11.17%), for the development of the judicial system (8.08%), for traffic (6.25%), for development of civil society, media and culture was placed (4.54%). Only 4.28% of the total amount of funds of the first two IPA components was allocated for the development of agriculture and rural development. More precisely, the possibility of placing funds in rural development was only within the component related to cross-border cooperation. Part of these funds was used for the development of multifunctional agriculture and its developmentally most significant segment - rural tourism (Radović, 2019).

By acquiring the status of a candidate for EU membership on March 1, 2012, Serbia acquired the right to use the remaining three IPA components. The fifth component – the IPARD Program, is the most important for financing agriculture and rural development. The goal of the IPARD Program is to prepare the future members of the European Union for the implementation of the measures of the Common Agricultural Policy (CAP).

IPARD – Instrument for Pre-Accession Assistance for Rural Development represents the most complex IPA component. It includes measures that are grouped into three axes. Measures within the 1st axis refer to the improvement of agricultural competitiveness, market efficiency and the implementation of EU standards. Measures within the 2nd axis refer to agro-ecological measures, environmental protection and support for good agricultural land management. Measures within the 3rd axis refer to the diversification of rural economies and the improvement of the quality of life of the rural population.

Figure 1. Participation of measures in the financial structure of the IPARD II in Serbia

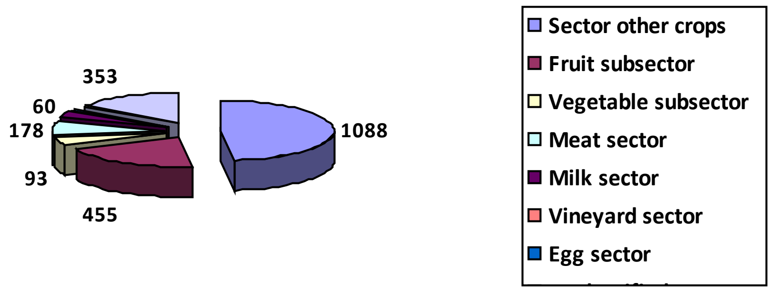


Source: IPARD II Program

The percentage of possible financial support for all accredited measures in the total financial resources available within the IPARD II program in Serbia is presented in Figure *(Figure 1).* By analyzing the graphic display, it can be concluded that more than half of the available financial resources of this fund are planned to be realized through Measure 1 and Measure 3. This paper analyzes the implementation of the IPARD II Program in Serbia from the beginning of implementation, from 2017, until February 29, 2024. In the mentioned period, Measure 1, Measure 3, Measure 7 and partly Measure 9 were implemented.

Measure 1 includes investments in the physical assets of agricultural holdings, namely investments in the sectors: milk, meat, fruits and vegetables, eggs, grapes, as well as in the sector of other crops (cereals, oilseeds, sugar beets). Beneficiaries of this support can be persons who are registered in the Register of Agricultural Farms and who are in an active status: natural persons (owners of commercial family agricultural farms), entrepreneurs, economic companies and agricultural cooperatives (IPARD Rulebook, a).

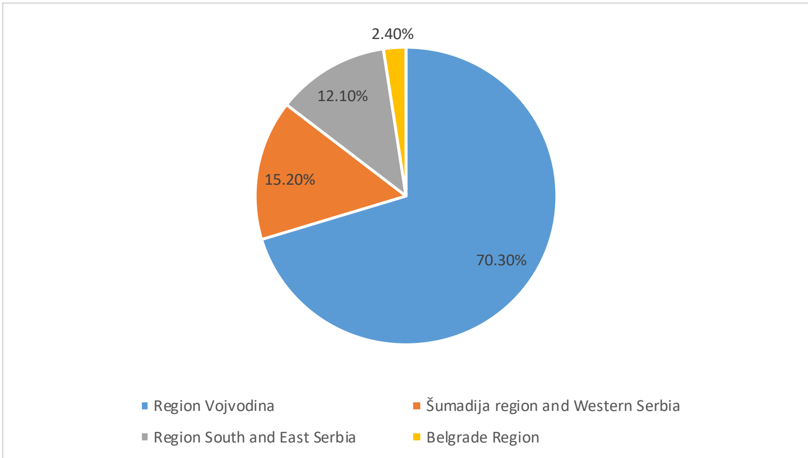
Figure 2. Structure of submitted requests - Measure 1 ending on June 30, 2023.



Source: Report IPARD II, June 30, 2023, p. 9.

As part of the implementation of Measure 1 of the IPARD II Program, ending on February 29, 2024, a total of seven calls were announced. The first invitation was published on February 26, 2018, and the last on April 22, 2022. A total of 2,260 requests for project funding were submitted. In their structure, projects in the sector of other crops had the largest share (48%). In second place are projects in the fruit sub-sector, which accounted for 1/5 of the total submitted requests for funding *(Figure 2)*. When analyzing the structure of submitted requests for funding according to the applicant's regional affiliation, it can be concluded that Vojvodina Region had a dominant share in the structure with 70.3% *(Figure 3)*.

Figure 3. Structure of submitted requests by region - Measure 1 ending on June 30, 2023.



Source: Report IPARD II, June 30, 2023, p. 15.

As part of Measure 1, the total available funds of the European Union were 88.3 million euros, of which 85% were implemented, as of February 29, 2024. Of the total number of submitted projects, 46.5% met the criteria *(Table 1)*.

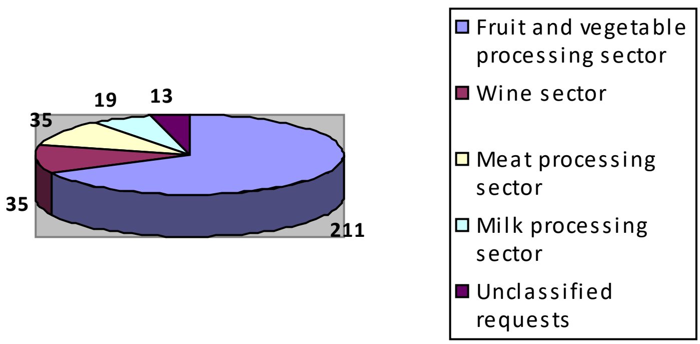
Table 1. Implementation of Measure 1 as of February 29, 2024.

Number of published calls (competitions)	Budget - EU contribution 2014-2020 (in €)	Submitted projects	Contracted projects	Realized budget contribution to the EU 2014-2020 (in €)	Realization of the available budget to the EU 2014-2020 (in %)
First call	6,276,676	85	32	2,079,782	33.14
Second call	3,490,023	393	143	3,132,048	89.74
The third call	19,126,808	151	54	8,583,155	44.88
The fourth call	7,710,539	437	265	7,435,984	96.44
The fifth call	24,777,548	169	84	12,926,664	52.17
The sixth call	41,212,499	369	244	32,395,306	78.61
The seventh call	8,622,028	656	228	8,520,019	98.82
Total	88,322,473	2,260	1,050	75,072,959	85.00

Source: http://www.minpolj.gov.rs/download/29.2.2024.pdf.

Measure 3 includes investments in physical assets, which concern the processing and marketing of agricultural and fishery products. These are investments in the following sectors: milk, meat, fruit and vegetables, eggs and grapes. Beneficiaries of this support can be agricultural entities: entrepreneurs, business companies and agricultural cooperatives, provided that they are registered in the Register of Agricultural Holdings or are registered in the Agency for Business Registers, and are in an active status (IPARD Rulebook, b).

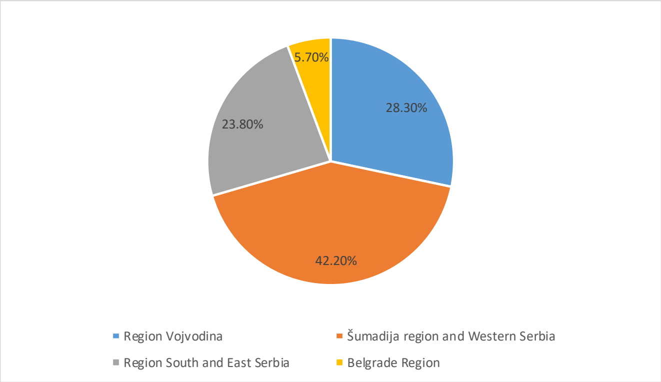
Figure 4. Structure of submitted requests - Measure 3 ending on June 30, 2023.



Source: Report IPARD II, June 30, 2023, p. 11.

As part of the implementation of Measure 3 of the IPARD II Program, four calls were announced. The first invitation was published on May 28, 2018, and the last on October 29, 2021. A total of 313 requests for project financing were submitted. In their structure, projects in the fruit and vegetable processing sector had the largest share, which accounted for 67% of the total number of submitted projects *(Figure 4).*

Figure 5. Structure of submitted requests by region - Measure 3 ending on June 30, 2023.



Source: Report IPARD II, June 30, 2023, p. 15.

When analyzing the structure of submitted requests for financing according to the applicant's regional affiliation, it can be concluded that the region of Šumadija and Western Serbia had the largest participation *(Figure 5).* The total available funds of the European Union, based on Measure 3 of the IPARD II Program, were 43.5 million euros and they were realized with 84.29%, as of February 29, 2024. Of the total number of submitted projects, 48.2% met the criteria *(Table 2).*

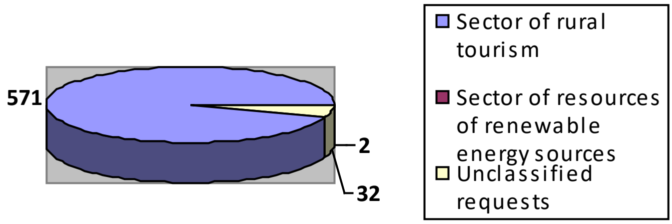
Table 2. Implementation of Measure 3 as of February 29, 2024.

Number of published calls (competitions)	Budget - EU contribution 2014-2020 (in €)	Submitted projects	Contracted projects	Realized budget contribution to the EU 2014-2020 (in €)	Realization of the available budget to the EU 2014-2020 (in %)
First call	5,554,284	26	12	1,324,160	23.84
Second call	22,312,225	81	34	7,563,794	33.90
The third call	34,529,501	95	45	10,725,065	31.06
The fourth call	19,142,564	111	60	17,023,016	88.93
Total	43,461,806	313	151	36,636,035	84.29

Source: http://www.minpolj.gov.rs/download/29.2.2024.pdf.

Measure 7 includes investments in the diversification of the activities of agricultural holdings and business development. This measure aims to encourage the creation of new jobs and a direct increase in the income of households in rural areas. The aim of this measure is to improve the quality of life in rural areas, which should have an impact on reducing migration from rural areas to urban areas. Beneficiaries of this support could be: physical persons (as holders of a family agricultural farm), entrepreneurs and companies, which are either registered in the Register of Agricultural Farms or registered in the Register of Business Entities and are in an active status (IPARD Rulebook, c).

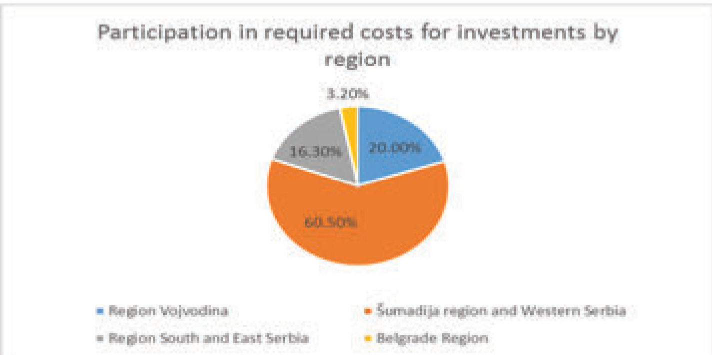
Figure 6. Structure of submitted requests - Measure 7 ending on June 30, 2023.



Source: Report IPARD II, June 30, 2023, p. 12-13.

As part of the implementation of Measure 7 of the IPARD II Program, two calls were announced. The first invitation was published on October 30, 2020, and the second on December 17, 2021. A total of 605 requests for project financing were submitted. In their structure, projects in the rural tourism sector had the largest share (94%). Only 2 projects were submitted in the resource sector in renewable energy sources *(Figure 6).* When analyzing the structure of submitted requests for financing according to the applicant's regional affiliation, it can be concluded that, both in Measure 7 and in Measure 3, the region of Šumadija and Western Serbia had the largest share *(Figure 7).*

Figure 7. Structure of submitted requests by region - Measure 7 ending on June 30, 2023.



Source: port IPARD II, June 30, 2023, p. 15.

The total available funds of the European Union based on Measure 7 of the IPARD II Program were 26.2 million euros and they were realized with 82.59%, as of February 29, 2024. Of the total number of submitted projects, 28.9% met the criteria *(Table 3).*

Table 3. Implementation of Measure 7 as of February 29, 2024.

Number of published calls (competitions)	**Budget - EU contribution 2014-2020 (in €)**	**Submitted projects**	**Contracted projects**	**Realized budget contribution to the EU 2014-2020 (in €)**	**Realization of the available budget to the EU 2014-2020 (in %)**
First call	15,000,000 €	311	102	11,321,556	75.48
Second call	11,251,837 €	294	73	10,318,050	91.70
Total	26,200,000 €	605	175	21,639,605	82.59

Source: http://www.minpolj.gov.rs/download/29.2.2024.pdf.

