
**Advancing Circular Economy Through Waste Management: Path-
ways to Sustainable Development in Transition Economies**

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Višnja Mihajlović¹, Sanja Stanisavljev¹, Mila Kavalić¹, and Luka Djordjević¹

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1 University of Novi Sad, Technical Faculty “Mihajlo Pupin” Zrenjanin, Serbia

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* Corresponding author: sanja.stanisavljev@uns.ac.rs;

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ACCEPTED MANUSCRIPT

Environmental protection and resource preservation are key priorities for modern societies, and the European Union's Circular Economy Package sets ambitious targets for 2030. As an EU candidate country, Serbia faces significant challenges in aligning its waste management system with these requirements and in increasing the use of waste as secondary raw materials. In 2023, Serbia generated 3.1 Mt of municipal waste, of which nearly 80% was landfilled, with over 60% consisting of biodegradable and mixed fractions. The analysis identified five priority streams—biodegradable waste, paper/cardboard, plastics, metals, and textiles/wood—that have the greatest potential to yield secondary raw materials and support the transition. However, the availability of recycled secondary raw materials remains limited, with metals dominating recovery and plastics declining in 2023 due to market conditions. A Delphi study involving 7 experts projected that the circular economy would be adopted more widely in 3.6 years, with the highest probability in 2030 ($P = 0.998$). Results indicate that Serbia remains in an early CE phase, and that transition priorities should include strengthening separate collection, improving the quality of secondary raw materials, and focusing on the five priority waste streams.

Keywords: secondary raw materials, sustainable development, obstacles, sustainable transition, resource efficiency

The globalisation of markets necessitates a revised approach to studying business management processes. The circular economy (CE) has emerged as a systemic paradigm of production, consumption and resource-flow optimisation, not just in Europe but globally. Empirical studies now apply quantitative modelling to trace their dynamics of their transitions across regions (Zhao *et al.*, 2025). Organisations cannot achieve sustainable success by relying on outdated management practices and principles. Effective organisational management must be aligned with consumer demands and environmental considerations.

The development of modern business, which prioritises environmental quality and the conservation of natural resources, has introduced new concepts in the production and design of products, namely the circular economy. In addition, a rapidly advancing technological development, known as Industry 4.0, has enabled an easier and faster exchange of information and technology transfer, which can have a huge impact on and contribute to the circular economy, modern business, and solving environmental problems on a global level (Hu *et al.*, 2025; Qiao, Xu and Lei, 2025).

The Circular Economy (CE) is regarded as a strategic and significant factor for organisations focused on profitability and value creation. The degree of CE implementation is positively influenced by Environmental Management System (EMS) certification and a commitment to enhancing environmental performance and adopting a sustainable business model (Fonseca *et al.*, 2018). CE boosts sustainable development and reduces risks without harming the environment or depleting resources (Ghisellini, Cialani and Ulgiati, 2016). Nevertheless, the successful adoption of CE faces several challenges, including insufficient technical and technological expertise (Rizos *et al.*, 2016). Resistance to change can stem from risk aversion, a lack of information and knowledge, or misperceptions (Van Buren *et al.*, 2016). Additionally, various stakeholders may require substantial short-term investments, such

as acquiring new skills, securing contracts, redesigning products and processes, and purchasing new 49
equipment, with returns expected over a longer period (Kavalić *et al.*, 2021). 50

Sustainability is not yet the first choice for management. In this context, the circular economy can 51
offer business models that integrate growth with sustainability, and companies across different indus- 52
tries that demonstrate improved environmental performance and numerous benefits, including the 53
rational use of resources, lower costs and economies, and flexible production (Nußholz, 2018; Rat- 54
talino, 2018). Also, some studies reveal that sustainability enables companies to achieve strategic 55
goals and survive in a market that expects socially responsible, sustainable business (Hart and Mil- 56
stein, 2003; Kiron *et al.*, 2013). Companies that prioritise environmental responsibility stay ahead 57
of future regulations, gaining an advantage over traditional competitors, and building a positive image 58
with consumers (Rattalino, 2018). Moreover, advances in corporate governance and financial struc- 59
tures show how CE and green innovation are interwoven in markets and firms (Ma, Benkraiem, *et al.*, 60
2025). 61

The global population continues to grow, leading to rising human needs and the emergence of social 62
challenges that are often addressed through economic growth. Economic growth is generally expected 63
to follow an upward trajectory, supporting the stable development of individual nations and the global 64
community. However, achieving a complete and lasting decoupling of economic growth from envi- 65
ronmental pressures and impacts appears unlikely globally (European Environment Agency, 2021). 66
Linking CE to climate and biodiversity agendas has become increasingly important, as corporate and 67
financial systems respond to resource- and ecosystem-related risks (Hu *et al.*, 2025; Zeng *et al.*, 68
2025). Current greenhouse gas emissions and waste generation far exceed the Earth's natural capacity 69
for self-purification. For instance, modern economic activities produce approximately 300 million 70
tons of plastic industrial waste annually. Critical environmental issues include rising lower-atmos- 71
phere temperatures, biodiversity loss, land degradation, and water pollution. Currently, it is estimated 72
that each individual generates 0.74 kg of waste per day, contributing to the overall waste burden of 73

the global population of 8 billion (Singh *et al.*, 2023; Skripnuk *et al.*, 2023). Even sectors such as 74
agriculture and mechanisation show CE-relevant pathways towards low-carbon production in the 75
Global South (Ma, Yan, *et al.*, 2025). 76

Although policy and infrastructure support the CE transition in emerging economies such as Serbia, 77
effective resource recovery increasingly depends on advanced digital technologies (Selvanarayanan 78
et al. 2025). IoT-based real-time monitoring, integrated with Hybrid-RNN and Fuzzy logic models, 79
enhances data accuracy, supports predictive decision-making, and improves resource management, 80
thereby addressing persistent challenges related to secondary raw material quality and enabling opti- 81
mized wastewater recycling and environmental remediation (Lekhya *et al.* 2024; Selvanarayanan *et* 82
al. 2025). In addition, recent studies show that municipal solid waste incineration fly ash can be val- 83
orised into geopolymers backfill with stable mechanical performance, supporting the role of secondary 84
raw materials in circular construction (Su *et al.* 2024) 85

The European Union (EU) introduced the circular economy concept in 2014 with a long-term strategy 86
focused on minimising, recycling, or repurposing waste and recognising waste as a secondary raw 87
material (European Commission, 2018). In 2015, the EU Action Plan for the Circular Economy was 88
introduced, as well as the Circular Economy Package in 2018, which established ambitious targets 89
for member states on recycling municipal and packaging waste, reducing landfill use, implementing 90
source separation systems, expanding producer responsibility, and improving food waste manage- 91
ment (European Commission, 2014b, 2014a). In 2020, the EU adopted the new circular economy 92
action plan 2020, with one of the aims to reduce waste and focus on the sectors that use the most 93
resources and where the potential for circularity is high, for example, packaging waste plastics, setting 94
70% 55% targets by 2030. 95

