Journal of Sustainable Development of Energy, Water and Environment Systems

http://www.sdewes.org/jsdewes

Year 2026, Volume 14, Issue 2, 1140674

Original Research Article

Circular Economy Opportunity, Acceleration, and Obstacle for a Transition Country: A Case Study of Serbia

Višnja Mihajlović[1]*, Goran Vujić[2], Bojana Tot[2], Aleksandra Anić Vučinić[3]

[1]University of Novi Sad, Technical Faculty Mihajlo Pupin, Djure Djakovića bb, 23000 Zrenjanin, Serbia

[2]University of Novi Sad, Faculty of Technical Sciences, Department of Environmental Engineering, Trg Dositeja Obradovića 2, 21000 Novi Sad, Serbia

[3]University of Zagreb, Faculty of Geotechnical Engineering, Hallerova aleja 7, 42000 Varaždin, Croatia

e-mail: visnjamihajlovic@uns.ac.rs

Cite as: Mihajlović, V., Vujić, G., Tot, B., Anić Vučinić, A., Circular Economy Opportunity, Acceleration, and Obstacle for a Transition Country: A Case Study Of Serbia, J. sustain. dev. energy water environ. syst., 14(2), 1140674, 2026,
DOI: https://doi.org/10.13044/j.sdewes.d14.0674

ABSTRACT

The circular economy has become a framework for improving resource efficiency, reducing waste, and supporting climate change mitigation. Yet, its adoption in transition economies such as Serbia remains limited by structural and financial constraints. This study applies the Analytical Hierarchy Process to evaluate perspectives from private-sector companies and circular-economy experts on the key barriers to circular economy implementation. Result values represent the normalised weights (priority vectors) where a value closer to 1.0 indicates a higher level of importance or impact of a specific factor within the model. The results reveal a discrepancy between stakeholder groups: while companies emphasised social barriers, including weak consumer culture and resistance to change, experts identified financial (0.338) and institutional barriers (0.272) as the most influential. At the sub-factor level, changes in accordance with European directives (0.062) emerged as the most significant social barrier, followed by understanding the concept of the circular economy (0.050) and education regarding the circular economy (0.042). Results provide evidence-based insights into the dominant challenges limiting circular economy adoption in Serbia and the relevance of multi-criteria decision-making for prioritising circular economy barriers in transition economies.

KEYWORDS

Circular economy, Transition country, Waste, Efficiency, Barriers.

INTRODUCTION

The escalating global imperative for sustainable development has firmly established the circular economy (CE) as a transformative and increasingly vital paradigm for both businesses and societies worldwide. By championing the systemic reintegration of materials and energy derived from waste streams and industrial byproducts back into the productive economic cycle, CE offers a compelling and urgently needed departure from the inherently unsustainable linear "take-make-dispose" model. This fundamental shift directly confronts pressing global environmental crises, including the pervasive and damaging effects of pollution, the growing threat of resource depletion across critical sectors, and the overarching existential challenge of climate change [1]. Circular economy is a systemic

* Corresponding author

approach aimed at minimising resource inputs and waste generation through closed-loop material flows, requiring coordinated changes in product design, business models, and regulatory frameworks [2]. Recent research emphasises that waste must be understood as a valuable resource within a broader systems perspective, rather than as an end-of-pipe burden, to advance circular economy transitions. Therefore, waste management is one of the downstream components within the circular economy framework, while CE focuses on preventing waste creation at its source and transforming production and consumption systems. Adopting a systemic CE approach can unlock new value streams, improve resource efficiency, and reshape organisational practices by re-integrating waste into productive cycles [3]. Comprehensive reviews show that CE transitions require coordinated systemic change across production, consumption, and governance domains [4]. Recognising this profound and multifaceted potential, the European Union (EU) has strategically positioned itself at the vanguard of this global transition. The EU keenly understands the inherent capacity of CE not only to mitigate environmental degradation but also to simultaneously stimulate robust economic growth and facilitate the achievement of ambitious, legally binding environmental targets [5]. This unwavering commitment is demonstrably evident through the adoption of landmark policy frameworks, most notably the 2015 Circular Economy Action Plan and its subsequent reinforcement and expansion in the comprehensive 2018 Circular Economy Package [6]. These pivotal initiatives underscore the EU's resolute dedication to establishing a robust and harmonised CE framework across its diverse member states, thereby significantly influencing prevailing business practices and proactively reshaping national and regional regulatory landscapes through a comprehensive suite of directives specifically targeting waste management protocols, the sustainable design of products [7], and the widespread implementation of extended producer responsibility schemes. This cohesive and forward-looking approach signals a clear, determined trajectory towards establishing a more resilient, resource-efficient, and ultimately sustainable circular economic model throughout the European continent.