In the past period of implementation of the IPARD II Program, two calls for Measure 9 - Technical assistance were published. This measure includes costs incurred for the purpose of implementation, monitoring of implementation, as well as possible changes to the IPARD II program (AAP MAFWM RS). The total available EU funds, within this measure, are 500,000 euros. In the period from the beginning of the implementation of Measure 9, and ending with February 29, 2024, two public calls were published. The invitations were published on December 30, 2022 and December 29, 2023, and data on the implementation of this measure are still being processed (http://www.minpolj.gov.rs/download/29.2.2024.pdf).

Table 4. Realization by all measures ending with June 30, 2023.

Submitted requests for project approval	Support Requested	Number of approved projects	Approved public support	Number of paid claims	Public support paid	Amount of EU contribution paid
3,179	407.6 mil €	1,490	186 mil €	808	71.4 mil €	53.5 mil €

Source: Report IPARD II, June 30, 2023, pp. 4-6.

Based on the data shown in Table 4, it can be stated that as of June 30, 2023, only 25% of the total number of submitted projects under published public calls for all measures (including one project for Measure 9) was paid *(Table 4).* Paid public support amounts to 74.4 million euros, within which the EU contribution amounts to 53.5 million euros. The average value of public support paid per completed project was 80,632 euros, and the EU contribution was 60,474 euros (Report IPARD II, June 30, 2023, pp. 4-6).

Conclusions

Based on the conducted research, it can be concluded the following:

• In the Republic of Serbia, there was significant utilization of EU funds for financing agriculture and rural development, available within the IPARD II Program, ending on February 29, 2024, according to all implemented accredited measures;

• Less than half of the submitted projects met the set criteria;

• The residents of rural areas in Serbia need to be better educated for writing projects:

• More available EU funds are needed in the next support programs.

More precisely, as of February 29, 2024, the utilization of available EU funds was as follows: (a) for Measure 1 it was 85%; (b) for Measure 3 it was 84.29%; (c) for Measure 7 it was 82.59%.

When analyzing the total number of submitted projects based on published calls for individual measures and the total number of projects that met the set criteria of the IPARD II Program, and on the basis of which the investment contracts were concluded, the situation is analytically viewed as follows:

- For Measure 1, 46.5% of the total number of submitted projects met the criteria;

- For Measure 3, 48.2% of the total number of submitted projects met the set criteria;

- For Measure 7, only 28.9% of the total number of projects that participated in the published calls met the set criteria.

The above data point to the conclusion that agricultural entities in the Republic of Serbia were very interested in using financial resources from the IPARD II Program, but also they were not sufficiently familiar with the methodology for developing projects in accordance with EU requirements. Also, it can be concluded that the available funds for all the implemented accredited measures of the IPARD II Program would be insufficient in a situation where all submitted projects met the set criteria.

From an analytical point of view, the realization by measures is as follows:

- For Measure 1, a total of 88.3 million euros was available, a total of 2,260 projects were submitted, in the structure of which the largest share was the sector of other crops (48%) and the sub-sector of fruit (20%), the most submitted projects were from the Region of Vojvodina (70.3%);

- For Measure 3, a total of 43.5 million euros was available, a total of 313 projects were submitted, in their structure the sector of fruit and vegetable processing had the largest share (67%), the most submitted projects were from the Region of Šumadija and Western Serbia (42.2%);

- For Measure 7, a total of 26.2 million euros was available, a total of 605 projects were submitted, in their structure the sector of rural tourism had the largest share (94%), the most submitted projects were from the Region of Šumadija and Western Serbia (60.5 %).

Collectively, according to all the accredited measures of the IPARD 2 Program, a total of 3,179 projects were submitted in Serbia. As of June 30, 2023, 25% of the total number of submitted projects had been paid. The total disbursed funds of the European

Union amounted to 53.5 million euros, which is 31% of the total available funds within the IPARD 2 program in Serbia.

In further research, it would be useful to analyze the implementation of the IPARD 2 Program in Serbia, once the entire process of document processing based on submitted projects is completed.

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Conflict of interests

The authors declare no conflict of interest.

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FACTORS AFFECTING FINANCIAL REPORTING QUALITY IN AGRICULTURAL COMPANIES IN THE REPUBLIC OF SERBIA

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ABSTRACT

The research objective is to establish the factors that influence financial reporting quality (FRQ) in agricultural companies in the Republic of Serbia. Based on a sample of 99 large and medium-sized companies in this sector (86.09% of the total population), and following the analysis of 2018-2022 financial statements and auditor's reports, we examine the conditionality of earnings management (EM) as a FRQ determinant at enterprise level. In order to achieve the defined objective, we apply statistical methods, i.e. correlation and multiple linear regression. The research results indicate that more profitable companies have better FRQ, i.e., a higher return on assets, then companies whose financial statements are audited by Big 4 audit firms and companies with low debts. Also, the research results indicate that FRQ of the sampled companies is not affected by their liquidity, board size and audit tenure.

Introduction

Making business decisions in order to effectively manage the company and improve its performance implies the existence of an adequate information base. Most of the required information can be found in regular financial statements, which, at the same time, have a public character and represent the primary source of information about the company's financial status and performance for external users. In order to have a positive impact and reduce the agency problem, increasing investment efficiency, financial market development and, ultimately, progressive national economy stand

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for fully justified efforts to improve financial reporting quality (FRQ). The role of regulatory bodies in this process is crucial; however, worldwide financial scandals and frauds impose the need to evaluate FRQ and financial statements that include important information. This also helps identify the leading factors that affect FRQ, all with the aim of observing the possibility of its improvement.

There is a large number of papers dealing with the issues of measuring FRQ and examining the factors affecting it. Financial reporting is indeed a very complex category so there is still no universally accepted definition of its quality. This explains difference in approaches and models of FRQ measurement. However, one of the main factors of FRQ violation is when managers use discretionary rights for their personal interests, which is why earnings management (EM) is very often used as a measure of FRQ. Also, when talking about the factors affecting FRQ, abundant research results are often contradictory as a result of different observation contexts.

The research objective is to examine the achieved FRQ level in agricultural companies in the Republic of Serbia and identify the factors affecting it. Discretionary accrual, as a measure of EM, calculated using the Kasnzik (modified Jones model), is used as a proxy FRQ. Based on the literature review and the dominance of these factors in previous studies, we single out six variables as potential FRQ predictors. These are factors related to the company's financial characteristics (return on assets, leverage and liquidity), the corporate governance system (board size) and audit activities (size of audit firm and audit tenure).

We believe that this research will have a double contribution, both theoretical and practical. First, the research results will increase database on FRQ in agricultural enterprises in the Republic of Serbia and fill the research gap about factors affecting it. Also, the research results are expected to improve financial reporting practice in agricultural companies, and, even more importantly, enterprise management, bearing in mind that accountants and managers will be able to identify the key components of the reliability of financial reporting, and, consequently, achieve business sustainability.

This paper is structured as follows. After the introduction, the theoretical background that explains the research subject is presented. The following part gives an overview of literature and hypothesis, followed by a part on the applied methodology, research results and discussion. The conclusion reached in the paper are given at the very end.

Theoretical background

As a product of financial reporting, financial statements are the most suitable way to provide stakeholders (current and potential investors, creditors, the state, the general public, etc.) with information about the company's financial status, its earning capacity and cash flow. Financial statements are the first source of information about the company and are used as a reference in preparing plans and making business decisions (Mbir et. al., 2020). According to Sahi et. al. (2022) in market economies, financial reporting has two key roles: valuation role – reduces information asymmetry by ensuring transparency of information in order to adequately value the company, and stewardship role – allows external capital suppliers to assess management performance. Nevertheless, in order for financial statements, along with additional non-financial disclosures, to provide crucial support in making efficient and effective decisions (Echobu et. al. 2017), their quality must not be questioned. Only high-quality financial statements are a condition of security and trust in the business environment. Therefore, effective communication takes place if financial statements provide information that reliably interprets the company's economic reality, i.e. if they provide users with the opportunity to assess the company's financial and structural position and its exposure to risks, timely detect signals about the company's future and upcoming performance seen as future earnings and cash flows, assess management's ability to create added value, etc. The importance of high-quality financial statements not only for their users, but also for stronger financial system, financial markets, lower risk of financial crises, stronger national economy and better economic integration justifies the view that quality financial reporting is in the public interest.

FRQ is the ideal to which professional accounting regulatory bodies have always aspired. The adoption of international accounting standards (IAS/IFRS) has significantly improved FRQ, which numerous authors confirm (Rad, Embong, 2013, Dayanandan et. al., 2016, Wadesango et. al., 2016, Anto and Yusran, 2023). What the International Accounting Standards Board (IASB) intended was to define accounting principles and policies to be applied in the preparation and presentation of financial statements, all with the aim of producing useful information for users when making business decisions. With this in mind, the IASB defined the qualitative characteristics of the information to be found in financial statements: faithful representation, relevance, reliability, timeliness, and understandability, thus building a tool for assessing the quality of financial reporting. In this sense, the IASB determines FRQ by the achieved level of qualitative characteristics. However, defining accounting principles and policies and qualitative characteristics of financial statements, which set the standards for their quality, certainly does not mean that this issue has been completely resolved. More precisely, IAS/IFRS give a lot of flexibility in accounting procedures and objective judgment when defining measurement rules and recognition criteria (Abed et. al., 2022). In this regard, creative accounting is enabled as "application of advance accounting techniques & knowledge supported by existing laws and regulations" (Rahman et. al., 2023). Also, apart from the legitimate practice of abuse of accounting techniques and principles (Dechow, Skinner, 2000), managers often intentionally violate accounting regulations and omit material facts, all with the aim of misleading users of information found in financial statements. If the information is not complete, it is not possible to expect protection from opportunistic insider manipulation (White, 2020).

Free judgment and manipulation take different forms, but as "one of the most significant criteria for evaluating the performance and prospects of a business is earning measured by accounting" (Doan et. al., 2021, 131), earnings management is especially pronounced. It is about "management intervention to determine the amount of profit, i.e. showing a higher profit and a better financial position or showing a lower profit and a worse balance sheet, depending on the interest" (Đorđevic, Spasic, 2022). This practice, which produces false information about the company's economic performance and thereby misleads users, is one of the main factors that ruins financial reporting quality (Tariverdi et.al., 2012). In this sense, FRQ should be viewed as a very complex category, bearing in mind the numerous, ever-present risks of deliberate, premeditated manipulation of information that reduces its reliability and objectivity. Numerous scandals in both non-financial and financial sectors confirm this, which imposes the need to address FRQ with special attention, or, as Pangaribuan et. al. (2023) says "Good quality and good financial reports are urgently needed".

Bearing in mind the importance of FRQ, a large number of renowned authors in the field of accounting focused on its definition in their research. However, as academics, first of all, have not yet agreed on the universally accepted definition of FRQ, so no single formula for its measurement has been adopted (Almaqtari et. al., 2018). Given that IAS/IFRS leave the possibility for earnings management activities, numerous authors find that FRQ is a considerably complex phenomenon influenced by numerous factors, both at the external and at the company level. Thus, Cioncan et. al. (2021) observe FRQ in: (1) macroeconomic terms, considering that the political and legal system of a country, valid accounting regulations and the tax system are recognized as its essential factors, and (2) microeconomic terms, because the established system of corporate governance, the characteristics of the company itself and the audit specifics have a particular impact on FRQ. In a similar way, DeFond and Zhang (2014) see FRQ through the following equation: „FRQ= f (AQ, R, I) and FRQ/AQ>0, where FRQ is a function of audit quality (AQ), the quality of the company's financial reporting system (R) and characteristics of the company itself (I)". It follows that achieving high FRQ is conditioned by the integrity of all participants in the financial reporting supply chain: accountants, managers, audit committees and external auditors (Barac, 2021).

Factors affecting FRQ – literature review and hypothesis development

A large number of empirical studies on this topic confirm the importance of identifying factors that have a leading influence on FRQ. While some authors focus on factors outside the company, most of them look at internal factors as dominant: the company's financial performance, corporate governance, external and internal audit, etc. (Hung et. al., 2023). The analysis of literature points to the conclusion that their results are very often contradictory; that is, in some cases certain factors are identified as having a large positive impact, in another case a negative one, while often having no connection with FRQ.

This research focuses on examining the impact of microeconomic factors, i.e. those at the company level, on FRQ. We select factors most often studied in previous research and whose impact on FRQ is particularly prominent. In this regard, we focus on company characteristics such as Return on Assets (ROA), Leverage (LEV), Liquidity (LIQ), then Board Size (BSIZE), related to the established corporate governance system, and finally factors related to audit quality – Size of the audit firm and Audit tenure.

Return on assets (ROA)

ROA is one of the leading indicators of the company's profitability, which indicates how much profit the company is able to generate from its assets. Rahman and Hasan (2019) emphasize that it is an indicator that is "much volatile and prone to be manipulated", which is why it is rightfully considered one of the significant factors of FRQ. As Cioncan et. al. (2019) point out, profitable companies tend to provide users with more extensive and better information in order to improve their reputation. Fathi (2013) is of a similar opinion, indicating that poorer financial performance is more easily subject to manipulative activities. What is more, Hung et. al. (2023) find that higher ROA gives better FRQ. Expectations of a positive relationship between ROA and FRQ can be explained by the fact that management in profitable companies has the need to justify their actions with better reporting, which maximizes the shareholder value and increases their compensation packages. Monday and Nancy (2016), Adebayo (2022), Balios et. al. (2021) and Ebrahimabadi and Asadi (2016) point to the opposite, that ROA has a significantly negative impact on FRQ, while Masud (2021), Cioncan et. al. (2019) indicate that the relationship does not even exist.