The Waste Framework Directive (WFD) was subsequently amended in 2018 by Directives 96
(2018)/850/EU, 2018/851/EU, and 2018/852/EU, collectively known as the Circular Economy Pack- 97
age (European Parliament and Council, 2018). This updated framework aimed to enhance resource 98

efficiency, promote waste as a valuable resource, reduce dependence on raw material imports, and 99
facilitate the transition to more sustainable material management and a circular economy (European 100
Parliament and Council, 2018). Member states are required to meet specific targets, such as preparing 101
municipal waste for reuse and recycling, with goals set at 55% by 2025, 60% by 2030, and 65% by 102
2035. Additionally, the landfill directive was amended by Directive (2018)/850/EU to further de- 103
crease the proportion of waste sent to landfills, with a target of no more than 10% by (Eurostat, 2024). 104
At the EU level in 2021, the average EU recycling rate was 64%, while the highest recycling rate 105
among EU members has Belgium at 80%, the Netherlands at 78%, Slovakia at 74 %, and Luxemburg 106
and Italy at 73% for monitoring compliance with policy targets, by type of packaging. In contrast, 107
Europe's circular material use rate slightly increases to 11,5% (Eurostat, 2024). Less than 12% of all 108
materials used in the EU are recycled. 109

In Serbia, a hierarchy of waste management has been established. However, the dominant waste treat- 110
ment in Serbia is waste disposal (Mihajlović *et al.*, 2016). As a result of the long-term linear economy, 111
80% of Serbia's waste is landfilled, in 12 sanitary landfills and more than 2,000 illegal dumpsites 112
(SEPA, 2023a). 113

Following EU waste management practices, in 2020, Serbia adopted a Circular Economy Roadmap 114
aimed at transitioning from a linear to circular economy within the country. The roadmap, through 115
the adoption of circular business models, promotes the creation of new job opportunities in the indus- 116
try and supports business innovation by identifying sustainable solutions in the market (SMoEP, 117
2020). 118

Applying the circular economy concept before the waste management process - during the design, 119
production, and use phases - can substantially decrease the volume of waste that requires recycling. 120
In addition, the circular economy framework promotes the efficient reintegration of waste into the 121
production system, facilitating a connection between waste generators and those who can repurpose 122
it as a resource. This approach, as opposed to traditional waste recycling models, enhances resources 123

management efficiency, reduces associated costs, and lowers the expenses related to recycling and waste processing (Kalkan *et al.*, 2018).

In many transition and developing economies, circular economy implementation commonly begins at the waste-management stage—often described as the “end-of-pipe” approach—because product eco-design, green public procurement, and industrial symbiosis practices are still in early stages of development. Under such conditions, improvements in collection, sorting, recycling, and landfill diversion become the most immediate and practical entry points to circularity. This “waste-first” pathway enables governments and municipalities to achieve visible environmental results while gradually building institutional, technical, and market capacity for more advanced circular-economy strategies.

This paper aims to analyse the current status of the circular economy concept in Serbia and identify municipal waste flows and quantities which can be used as secondary raw materials to foster sustainable development and support transition to circular economy in Serbia. Additionally, the objective is to assess the current state of CE adoption among companies in Serbia, identify the key factors influencing its implementation, anticipate the implementation of CE, and increase the number of companies in Serbia operating according to circular economy principles. The paper uses collection, analysis, and synthesis methods to draw on data from various national statistics to inform strategies for waste reduction. Also, an exploratory approach - an intuitive method of technological forecasting - a standardised Delphi technique, was used to analyse the situation in the area of municipal waste management as well as the development of a circular economy in companies.

The paper's novelty lies in its fusion of quantitative national MSW evidence (2019–2023) with a rigorous, multi-round expert Delphi forecasting method to analyse and predict the necessary steps and estimated timelines for successful Circular Economy uptake, specifically addressing the unique waste management challenges and implementation gaps prevalent in a transition economy like Serbia. Therefore, the research combines qualitative data, national MSW data (2019–2023), with an

expert-based Delphi forecast to predict and quantify the timeline for CE adoption under Serbia's 148
transition-economy conditions. 149

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2. Methodology 151

Serbia is a country in Southeast Europe and a candidate for European Union membership. In recent 152
years, the country has experienced challenging development, which can be considered a transition 153
period in terms of changes in sector policies by following EU criteria. Meeting and aligned with cri- 154
teria is particularly challenging for developing and transition countries like Serbia. These nations face 155
numerous social, political, institutional, and technical obstacles from the past that need to be resolved. 156

2.1. Research Framework 157

The increasing amounts of municipal waste ending up in landfills in Serbia, driven by accelerated 158
technological development and production alongside growing resource consumption, are not aligned 159
with the Sustainable Development Goals. Companies often prioritise profit, neglecting socially re- 160
sponsible business practices and sociological and ecological concerns. 161

This research is twofold. The first part aims to analyse the current situation in the Republic of Serbia 162
regarding the circular economy and solid waste management. It seeks to identify potential material 163
flows from municipal solid waste quantities that can be utilised as secondary raw materials (SRM) 164
and other waste streams supporting the "green transition" in Serbia, facilitating a shift from a linear 165
to a circular economy. The newly adopted long-term Programme for waste management in Serbia, 166
effective from 2022-2023, focuses on aligning with the new EU goals in the waste management sector 167
as part of the "green transition." To transition to a circular economy in the EU, it is necessary to 168
establish new objectives for waste management in the Republic of Serbia (Official Gazette, 2023). 169
Given that the long-term Programme for the "green transition" has set a timeframe for the transition 170

to a circular economy, the second part of the research employs the Delphi method to identify when 171
improvements can be anticipated in the circular economy, including a greater number of companies 172
in Serbia operating on the principles of a circular economy. 173

The research problem addresses the increasing amounts of municipal waste in landfills, driven by 174
accelerated technological development and production. It also addresses growing resource consump- 175
tion that is not aligned with the Sustainable Development Goals. Companies aim for profit, often 176
neglecting socially responsible business practices and sociological and ecological aspects. 177

Companies have access to a number of techniques, tools, analyses and concepts that can help them 178
achieve their goals while operating in a sustainable manner. The circular economy is one concept that 179
makes this possible. Landfill and exported waste can be used as SRM in companies, reducing their 180
dependence on raw materials, cutting costs and creating numerous advantages (Đorđević *et al.*, 2023). 181

2.2. Data collection 182

Data used to identify material flows that can be used as SRM are from the national GIS (Geographic 183
Information System) database for Waste Management and official national reports from 2019-2024 184
(SEPA, 2020, pp. 2011–2019, 2021, pp. 2011–2019, 2022, pp. 2011–2019, 2023b, pp. 2011–2019, 185
2024, pp. 2011–2019, 2025). GIS database includes data on Serbia and its regions, on generated 186
waste, treated waste, temporary stored waste, collected waste, waste treatment, exported and imported 187
waste. Waste flows are listed according to the national waste catalogue. The national waste catalogue 188
has twenty main groups, including hazardous and non-hazardous waste flows. Data on imported and 189
exported waste, which can be used as SRM, have also been used. 190

National reports include data on generated waste, generated MSW treatment, used waste, hazardous 191
and industrial waste, landfilled waste, transboundary waste flows, and exported and imported waste. 192

All quantitative waste data come from national SEPA reports and GIS waste portal for 2019–2023 and hazardous/industrial waste was excluded because of data gaps and different treatment chains. The material flows of interest for this research are the ones which can be used as SRM and flows for which recycling and reuse technologies are well established.