Influential and widely cited studies, such as "Inward Growth: A Circular Economy Vision for a Competitive Europe" [8], project substantial, strategically important gains in overall resource productivity, alongside the realisation of significant potential economic advantages for the EU as a unified economic entity. Furthermore, detailed and insightful analyses of evolving labour market dynamics [9] indicate the potential for considerable, strategically important job creation across a diverse, yet interconnected range of sectors intrinsically linked to the principles and practices of a circular economy.

Against this backdrop of increasing global and, critically, European emphasis on the transformative power and multifaceted benefits of CE, this research strategically focuses its analytical lens on the specific context of Serbia. As a nation actively navigating the complexities and challenges of a period of significant economic transition and holding firmly to its aspirations for full membership in the European Union, Serbia presents a particularly relevant, nuanced, and potentially instructive case study [10]. Historically, the trajectory of Serbia's economic development has predominantly adhered to a linear model of production and consumption. This established pattern has, unfortunately, resulted in substantial quantities of waste and a range of interconnected, pressing environmental challenges [11]. The current state of waste management infrastructure and practices in Serbia is starkly characterised by a concerning prevalence of unregulated, environmentally damaging illegal landfills alongside alarmingly low rates of material recycling [12]. It highlights the urgent and compelling necessity for a fundamental paradigm shift towards the widespread adoption of CE principles and practices. However, Serbia's clearly articulated aspirations for accession to the European Union present a unique and timely opportunity to strategically leapfrog traditional, often environmentally damaging linear development pathways and, instead, establish a national economic system inherently aligned with the core tenets and principles of CE from its foundational stages [13]. This proactive, strategically

informed transition holds significant promise of enhancing national resource resilience and security. It fosters the emergence of innovative and sustainable business opportunities across sectors, leading to tangible, lasting positive environmental and broader societal outcomes [14].

Many studies show that the circular economy is frequently misinterpreted by companies as waste management or recycling, even though CE represents a broader systemic approach centred on maintaining materials at their highest value and preventing waste generation [2]. The circular economy aims to keep products and materials in use for as long as possible by reusing, repairing, and redesigning them, thereby reducing waste. Waste management, on the other hand, focuses primarily on handling waste after it is generated, including collection, treatment, and disposal. Also, studies emphasise that CE includes upstream strategies such as redesign, reuse, remanufacturing, and energy-efficiency improvements, which clearly distinguish it from traditional end-of-pipe waste management practices [15]. Despite the widely acknowledged and increasingly understood potential benefits of the transition to a circular economy, the widespread and effective adoption of CE practices in Serbia faces a complex, interconnected web of persistent challenges [16]. These include inherent and often significant economic constraints, as well as a national regulatory framework that is still in a crucial phase of active evolution [17]. Alignment with EU standards and various organisational and operational hurdles that companies, particularly smaller enterprises, must navigate and overcome [18]. While recent years have indeed witnessed a growing level of awareness regarding the fundamental concepts of the CE and the implementation of initial, albeit limited, steps towards its broader integration within the national economic landscape [19], a comprehensive and in-depth understanding of the specific and often context-dependent barriers that are currently hindering its widespread and impactful implementation remains critically important. It is particularly and strategically true within the private sector, which constitutes a significant and vital component of the overall Serbian economy.

The private sector plays a central role in the transition to a circular economy because companies are the primary actors in designing products, managing resource flows, and determining how materials are used, reused, or discarded. Their investments, innovation capacity, and business models directly influence whether circular strategies – such as redesign, reuse, repair, remanufacturing, and industrial symbiosis – can be implemented at scale. Private companies also drive market demand for secondary materials and low-waste solutions, making them essential partners in reducing resource consumption and lowering environmental impacts. Without active engagement from the private sector, circular economy goals cannot be translated into practical, economically viable, and scalable solutions.

Current academic research focusing specifically on the nuanced barriers to effective CE implementation is still in a relatively early stage of development, with a noticeable and potentially limiting tendency to predominantly emphasise the theoretical advantages and potential benefits of the circular economy, rather than systematically and empirically analysing the specific obstacles and challenges that actively impede its practical adoption and widespread diffusion [20]. To directly address this identified and significant gap in the existing scholarly literature and to provide a more robust, empirically grounded, and policy-relevant analysis, this study strategically employs the Analytical Hierarchy Process (AHP). AHP represents a well-established, rigorously tested, and widely respected Multi-Criteria Decision-Making (MCDM) method [21]. AHP is renowned for its inherent capacity to systematically evaluate, structure, and prioritise complex sets of often interdependent factors. This fundamental capability makes the AHP particularly well-suited to gaining a deeper and more nuanced understanding of the relative significance of context-specific barriers currently hindering the widespread adoption of CE principles and practices [22].