Leverage (LEV)

LEV points to the company's ability to cover all its obligations to creditors in the long term. Since the company's ability to operate smoothly in the long term depends on this ability, this factor is recognized as potentially influential on FRQ, which is why it was the subject in a large number of studies (Fathi, 2013, Takhtaei et. al., 2014, Okika et. al., 2019, Saleh et. al., 2020, Cioncan et. al.,2021, Bui, Nguyen, 2021, Balios et. al. 2021, Hung et. al., 2023). One of the starting points is that companies that are highly indebted, that is, those that strive to attract the necessary funds, have a greater motivation to provide high-quality information to investors Okika et. al., (2019). However, on the other hand, rising indebtedness without assets growth can be a reason for manipulation in accounting. LEV has often been used as a factor of FRQ. However, except for Takhtaei et. al. (2014), who indicate a positive relationship between these variables, and Adebayo (2022), Okika et. al., (2019), Bui and Nguyen, (2021), Masud (2021), who point to a negative relationship, other authors do not find a statistically significant relationship.

Liquidity (LIQ)

A company's liquidity presupposes its ability to pay all its obligations when they fall due. As it is a solid indicator of the company's financial stability, it is fully expected that companies with a high liquidity ratio also need to disclose high-quality information in their financial statements. This implies that liquidity and FRQ are in a positive relationship, that is, the higher the company's liquidity, the higher the FRQ, which Shehu and Ahman (2013) confirm. In contrast, Adebayp (2022), Echobu et. al. (2017) and Okika et. al. (2019) indicate that company management has a greater tendency to manage earnings (which negatively affects FRQ) in cases of higher liquidity. Apart from these contradictory results, Hung et. al. (2023) and Masud (2021) find that LIQ does not have a statistically significant effect on FRQ.

Board Size

Board Size is one of the most frequently analyzed indicators among corporate governance factors (Cioncan et. al., 2019), bearing in mind that the company board has a significant role in monitoring and controlling managers' opportunistic behavior. Having that in mind, research results are contradictory. Fathi, (2013), Mahboub (2017), Bui and Nguyen (2021), Hung et. al. (2023) believe that boards with more members have more knowledge and competences, as well as the capacity to more effectively control management's potentially manipulative activities, which then improves FRQ. On the other hand, Ostadhashemi et. al. (2017) point to a negative relationship between board size and FRQ, due to the fact that boards with a small number of members assume easier work coordination and communication between members.

The Size of the Audit Firm

By providing assurance on the truthfulness and objectivity of information in financial statements, audit is one of the main guardians of FRQ. „Strengthen external independent audits to evaluate the effectiveness of existing accounting policies and processes" is one of the measure to limit profit adjustment, i.e. opportunistic management behavior (Hung, 2023). Therefore, the fulfillment of that role can only be expected from a well-conducted audit. One of the criteria that is often taken as a proxy for audit quality is the size of the audit firm, and some authors state that audit firms belonging to the Big 4 group are synonymous with quality (Cioncan et. al. 2019). The reason for that is that the Big 4 audit firms have a reputation that they want to preserve, and they are not inclined to take risks and be involved in scandals due to omissions in their work. In addition, the Big 4 audit firms are considered to have a better financial position, technology and a greater number of competent auditors. Lopes (2018), Alzoubi (2016, 2018), Cioncan et. al. (2019), Mesbah & Ramadan (2022) confirm this. On the contrary, Krismiaji (2021), Sharf and Abu-Nassar (2021), Masud (2021) are of the opinion that the superiority in identifying earnings management activities is not exclusively related to the Big 4 audit firms, which they prove in their research.

Audit Tenure

Audit tenure, or the number of years an auditor has audited a company, is also recognized as a factor that particularly affects audit quality, and, indirectly FRQ. Mesbah and Ramadan (2022) distinguish long term audit tenure, which implies a period of auditor's work for the same client for more than three years, and short audit tenure, when that period is three years or less. Authors who have dealt with this relationship have a divided opinion on the impact of audit tenure on FRQ. On the one hand, a longer audit tenure with a client leads to a friendly auditor-client relationship, which threatens the auditor's independence and may decrease audit quality and FRQ. Mesbah and Ramadan (2022) and Salehi et. al. (2022), Alzoubi (2018) confirm this. On the other hand, Sharf and Abu-Nassar (2021), Krismiaji (2021) come to the conclusion that a longer tenure actually allows the auditor to better understand the client's business and thus has greater opportunities to spot irregularities and influence the reduction of earnings management.

Proceeding from the theoretical assumptions and previous research results, the following hypothesis has been defined:

H1: Return on assets (ROA), Leverage (LEV), Liquidity (LIQ), Board Size (BSIZE), Size of Audit Firm (SAF) and Audit tenure (AT) are factors that significantly affect financial reporting quality (FRQ) in agricultural companies in the Republic of Serbia.

Methodology

Sample selection

In order to examine the possibility of predicting financial reporting quality using the selected factors, the sample consists of private companies in the fields of agriculture, forestry and fishing in the Republic of Serbia. Bearing in mind that two predictors refer to audit, large and medium-sized companies that are liable for audit under the Law on Auditing (Article 26) are taken into account. According to the data available in the Serbian Business Registers Agency database, 115 private companies (8 large and 107 medium-sized) are actively operating in this sector, and they constitute the initial sample.

In order to test the quality of financial reporting and identify the factors affecting it, the primary sources of data were the companies' financial statements covering the period 2018-2022, as well as the accompanying auditor's reports available on the Serbian Business Registers Agency's website. Since 7 companies did not make all the necessary data available in their financial statements, they were excluded from the research. Also, no auditor's reports were available for 9 companies (7 companies did not have an auditor's report for any of the observed years, while 2 companies in the last two observed years moved from the small to medium-sized category and then became liable for audit). For these reasons, the final sample consists of 99 companies and 396 financial statements and auditor's reports over a four-year period. In this sense, the final sample makes up 86.09% of the total number of companies, which can be considered relevant for our research.

The collected data was analyzed using the statistical package for social sciences IBM SPSS Statistics 20.0 (Statistical Package for Social Sciences - SPSS, Version 20.0).

Selection and measurement of variables

Measurement of dependent variable

The dependent variable in this research is Financial Reporting Quality (FRQ). In order to test the defined hypothesis as a measure of FRQ, we look at Earning Management (EM). There are numerous EM calculation models in literature; however, the models mostly applied are Discretionary accruals. In these models, the total calculation is divided into a non-discretionary part (economically determined calculation) and a discretionary part, which is the result of managerial discretion in the choice of accounting estimates and methods. In this sense, Discretionary accruals (DA) assume the measure of EM, i.e. a higher share of discretionary accruals in the total accruals indicates a higher level of EM and consequently lower FRQ.

We apply Kasnzik (modified Jones model) for the purpose of discretionary accruals, which can be presented as follows:

(1) $TA_{it}/A_{it-1} = \beta_0 1/A_{it}\text{-}1 + \beta_1(\Delta REV_{it}\text{-}\Delta REC_{it}/A_{it-1}) + \beta_2(PPE_{it}/ A_{it-1}) + \beta_3(\Delta CFO_{it}/ A_{it-1}) + \varepsilon_{it}$

where:

TA_{it} - total accruals for the company i in the current period t;

A_{it-1} - total assets for the company i in the previous year t-1

β0, β1, β2, β3 – estimated parameters or regression coefficients;

ε_{it} – residual variable or Earnings management (EM) = Discretionary accruals (DA)

ΔREV_{it} – change in net sales revenues of the company i in the current year t compared to the previous year t-1;

ΔREC_{it} – changes in net receivables from sales in the current year t compared to the previous year t-1

ΔCFO_{it} - change in net cash flow from operating activities in the current year t compared to the previous t-1

PPEit – gross value of property, plant and equipment for the company i in the current year t

The DA procedure first implies the determination of the total accruals TA_{it} as follows:

(2) $TA_{it}=Ni_{it} - CFO_{it,}$

Where:

Ni_{it} is net income for the company i in current year t. Given that

(3) $TA_{it}= NDA_{it} + DA_{it}$, i.e. $TA_{it}= NDA_{it} + \varepsilon_{it}$

In the next step we calculate NDA_{it} using multiple linear regression analysis. In the last step, we calculate the discretionary accruals as follows:

(4) $DA_{it}\ (\varepsilon_{it}) = TA_{it} - NDA_{it}$.

It is especially important to divide all variables by the value of total assets at the beginning of the year A_{it-1} in order to mitigate potential heteroskedasticity.

After the steps performed using data related to the companies in the sample, the model of discretionary accruals has the following form:

(5) $\varepsilon_{it}\,(DA_{it})= TA_{it}/A_{it-1} - 1433{,}65/A_{it-1} + 0{,}02369\ (\Delta REV_{it}\text{-}\Delta REC_{it}/A_{it-1})$

$+ 0{,}03834\ (PPE_{it}/A_{it-1}) - 0{,}63578\ (\Delta CFO_{it}/ A_{it-1})$

Measurement of independent variables

In accordance with the theoretical background, the literature review and the defined hypothesis, the independent variables are: Return on assets, Leverage, Liquidity, Board Size, Size of audit firm and Audit tenure. An overview of the independent variables and their measurement methods is given in Table 1.

Table 1. Description of independent variables

Variables	Acronym	Measurement Techniques
Return on assets	ROA	The ratio of net income to total assets
Liquidity	LIQ	The ratio of current assets to current liabilities
Leverage	LEV	The ratio of total debt to total assets
Board Size	BSIZE	Number of members in board of directors
Size of the auditing firm	SAF	Assigned 0 for Big Four audit firms and 1 for Non Big Four audit firms
Audit tenure	AT	Assigned 0 – long audit tenure is when the same audit firm performed audits for more than 3 years Assigned 1 – short audit tenure is when the audit firm performed audit for 3 years or less

Source: author's own account

Methods

Testing the influence of the selected factors on FRQ, i.e. their predictive power, requires multiple linear regression. In this sense, the following regression model is developed:

(6) $FRQ_{it} = \beta_0 + \beta_1 ROA_{it} + \beta_2 LIQ_{it} + \beta_3 LEV_{it} + \beta_4 BSIZE_{it} + \beta_5 SAF_{it} + \beta_6 AT_{it} + \varepsilon_{it}$

$_{it}$ indicates the observed predictor variables for firm $_i$ in time $_{t.}$

Research results and discussion

The results of the analysis first refer to the descriptive statistics of all variables included in the model, which is presented in Table 2. The mean, minimum, maximum and standard deviation of the variables are shown for the total number of 396 observations.

Table 2. Descriptive Statistics

Operational Variables	Obs.	Minimum	Maximum	Mean	Std. Deviation
DA	396	-3,16845	,56585	-,03733	,25889
ROA	396	-5,86	10,79	3,09	1,35
LIQ	396	,08	6,27	1,90	,31
LEV	396	1,37	84,42	49,55	25,46
BSIZE	396	1	11	3,26	2,60
SAF	396	0	1	,89	,30
AT	396	0	1	,66	,47

Source: Authors' calculations

The preliminary analysis proves the assumption of normality of the variance, and in further analysis we determine the degree and direction of the linear relationship between the dependent and independent variables, as shown in Table 3.

Table 3. Correlation Matrix

Variables		FRQ	ROA	CLIQ	LEV	BSIZE	SAF	AT
DA	Pearson Correlation Sig (1-tailed)	1	-,552 ,000	,077 ,063	,520 ,000	-,328 ,005	-,358 ,026	,440 ,003
ROA	Pearson Correlation Sig (1-tailed)		1	,066 ,096	-,463 ,000	-,160 ,001	,181 ,000	,032 ,264
LIQ	Pearson Correlation Sig (1-tailed)			1	-,278 ,000	-,043 ,916	,069 ,084	-,520 ,000
LEV	Pearson Correlation Sig (1-tailed)				1	,146 ,002	-,025 ,311	-,298 ,000
BSIZE	Pearson Correlation Sig (1-tailed)					1	-,076 ,067	-,091 ,036
SAF	Pearson Correlation Sig (1-tailed)						1	-,007 ,442
AT	Pearson Correlation Sig (1-tailed)							1

Source: Authors' calculations

The correlation matrix, the correlation coefficients and the appropriate degree of significance (Sig<0.05) show that only ROA and LEV have a strong relationship with DA. ROA has a negative correlation (r= - .552, p<0.05), which means that DA decreases as ROA increases. LEV shows a positive correlation (r= - .520, p<0.05), which implies that changes in LEV have the same direction as DA.

For other variables, we find the following relationships: BSIZE moderately negative, SAF moderately negative and AT moderately positive correlation with DA. LIQ has a weak relationship (below 0.3) with ROA, and this relationship is not statistically significant (p= .063), which is why we believe that this variable should be excluded from further research.

In the correlation matrix, it is also necessary to look at the collinearity of the independent variables, because it is not recommended to include independent variables whose linear correlation is 0.7 or more in the same analysis. In our analysis this is certainly not the case. However, as problems with multicollinearity of independent variables cannot always be identified in the correlation matrix, the results stem from the Variance Inflation Factor (VIF) and Tolerance, as shown in Table 4.