Data from official reports, national strategies on environmental protection and waste management, and national databases on waste flows have been used to identify waste flows and quantities that can be used as secondary raw materials (SRM). The material flow of interest for this research is the one that can be used as SRM and flows for which recycling and reuse technologies are well established. Based on the results, recommendations are made for improving and developing waste management to achieve a sustainable development and transit to circular economy.

2.3. Data analysis

Data from national reports and the GIS database were summarized based on the morphological properties of the waste flow. Regarding the morphological composition of MSW in Serbia, 45% is biodegradable waste, paper and cardboard 6%, PET packaging 5%, and other plastic waste 5%. Other potential secondary raw materials, including glass, metal, metal Al cans, composite materials, other plastic waste, plastic bags, and textiles, account for 23% of waste landfilled (SEPA, 2021). In addition, the municipal solid waste flows that are landfilled can be used as SRM. In this analysis, textile and wood waste flows have been assessed as SRM, and batteries and accumulators have been analyzed since recycling capacities are available in the country.

For this study, a group of decision-makers and experts involved in waste management and the circular economy in Serbia has been identified.

The questions were selected and formulated using the Delphi method, which was achieved by selecting a previously formed set of questions after analysing the available relevant, verified data and the current status of CE implementation in Serbia.

Although history and events from the past play a role and are fully appreciated in forecasting methods, 217
technological forecasts require more than that: the application of imagination and creativity, which is 218
connected with the talent, knowledge and intuition of individuals, to be able to perceive changes in 219
the long term successfully (Levi-Jakšić, Marinković and Obradović, 2011). Thus, for our research, 220
the experts were chosen based on their expertise, knowledge, business functions, narrow speciality 221
closely related to forecasting and prior consent, and according to the standardised Delphi method. 222
Participants are anonymous and do not know each other to avoid influence and achieve objectivity. 223
The selected group of participants that provides the answers are called a panel. 224

During the questionnaire implementation, the participants were asked several questions needed to 225
answer the research question. 226

Intuition, judgment, and expertise are essential to applying the technical forecasting method and are 227
more important than the forecasting technique in making a successful forecast. However, one should 228
not ignore the role and connection of the forecasting techniques themselves, the goal of which is to 229
organise the knowledge, intuition and abilities of people rationally and systematically in the direction 230
of performing the most successful qualitative, technological forecasting for the sake of formalising 231
thought processes and predicting the future. 232

In the Delphi method, the model used as a basis for prediction is always knowledge expertise, and 233
individual knowledge is also used. 234

The Delphi method includes repeated voting, with the same experts giving answers, considering pre- 235
vious results. This approach is used to avoid the influence of “lawyers”. 236

The Delphi method (Linstone, 2002) is one of the fundamental forecasting methods and represents 237
the most well-known and widely used expert evaluation method. Expert evaluation methods signifi- 238
cantly improve the traditional ways of obtaining forecasts through the joint consultation of experts 239

on the studied phenomenon. In other words, it is a methodologically organised use of expert knowledge to predict future states.

The Delphi technique is a flexible and rapid research method that can be used to analyse educational needs. This technique becomes more valid and effective if a group of experts monitors and analyses information until a consensus is reached. Its significance is reflected in the characteristics of the Delphi method, which include:

- Anonymity
- Interactive Process, conducted in “rounds” with controlled feedback
- Statistical Calculation
- Defined Questionnaires

The starting point of the method is the definition of the problem for which a forecast is sought. After defining the problem, a group of experts is formed to participate in the forecasting process. It is recommended that the group contains 7-15 experts, with a maximum of 35. Experts are asked to provide forecasts and other information via questionnaires, ensuring the anonymity of both the experts and the forecasts obtained. The Delphi method is a quantitative research method with qualitative elements, relying on the opinions of a panel of experts and conducted through several rounds of inquiry.

In our study, experts were selected for their competence, years of experience, and specialist knowledge, with a mandatory inclusion criterion requiring direct involvement in MSW or CE policymaking or operational activities (Levi-Jakšić, Marinković and Obradović, 2011). This approach ensures methodological relevance and strengthens the panel's representativeness.

The expertise of the panel members covered several key sectors relevant to CE implementation:

- national ministries and state environmental agencies,
- local government authorities,

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- operators of waste-treatment and recycling facilities, 263
 - representatives of the business/industry sector, 264
 - academia and research institutions, and 265
 - chambers of commerce and sectoral organisations. 266

All participants provided informed consent, and the Delphi process was conducted anonymously to prevent mutual influence and ensure impartiality of responses. 267
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The Delphi method is carried out through several rounds of inquiry. In the first round, experts complete a questionnaire. After processing the statistical data, the questionnaire results are returned to participants, and the same questionnaires are completed again. However, they may change their opinions based on the results of the first round. The number of rounds is not defined; typically, four rounds are conducted, whereas in this study, five rounds were performed. From this, we can conclude that the Delphi method is: 269
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- An exploratory and intuitive method; 275
- A method that leverages the advantages of group thinking 276
- A method that overcomes obstacles that arise in group work 277
- A technique that relies on expert opinions; 278
- Conducted through several rounds of inquiry. 279

There are two distinct forms of the Delphi method: 280

1. **Conventional Delphi Technique:** Often referred to in literature as the Delphi exercise, this approach is conducted manually using paper and pencil. A team is formed to oversee and implement the method questionnaires are developed, and responses are collected, in accordance with the standard procedure described. 281
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2. **Online Delphi (Delphi Conference):** This is a more recent form of the Delphi method, in which 285
the implementation and coordination team is largely replaced by a computer that performs statistical 286
data processing. This approach has advantages in terms of faster result processing, allowing immedi- 287
ate forecasting, as all members simultaneously respond to questionnaire items and can revise their 288
answers more efficiently in the next round. Results can be presented as graphs, comparative tables, 289
etc. (Sharma *et al.*, 2021). 290

For this study, the Online Delphi method was used. Standardised formulas will be employed to 291
calculate each expert's individual prediction time, the overall expected value, the dispersion for each 292
expert t_i , the total dispersion, the standard deviation, and the probability values using the Laplace 293
table. 294

A variation based on response was used - the Delphi method allows for three possible answers. These 295
three responses can relate to 1. the earliest, optimistic (*o*), 2. the expected (*m*), and 3. the latest reali- 296
sation of the event, pessimistic (*p*). 297

An online Delphi method was used to determine the timeframe within which progress in the imple- 298
mentation of the circular economy can realistically be expected in Serbia. This method is particularly 299
suitable for transition economies, where official statistics are fragmented, and policy development is 300
still evolving (Linstone, 2002). The Delphi technique enables structured collection of expert opinions 301
across several rounds, ensuring anonymity, controlled feedback, and gradual convergence toward 302
more reliable estimates. 303

In this study, the Delphi method is used not to provide a general overview of trends, but to establish 304
an expert-based timeline for when circular-economy practices may become operational in Serbia. 305
Conditions typical of transition economies-fragmented and incomplete data, unstable regulatory 306

frameworks, and strong dependence on external funding-make expert judgement especially appropriate, offering a robust form of prediction where quantitative indicators are insufficient.