The need for structured approaches to complex sustainability challenges has long been recognised, demonstrating how hierarchical planning methods can support systematic decision-making [23]. Recent applications of multi-criteria methodologies in environmental management show their effectiveness in addressing real-world sustainability and resource governance problems [24]. Importance of constructing meaningful and transparent environmental indices, emphasising the role of rigorous evaluation frameworks in guiding sustainable development strategies [25]. Given the unique socio-economic and regulatory context of Serbia and the specifically identified challenges encountered in the practical adoption of novel CE practices [26], Gaining a clear and empirically supported understanding of critical barriers represents a crucial and necessary initial step towards the evidence-based development of targeted strategies and the design of effective support mechanisms specifically tailored to accelerate Serbia's crucial transition towards a more resilient, resource-efficient, and ultimately sustainable circular economic future.

The objective of this paper is to rigorously identify and systematically classify the key barriers currently hindering the effective adoption and widespread implementation of CE practices within the private sector. For this, the study will use the AHP as its core methodological framework. This robust analytical approach will enable the determination of the relative priorities of these empirically identified barriers, thereby providing valuable, evidence-based, and actionable insights for policymakers, business leaders, and other relevant stakeholders who are actively seeking to advance the CE agenda within the specific and evolving context of a transition economy such as Serbia, ultimately contributing to a more sustainable and prosperous future for the nation.

METHODS

This research adopted a mixed-methods approach, collecting empirical data and using a quantitative evaluation through the AHP to identify and prioritise the multifaceted barriers to the effective implementation of the CE within organisations.

The qualitative phase was based on insights obtained from this data/ collection, and the interview and the criteria and sub-criteria were defined, which led to the development of the final hierarchical structure and the formulation of the AHP questionnaire. This approach produced input for the quantitative evaluation.

The quantitative phase was conducted with a panel of 15 selected circular economy experts, who systematically performed pairwise comparisons of factors and subfactors to quantify the perceived importance of one element relative to another in hindering CE implementation within the Serbian private sector.

Sample Selection and Data Collection

The study strategically focused on a selected sample of 18 companies operating across a diverse spectrum of industries within the Serbian private sector. These enterprises were identified and recruited for participation in close cooperation with the Chamber of Commerce of Serbia, based on their explicitly expressed interest in exploring and actively implementing CE principles within their operations or actively considering or already engaging with CE concepts, thereby providing rich and relevant insights into the practical challenges they encounter in this transition. This purposeful sampling strategy was applied to ensure insight into the practical challenges faced by entities actively engaged in the CE transition.

Data collection was conducted through a structured two-phase process that established a clear link between empirical insights from companies and the quantitative evaluation performed by experts.

The initial qualitative phase involved detailed CE audits conducted through in-depth interviews with key decision-makers (managers and engineers) within the selected companies. The primary objective of these interactions was to collect empirical data on potential

challenges and systemic barriers related to the circular economy at the enterprise level. Based on insights from this data/interview collection and an extensive review of relevant scientific literature, criteria and sub-criteria were determined, leading to the development of the final hierarchical structure and the formulation of the AHP questionnaire. Thus, the qualitative phase served as an essential input to the model, rigorously establishing the elements to be subjected to quantitative evaluation.

The quantitative phase was conducted with a panel of 15 carefully selected circular economy experts. These experts were chosen based on recognised and verifiable expertise in the field. The experts were provided with a comprehensive explanation of the AHP methodology and the principles of pairwise comparison. This phase employed structured AHP questionnaires in which experts systematically compared factors and subfactors in pairs. Saaty's fundamental scale (ranging from 1/9 to 9) [21] was used to quantify these comparisons, ensuring a numerical representation of the relative preference or perceived importance of one element over another in hindering CE implementation within the Serbian private sector.

The private companies included in this research span all size categories as defined by the Serbian Law on Accounting, see **Table 1**. The study applies the official national definition of micro, small, medium and large companies, based on meeting two of the following three criteria: average number of employees, annual business revenue, and average value of business assets [27]. The normalised geometric mean was used to aggregate individual expert judgments into a collective priority vector for the entire expert group [24].

Table 1. Company size classification according to the Serbian Law on Accounting

Legal entity or entrepreneur	Average no. of employees	Business Revenue [EUR]	Total Asset Value on Balance Sheet Date [EUR]
Micro	≤ 10	≤ 700,000	≤ 350,000
Small	> 10 and ≤ 50	> 700,000 and ≤ 8,000,000	> 350,000 and ≤ 4,000,000
Medium	> 50 and ≤ 250	> 8,000,000 and ≤ 40,000,000	> 4,000,000 and ≤ 20,000,000
Large	> 250	> 40,000,000	> 20,000,000

Given that the process heavily relies on policies, plans, and activities at various levels within the country, it must encompass key decision-makers from all these levels [26]. **Table 2** lists the companies that participated in the questionnaires. These companies represent various industries and range from micro to large enterprises, all based in Serbia.