Table 4. Multicollinearity of independent variables

Variable	VIF	Tolerance
ROA	1,272	,786
LEV	1,004	,996
BSIZE	1,026	,974
SAF	1,034	,967
AT	1,001	,999

Source: Authors' calculations

As already known, if VIF is above 10, and Tolerance is below 0.10, then there is the problem of multicollinearity. Table 2 shows that VIF does not go beyond 10 in any of the variables. What is more, Tolerance does not go below 0.10 in any of the variables, so there is no problem with multicollinearity between the variables in this research.

After proving that the assumptions of the regression have not been violated, the regression analysis starts using the SPSS. At the beginning, we evaluate the model with the help of r^2 ie. coefficient of determination. This coefficient shows how much of the variance of the dependent variable is explained by the model. In our case, $r^2 = 0.395$, which means that the defined model explains 39.5% of the variance of DA. The model in our example is statistically significant (Sig= 0,0000, $p < 0,05$).

Table 5. Variables in the Equation

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Const.)	,058	,043		1,348	,178	-,027	,144
ROA	-,011	,001	,404	8,820	,000	,009	,014
LEV	,002	,000	-,332	-6,843	,000	-,003	-,002
BSIZE	-,004	,004	-,016	-,393	,694	-,009	,006
SAF	-,021	,034	-,025	-,612	,016	-,087	,046
AT	,016	,023	,029	,707	,148	-,029	,061

a. Dependent Variable: DA

Source: Authors' calculations

Given the data in the table, a classic linear regression model can be represented by the following equation:

(7) $FRQ_{it} = 0{,}058 - 0{,}011\,ROA_{it} + 0{,}002\,LEV_{it} - 0{,}004\,BSIZE_{it} - 0{,}021\,SAF_{it} + 0{,}016AT_{it} + \varepsilon_{it}$

Bearing in mind that the FRQ measure is a discretionary accrual, Table 6 provides an overview of the impact of each variable on DA, and consequently on FRQ, and then we briefly explain it.

Table 6. Connection of variables

Independent Variables		DA	FRQ	Significance
ROA	Decrease	Increase	Decrease	
LEV	Increase	Increase	Decrease	
BSIZE	Decrease	Increase	Decrease	×
SAF	Decrease	Increase	Decrease	
AT	Increase	Decrease	Increase	×

Source: Authors' calculations

Financial Reporting Quality and Return on Assets - ROA is a variable whose influence on FRQ is statistically significant and which, taking into account the Beta coefficient, predicts FRQ to the greatest extent. It has a strong negative relationship with DA, i.e. decrease in ROA leads to an increase in DA, which actually reduces FRQ. Based on that, it can be concluded that the management has greater tendency to manipulate earnings when the company operates less profitably, i.e. more profitable companies have better FRQ. This finding is consistent with the results of the Fathi (2013) and Hung et. al. (2023) research.

Financial Reporting Quality and Leverage – LEV indicates the company's financial position and the degree of its indebtedness, and has a statistically significant and positive relationship with DA. It follows that managers in companies that borrow more are more likely to resort to manipulations, which consequently reduces FQR which is in line with the results of Adebayo (2022), Okika et. al., (2019), Bui and Nguyen, (2021) and Masud (2021) research.

Financial Reporting Quality and Board Size – BSIZE has a negative relationship with DA, which means that as the number of managers on the board increases, so does earnings management, while FRQ decreases. However, in companies operating in agriculture, mining and forestry sectors in Serbia, this influence is not statistically significant, bearing in mind that $p>0,05$ which is consistent with the result of Adebayo (2022) research.

Financial Reporting Quality and Size of audit firm – SAF has a negative relationship with DA, i.e. an indirectly positive influence on FRQ. As Lopes (2018), Alzoubi (2016, 2018), Cioncan et. al. (2019), Balios et. al. (2021) and Mesbah & Ramadan (2022) stated in their research, our results indicate that those companies whose financial statements are audited by Big4 companies are less likely to manipulate accounting information.

Financial Reporting Quality and Audit tenure – AT has a positive relationship with DA, which indicates that the longer the period of auditor's work for the same client, the greater the manipulation in financial statements and consequently the lower FRQ. These results are consistent with the results of Mesbah and Ramadan (2022) and Salehi et. al. (2022), Alzoubi (2018), however, in the selected sample, this influence is not statistically significant.

Summarizing the research results, it can be concluded that the hypothesis can only partially be proven. More precisely, ROA, LEV and SAF are factors that significantly influence FRQ, while LIQ, BSIZE and AT are without influence.

Based on the presented results, it can be said that the defined hypothesis has been partially confirmed, i.e. that Return on assets (ROA), Leverage (LEV) and Size of Audit Firm (SAF) significantly influence the quality of financial reporting (FRQ) in agricultural companies in the Republic of Serbia, while Liquidity (LIQ), Board size (BSIZE) and Audit tenure (AT) have no predictive power.

Conclusions

The constant complication of business activities in companies subject to financial reporting, which brings greater opportunities for manipulating financial information, makes the issue of FRQ, although always present in accounting practice, especially popular. High-quality financial statements increase the trust of the company's stakeholders, thereby creating a favorable environment for investment and economic activity, but also strengthening the national economy and ensuring social well-being as the supreme goal of society.

As agricultural activity is one of the key drivers of the national economy, this research examines the factors affecting the quality of financial reporting in agricultural companies in the Republic of Serbia. On a sample of 99 large and medium-sized companies, three factors with the leading influence on FRQ are tested. Research has shown that more profitable companies are more responsible in disclosing high-quality information in their financial statements compared to less profitable companies. The same is true with companies whose level of indebtedness is at a lower level, as well as companies that hire audit firms from the Big4 group for the purpose of auditing their financial statements. In the case of the remaining two analyzed factors, board size and audit tenure, although they have a positive or negative correlation with FRQ, this correlation is not statistically significant, i.e. these factors do not significantly affect the realized level of FRQ in agricultural companies in the Republic of Serbia.

Regardless of the statistical significance of certain factors, we believe that their consideration by management is of key importance for the improvement of FRQ in these companies and at the same time for the improvement of their operations. Namely, the management of less successful and more indebted companies must be more careful in reporting because the disclosed financial position and performance may be the result of accounting manipulation. In addition, increasing the quality of disclosed information in financial statements opens up a greater possibility of attracting the necessary funds and thus improving the company's operations.

Also, the boards of directors, especially the smaller ones, should show greater responsibility in controlling and monitoring management's opportunistic behavior, especially when hiring audit firms. This is because research results show that longer period of cooperation with the same audit firm decreases FRQ. In this regard, special attention must be paid to the importance of rotation of audit firms in order to avoid a possible drop in the auditor's independence, lower quality of the conducted audit activities, and consequently lower FRQ.

The presented research results should attract the attention of regulatory bodies that have significant responsibility in preserving the stakeholders' trust in FRQ. By analyzing the factors affecting earnings management, special attention should be paid to the improvement of control mechanisms, especially external auditing. Also, based on the research of Aničić et. al. (2023) special attention in the Republic of Serbia regarding the improvement of the FRQ should be focused on the greater participation of the accounting profession in the adoption of legal regulations, the establishment of national accounting standards, greater practical education and training of accounting staff, harmonization of legal regulations with EU Directive 2013/34 EU and so on.

Conflict of interests

The authors declare no conflict of interest.

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SOLAR ENERGY AS A DRIVER OF SUSTAINABLE DEVELOPMENT IN AGRICULTURE: POTENTIAL AND LEGAL FRAMEWORK FOR IMPLEMENTATION IN THE REPUBLIC OF SERBIA

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A B S T R A C T

The authors analyze two very important topics, which are intertwined, and relate to the legal regulation and application of solar energy in agriculture in our country. Solar energy reduces the costs of agricultural production in the long term and increases sustainability and competitiveness. Therefore, when it comes to the application of solar energy in agriculture, an important factor that directly affects market positioning is the greater competitiveness of food produced using clean energy. In addition, legal frameworks significant for the use of solar energy in agriculture at the European level and within the borders of the Republic of Serbia were considered as the subject of the paper. The Republic of Serbia has real potential for the production and application of solar energy, but these potentials are not sufficiently used, and the experiences of EU countries can be significant when adopting measures from the sphere of energy policy, especially if one takes into account the context of European integration in accordance with environmental protection.

Introduction

Food, energy and water are the three most important resources on our planet that life depends on (Sarr et al., 2023, Barron-Gafford et al., 2019). These three resources are also of limited availability, increased global demand and limited sustainability (Carmona-Moreno et al., 2021; Acosta-Silva et al., 2019). Due to the rapid growth of

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the population and the satisfaction of their basic needs, the demand for these three basic resources is expected to increase in the future (OCDE/FAO., 2019; Iheanetu, 2022; Mughal, 2022). According to United Nations (UN) projections, the world population will increase from 8.5 billion, which is expected in 2030, to 9.7 billion in 2050 (Nations Unis. 2022). Accordingly, food production should be increased to meet the needs of the growing population. (Rao et al., 2023)

Agriculture, as a very important factor in sustainable development, is however facing the need for greater, but limited, access to energy. The agricultural sector consumes about 40% of energy worldwide. (Nazim et al., 2021)

Many energy policies in developing countries are designed for the needs of industry, transport and urban infrastructure. (FAO, 2000) The energy requirements of agriculture are often neglected, and although agriculture contributes significantly to economic and social development, often accounting for around 30% of the GDP of developing countries, the energy supply in agriculture has not received the attention that this sector deserves. (Benedek et al., 2023)

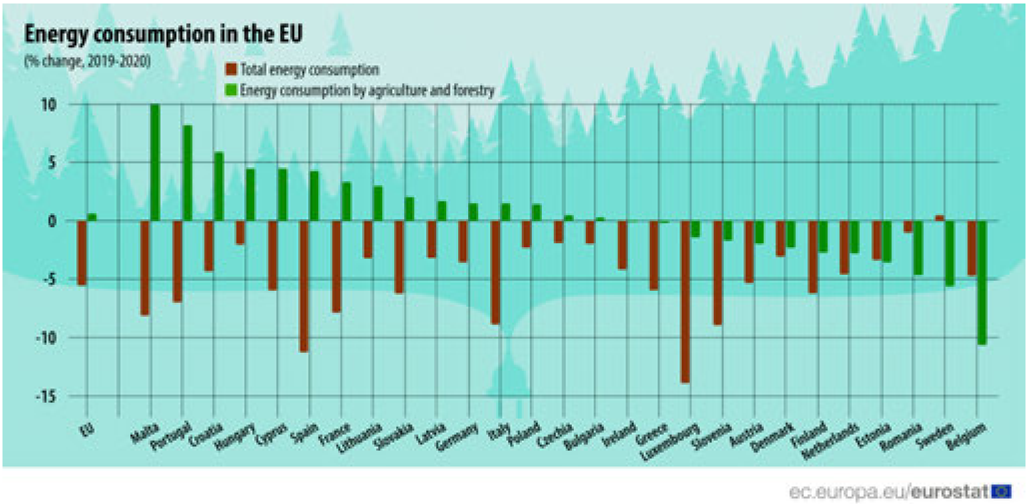
Ensuring a sufficient amount of available energy for agriculture should have a higher priority when evaluating the rural policy of the Republic of Serbia. Therefore, there is a need for urgent actions, due to the slow economic development in many rural regions and the migration of the rural population to urban areas. Modern agricultural production plays a key role in rural development.

Energy-sustainable agricultural production

Agriculture in itself represents the process of energy conversion, i.e. the conversion of solar energy through photosynthesis into food energy for humans and animal feed. (Zaman et al., 2012) Modern agriculture requires energy input in all phases of agricultural production, such as direct energy use in agricultural machinery, irrigation, cultivation, water management, and harvesting, but also after harvesting it involves energy for food processing, storage and transport to the market. In addition, there are many indirect or separated energy inputs used in agriculture in the form of mineral fertilizers and chemical pesticides, insecticides and herbicides. (Subić et al., 2017) Energy consumption in agriculture increased with the introduction of high-yielding plant varieties and mechanized crop production. (Acosta-Silva et al., 2019) According to Eurostat, between 2019 and 2020, an increase in the rate of energy consumption in agriculture and forestry was recorded, of which the highest growth was achieved by Malta at 10%, Portugal at 8% and Croatia at 6%. However, the decline of consumption in these sectors was recorded in Belgium by 11%, Sweden by 6% and Romania by 5%. (Figure 1.)

The largest share in total energy consumption in 2020 was in the Netherlands at 9%, followed by Poland and Latvia, both with 6%. In the Netherlands, greenhouse production had the greatest impact on energy consumption in agriculture. (Eurostat, 2020)

Figure 1. Growth in energy consumption for agriculture and forestry from 2019 to 2020.