2.4 Validity, Security, and Reliability

The Delphi method ensures a high level of validity and reliability through several core procedural elements. Expert anonymity prevents dominance effects and conformity bias, thereby securing independent judgment. Controlled feedback enables reflection, argumentation, and potential adjustment of views across rounds. The multi-round structure contributes to the gradual stabilization of opinions and the reduction of extreme values, while the combination of expert intuition, experience, and analytical reasoning is particularly relevant in contexts where reliable quantitative data are lacking (Levi-Jakšić, Marinković and Obradović, 2011).

Validation of results is achieved by assessing response stability across rounds and measuring convergence toward consensus. A reduction in variance between rounds represents a key indicator of validated and stable outcomes.

Security of the process is ensured by participants' complete anonymity, controlled access to the online platform, and the absence of direct communication among experts. These measures eliminate mutual influence and minimize the risk of bias. The online environment further enhances procedural safety by reducing operational errors and facilitating efficient processing of responses.

Reliability of results is strengthened by the use of standardized statistical procedures applied during data analysis, which enable accurate calculation of central tendency measures, dispersion values, and probabilities of realization. Although the Delphi method provides a high degree of reliability, its

inherent limitation remains the subjective nature of expert assessments. Consequently, careful interpretation of the results is required, particularly in highly uncertain policy environments.

2.5 Measurements and Data Processing

During data processing, standardized statistical procedures commonly used in Delphi studies were employed. The following formulas and accompanying calculations were employed:

1. The formula for deriving the individual expected prediction time based on the combination of optimistic (o), most likely/median (m), and pessimistic (p) estimates;
2. The formula for calculating the expected time of event realization (E);
3. The formula for computing the individual expert's variance.
4. The formula for calculating the overall variance (dispersion) of the expert panel;
5. The formula for obtaining the standard deviation and the standardized value γ ;
6. The probability estimation based on the Laplace cumulative distribution table.

For additional clarity, this section now includes a brief mathematical overview explaining the logic behind the performance evaluation of the Delphi panel. Individual expert assessments are first transformed into expected values through weighted combinations of o/m/p estimates. Subsequently, variances and standard deviations are calculated to quantify the degree of agreement within the panel. The total dispersion and γ -values provide insight into the stability and convergence of expert responses across rounds, while the calculated probabilities indicate the reliability of the predicted timeframes.

All formulas (1)–(6), numerical examples, probability tables, and graphical illustrations are presented in **Appendix A** for transparency and reproducibility.

3. Results and Discussion

3.1. Analysis of the Circular Economy and Waste Management in Serbia

Serbia's progress in the circular economy and sustainable development, which are important for economic development and future growth, remains limited. A key indicator of this issue is the substantial amount of waste that ends up in landfills and is poorly managed, despite the potential to repurpose it as SRM. This mismanagement affects all dimensions of sustainable development, including the economic, social, and ecological. Additionally, excessive resource consumption generates large volumes of waste from manufacturing processes, which are not used as secondary raw materials. Therefore, it is essential to analyse the current situation thoroughly and develop guidelines for improvement.

The total amount of municipal waste deposited in Serbia for 2019-2023 is shown in Table 1. Despite the legal framework in the area of waste management, which is adopted, a significant amount of municipal solid waste is landfilled, around 80% of total generated waste, where the amount of waste that is landfilled has risen in the past five years (Mihajlović *et al.*, 2016; SEPA, 2023a).

Table 1 Municipal solid waste indicators in Serbia from 2018-2022 [33].

Indicator	2019	2020	2021	2022	2023
MSW generated (t)	2 827 910	2 947 497	3 021 741	3 178 770	3 095 422
Total MSW landfilled (t)	2 243 661	2 341 732	2 356 432	2 457 216	2 460 777
Generated MSW landfilled (%)	79.34	79.45	77.98	77.30	79.5

Regarding the morphological composition of landfilled waste, 45% is biodegradable waste, 6% paper and cardboard, 5% PET packaging, and 5% other plastic waste. In contrast, other potential secondary raw materials include glass, metal, metal-aluminum cans, composite materials, other plastic waste, plastic bags, and textiles, accounting for 23% of landfilled waste (Mihajlović *et al.*, 2016). Fine elements and other materials account for 16% of landfilled waste. Therefore, excluding fine elements and other potential secondary raw materials, which are landfilled, is 84%, 2.034.575 tons of MSW in 2023, Figure 1. The largest share of landfilled waste in 2023 was biodegradable waste (1 120 490 tons), of which only 1.32% was recycled (SEPA, 2023a). The rise of landfilled waste shows that CE

is not at a satisfactory level in Serbia, and landfilled waste is a lost SRM, which can be used instead of virgin materials, which cost more and increase the cost in the production chain.

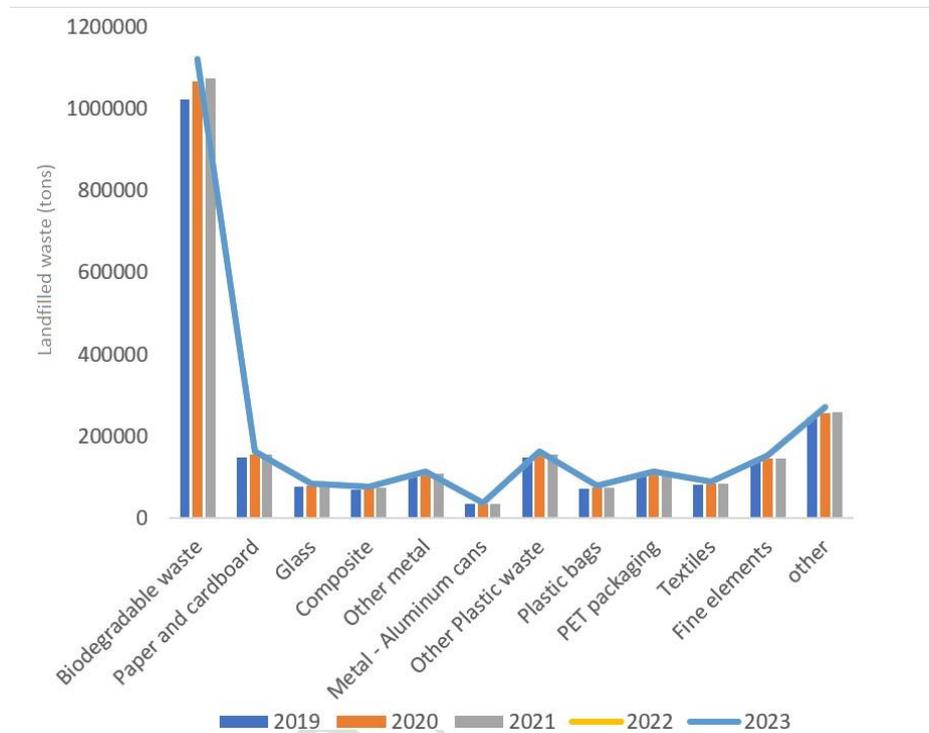


Figure 1 Morphological composition of waste landfilled in Serbia from 2019 to 2023