AHP or an adequate and reliable evaluation of complex factors, the application of an appropriate Multi-Criteria Analysis (MCA) method is essential to ensure robust results [28]. Normalisation procedures play a critical role in multi-criteria analysis and demonstrate how different normalisation approaches can influence the robustness and reliability of decision-making outcomes [29]. The research Dobbie and Dail [30] further emphasises that the construction of composite indices depends heavily on appropriate weighting and aggregation techniques, underscoring the need for careful methodological choices in empirical evaluations. A systematic review shows that multi-criteria decision-aid methods have been widely applied across diverse fields for more than four decades, highlighting their importance in addressing complex real-world problems [31]. The study [32] confirms that the AHP is a reliable and frequently used tool for structured, high-quality decision-making, reinforcing its suitability for the analytical framework adopted in this study. Given the Serbian context and the challenges of implementing new CE practices, the AHP method was selected to identify and prioritise barriers, thereby providing a crucial decision-support tool. The relevance of AHP and related

multi-criteria tools in environmental decision-making has been demonstrated in several siting, planning, and waste-management applications [33].

Table 2. List of companies which have been participating

Company No.	Industry	Company's core business	Average no. of employees
1	Industrial engineering and environmental protection	Cleaning and servicing of industrial plants and tanks, site preparation, collection and transport of non-hazardous and hazardous waste and landfill cleaning	37
2	Mineral fertilisers production	Mineral fertiliser producer	397
3	package and packaging waste management	Collection, transport and treatment of packaging waste, paper, and cardboard	4
4	Cement production	Production of different cement products	209
5	Beer and beverage production	Production of light beer, cider, fruit-flavoured beer, black beer, wheat beer, wheat black beer, non-alcoholic beer, and special beers	446
6	Treatment and disposal of non-hazardous waste	Treatment and disposal of foils	5
7	Reuse of waste materials	Reuse of sorted materials, primarily the reuse of particleboard, wood packaging waste, sawdust, etc., in order to produce pellets, briquettes, and packaging pallets.	100
8	Food industry	Products, raw materials and application expertise to the bakery, patisserie, and chocolate sectors	73
9	Automotive industry	Manufacturer of bodies for commercial vehicles, truck superstructures and special vehicles	45
10	Confectionery industry	Production of sweets, marmalades and biscuits	131
11	Food industry	Production of sunflower oil, margarine, mayonnaise, and ketchup	349
12	Production of alcoholic beverages	Production of fruit brandy and liqueur	2
13	Wine production	Production of wine	5
14	Wine production	Production of wine	1
15	Catering services/restaurant	Production, preparation, and distribution of food	
16	Catering services/restaurant	Production, preparation, and distribution of food	
17	Retail sale of consumer goods	Selling consumer goods	
18	Organic production	Organic production of dairy products and organic meat	116

Expert Panel Profile

The data collection methodology combined individual consultations and written techniques over six months, from May to October 2021. The process involved individual meetings (in-person) with some experts, while email exchange was used with others. These interactions

served a dual purpose: to validate and define the hierarchy of barriers (the qualitative phase), which was a necessary pre-step for applying AHP, and subsequently, to allow experts to complete the AHP questionnaires for quantitative assessment individually. Experts were informed about the operation of the AHP method and the principles of pairwise comparison of factors and sub-factors [28].

The expert panel comprised 15 decision-makers. Table 3 provides information confirming the relevance and high level of expertise of these 15 panel members regarding the Circular Economy and its implementation in Serbia, covering the academic, regulatory, and business sectors.

Table 3. Profile of the expert panel for circular economy (N=15)

No. of experts	Position / Role	Occupation (institution)	Area of expertise	Country
8	Professor, Assistant, Lecturer	Academic Staff (Universities, Academies)	CE, Environmental Protection, Energy Efficiency	Republic of Serbia
2	Head of Department, Advisor	Regulatory and Business Bodies (Chamber of Commerce and Industry of Serbia)	CE Regulation, Strategies, Support for private sector development	Republic of Serbia
2	Advisor, Deputy Project Manager	Industrial and Development Sector (German Development Cooperation, Industrial Group)	CE Implementation, Waste Management, Industrial Application	Republic of Serbia
1	Ambassador / Expert	Expert Function (International Climate Pact)	Strategies, Sustainable Development, CE, Climate Change	Republic of Serbia
2	Chairman of the Board, Head of Research and Development	Civil Sector / Research (Associations, Innovative Companies)	Innovation, Civil Participation in Environmental Protection	Republic of Serbia

Analytical Hierarchy Process Implementation and Consistency Check

The application of AHP adhered to the established multi-stage methodology described by Saaty in his foundational work on deriving priority scales for hierarchical structures, ensuring mathematical consistency in all pairwise comparisons [21]. Additionally, the broader decision-structuring principles outlined by Saaty and Kearns provided a framework for organising complex CE barriers into a clear, analysable hierarchy [23]. Together, these methodological foundations ensured that the AHP approach applied in this study followed a rigorous and well-validated procedure recognised in multi-criteria decision analysis.