Source: (https://www.agroklub.rs/poljoprivredne-vesti/porasla-potrosnja-energije-u-sektoru-poljoprivrede-i-sumarstva-u-2020/80819/)

After labour costs, energy is usually the largest overhead cost in greenhouse crop production, even in temperate climates. Of the required total energy, about 75% is spent on heating, 15% on electricity, and 10% on transport. (Acosta -Silva et al., 2019) In order to ensure better conditions for the growth of crops such as adequate lighting, temperature, humidity, composition and gas concentration when growing plants in a greenhouse, the use of electricity is required. The decrease and increase in the price of available energy resources, climate change and the unstable price of fossil fuels have increased the need for more environmentally friendly energy sources, which represents a challenge for sustainable agricultural production. (Babatunde et al., 2019)

The application of RES can therefore be a solution to this challenge (Gajdobranski et al., 2021) and solar energy, as it is available everywhere, represents one of the most suitable renewable energy sources (RES) (Al-Saidi et al., 2019). Solar energy in agriculture brings several other advantages, such as greater competitiveness of food produced using clean energy. According to research the application of photovoltaic (PV) solar systems on agricultural farms can reduce electricity costs by 50 to 70%. (Acosta-Silva et al., 2019)

Materials and methods

The methodological approach to the research was determined following the previously defined goal of the research and consists of a theoretical and empirical segment. The theoretical part of the research includes a normative analysis of the provisions of the Law on Renewable Energy Sources (LURES) and a comparison of the legal framework important for the use of solar energy in agriculture at the European level and within the borders of the Republic of Serbia. First of all, the authors, through a normative analysis of LURES provisions, indicate the need for further harmonization of domestic legislation with world and European legislation in the field of solar energy, as well as with obligations from ratified international documents and European integration processes. The theoretical part of the research aims to show that solar energy, as clean energy, can be used to increase the competitiveness of agriculture in the Republic of Serbia, and that there is adequate regulation for its application. Because the Republic of Serbia is predominantly an agricultural country, it has real potential for the production of solar energy in agriculture. These potentials are not sufficiently used, and the experiences of European Union (EU) countries in this sphere can be significant when adopting measures from the sphere of energy policy, especially if the context of European integration is taken into account, which must not neglect the requirements of environmental protection, and which is particularly reflected in the advantage of using solar energy in agriculture. “There are the conditions (clearly defined laws, conditions, and incentives) for investments in solar energy plants”. (Pavlović, 2017).

The empirical part of the research includes the analysis of relevant and available data on the application of solar energy in agriculture. The analysis aims to determine the relevant and available ways of applying solar energy in agriculture based on the experience of other countries.

The research is theoretical and empirical, in which the authors opted for the application of a descriptive, normative and comparative method. During the preparation, some current scientific and professional literature was used, through the research of foreign and domestic literature dealing with issues of solar energy in agriculture: books, collections of works, textbooks, and professional articles.

Bearing in mind the strategic importance of agriculture in the Republic of Serbia and the fact that solar energy in agriculture synergistically connects several components - economic, political, legal and environmental issues, the main hypothesis of this work is based on the assumption that solar energy can serve to increase competitiveness and sustainability in the long term, of agriculture in the Republic of Serbia, that is, the competitiveness of food produced using clean energy is greater. The sub-hypothesis is based on the assumption that there is an appropriate legislative framework in our country that ensures the use of solar energy in agriculture, to achieve sustainability and competitiveness, but it still needs to be harmonized with the legislation of EU countries, as well as with the obligations of harmonization with trends. European integrations and accepted international obligations.

In the end, a SWOT analysis was done, so that an important segment, in which all the mentioned components intertwine, was also processed. “Individual SWOTs can be examined in relation to one another according to estimates of their contribution to desired performance, along with approximations of the degree to which each factor is or is not within an organization’s control”. (Leigh, 2009)

Background

In the last fifteen years, the legislation regulating RES in the EU has been developing more and more. Massive, rapid deployment of renewable energy is at the heart of the REPowerEU PlanCOM/2022/230– the EU's initiative to end dependence on Russian fossil fuels. Solar energy is the main driver of these measures. A simple and abundant resource, such as solar energy, should contribute to reducing the EU's dependence on fossil fuels in all sectors of the EU economy, from heating residential spaces to agricultural use.

Key legislation in the area of renewable energy includes Directive 2009/28/EC on the promotion of the use of energy from RES (Renewable Energy Directive (RED)).[4] The European Green Deal was published at the end of 2019 and represents EU's biggest action to reach climate neutrality.(Kougias, 2021) The European Green Deal and the more ambitious EU climate goals enshrined in the European Climate Law (at less than 55 % greenhouse emissions by 2030 and climate neutrality by 2050) required further changes to achieve a higher share of RES in EU. The Fit for 55 (2021), which included another proposed revision of the Directive (EU) 2023/2413 (RED III) seeking to increase the share of RES in final energy consumption to 40 % by 2030. (EPRS, 2022)

The European Parliament adopted RED III, which is crucial for accelerating the introduction of RES, and is in line with the European Green Deal and the REPowerEU PlanCOM/2022/230). In RED III, the binding share of RES for 2030 is raised from 32 to 42.5%, with the directive calling on member states to reach 45%. RED III is also part of the Fit for 55 legislative and regulatory package. RED III has not been implemented in our legislation.

Changes from 2023

- The EU has updated its rules on energy in the framework European Green Plan and the Fit for 55 package, which aims to bring those rules into line with the EU's goal of climate neutrality by 2050, as well as the goal of reducing net greenhouse gas emissions by 2030 by at least 55% compared to 1990 levels.[5]
- Those rules have also been amended to include plan REPowerEU Plan COM/2022/230) which aims to reduce the EU's dependence on Russian oil and gas.
- Directive (EU) 2018/2001 was amended by Directive (EU) 2023/2413. (Most of the rules introduced by Directive (EU) 2023/2413 are to be transposed into

4 Originally adopted in 2009, it set the target of a 20 % share of RES in final energy consumption by 2020. The recast RED of 2018 (Directive (EU) 2018/2001) (RED II) increased this objective to 32 % of RES in final energy consumption by 2030 (it was supposed to be transposed into national law by 30 June 2021). (European Parliamentary Research Service (EPRS), 2022)

5 It is predicted that 25% of the required electricity will come from solar FN energy by 2050, with a reduction of 4.9 Gt $CO_{2,}$ which corresponds to a 21% reduction in emissions in the energy sector (IRENA, 2021).

national law by 2025, while most of those rules relating to licensing procedures are to be transposed by 1 July 2024).

Solar energy plays a crucial role in the global transition to clean energy and zero net emissions. (Pulselli et al., 2022) For the EU to achieve the 2030 RES target proposed by the Commission and the objectives of the REPowerEU Plan COM/2022/230), it must accelerate the process of introducing solar energy. To achieve this, the EU will have to install an average of 45 GW per year.[6] (EU Solar Energy Strategy (Com (2022) 221)) According to Solar Power Europe, the EU's solar energy production capacity continues to grow and reach an estimated 259.99 GW in 2023.

The potential of solar energy in the Republic of Serbia

Solar PV energy is everywhere available, a more environmentally friendly and economically viable alternative to conventional energy sources (Sass, 2020, Dos Santos et al., 2019, Belaud et al., 2019, Kibar, 2003). In 71 minutes, our planet receives as much solar energy as is sufficient for the energy needs of humanity for an entire year.

Serbia shows excellent potential for using solar energy. (Licastro, 2022) The potential of solar energy represents 16.7% of the usable potential of RES in the Republic of Serbia. The energy potential of solar radiation is about 30% higher in the Republic of Serbia than in Central Europe and the intensity of solar radiation is among the highest in Europe. (Lambić, 2011; Prvulović et al., 2018) Even so, the use of solar energy in the Republic of Serbia is still at the beginning. (Jakovljević et al., 2022)

The average daily energy of global radiation for a flat surface in the Republic of Serbia during the winter period ranges between 1.1 kWh/m2 in the north and 1.7 kWh/m2 in the south, and during the summer period between 5.4 kWh/m2 in the north and 6.9 kWh /m2 in the south. (Lambić, 2011) The most favourable areas in the Republic of Serbia record a large number of sunny hours, and the annual ratio of actual irradiance to total possible irradiance is approximately 50%. (Stamenić, 2009)

Application of solar energy in agriculture

Application of solar energy can be achieved in two ways: by converting solar energy into heat and electricity. (Stamenić, 2009) Solar systems for heat production are used in households, agricultural facilities and in the processing of agricultural products, where

6 EU Solar Energy Strategy (Com (2022) 221) it foresees that most of the funding will be private, but partly supported by public funding, among other EU funds. Within the "Recovery and Resilience Mechanism" at least EUR 19 billion has already been allocated to accelerate the introduction of RES. These measures will be financed from other instruments such as: cohesion policy funds, InvestEU, Innovation Fund, Modernization Fund, Horizon Europe and LIFE programs. The horizon of Europe framework program (from 2021 to 2027)," is the EU's main instrument for stimulating research in the field of energy with a budget of EUR 95.5 billion, including EUR 5.4 billion from the Next Generation EU program". (Locci, 2023)

large amounts of sanitary water are used. Solar thermal systems transform solar energy into thermal energy and help farmers create optimal growing conditions and reduce reliance on fossil fuel-based heating methods. Thermal energy in agriculture is necessary for heating sanitary water and heating air in dryers, silos, barns, farms and greenhouses.

Supplying agricultural holdings with electricity originating from the PV system has become more and more common in the field of agriculture in the EU. PV systems provide farms with a renewable and reliable source of electricity. These systems feed different aspects of agricultural activities (Ali, 2022):

1. Irrigation system: Solar panels are used to power irrigation pumps. This is especially useful in rural areas where grid electricity is not available. Solar irrigation systems enable efficient use of water and reduce energy costs. Solar energy sources have emerged as a green alternative with lower energy costs and, consequently, lower environmental impacts. (Picazo et al., 2018) These systems use solar energy to pump water from wells, rivers or reservoirs, providing an efficient and sustainable irrigation solution.
2. Reliable energy supply for farms: Solar panels can be used to ensure uninterrupted energy supply to farms. This may include lighting barns, powering cooling or heating systems, and other electrical needs.
3. Greenhouse climate control: Solar panels can be used to power greenhouse climate control systems. This includes heating, cooling, ventilation and automatic irrigation systems. By using solar energy for these purposes, farmers can reduce energy costs while being environmentally friendly.
4. Crop monitoring and surveillance: Solar panels can be used to power crop monitoring and surveillance systems, including sensors for moisture, temperature, soil pH, and other parameters critical to optimal plant growth and development.
5. Powering electric vehicles and machinery: Solar panels can be used to charge the batteries of electric vehicles and machinery used in agriculture, such as tractors, harvesters, mowers and other work tools. This can reduce fuel costs and emissions. „Although solar-powered tractors are in the initial development phase, the results are hopeful for a bright agricultural future." (Ali, 2022)
6. Solar spraying and seed transplant machines: Solar pesticide spraying machine is designed for small farmers to improve their productivity. (Khule et al., 2004) Solar-powered seed diffuser and transplant machines offer a simple and convenient way to spread and plant seeds in small fields, as well as in those areas where traditional machines are not available. It will be most beneficial for small farmers and the agricultural community. (Tariq et al., 2021) "Today, radio controlled solar transplants are designed to provide farmers with eco-friendly seed planting and diffusion." (Ali, 2022)

7. Solar Crops Drying: One of the applications of solar energy in agriculture is a solar drying system that depends on a variety of options. Solar dryers are available in different shapes and structures. (Norton, 2017; Kumar et al., 2018) Different types of solar dryer are available for different applications, which are used to dry agricultural products such as potatoes, cereals, carrots and mushrooms. (Tariq et al., 2021) The positive effects of investing in mini digital solar dryer (according to all indicators of the dynamic methods of investment assessment) indicate the justification and importance of implementing the modern systems in agricultural production that are based on the use of renewable energy sources. (Nastić et al., 2023)
8. Providing shade for crops. The application of photovoltaic panels can also be used to provide shade for crops, thus reducing their need for water. This concept, where the shade of the panel is combined with hydro-technics, is particularly suitable for use in areas with high daily temperatures during the summer period. "This innovative approach optimizes land use by achieving synergy between solar energy production and crop cultivation." (Wagner et al., 2023) On the other hand, while the crops are generating income, the electricity produced by the solar panels can be sold or used to offset farm energy costs.[7] "The convergence of solar energy and the agricultural industry has opened the door to a new era of sustainable agricultural practices". (Wagner et al., 2023)
9. The problem of lack of land for the construction of PV power plants has led to the development of technologies of floating PV power plants that are placed on dedicated platforms on calm water surfaces, such as ponds and reservoirs. The advantage of such systems is that they reduce water evaporation, and can contribute to the improvement of water quality. "Such plants can be planned on artificial lakes, while on natural lakes their construction may be conditionally acceptable if the coverage does not exceed 5% of the lake surface". (Đurišić, 2022).
10. Mobile solar units:[8] In addition to large power solar power plants, smaller power solar units, which can be stationary or mobile, are increasingly appearing on the market. Mobile solar units are especially interesting for agricultural applications. (Despotović, 2016)

7 "Solar panels are strategically placed above the crops, providing shade, thus reducing water evaporation and creating a more favourable microclimate for the crops while generating electricity, which can be used on-site or fed into the grid. This dual land-use approach optimizes resource allocation and promotes sustainable land management." (Wagner et al., 2023)

8 "They are ideal for use in agriculture because they are portable, easy to use, reliable and robust in exploitation, do not require special maintenance except for regular cleaning of the panels from dust, have a long service life (more than 20 years), do not produce noise and do not pollute nature. (Despotović, 2016)

Results and discussions

Solar energy reduces the costs of agricultural production in the long term while increasing sustainability and competitiveness. The application of solar energy in agriculture increases the chances for farmers, because sustainability, primarily the reduction of harmful emissions, is one of the key goals of the EU in the framework of the green transition. More work should be done to increase farmers' awareness of the benefits of using solar energy.