However, Serbia continues to export waste to neighbouring countries despite its available processing capacity. Most of the waste was exported to the Republic of Croatia, the Republic of Bulgaria, the Republic of North Macedonia, the Republic of Slovenia, and Hungary. Also, Serbia imports a significant amount of waste, mostly hazardous waste, and the same material waste flows that are exported (Levi-Jakšić, Marinković and Obradović, 2011; SEPA, 2021, pp. 2011–2020, 2022, pp. 2011–2020, 2023b, pp. 2011–2020, 2024, pp. 2011–2020). Exporting SRM to neighbouring countries despite available processing capacity indicates that strategic planning is important for implementing the CE concept and that CE is not at a satisfactory level. SRM exports persist due to unstable feedstock from poor source separation, variable quality, and lower prices of virgin materials.

Material flows of recycled waste used as secondary raw materials 2020-2023 are shown in Figure 2 (SEPA, 2020, pp. 2011–2020, 2021, pp. 2011–2020, 2022, pp. 2011–2020, 2023b, pp. 2011–2020, 2024, pp. 2011–2020). The highest share is metals; the price is per kg, so the profit is higher. The share of plastic waste decreased in 2023, and the share of paper and cardboard decreased significantly due to fluctuations in the prices of secondary raw materials. The share of other material flows is much lower, even insignificant, in the case of textiles and accumulators.

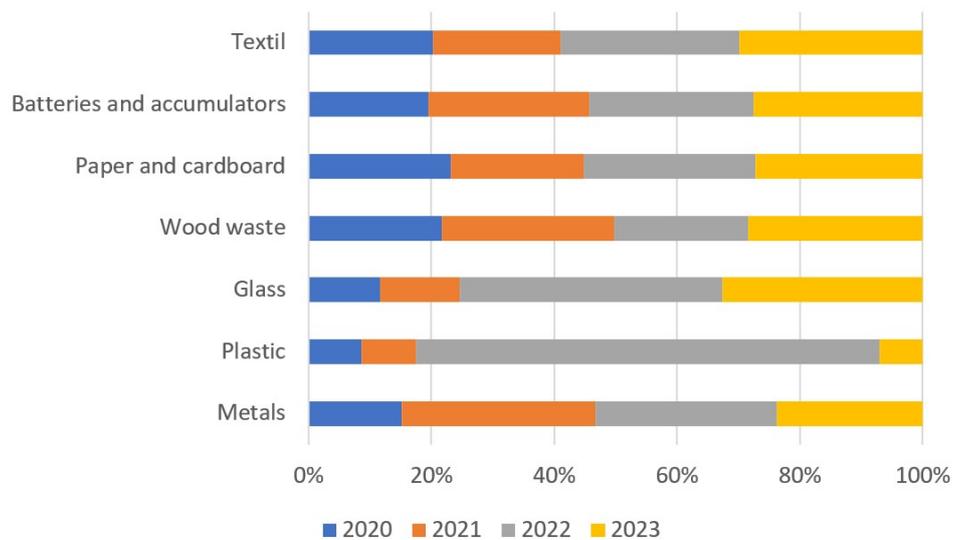


Figure 2. Material flows of recycled waste used as secondary raw materials from 2020 to 2023

The import and export of secondary raw materials for 2019-2023 are shown in Figures 3 and 4 (SEPA, 2020, pp. 2011–2020, 2021, pp. 2011–2020, 2022, pp. 2011–2020, 2023b, pp. 2011–2020, 2024, pp. 2011–2020).

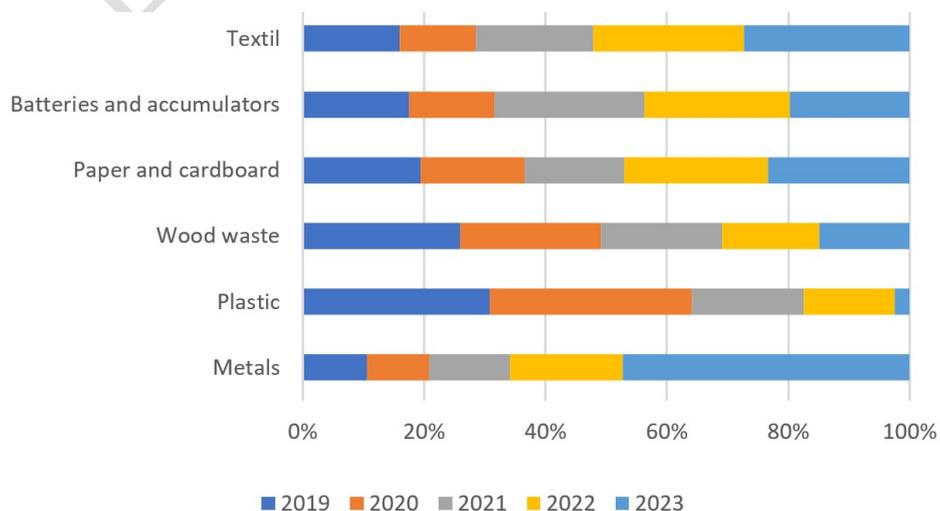
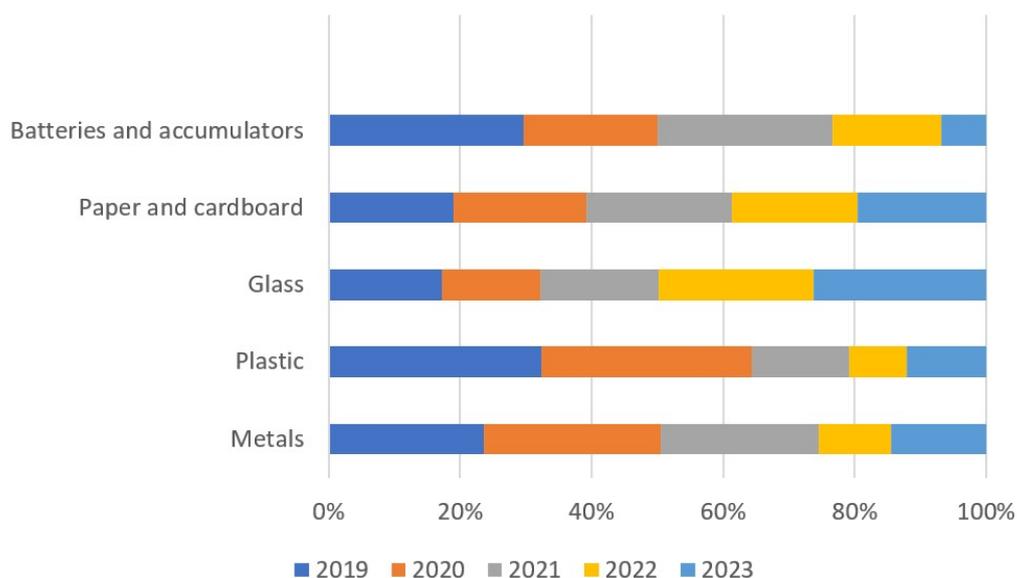