Hierarchy structuring and qualitative input. The methodological process began by establishing the decision hierarchy, which featured the overall research goal (Prioritising Barriers to CE Implementation) at its apex, followed by the primary factors and subsequently the sub-factors. This structure was rigorously defined and validated through initial qualitative consultations with the expert panel. These expert insights served as the essential model input, allowing us to identify, validate, and structure the hierarchy of barriers, thereby defining the exact structural framework and establishing what would be subjected to quantitative evaluation.

Pairwise comparison and weight calculation. The second phase involved the expert panel making pairwise comparisons of elements at each level of the hierarchy relative to elements at the immediately higher level [33]. These comparisons were structured using Saaty's fundamental scale [21], in which each pair is assigned a value from 1/9 to 9, reflecting the degree of preference or importance. The third stage determined the local priority vectors [22], and the fourth stage synthesised these local priority vectors, yielding the overall weighting coefficients. The normalised geometric mean was used to aggregate individual expert judgments into a collective and representative priority vector [34].

Consistency check and final panel selection. The final stage of AHP application involved a consistency check [21]. The internal consistency of the experts' judgments was evaluated by calculating the Consistency Ratio (CR). Recognising that a degree of inconsistency is inherent, a consistency ratio of up to 0.20 is generally considered acceptable [23]. Crucially, the final decision was to exclude all experts who demonstrated inconsistencies greater than 0.20, ensuring their individual weights were not incorporated into the final aggregated results. Given that the AHP method in a group context does not require a large sample size [35], we ultimately proceeded with the questionnaires from the 15 consistent experts for the final computations. This approach allowed us to draw methodologically sound conclusions regarding the weighted priorities of the barriers and sub-barriers. Ultimately, the AHP determined the relative importance by establishing the ranked, weighted priorities for the identified barriers. To mitigate the risk of subjective bias, group decision-making is recommended, with one approach being the aggregation of individual judgments into a representative group judgment. The calculated global weights were then used to rank the identified barriers based on their perceived importance in hindering CE implementation in the Serbian private sector.

RESULTS AND DISCUSSION

Companies initiated the process of identifying potential directions for CE development by interviewing their representatives. In some cases, multiple options were considered, but the final selection was narrowed down to one, primarily based on financial projections. Key factors affecting the decision to launch CE initiatives included the availability of subsidies or other incentives, the existence of a market for secondary raw materials and products derived from them, and the recognition of CE as a sustainable business model at the national level, see **Table 4**.

Implementing the principles of the CE faces numerous challenges, both internal and external to companies. In this research, stakeholders from companies analysed various barriers affecting the implementation of the circular economy. Notably, almost all mentioned barriers were perceived as having a moderate to high impact, see **Table 5**.

Company employees indicated that social barriers are the most significant obstacle. Specifically, an underdeveloped consumer culture, a lack of awareness and sense of urgency regarding the CE within society, and resistance from powerful social actors seeking to maintain the status quo were identified as the two most substantial barriers. Other significant barriers include deeply ingrained linear production technologies, the absence or low level of subsidies for companies engaging in the circular economy, and the substantial initial investment required to adopt CE principles. Similar CE barriers related to organisational capacities, institutional conditions, and economic constraints have been reported in transition-economy studies [36].

A portion of the respondents also expressed uncertainty about where to seek advisory, financial, or technological support for CE implementation. Furthermore, most companies lacked dedicated personnel or external consultants responsible for CE initiatives. Regarding specific activities related to resource and energy efficiency, most companies were in the initial planning and consideration stages. A pivotal finding emerging from the mixed-methods approach is the pronounced discrepancy in the prioritisation of CE barriers between the qualitative phase (company audits) and the quantitative phase (AHP expert assessment).