Solar PV and solar thermal technology can be introduced quickly, they can have a favourable effect on the climate, and citizens can save money. This is because the cost of solar energy has come down significantly over time.[9] The EU's RES policies in the last decade according to data IRENA have contributed to reducing the deployment costs of PV technology by 82% from 2010 to 2020, making it one of the most competitive sources of electricity in the EU.

They can be introduced very quickly because they use existing structures and do not harm nature, which is important for the agricultural production of ecologically safe food. Therefore, attractive financing conditions are key to their competitive introduction. The Commission's analysis indicates that additional investments in solar PV systems within the REPowerEU Plan (COM/2022/230) in the period up to 2027 would amount to an additional 26 billion EUR in addition to the investments needed to achieve the goals of the proposal from the Fit for 55 package. "Serbia plans to be part of the EU ETS system, on the way to joining the EU, for which, in addition to the analysis and technical assistance of the Energy Community, we also need financial assistance from the EU, as well as a sustainable period for implementation, after 2030, when we will have enough built green energy capacities" states MRE (2024).

EU Solar Energy Strategy (Com (2022) 221)

The EU, as a single area and a single market, strives to harmonize the national regulations of the member states. (Dukić Mijatović, 2022) Within the framework of the REPowerEU Plan (COM/2022/230), the Commission passed EU Solar Energy Strategy (Com (2022) 221) to double solar PV energy capacity to 320 GW by 2025 and to install 600 GW by 2030. Based on the plan, member states must establish and adopt plans for dedicated RES areas, with shortened and simplified permitting procedures.[10]

9 Solar PV sone of the cheapest sources of electricity available**.** Estimated at 24–42 EUR/MWh (depending on location within the EU) according to research by Eero Vartiainen et al; estimated at 32–74 EUR/KWh (depending on location within the EU) according to a study by Lugo-Laguni et al, (2021). According to the 2021 International Energy Agency (IEA) world energy forecast, it is estimated at approximately 60 USD/MWh in the EU. Estimated at USD 75-131/MWh in Italy, Spain, France and Germany according to the technical report IRENA: Renewable Power Generation Costs 2020. (IRENA, 2000).

10 he European Commission has launched the European Solar Academy, the first in a series of academies to be implemented under the Net Zero Industry Act (NZIA). The Commission allocated EUR 9 million from the Single Market Program for its launch.

By adopting this strategy, the EU Commission considered it necessary to solve several challenges in this area. It is important to point out that the EU Solar Energy Strategy (Com (2022) 221) as an innovative form foresees "multiple use of space." "Multiple uses of space can contribute to alleviating land constraints associated with competition over the use of space, among others for nature conservation, agriculture and food security." For example, the use of land for agriculture can under certain conditions be combined with the production of solar energy by agricultural PV systems. That is why in theory it is considered that "synergies can be established in these activities, within which PV systems can contribute to crop protection and yield stabilization,[11] (Barron-Gafford et al., 2019) where the land is still primarily used for agriculture."

EU The Solar Energy Strategy (Com (2022) 221) foresees that EU member states should consider incentives for the development of agricultural PV systems (e.g. by including agricultural FN systems in tenders for energy from renewable sources) when developing their national strategic plans for the common agricultural policy and within the support for solar energy. In doing so, it is emphasized that it is important to note that the EU rules on state support in the agricultural sector enable support for investment in sustainable energy. „State aid to promote the economic development of the agricultural sector is part of the wider framework of the „Common Agricultural Policy" (CAP). (Maksimović Sekulić et al., 2024)

The EU has developed an energy model that creates incentives to attract investment in RES and to integrate it into the grid. In the EU Solar Energy Strategy (Com (2022) 221), it is stated: "Many member countries of the Energy Community are interested in implementing that model with the support of regional electricity markets, and cross-border cooperation and infrastructure. Through its diplomatic action and strategic engagement in third countries, the EU will work on the expansion of solar energy and other RES to reduce exposure to the instability of fossil fuels and geopolitical risks". This is a chance for member countries of the Energy Community to expand solar energy in agriculture as well as other RES. That is why the adoption of LURES in our country is important so that this can be achieved.

Law on the Use of Renewable Energy Sources (LURES)

Due to the international agreement, the Stabilization and Association Agreement (SAA), which entered into force on September 1, 2013, the Republic of Serbia received the status of an EU-associated country, as well as based on the fact that with the adoption of the Law on the Ratification of the Treaty on the Establishment of the Energy Community, the Republic of Serbia became a member of the Energy Community, and thus accepted the obligation to apply European directives in the field of RES, we can conclude that with the adoption of LURES, Directive (EU) 2018/2001-RED II was "for the most part transferred" into our legal system. [12]

11 See the research conducted by the Fraunhofer ISE Institute on the subject: https://agri-pv.org/

12 This is stated by the Government of the Republic of Serbia in the document "Negotiating Position of the Republic of Serbia for the Intergovernmental Conference on the Accession of the Republic of Serbia to the EU" for Chapter 15 "Energy" from June 2021.

LURES like *a lex specialis* in the area of RES, it should also enable a concrete increase in the capacity of plants that produce energy from renewable sources. The most significant changes and novelties include new incentive measures (as instruments, i.e. support mechanisms for energy production from RES), as well as provisions related to the balanced responsibility of guaranteed suppliers (by the Guidelines on State Aid for Environmental Protection). Therefore, the adoption of LURES is significant, especially taking into account trends in the energy market, as well as internationally assumed obligations, which primarily relate to decarbonization and climate change.

After the adoption of LURES, it was necessary to adopt the relevant bylaws as soon as possible, which should enable the implementation of the law in full. LURES predicted a time frame of 6 months for the adoption of all relevant by-laws necessary for implementation, however, that deadline was not fully respected. In this way, there was no integral regulation of the legal framework, by not adopting complete by-laws. However, as a priority in the coming period, it is necessary to adopt the remaining by-laws so that the implementation of the law can be fully implemented and to cancel the collision between LURES and the umbrella Law on Energy (LE). LURES has fundamentally changed the provisions of the LE provided up to then, which refer to RES and which were in force until that moment. The fact is that, mainly due to this, there were certain gaps and a collision with the umbrella LE, which, until the amendments and additions, regulated certain issues in a directly opposing manner. However, in 2021, the Amendments to the Law were passed. However, the Republic of Serbia is still working on harmonizing with EU regulations, so by the end of 2024, changes to the LE should create regulatory conditions for integration into the single electricity market.

By analyzing the legal solutions, it can be seen that LURES abounds in numerous novelties and is aimed at harmonizing with international obligations, but at the same time, with the market needs relating to this type of energy production, which in the current circumstances is becoming “cheaper” and commercially more profitable for potential investors. Many authors believe that this reduces the need for incentives that are not sustainable on market and commercial principles and that lose their meaning given the above circumstances. (Despotović, 2016) On the other hand, there are new legal solutions, such as the buyer-producer model and the introduction of guarantees of origin.[13]

The adoption of LURES resulted in a significant change in the incentive system due to the introduction of two new incentive models: market premium and feed-in tariff. The

13 “In practice, the buyer-producer model is the fastest implemented, at least when it comes to citizenship.” (RERI)

legislator, by general trends, abandoned the original fixed feed-in tariff. [14] The market premium system is regulated in detail. By the way, this is a highly market-oriented method of incentives, and a liquid electricity market is necessary for success. The Republic of Serbia has yet to join the single European electricity market. But the Republic of Serbia is the only one in the region that has an intraday and day-ahead electricity market and is part of the regional stock exchange with two EU members - Hungary and Slovenia. The Ministry of Mining and Energy (MRE) is preparing an analysis and impact assessment of the implementation of the Carbon Border Adjustment Mechanism (CBAM) and is working on defining the most acceptable option for carbon taxation.[15]

The feed-in tariff based on LURES differs from the earlier regulatory framework of fixed tariffs and is determined at auctions. In contrast to market premiums, no regulation on the Model contract for the feed-in tariff has been adopted, so the legislative framework has not been fully defined. Also, no quotas were adopted for the feed-in tariff. That's why existing investors are increasingly choosing to develop plants that would be completely market-oriented, and LURES brings an important innovation here as well.

One of the novelties, which represents an improvement, is that LURES foresees that producers of electricity from RES can conclude contracts on the purchase of electricity with customers by market principles. (Article 46. LURES) The current LURES provides regulated rules for guarantees of origin for energy produced from RES.

An important innovation in LURES is the regulation of the concept of buyer-producer in the construction of plants for the production of electricity from RES for their own needs. Based on this concept, it is stipulated that "the customer-producer is the final customer who has connected his own facility for the production of electricity from RES to the internal installations (whereby the electricity produced is used to supply his own consumption), and the excess electricity produced is delivered into a transmission system, a distribution system, or a closed distribution system." (Article 4. paragraph 1. point 23. LURES) This can have an extremely positive effect on increasing the share of small RES power plants owned by citizens, and even cooperatives in agriculture, given that the procedure is significantly simplified, and there is also the possibility of financial savings. A big change compared to the previous regulation is the question of balance responsibility.

14 The primary incentive method, in terms of its applicability to large projects, is the market premium, which is "a type of operational state aid that represents an addition to the market price of electricity delivered to the market by market premium users and determined in Eurocents per kWh in the auction process." (Article 14. LURES)

15 "Carbon taxation at the local level can be one of the acceptable options for now, because with a fixed price, it would give predictability to the economy during the adjustment period. The introduction of a regional system for trading carbon emissions at the same price and modeled after the system that exists in the Emission Trading System (EU ETS) until 2030 is not an option for Serbia, due to the excessive financial consequences and complex application above all." (MRE-Đedović Handanović, 2024)

The evaluation of internal strengths and weaknesses, as well as external opportunities and threats for the application of solar energy in agriculture, was done with the help of a SWOT analysis. The results of the SWOT analysis were used to identify the strategy for achieving the goals. (*Table 1.)*

Table 1. SWOT analysis for the legal and political development of solar energy in agriculture in Serbia

Strengths	**Weaknesses**
• Sustainability: The use of solar panels enables the reduction of harmful gas emissions and supports sustainable agriculture practices. • Cost reduction: Solar panels can reduce energy costs, especially in rural areas where conventional energy sources are expensive or unavailable. • Diversification of income: The implementation of solar systems provides farmers with an additional source of income through the production of electricity. • Technological progress: Advances in solar panel technology lead to increased efficiency and reduced prices. • Competitiveness: Greater competitiveness of food produced using clean energy. • Legislative activity: LURES was adopted, which was mostly transferred to RED II.	• High initial costs: Initial costs for solar energy technologies are relatively high compared to other energy sources, but operating costs are therefore low. • Dependence on weather conditions: Solar panels depend on sunlight to produce electricity, which can be a challenge in cloudy or rainy areas. • Need for maintenance: Solar systems require regular maintenance to maintain optimal performance, which can be an additional expense for farmers. • Legislative activity: Not all by-laws necessary for the implementation of LURES have been adopted. • Administrative measures: There is a long wait for the approval of projects, and the administrative application is extensive, unlike in the EU, where new measures reduce this.
Opportunities	**Threats**
• Incentive policies: Government policies support the use of RES, which can facilitate investment in solar panels. • Legislative framework: It is necessary to continue harmonizing our legislation with EU legislation. • Technological development: Continuous progress in solar panel technology opens up new opportunities to increase efficiency and reduce costs. • Growing awareness of sustainability: A growing number of consumers and farmers recognize the importance of sustainability, which can increase demand for sustainably produced products. • Regulation: regulatory conditions for integration into the single electricity market should be created by amending the LE.	• Competition with other energy sources: Competition with other RES, as well as with traditional sources, can be a challenge for solar energy. • Policy and regulation: Changes in policy and regulation, including reductions in contributions or changes in tax treatment, can affect the economic viability of solar systems. • Lack of education: Lack of education about the advantages and possibilities of using solar panels in agriculture can limit their wider application. • Lack of connection with scientific institutions to develop research in this area.

Source: Authors

This SWOT analysis can help to better understand the factors affecting the application of solar panels in agriculture and identify strategies to determine the benefits and minimize the risks.

Conclusions

The energy requirements of agriculture are very often neglected, even though agriculture contributes significantly to economic development because the energy supply in agriculture has not received the attention that this sector deserves. Ensuring a sufficient amount of available energy for agriculture should have a higher priority when evaluating the rural policy of the Republic of Serbia. The reduction and increase in the price of available energy resources, climate change and the unstable price of fossil fuels have increased the need for more environmentally friendly energy sources, which represents a challenge for sustainable agricultural production.

In addition, since solar energy reduces the costs of agricultural production in the long term, it increases sustainability and competitiveness. When it comes to the application of solar energy in agriculture, an important factor that directly affects market positioning is the greater competitiveness of food produced using clean energy. Also, agricultural farms can produce energy for sale, and there is the branding of the destination in tourism as a green destination. Through reduced energy costs, environmental sustainability and energy independence, solar energy affects the sustainability of the agricultural community. By switching to solar energy, farmers actively contribute to the fight against climate change, the preservation of natural resources and the preservation of the environment for future generations. Solar energy gives farmers energy independence and reliability. Unlike the EU where farmers are often encouraged to finance through grants, tax credits and subsidies, this is not the case in the Republic of Serbia. In addition, in the Republic of Serbia, there is a lack of information for farmers on this topic, in the context of the green transition towards climate neutrality.