Figure 3. Import of waste as secondary raw materials in Serbia from 2019 to 2023

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Figure 4. Export of waste as secondary raw materials in Serbia from 2019 to 2023

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In addition to importing and exporting waste for use as an SRM, Serbia lacks primary materials that could be recycled. Additionally, waste prices fluctuate throughout the year, and in Serbia, virgin materials remain more attractive and cheaper than recycled materials, which are more expensive. Therefore, unprocessed materials are often more affordable than recycled materials, while large amounts of plastic waste are still disposed of in landfills.

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Market drivers further shape SRM recovery patterns, as evidenced by the dominance of metals in recycled material flows (Figure 2). Metals remain economically attractive due to higher and more stable market prices, whereas plastics and paper exhibit strong volatility, resulting in declining recovery rates in 2023. This market sensitivity explains the continued export of SRM despite the availability of domestic processing capacity (Figures 3 and 4), as inconsistent quality and price competitiveness undermine local recycling value chains and limit the integration of secondary materials into domestic circular-economy production systems.

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The comparison with EU averages—where SRM utilisation exceeds 11% of material consumption—highlights Serbia’s gap and also its growth potential. Integrating SRM recovery into industrial value

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chains, particularly in the metal, paper, and plastic sectors, could create 1,500–2,000 new jobs in 418
collection and reprocessing by 2030. These empirical results confirm that SRM development is both 419
an environmental and an economic opportunity, positioning waste management as a central lever in 420
Serbia’s circular-economy transition. In neighbouring countries Croatia, Romania, and Bulgaria, one 421
of the main obstacles to transition to a circular economy is that key drivers of the circular economy, 422
technology and innovation, and human resources are very low (World Bank, 2022). This implies that 423
green production has not yet developed, as sectoral policies remain focused on waste management 424
activities at the end of a product’s lifecycle. 425

In contrast, the potential for circular products is typically established at the outset, during the design 426
phase. A regional and material-specific focus can enhance the viability of developing a circular busi- 427
ness. Developers emphasised the importance of public financing availability while underscoring the 428
need to integrate circular requirements into public procurement processes. Studies have shown that 429
product branding is crucial in utilising waste as a raw material. Additionally, key market drivers, 430
including price volatility, resource scarcity, increased resource consumption, material cost savings, 431
and the creation of new markets, significantly influence the adoption of circular practices (Rizos *et* 432
al., 2016; Feng and Goli, 2023; Reis, Barreto and Capelari, 2023). 433

The European Union set a target for the circular material use rate of 23.2%, but only 11.7% of these 434
materials came from recycled waste . Data on the circular material use rate in Serbia for 2019 indicate 435
1.4%, which is far lower than the EU average and, compared with EU members, is comparable to 436
Romania (Statistical Office of the Republic of Serbia, 2021). In addition to the circular material use 437
rate, Serbia also lags in other waste management indicators Table 2. 438

Table 2. Comparison of EU and Serbia Waste Indicators 439

Indicator	European Union (average 2023)	Serbia (2023)
Circular Material Use Rate	11.7 %	1.4 %
Municipal Waste Landfilled	< 20 %	≈ 80 %
Packaging Waste Recycling	64 %	30–35 %
Illegal Dumpsites	-	> 2 000

These quantitative comparisons clearly demonstrate that Serbia's waste-management system remains 441
in the early phase of a CE transition, dominated by disposal rather than recovery. However, the grow- 442
ing trend in waste generation, coupled with the existing domestic recycling capacity, highlights a 443
significant untapped opportunity: redirecting even a fraction of landfilled materials into recycling 444
streams could substantially increase Serbia's CMU rate within the following policy cycle. The find- 445
ings confirm that improving source separation, expanding composting for biodegradable fractions, 446
and strengthening extended producer responsibility mechanisms are the most empirically justified 447
measures for accelerating progress toward the circular economy. The differences in material use and 448
disposal pathways highlight that the primary obstacle to CE uptake in Serbia is rooted in fundamental 449
inefficiencies in the end-of-pipe waste management system (collection, sorting, and landfill diver- 450
sion). 451

The observed trends in recycling, landfilling, and SRM flows are closely linked to both policy imple- 452
mentation gaps and market dynamics. Despite the formal alignment of Serbia's waste-management 453
framework with EU directives, the persistently high landfilling rate (≈80%) reflects delayed enforce- 454
ment of source separation obligations, the absence of landfill taxation, and weak economic incentives 455
for recycling. Figures 1 and 2 clearly show that biodegradable waste and plastics dominate landfilled 456
fractions, indicating that policy measures have not yet translated into effective upstream separation 457
or stable recycling feedstock, thereby slowing the transition from a linear to a circular resource model. 458

Table 2 highlights the structural gap between Serbia and EU averages, confirming that limited SRM utilization is not primarily a capacity issue but a systemic outcome of insufficient policy enforcement, fragmented collection systems, and market uncertainty. These results indicate that accelerating the development of the circular-economy in Serbia requires not only infrastructure investment but also coordinated policy instruments—such as landfill taxes, extended producer responsibility enforcement, and price-stabilization mechanisms—to improve SRM quality, reduce landfilling, and strengthen domestic recycling markets. By developing production models that reduce reliance on raw materials and consistently recycle materials back into production, companies can gain a competitive advantage and mitigate market volatility (SEPA, 2023b). However, planning a waste management system in line with EU legislation is costly for less-developed countries, and economic stability is a prerequisite for long-term, sustainable waste management (Ly, 2021).

The Ministry of Environmental Protection has recognized and awarded innovative initiatives that advance circular economy principles. Additionally, local communities have implemented waste-separation programs and incentivized citizen participation. Despite these advances, however, a substantial share of waste still ends up in landfills. This includes materials that could otherwise be used as secondary raw materials, underscoring a significant gap in the effective implementation of circular economy practices. Moreover, Serbia's recycling sector is characterized by excess capacity, exacerbated by the absence of an efficient primary waste-separation system. As a result, a considerable amount of recyclable material is lost in landfills because the available raw materials for recycling are of insufficient quality, preventing the industry from reaching its potential. The underperformance of Serbia's waste management sector - characterized by the absence of a landfill tax, a weak market for raw materials, insufficient financing for the circular economy industry, and limited capacity for waste management, particularly in separate collection - represents a significant barrier to initiating the transition to a circular economy.