Table 4. Circular economy activity audit

Company No.	Circular economy activity audit	Decided circular economy activity
1	Composting of biodegradable waste; Production of RDF from MSW	Composting of biodegradable waste
2	Reduction of recyclates in fertiliser production; Introduction of waste residues as a secondary raw material (SRW)	Introduction of waste residues as an SRW
3	New abroll container to increase the recycling rate; Technology improvement for cardboard recycling quality	New abroll container to increase the recycling rate
4	Solar panels for electricity and heating; Increase the share of alternative fuel for cement production	Solar panels for electricity and heating
5	Collection of rainwater; Solar panels	Solar panels
6	Development of a system for HDPE plastic recycling; Mobile upcycling plant	Development of a system for HDPE plastic recycling
7	Production of lightweight concrete building block with recycled styrofoam aggregate; New abroll container to increase the recycling rate	Production of lightweight concrete building block with recycled styrofoam aggregate
8	Heat pumps for heating sanitary water and central heating systems; Waste heat recovery of compressors for sanitary water heating	Heat pumps for heating sanitary water and central heating systems
9	Material cutting optimisation; New technology for treating wastewater contaminated by industrial processes, and producing biogas to generate clean energy	Material cutting optimisation
10	Increase energy efficiency in the production process; Flexible Packaging (CEFLEX).	Increase energy efficiency in the production process
11	Treatment of wastewater; Use of cooking oil for manufacturing other non-food products	Treatment of wastewater
12	Biodegradable waste management improvement; Solar panel	Biodegradable waste management improvement
13	Biomass use for energy production; Solar panel	Biomass use for energy production
14	Solar panel; Recovering useful bio-based products, such as grapeseed oil	Solar panel
15	Prevention of food waste generation; Restaurant green roof	Prevention of food waste generation
16	Prevention of food waste generation; Green wall in restaurant area	Prevention of food waste generation
17	Modular anaerobic digestion facility for food waste treatment; Designing spaces with healthy and perpetually cyclable materials	Modular anaerobic digestion facility for food waste treatment
18	Drying process for hay; Bio-products	Drying process for hay

The initial qualitative audit, based on interviews with company managers and engineers, revealed that the most frequently cited obstacles were centred on social factors and immediate operational and investment constraints. Specifically, an underdeveloped consumer culture, a lack of societal awareness regarding the CE, and political resistance to systemic change were identified as highly significant. These responses are characteristic of the 'bottom-up' perspective, reflecting the daily difficulties in marketising circular solutions and securing initial, unknown investments in a transition context.

Table 5. Perception of managers and engineers about the obstacles affecting the slow implementation of the circular economy in the representative companies

Company No.	Obstacles in Implementing the Circular Economy
1	Lack of investment and effective policies and regulations.
2	Expensive technologies, availability of international and national funds
3	Political decision, resistance from powerful social actors who want to maintain the status quo
4	Inadequate planning, deep-rooted technologies of linear production
5	Insufficient funds for investment in new technologies, a lack of persons responsible for the circular economy
6	Lack of skilled labour and experts.
7	Lack of investment, availability of international and national funds
8	Lack of investment,
9	Lack of financial support from local authorities for investing in unknown practices, a high initial level of investment required to implement CE principles
10	There are policies and regulations, but they are not implemented or adequately forced
11	Absence of strict regulations
12	Lack of financial resources, lack of awareness and sense of urgency for the issue of CE in society
13	Limited funding to promote environmental awareness among stakeholders
14	Weak participation due to insufficient awareness of industrial actors, non-existence or low level of subsidies for companies participating in the circular economy
15	Perception of public awareness, lack of political will for the implementation of a developed strategy, and the indifferent attitude of the general public
16	Perception of public awareness, lack of supporting legislation
17	Perception of public awareness, expensive process
18	Lack of skilled labour and experts, and an insufficiently developed consumer culture

Based on the subjective opinions of company representatives, problems and challenges were categorised into four main factors (financial, institutional, technological, and social) and their respective sub-factors. These four factors were ranked by experts in order of importance for CE implementation using the AHP.

Evaluation of factors

The ranking results from the 15 experts in environmental engineering, waste management, and renewable energy, **Table 6** indicated that the financial factor (normalised geometric mean weight of 0.338) has the most significant influence on the adoption of the CE in companies, followed by the institutional indicator (0.272), the technological indicator (0.236), and the social indicator (0.154), which was deemed the least important. The research findings indicated a high degree of agreement among experts regarding the importance of the defined factors, with a majority emphasising the financial aspect as primary. Socio-economic conditions significantly influence material flows and waste-generation patterns, which, in turn, affect the potential for CE implementation **[37]**.

Evaluation of institutional sub-factors. The institutional indicator comprises three sub-factors: Degree of development of legal regulations, Connection between institutions and the private sector in the application of regulatory frameworks, and Personnel capacity for the application of the circular economy.