The average solar radiation in Serbia is about 40% higher than the European average, but the use of solar energy for the production of electricity is far behind the EU countries. (Stamenić, 2009) At this moment, it is justified to encourage the use of solar energy for the production of heat and electricity in the field of agriculture due to smaller investments. Such a policy would, among other things, be useful for the development of the domestic economy, as well as employment in the field of clean energy.

Solar energy plays a crucial role in the global transition to clean energy and zero net emissions in EU. That is why the REPowerEU Plan (COM/2022/230) was adopted, an initiative that was amended in 2023, and which aims to reduce the EU's dependence on Russian fossil fuels. Under this plan. In 2022, the Commission adopted the EU Strategy for Solar Energy (Com (2022) 221). Key act in the area of renewable energy includes Directive (EU) 2018/2001) on the promotion of the use of energy from renewable sources, which has had three revisions so far.

In our country, LURES should enable a concrete increase in the capacity of plants that produce energy from renewable sources. By analyzing the legal solutions, it can be seen that LURES is full of numerous novelties and is aimed at harmonizing with European integration, but at the same time, with market needs related to this type of energy production from renewable sources. It mostly transposed the RED II Directive, but not the latest RED III amendment. There are new legal solutions in it, such as the buyer-producer model, which was the fastest implemented in our legal system, when it comes to citizenship, but also the introduction of guarantees of origin, and others. Immediately after the adoption of LURES, due to the non-adoption of the relevant by-laws, there was no integral regulation of the legal framework in this area, this is being corrected. Given that LURES fundamentally changed the provisions of the second law - LE, there were certain gaps and a collision with LURES. However, in 2022, the Amendments and Supplements to the LE were adopted, which, for example, introduced the term buyer-producer into this act. However, the legislator is still working on harmonization with the EU regulation, so another amendment of the LE is foreseen to create regulatory conditions to join the single European electricity market. The Republic of Serbia is the only one in the region that has an intraday and day-ahead electricity market and is part of the regional stock exchange with two EU members - Hungary and Slovenia. The MRE is preparing an analysis and assessment of the impact of CBAM implementation and is working on defining the most acceptable option for carbon taxation. Finally, in the paper, an assessment of internal strengths and weaknesses, as well as external opportunities and threats for the application of solar energy in agriculture in our country was made with the help of a SWOT analysis.

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Conflict of interests

The authors declare no conflict of interest.

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BEYOND DISPOSABLE DESIGN: CHALLENGING PLANNED OBSOLESCENCE THROUGH CIRCULAR ECONOMY PRACTICES

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A B S T R A C T

The notion of obsolescence has transitioned from a naturally occurring phenomenon to a planned obsolescence, a strategic business model influenced by consumer demand, market forces, and technological progress. This paradigm began to take shape in the early 20th century and entails the production of pre-designed goods with a limited lifespan. Its widespread implementation has given rise to environmental degradation and increased waste generation. To tackle these challenges, we need to adopt responsible manufacturing practices. Currently, circular economy business models offer a chance to use more conscientious production methods. These methods focus on increasing output efficiency using fewer natural resources and materials. In addition, there is a focus on prioritising material reutilization and recyclability. This paper offers a detailed analysis of the development of planned obsolescence, including its historical evolution, causes, consequences and potential for modification of existing production practices to more fully implement the principles of the circular economy.

Introduction

Obsolescence is an inevitable aspect of an industrial production process. Obsolescence in manufacturing occurs when parts, services, and resources previously available are no longer produced by the original equipment manufacturer, as defined by the International Institute of Obsolescence Management (available at: IIOM), or in other words, the state where materials, chemicals, or equipment used in the production process become outdated or no longer useful.

From the user's perspective, product obsolescence refers to the state where a product becomes outdated, less desirable, or no longer meets their needs, leading to a desire to replace it with a newer model or alternative (Becher, 2021; Fels, 2016). This can be due to various factors, such as technological advancements, changes in fashion, style, or

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trends, wear and tear or deterioration of the product's functionality or appearance over time, incompatibility with newer technologies or services, lack of support, updates, or spare parts from the manufacturer (Fels, 2016).

Although product obsolescence can occur naturally (as technology progresses and consumer preferences evolve), perceived product obsolescence can be influenced by the manufacturer's marketing strategies, as planned obsolescence (Becher, 2021; Fels, 2016). According to J. Bulow's influential paper, "An Economic Theory of Planned Obsolescence" (1986), *obsolescence can be a deliberate strategy manufacturers employ, aiming at products that are designed with predetermined, limited lifespans to ensure consistent demand and consumption patterns (to* encourage repeat purchases*)* (Bulow, 1986).

From the moment this approach was recognised until today, different formulations of the production concept can be found in scientific and professional literature, such as dynamic obsolescence (Grattan, 2016) designed obsolescence, intended, built-in or programmed obsolescence (EP, 2016) or artificially limited lifespan as well early obsolescence (Directive 2024/825).

This obsolescence practice significantly challenges contemporary sustainability principles and the CE. Instead of promoting reuse and recycling, planned obsolescence fosters a culture of constant product replacement, leading to unsustainable consumption, increased waste, and a continuous demand for raw materials and energy. Planned obsolescence put a significant challenge that must be addressed to achieve the sustainability, waste reduction, and long-term resource efficiency advocated by the CE framework (Satiro et al., 2017). In the CE context, planned obsolescence impedes the transition to a more sustainable model and adversely affects consumers. By limiting the repair and extension of product lifespans, promoting continuous resource extraction over reuse and recycling, and imposing financial burdens on consumers, this practice prioritises corporate profit over environmental sustainability and the economic well-being of individuals. It creates a cycle of consumption that contradicts the core principles of the CE (Satiro et al., 2017; Barros, M. & Dimla, E., 2021). Understanding the historical implications of planned obsolescence development is crucial for comprehending potential ways to change industrial practices today.

The evolution of planned obsolescence

The development of the manufacturing concept of "planned obsolescence" dates back to the early 20th century and gained momentum during the Great Depression and also in the post-World War II era. An insight into the mechanisms that have helped to maintain this practice of industrial production to this day, as well as the accompanying consumption strategies, can help to overcome the observed approaches or make them more sustainable.

Historical insights modern implications

A significant change in the established approach to production came with new scientific knowledge and numerous technical discoveries in the era of the Second Industrial Revolution. Manufacturers used mass production methods to improve product efficiency. Torstin Veblen observed the social and economic dynamics of the United States of America in the late 19th century, and his work from 1899, The Theory of Leisure Class, was among the first to criticise the behaviour of the wealthy elite during the so-called Gilded Age (1870-1900) (Veblen, 1899). Veblen's concepts of "conspicuous consumption" and "conspicuous leisure" emphasised the ostentatious display of wealth and the non-productive activity of the upper class, emphasising the role of imitation and social comparison in driving consumption patterns (Veblen, 1899). He observes that goods can be made more desirable as their price rises because of the value placed on them as a status symbol, thereby defying the traditional law of demand. From a financial perspective, Veblen believed that the economy should provide for material needs, not vanity; its primary goal is to support life, not to satisfy whims.

For industrial production growth to be more justified by demand for specific goods, assistance in product promotion was becoming increasingly important. It is important to mention the science behind successful advertisements. This is the field in which Earnest Elmo Calkins (prominent American advertiser of 1920s and 1930s) approaches particularly excels. He introduced the concept of "consumer engineering" as a new "business science", which involves planned product development and marketing obsolescence to encourage repeat purchases by combining consumer insights, art, and strategic design (Calkins, 1932). He aimed to create a desire for specific goods by understanding consumer behaviour and preferences. It asks questions like *Would any change in goods or people's habits accelerate their consumption? Can new product models replace existing ones? Can artificial obsolescence be created?* Calkins suggested manufacturing demand through planned obsolescence, intentionally designing products to become obsolete and encouraging repeat purchases: "We have learned that prosperity lies in spending, not in saving. […] The increased profits come from increased production made possible by increased consumption." (Calkins, 1932). The advertising concept promoted by Calkins continues to impact marketing practices today.

During the Great Depression in the USA, the economic downturn was exacerbated by factors like the stock market crash in 1929, financial difficulties in Europe, and adherence to the gold standard. This global financial crisis led to widespread economic challenges, with countries struggling to recover (available at: history.state.gov). To stimulate the economy, Bernard London proposed planning the obsolescence of products to encourage the continuous purchase of new goods, thereby generating income and restoring employment and business prosperity (London, 1932). He coined the term "planned obsolescence" in 1932 with the pamphlet "Ending the Depression through Planned Obsolescence", with the basic idea for the government to impose a legal expiration date on personal items to encourage and sustain purchases, in this way addressing the problem of people not consuming enough during the depression, impacting the manufacturing sector.

The study of the renowned psychologist Abraham Maslow, scientifically confirmed that analysing customer preferences, a practice started by Calkins, can contribute to shaping consumption.

Abraham Maslow proposed a theory of human motivation in 1943 (Maslow, 1943). This theory, commonly applied in human resource management, categorises human needs into five tiers. It starts with fundamental necessities like sustenance, attire, and shelter, followed by security and social standing. The hierarchy culminates in the pinnacle of 'self-actualisation', which emphasises the universal human aspiration to fulfil one's inherent potential. This theory is relevant to planned obsolescence as it helps understand the psychological factors that drive consumer behaviour.

Walter Rostow also deals with the topic of consumption. In 1960, he traced the evolution of society in five stages - from a primarily agricultural society to the use of technologies that led to industrialisation and, finally, the entry into the era of mass consumption (the final stage in the development of society). Rostow based his model on real-life examples of the USA, UK, Germany, Japan and other wealthy nations, which followed more or less the same path (Reid-Henry, 2012). According to Rostow, the era of mass consumption represents the ultimate destination for any advanced economy, underscoring consumption's profound impact on societal advancement.

While Maslow's hierarchy links the self-actualisation of human needs with materialistic aspirations, Rostow's theory identifies mass consumption as the final stage of economic development (implying that increased consumption drives social progress). Both models suggest that excessive consumption is the driver of progress, prioritising it. However, these models do not consider the long-term unsustainable consequences of this approach, such as environmental degradation, overexploitation of resources, and strengthening of the culture of materialism, which is becoming more and more noticeable nowadays.

Rapid industrial development and increasing mass consumption raised concerns among the scientific community about the irrational use of resources. The report "Limits to Growth" (1972) predicted that without intervention, Earth's resources would be depleted due to the existing economic model (Meadows, 1972). The computer model in the report underscores mass production and consumption concerns, often resulting in resource depletion and environmental degradation.

Modern implications of planned obsolescence

Today, it is evident that maintaining the mass industrial production model requires implementing various mechanisms to support this approach. Market policies have led to different methods of guiding consumers towards purchasing new products.

Types of obsolescence are usually identified as:

1. Planned obsolescence: Bulow, in his seminal work, discussed that planned obsolescence can be a deliberate manufacturing strategy and stated that it is "much

more than a matter of durability; it is also and perhaps primarily about how often a firm will introduce a new product, and how compatible the new product will be with older versions" (Bulow, 1986). Maybe the most simplified understanding of the term involves designing a product to have a shorter lifespan or to function for only a limited number of operations (EP, 2016).

2. Indirect obsolescence: This occurs when the component required for repair is unobtainable or when it is not practical or cost-effective to repair the product.

3. Incompatibility or system obsolescence occurs when products fail to operate efficiently following successive software updates, prompting consumers to replace the product rather than attempt a potentially more expensive repair. An example is software updates that might slow or make a device stop functioning. Obsolescence related to software is an increasing worry as digitisation increases. Another example is electronic devices, where only specific components, such as batteries, become obsolete, but the repair cost exceeds the cost of replacing the entire commodity. Therefore, consumers are often indirectly forced to buy a new product rather than repairing the broken one.

4. Style, aesthetic, or psychological obsolescence: This is related to marketing campaigns encouraging the replacement of perfectly functional products due to changing styles. Marketing campaigns drive this obsolescence, which is usually studied in the fashion domain and consumer goods. A product still in perfect shape goes 'out of style' when a newer version or model that includes new features is released.

5. Technological or functional obsolescence occurs when a product becomes out of date because consumers are more interested in products with improved performance due to improved technology. In his book, The Waste Makers (1960), Packard addmits that "we are all heartily in favour of the functional type of obsolescence that is created by introducing a genuinely improved product (Packard, 1960)."

The easiest way to categorise planned obsolescence approaches is through three categories: function, quality, and desirability.

Planned obsolescence can impact the economy in multiple ways. This approach can provide short-term economic benefits for manufacturers and retailers by driving increased sales and revenue by constantly replacing products. It helps maintain stable or growing sales, as consumers are compelled to repeat purchases more frequently. But a society built on excessive consumption and disposal of goods is unsustainable in the long run, leading to resource depletion, environmental degradation, and a culture of waste, so this approach can have negative long-term consequences for the overall economy, as it undermines the principles of a CE and sustainable development.

Systematic directing of consumers towards purchasing new goods places a financial strain on consumers, who are forced to replace products, even if they are still functional constantly. This can lead to a reduction in consumer spending power and overall economic stability. With further technological development, additional consequences of mass production with built-in obsolescence is the increased generation of particular types of waste, for example, electronic waste, which has significant environmental and economic costs, such as pollution, resource depletion, and the need for waste management infrastructure. These environmental costs can ultimately impact the broader economy and society.