The national strategic documents aim to enhance the industrial sector's sustainable development by addressing issues of excessive waste generation and inefficient use of raw materials. At the same time, transitioning to a circular economy cannot be achieved without integrating knowledge, innovation, sustainable innovative technologies, and advanced assessments. Furthermore, adopting sustainable high-tech production methods and modern business concepts, such as CE, is essential for driving this transformation (Official Gazette of RS", number 21/20, 2020; "Official Gazette of the RS", no. 35/20, 2021).

According to the Waste Management Programme of the Republic of Serbia 2022–2030, transitioning the industrial sector from a linear to a circular economy model requires the continuous development of a legal framework aligned with European Union (EU) standards. Promoting recycling and waste reuse is expected to reduce demand for primary raw materials. In cases where these materials were previously imported, this shift will enhance local sustainable development by stimulating domestic production and reducing reliance on foreign resources (Tomić and Schneider, 2020).

The economic dimensions of sustainable development and strategic planning are crucial to the successful transition from a linear to a circular economy (Lei, 2025; Ma and Appolloni, 2025). Alongside the ecological and social aspects, the economic aspect of the business/production organisation (OP) is essential.

This triumvirate and its synergy constitute the Circular Economy (CE) concept. The successful implementation of the CE requires significant investments, which is a key obstacle to the transition to a circular economy. On the other hand, the transition to the CE opens new opportunities, such as creating new jobs, reducing the unemployment rate, decreasing the consumption of natural resources, strengthening sustainable development, and fostering creativity and innovation.

In addition, data show very poor performance in terms of circular economy in waste management in Serbia, and the global green economy index is low compared to European countries as well Table 3.

The transition from a “brown” to a “green” economy is a focus of economic policymakers, who seek a global index to measure the performance of the green economy. In this sense, the Global Green Economy Index (GGEI) initiative, launched by the private consulting firm Dual Citizen based in the United States of America, is particularly noteworthy (Dual Citizen, 2023).

Table 3. Global Green Economy Index for EU countries adjusted from (Dual Citizen, 2023)

Country	Global Green Economy Index
Sweden	0.799
France	0.744
Denmark	0.742
Austria	0.711
Ireland	0.703
Portugal	0.701
Latvia	0.697
Luxembourg	0.696
Belgium	0.693
Spain	0.689
Finland	0.688
The Netherlands	0.685
Germany	0.674
Malta	0.672
Italy	0.699
Lithuania	0.668
Croatia	0.667
Estonia	0.666
Slovenia	0.639

Romania	0.623
Greece	0.617
Cyprus	0.613
Slovakia	0.606
Bulgaria	0.604
Czech Republic	0.585
Poland	0.559
Hungary	0.557
Serbia	0.495

3.1.1. Priority streams

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The composition of municipal solid waste (MSW) in Serbia indicates several key fractions suitable for circular-economy (CE) initiatives. Based on the morphological composition of municipal solid waste (MSW), five priority streams can be identified for circular-economy action:

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1. Biodegradable waste (food and green waste) - suitable for composting and anaerobic digestion to produce biogas and compost;
2. Paper and cardboard - can be efficiently recycled within existing industrial capacities;
3. Metals - offering high recycling value and direct substitution for virgin materials;
4. Plastics - particularly packaging fractions, which are price-sensitive but essential for reducing landfill volumes; and
5. Textiles and wood - currently low in generated quantities and recovery but showing rising potential through reuse and upcycling.

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Prioritizing these five material streams would yield the fastest progress toward higher recycling rates and reduced landfilling, thereby providing a practical foundation for Serbia's circular-economy transition.

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Also, it will provide clear guidance for policymakers and municipalities to achieve measurable progress toward circular-economy targets.

3.2. Forecasts and Projections - Delphi Method

The preparation and implementation of the Delphi method adhered to the previously defined rules. Questionnaires were completed with response options: o (optimistic), m (expected), and p (pessimistic), and statistical formulas were used for calculations. The predictions were made in 2024; therefore, the first answer is also possible, i.e., the current year, which would mean that the observed event will take place in 0 years. Furthermore, the answers can be 2025, 2026, 2027,..., which would mean in 1, 2, 3,... years, respectively. A group of experts relevant to planning and forecasting was selected, questionnaires were formulated, and questions were posed in line with the established goals. Table 4 shows the experts' responses after the third round of inquiry.

The standardized formulas which are used for the calculations, as well as the complete calculation, are given in the Appendix.

Table 4. Expert Responses

Experts	In how many years?	0	1	2	3	4	5	6	7
	Year	2024	2025	2026	2027	2028	2029	2030	2031
Expert 1				o		m	p		
Expert 2						m			
Expert 3					m				

Expert 4				o		m		p	
Expert 5			o		m			p	
Expert 6				o	m	p			
Expert 7						m			

Due to the length of the calculations, the application of the Delphi method formulas are provided in the Appendix. Based on the experts' responses, statistical indicators are calculated. Probability Values are given in Table 5.

Table 5. Probability Values

Year	Time t_1 (year)	Value Υ	Probability P
2024	0	-5.88	0.0001
2025	1	-4.24	0.001
2026	2	-2.61	0.0045
2027	3	-0.98	0.1635
2028	4	0.65	0.742
2029	5	2.28	0.988
2030	6	3.9	0.9986
2031	7	5.5	0.9999

Using the Laplace table, probabilities can be graphically represented, as shown in Figure 5 (Rizos *et al.*, 2016).

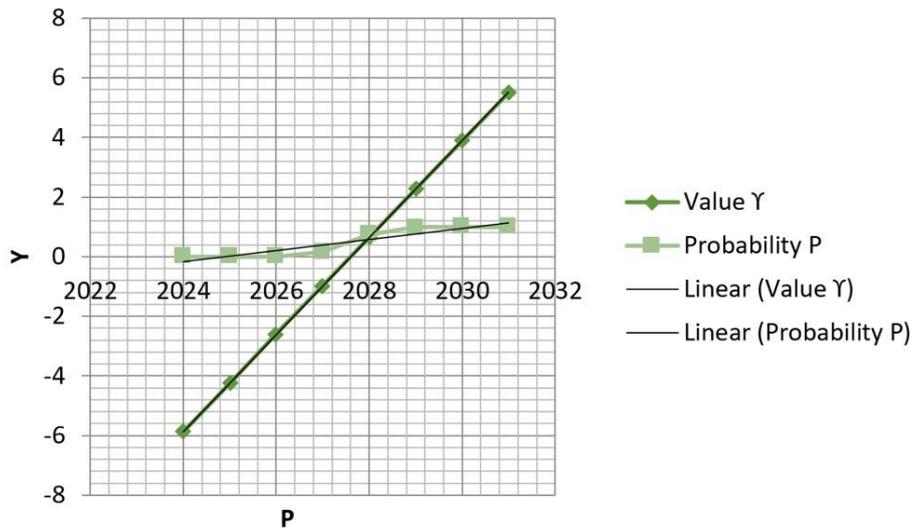


Figure 5. Probability Values

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Based on the experts' responses, a larger number of companies in Serbia operating on the principles of a circular economy can be expected in 3.6 years, i.e., by mid-2027, with the highest probability of realisation in 2030.