Table 6. Priorities in relation to the goal, geometric mean weights, decision matrix (expert 1 – expert 15)

Expert No.	Individual weight of the indicator in relation to the goal *W*				Degree of consistency CR
	Institutional factor	Technology factor	Financial factor	Social factor	
1	0.205	0.044	0.611	0.139	0.20
2	0.130	0.225	0.590	0.055	0.13
3	0.464	0.212	0.272	0.052	0.16
4	0.312	0.127	0.530	0.031	0.19
5	0.249	0.045	0.626	0.081	0.15
6	0.329	0.145	0.287	0.239	0.18
7	0.148	0.313	0.449	0.090	0.13
8	0.407	0.295	0.119	0.179	0.18
9	0.177	0.681	0.103	0.039	0.15
10	0.107	0.715	0.134	0.044	0.08
11	0.427	0.282	0.213	0.080	0.04
12	0.153	0.060	0.661	0.126	0.15
13	0.599	0.081	0.211	0.108	0.10
14	0.130	0.178	0.389	0.303	0.06
15	0.101	0.348	0.449	0.101	0.01
Normalised geometric mean of factor weights [a]	0.272	0.236	0.338	0.154	
Rank	(2)	(3)	(1)	(4)	

[a] relative to the target

Based on the evaluation of these sub-factors, **Table 7** shows that the sub-factor "Degree of development of legal regulations" is the most critical, with the highest normalised geometrically averaged weight (0.367) and priority vector relative to the target (0.100). It was followed by "Personnel capacity for the application of the circular economy" (0.348 and 0.095, respectively). The sub-factor "Connection between institutions and the private sector in applying regulatory frameworks" was ranked lowest (0.284 and 0.077). Institutional fragmentation and weak cross-sector coordination are acknowledged barriers in closing resource loops, consistent with findings in other domains such as wastewater reuse **[38]**.

Evaluation of technological sub-factors. The technological factor encompasses three sub-factors: Possibilities of applying new technologies for the circular economy, the Possibility of adapting new technologies, and the Level of professional education of workers. Based on the analysis presented in Limitations and future research

Several methodological considerations limit the generalisability of the present findings. Firstly, the sample of 18 private-sector companies, although purposefully diverse, may not fully reflect the heterogeneity of the Serbian economy as a whole, particularly given the exclusion of public enterprises and other major sectors. Secondly, the AHP results are inherently reliant on the subjective judgments and collective prioritisation of the 15-member expert panel. While internal consistency checks (CR < 0.20) mitigated bias, alternative expert compositions could potentially yield variations in barrier prioritisation. Furthermore, while the

study prioritises barriers, it does not conduct a full cost–benefit or feasibility assessment of the specific CE interventions identified during the company audits.

Future studies should aim to expand the sample size to include a broader range of the private sector, in particular large enterprises, to improve the representativeness of the findings. Comparative studies across multiple Western Balkan or other transition economies would also help validate whether the barrier structure identified in Serbia is regionally consistent. Further work should integrate AHP with more complex MCDM tools, such as the Analytic Network Process (ANP) or the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), or with scenario modelling, to strengthen the robustness and comparative validity of the priority rankings. **Table 8**, the experts assigned the greatest importance to the "Possibilities of applying new technologies for the circular economy". Sub-factors, the "Possibility of adapting new technologies" and the "Level of professional education of workers", were considered less important, but equally significant. Experts highlighted the crucial role of new technologies in enabling effective CE adoption, but noted a lack of strategic commitment and underdeveloped infrastructure. The findings corroborate studies showing that new CE business models depend on coordinated actions among multiple stakeholders **[39]**.

Table 7. Priorities in relation to the factor to which they belong, priority vectors in relation to the goal, decision matrix (expert 1 – expert 15)

	Individual priority vectors W_i			
Expert No.	Degree of development of legal regulations	Connection between institutions and private sector in applying regulatory frameworks	Personnel capacity for the application of the circular economy	Degree of consistency CR
1	0.218	0.067	0.715	0.17
2	0.715	0.218	0.067	0.17
3	0.319	0.46	0.221	0.13
4	0.333	0.333	0.333	0.00
5	0.715	0.067	0.218	0.17
6	0.143	0.143	0.714	0.00
7	0.304	0.519	0.177	0.28
8	0.637	0.105	0.258	0.04
9	0.319	0.221	0.460	0.13
10	0.174	0.132	0.694	0.08
11	0.600	0.200	0.200	0.00
12	0.772	0.173	0.055	0.20
13	0.135	0.281	0.584	0.13
14	0.105	0.258	0.637	0.04
15	0.200	0.600	0.200	0.00
Normalised geometrically averaged weights of institutional sub-factors [a]	0.367	0.284	0.348	
Priority vectors [b]	0.100	0.077	0.095	
Rank	(1)	(3)	(2)	

[a] in relation to the institutional factor; [b] relative to the target

Limitations and Future Research

Several methodological considerations limit the generalisability of the present findings. Firstly, the sample of 18 private-sector companies, although purposefully diverse, may not fully reflect the heterogeneity of the Serbian economy as a whole, particularly given the exclusion of public enterprises and other major sectors. Secondly, the AHP results are inherently reliant on the subjective judgments and collective prioritisation of the 15-member expert panel. While internal consistency checks (CR < 0.20) mitigated bias, alternative expert compositions could potentially yield variations in barrier prioritisation. Furthermore, while the study prioritises barriers, it does not conduct a full cost–benefit or feasibility assessment of the specific CE interventions identified during the company audits.