Discussions

Mass production and consumption generate large amounts of waste. In this era of accelerated social, economic, and technological development, this waste is viewed as a challenge that needs consideration and new, more rational solutions.

The "3R Initiative", focusing on *reduce*, *reuse*, and *recycle* (Initiative, 2005) plays a crucial role in addressing resource depletion and mass consumption, not merely a proposal but a resounding global call to action. Its inception at the 2004 G8 Summit and subsequent official launch at the Ministerial Conference in 2005 marked a pivotal moment (Barrie, 2022) [19]. This international recognition addresses the urgent issues of waste management and environmental sustainability.

The linear economic model supports resource consumption and contributes to waste generation primarily for profit. In response to this established industrial approach and to address the environmental and economic limitations of the "take-make-waste" method, there is a push to promote more sustainable production and consumption patterns through the CE approaches (EMF, 2013). Encouraging the constant replacement of products, generating an unsustainable consumption cycle, leading to the premature disposal of still functional products and wasting natural and energy resources used in their production, planned obsolescence, directly conflicts with the principles of the CE (hereafter "CE") which aims to minimise waste and promote sustainability through reuse, recycling, and reduction of consumption. To date, ten separate R's (R0-R9) have been stratified as different CE strategies, forming "9R-Framework" or R circularity strategies (Potting, 2017). By adopting tactics like *refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle*, and *recover*, businesses can prolong the lifespan of products, reduce waste output, and encourage a transition towards greener production practices (Alivojvodic, 2024). R-strategies' hierarchy ranges from R0 to R9, with higher priority indicated by lower R numbers (Alivojvodic, 2024).

Potentials for the shift of industrial systems towards circular economy practices

The 9R framework offers a valuable approach to combat planned obsolescence in industrial manufacturing by promoting sustainable methods prioritising resource efficiency, product longevity, and waste reduction. These methods underscore the importance of creating durable, easily repairable products suitable for reuse, effectively mitigating the adverse effects of planned obsolescence and fostering a circular, sustainable ethos within industrial operations. The critical changes industrial systems need to make to transition from a linear economy based on planned obsolescence to a circular economy include.

By addressing these key areas, such as product durability, extended producer responsibility, service-centred business models, and enhancing the reuse and refurbishment market, industrial systems can transition from planned obsolescence to a circular economy (hereafter: CE). This shift leads to more sustainable production and consumption patterns, reducing waste and promoting overall sustainability.

Contemporary industrial systems need to transition from a linear economy approach with usually embedded planned obsolescence to a CE. Modification of existing systems requires a comprehensive approach. Some of the critical steps to shift towards a CE:

1. Redesigning products for longevity and reusability through durability - design products to last longer, reducing the need for frequent replacements; modularity - utilise modular designs for easy repair and upgrades, or standardisation - incorporate standardised parts to facilitate repair and recycling (Bakker, 2015).
2. Establishing circular business models, some of them are:

- Product-as-a-Service (PaaS) - transition from product sales to service offerings, maintaining ownership and responsibility for the product lifecycle.
- Leasing and sharing models - promote models where consumers lease or share products instead of owning them outright (Lacy, 2015).

3. Improving the reuse and refurbishment market by enhancing connectivity between consumers and automating processes like disassembly, sorting, and refurbishment to facilitate the continuous circulation of products and materials.
4. Legislation and policy support – through regulations on planned obsolescence (implementation of policies that discourage planned obsolescence and promote product longevity) and incentives for circular practices (offering tax breaks, grants, or subsidies for companies that adopt CE practices) (European Commission, 2020).
5. Promoting consumer awareness and participation - through education campaigns or incentives for participation, it is possible to raise awareness about the benefits of a CE and the importance of product longevity and/or provide incentives for consumers to return products or participate in recycling programs.
6. Developing reverse logistics systems (Barrie, 2022):

- Collection systems: Establish systems for collecting used products from consumers.
- Sorting and processing: Create facilities for sorting, cleaning, and refurbishing products.
- Take-back programs: Implement programs where consumers can return old products.

7. Implementing recycling and resource recovery (Lacy, 2020):

- Material recovery: Invest in technologies to recover materials from end-of-life products.
- Closed-loop recycling: Promote processes that allow materials to be recycled into the same product.

8. Collaboration across the supply chain through cross-sector collaboration (work with suppliers, manufacturers, and recyclers to create a closed-loop system), and applying transparency and traceability (developing systems to track the lifecycle of products and materials) (Barrie, 2022).

Agri-Food industry. It is essential to mention that a planned obsolescence strategy designed to shorten product lifespans has significant implications for the agricultural sector and food production industries. In these sectors, planned obsolescence manifests through practices such as developing non-reproductive seeds, rapid turnover of agricultural equipment, and promoting disposable packaging in food products. These practices contribute to increased waste generation, environmental degradation and resource depletion (available at: www.rubbermaid.eu). Moreover, the linear "take-make-waste" model in the food industry leads to substantial food waste throughout the supply chain, from farm to plate. According to the Ellen MacArthur Foundation, *for every dollar spent on food, society pays two dollars in health, environmental, and economic costs* (EMF, 2019). This unsustainable approach impacts the environment and challenges food security and financial stability in the long term.

The circular economy approach offers change by implementing modular designs for agricultural equipment, developing durable bio-based materials, and creating closed-loop systems for nutrient recycling, extending product lifespans and minimising waste. It also encourages valorising food waste and by-products, creating new value streams and reducing environmental impact (Alzaabi et al., 2024).

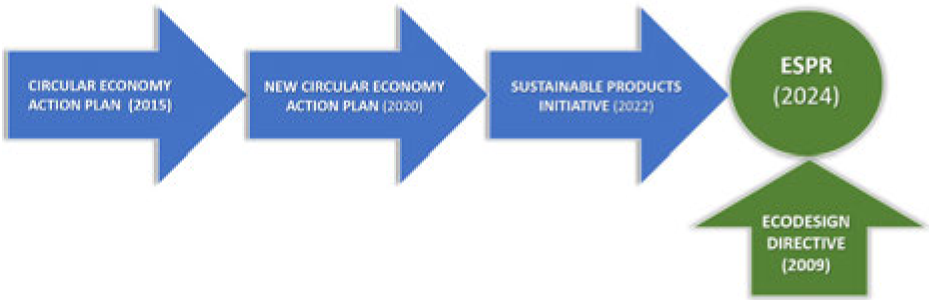
The European Union's fight against planned obsolescence

To combat planned obsolescence, adopting a more responsible production and consumption pattern is crucial, reducing waste generation and promoting the reuse and recycling of products. Implementing the changes within the existing situation requires a complex systematisation and analysis of various forms and characteristics of planned obsolescence, as well as legislation that would support these developments, which are necessary.

The European Union has recognised the urgent need to address planned obsolescence systematically by applying CE principles and integrating them within legislative regulations. Significant steps have been taken to solve complex challenges, including adopting the Circular Economy Action Plan (2015) that sets a target to achieve a carbon-neutral, environmentally sustainable, toxic-free, and fully CE by 2050 through introducing measures to improve resource efficiency and waste management. The document stated that "planned obsolescence practices can limit the useful lifetime of products". Further development led to the New Action Plan for the Circular Economy (2020), which aims to enhance the entire life cycle of products by promoting sustainable practices and preventing waste generation in the EU economy (EC, 2020). The Action Plan consider establishing sustainability principles for restricting single-use and countering premature obsolescence, empowering consumers and providing cost-saving opportunities, strengthening consumer protection against greenwashing and premature obsolescence, setting minimum requirements for sustainability labels/logos and information tools, as well as implementing the 'right to repair' in electronics and ICT, including a right to update obsolete software (EC, 2020).

In 2017, the European Parliament adopted a non-binding resolution entitled "A Longer Lifetime for products: benefits for consumers and companies" (EP, 2017). This resolution advocated that prolonging the lifetime of goods would benefit consumers and companies. Parts of proposed EU actions are the development of a unified definition of planned obsolescence for goods and software in consultation with stakeholders, exploring the potential for establishing an independent system to detect built-in obsolescence in products in cooperation with market surveillance authorities, providing better legal protection for whistleblowers and producer deterrents. The document also highlighted initiatives by Benelux countries to combat planned obsolescence and extend household appliance lifespan. It recognised that upgradeable products can slow obsolescence and reduce environmental impact and user costs (EP, 2017). In 2022, the European Commission published its Sustainable Products Initiative (SPI) (European Commission, 2022), which focuses on sustainability requirements, supports durable, reusable, and repairable products and helps prevent greenwashing and premature obsolescence. The Initiative aims to accelerate the revision of Ecodesign Directive 2009/125/EC towards the new Directive - Regulation on Ecodesign on sustainable products (ESPR), with the expected entry into force in the middle of 2024 (Figure 1).

Figure 1. Policy framework around The Ecodesign for Sustainable Products Regulation (ESPR)



Source: Author's

Meanwhile, no specific actions or new measures were proposed towards solving challenges connected with observed planned obsolescence practices, even though the latest, European Union Directive (2024/825) on empowering consumers for the green transition, Empowering Consumers Directive or ECD, entered into force in 2024 (EU Directive 2024/825, 2024). The Directive aims to protect consumers from being misled by communications relating to the environmental, social, or circular aspects of a product and services, including practices associated with the early obsolescence of goods (EU Directive 2024/825, 2024). The law does not prohibit early obsolescence, the intentional limitation of a product's life for immediate repurchase, nor does it restrict practices that impede repair; it does not impose obligations to improve product longevity and repairability, and it prohibits advertising of defective products, but only if marketers are aware of the defects. The new Directive, ESPR and the ECD would systematically and simultaneously promote sustainability and protect consumers in the EU, with the ESPR insisting on setting minimum standards for products to improve durability, reusability, recyclability, upgradability, and reparability, reducing environmental impacts and enhancing market functioning (EP, 2022).

The common understanding is of crucial value through standardisation for all activities towards incorporating changes within production-consumption relations. Monitoring frameworks should standardise terminology, define quantifiable baselines, and improve data quality to capture circularity effectively (Alivojvodic, 2023).

Conclusions

The concept of product obsolescence has evolved from a natural phenomenon to planned obsolescence, a more strategic business model driven by consumer and market dynamics and technological developments.

Historical insight into the development of planned obsolescence is not just informative but crucial for identifying opportunities to reform industrial practices, promote sustainable consumption, and mitigate the environmental impact of single-use culture. By learning from the past, industries and consumers can work together to create a more sustainable and CE that prioritises longevity, resource conservation, and responsible consumption practices.

A focus on eliminating the concept of planned obsolescence can divert resources and attention from developing more durable, repairable, and sustainable products, hindering the long-term innovation and competitiveness promoted by the concept of a CE.

The transition to a circular production approach takes work for the industry sector. Planned obsolescence is only one aspect of industrial approaches, but changing this industrial production practice is challenging and could bring useful changes. For example, the agri-food industry can transform from a linear model to a circular approach by implementing modular designs for agricultural equipment, developing sustainable bio-based materials, and establishing closed nutrient recycling systems. These changes will lead to extended product life, reduced waste, and the creation of new value streams.

The European Union’s example shows that changes require time and effort to obtain legislation that can modify existing practices. The EU’s proactive approach in the fight against planned obsolescence incorporates initiatives, legislative actions, and strategies to promote the CE. The goal is to extend the life cycle of products, empower consumers, and improve environmental sustainability within the EU.

In summary, while planned obsolescence may provide short-term economic benefits, it may have harmful long-term consequences for the economy, including environmental degradation, resource depletion, and reduced consumer welfare and financial stability.

However, it is important to emphasise consumers' role and the power to reshape production patterns.

Conflict of interests

The authors declare no conflict of interest.

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Table 1. The distribution cost of packaged goods from Subotica to retail-store objects

Indicators	Period			Total
	Month 1	Month 2	Month 3	
Distance crossed (km)	12.926	11.295	13.208	37.429
Fuel consumption (litre)	3.231	2.823	3.302	9.356
Value of fuel consumption (RSD)	242.378	211.790	247.653	701.821
Total time spend on touring (hour)	314	266	417	997
Value of total time spend on touring (RSD)	47.048	39.890	62.570	149.508
Number of tours	98	77	102	277
Toll value (RSD)	0	0	0	0
Number of pallets transported (piece)	1.179	976	1358	3.513
Total weight transported (kg)	602.600	429.225	711.116	1.742.941
Vehicle maintenance costs (RSD)	203.858	164.970	224.806	593.634
Lease costs (RSD)	480.938	454.214	565.784	1.500.936
Total sum (RSD)	974.222	870.864	1.100.813	2.945.899

Source: Petrović, 2012

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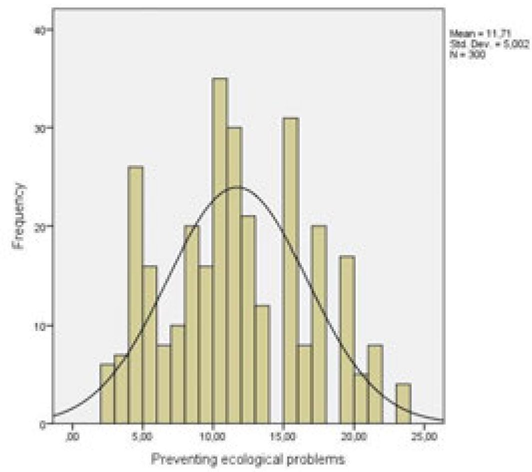
Figure 1. Agriculture, value added (% of GDP)



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