Future studies should aim to expand the sample size to include a broader range of the private sector, in particular large enterprises, to improve the representativeness of the findings. Comparative studies across multiple Western Balkan or other transition economies would also help validate whether the barrier structure identified in Serbia is regionally consistent. Further work should integrate AHP with more complex MCDM tools, such as the Analytic Network Process (ANP) or the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), or with scenario modelling, to strengthen the robustness and comparative validity of the priority rankings.

Table 8. Evaluation of technological sub-factors

	Individual priority vectors W_t			
Expert No.	Possibilities of applying new technologies for circular economy	Possibility of adapting new technologies	Level of professional education of workers	Degree of consistency CR
1	0.333	0.333	0.333	0.00
2	0.747	0.119	0.134	0.01
3	0.715	0.218	0.067	0.17
4	0.701	0.202	0.097	0.13
5	0.701	0.202	0.097	0.13
6	0.429	0.429	0.143	0.00
7	0.086	0.297	0.618	0.13
8	0.333	0.333	0.333	0.00
9	0.405	0.114	0.481	0.03
10	0.319	0.221	0.460	0.13
11	0.114	0.481	0.405	0.03
12	0.714	0.143	0.143	0.00
13	0.135	0.281	0.584	0.13
14	0.200	0.600	0.200	0.00
15	0.114	0.405	0.481	0.03
Normalised geometrically averaged weights of technological sub-factors [a]	0.367	0.324	0.310	
Priority vectors [b]	0.087	0.077	0.073	
Rank	(1)	(2)	(3)	

[a] in relation to the technological factor; [b] relative to the target

Longitudinal studies are necessary to examine how CE barriers evolve as regulatory frameworks and financial instruments mature over time. Future research should also evaluate the economic, environmental, and social impacts of specific CE interventions. Coming to the final recommendation, there is a need for complementary qualitative investigations into consumer behaviour, supply chain dynamics, and institutional coordination to provide deeper insights into the social and organisational barriers that often remain less explored by quantitative methods.

CONCLUSIONS

Research on the CE in the private sector in Serbia was conducted to provide a more detailed insight into the level of business awareness of the circular economy concept, and to identify the actual needs for transitioning from linear to circular production. Additionally, the research sought to determine the level of information among companies regarding available sources of advisory, financial, and technological support, the perception of the economic viability of the circular model, and the awareness of the necessity of introducing the CE in the context of the changing business environment and relevant European Union legislation, including standards related to the carbon footprint of products upon export to the EU starting in 2026.

The Serbian case provides a relevant example for other transition countries because it reflects common conditions such as evolving regulatory frameworks, limited financial incentives, low CE awareness, and strong dependence on the private sector – all of which characterise many emerging economies worldwide. The mixed-method approach used in this study, combining company-level CE audits with expert-based AHP prioritisation, offers a replicable framework that can be applied in countries facing similar institutional and economic constraints. It allows for quantitative ranking of CE barriers, going beyond descriptive studies that list obstacles without assessing their relative importance.

The study also reveals differences between companies and expert perceptions, providing new insight into gaps in CE readiness and communication across key stakeholder groups. Overall, the research contributes existing knowledge by offering an evidence-based decision-support tool to guide targeted CE interventions in Serbia and other transition economies. Those findings reflect real market conditions rather than a narrow segment of the economy. As a result, the study offers broader insights that can support tailored CE interventions for companies of different sizes.

The mixed-method approach utilised in this paper, combining qualitative company audits with quantitative AHP prioritisation, offers a replicable, evidence-based framework for assessing CE readiness in transition economies. The quantitative ranking of CE barriers, moving beyond descriptive cataloguing of obstacles, unequivocally demonstrates that the Financial and Institutional factors represent the most significant systemic impediments to CE adoption in the Serbian private sector. Crucially, the research reveals a no difference in perception, wherein companies emphasise social and operational barriers, while the expert panel prioritises macro-level financial and institutional constraints. Consequently, a successful transition towards a CE mandates a comprehensive approach that prioritises the establishment of robust, accessible financial instruments and the strengthening of the institutional and legal frameworks, concurrently with intensified educational activities and awareness-raising campaigns aimed at citizens as a crucial segment.

NOMENCLATURE

Abbreviations

AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
CE	Circular economy

CR	Consistency ratio
EU	European Union
MCA	Multi-Criteria Analysis
MCDM	Multi-Criteria Decision-Making
MSW	Municipal solid waste
RDF	Refused derived fuel
SRM	Secondary raw material
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution

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Paper submitted: 01.08.2025
Paper revised: 03.12.2025
Paper accepted: 16.12.2025