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Positive examples in practice exist and should serve as a model for transitioning from a linear to a circular economy. Germany was the first country to formally adopt this concept and incorporate its principles into legislation, enacting the Closed Substance Cycle Waste Management Act in 1996. Japan followed suit in 2000 by adopting the Basic Act for Establishing a Sound Material-Cycle Society. China and the European Union have made the most significant progress in transitioning to a circular economy. China passed the Circular Economy Promotion Law in 2009, laying the legal and political foundations and initiating activities to promote the concept of a circular economy.

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Energy recovery, specifically anaerobic digestion with energy recovery, of the separated biological waste fraction from mixed waste, which in other cases would be landfilled, in Serbia could support economic and social sustainability in implementing changes to the waste management of biodegradable waste. Integrating material and energy recovery technologies transforms the existing economy

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into a low-carbon, sustainable, and resource-efficient economy as a part of the circular economy and 573
the “closing the loop” concept (Dual Citizen, 2023). 574

Despite the development of a waste management system, some studies have identified obstacles and 575
barriers to CE implementation. In Finland, sustainable development professionals do not share a com- 576
mon view of the key barriers and means of overcoming them, which can lead to a lack of commitment 577
or even to conflicting measures to facilitate the CE transition (Salmenperä *et al.*, 2021). According to 578
research on performance in the transition to a circular economy, countries in the SEE region have not 579
achieved significant transition outcomes relative to EU investments in the transition process, due to 580
difficulties in implementation and in the transition strategy (Marino and Pariso, 2020). Croatia, Bul- 581
garia, and Romania primarily focus on waste management, without tax incentives to introduce circu- 582
lar-economy measures that support CE investments, and actions to transition from a linear to a circu- 583
lar economy are partial and uncoordinated. Evidence from developing economies indicates that inef- 584
ficient construction-waste management increases life-cycle human-health impacts, highlighting the 585
broader consequences of low circular-economy uptake (Wang *et al.* 2025). However, Slovenia has 586
undertaken numerous successful initiatives, but still lacks improvements in waste management and a 587
production system that remains firmly anchored in the linear economy. Evidence from recent regional 588
studies confirms that transition economies, including those in Southeast Europe, face systemic barri- 589
ers to CE implementation but also emerging opportunities for policy-driven industrial innovation 590
(Zhang *et al.*, 2025). 591

The roadmap for the circular economy adopted in Serbia aligns with the EU legal framework, sup- 592
porting the transition to a Green Economy, smart, inclusive, and sustainable development, increasing 593
waste-management targets for recycling, and reducing the amount of waste landfilled. Circular econ- 594
omy models may be considered key drivers towards the transition to a Green Economy, whereas 595
waste management plays an important role. Adapting and strengthening the implementation of legal 596

regulations and strategic frameworks at the local and national level in sustainable development and 597
circular economy is one of the prerequisites for the transition to a circular economy. 598

5. Conclusion 599

Results indicate that the number of companies in Serbia operating on the principles of a circular 600
economy is expected to increase in 3.6 years (i.e. by mid 2027), with the highest probability of reali- 601
sation in 2030. Material consumption and waste generation remain high, and the implementation of 602
a circular economy in Serbia is unsatisfactory; examples of circular-economy models are scarce. 603

To begin the transformation to a circular economy, some of the guidelines for achieving sustainable 604
development in waste management may include adapting and strengthening legal regulations, focus- 605
ing on strategic planning, changing the habits of individuals and producers, educating the community 606
on circular economy benefits, applying green technologies, and producing green products that are 607
easier to reuse in production after use. 608

The economic aspect and modern business practices must consider both profit and socially responsi- 609
ble behaviour from consumers and producers, sustainable production and consumption, and GDP 610
growth. Strategic planning is crucial and requires thorough analysis, assessment of the situation, and 611
the definition of goals, priorities, action strategies, vision, and mission. 612

Shifting to the circular economy business model will enable the development of a resilient economic 613
system by reducing waste and maximising resource efficiency. In addition, companies can optimise 614
resource use, reducing the need to extract raw materials and minimising production costs, thereby 615
improving profitability. As a transition country, Serbia will change and develop its economic system 616
and open the market to the EU as a member state. Companies that adopt circular business models 617
early will achieve sustainable long-term growth. 618

Investments are inevitable for transitioning from the traditional to the circular economy, which alone 619
can provide sustainable development. However, the initial transition to a circular economy may be 620
characterized by lower investment costs and greater reliance on markets, making it less sensitive to 621
changes in waste quantity and quality and more sustainable over the long term. It is necessary to raise 622
awareness about the importance of a circular economy. In the long term, CE provides numerous ad- 623
vantages, including creating new jobs, reducing the unemployment rate, promoting sustainable re- 624
source consumption, reducing waste, advancing clean, green technologies, encouraging innovation, 625
and fostering a sustainable society and economy overall. Additionally, the utilisation of waste energy 626
can help reduce dependence on fossil fuels. 627

The study is limited to MSW and the reliance on aggregated national data prevents a detailed assess- 628
ment of regional and local disparities in CE readiness. While the Delphi methodology yields a strong 629
consensus forecast, the reliance on a small, targeted panel of national experts means that the projected 630
timelines and policy conclusions should be interpreted as expert consensus rather than as a definitive 631
prediction derived from comprehensive economic or infrastructure modeling. 632

Future research should focus on expanding the database to include industrial, construction, and haz- 633
ardous waste streams and to integrate regional-level indicators of CE performance. Broader Delphi 634
panels, including private-sector investors, non-governmental organizations, and regional develop- 635
ment agencies, could enhance representativeness and robustness of consensus. Moreover, applying 636
econometric modelling and life-cycle assessment (LCA) techniques could quantify the potential en- 637
vironmental and economic benefits of CE adoption. In addition, future work should explore mecha- 638
nisms to increase circular-material-use rates by strengthening extended producer responsibility 639
(EPR), introducing landfill taxes, and promoting green public procurement. In parallel, investments 640
in recycling infrastructure, composting facilities, and digital monitoring systems (IoT and smart waste 641
platforms) will be crucial. 642

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Appendix A

The preparation and implementation of the Delphi method adhered to the previously defined rules. Questionnaires were completed with response options: o (optimistic), m (expected), and p (pessimistic), and statistical formulas were used for calculations.

The individual prediction time for each expert is computed as follows:

$$t_1 = \frac{r_1 \cdot o_1 + r_2 \cdot m_1 + r_3 \cdot p_1}{r_1 + r_2 + r_3} \quad (1)$$

$$r_{1-3} \text{ are constant } r_1 = 1 \quad r_2 = 4 \quad r_3 = 1$$

$$t_1 = \frac{r_1 \cdot o_1 + r_2 \cdot m_1 + r_3 \cdot p_1}{r_1 + r_2 + r_3} = \frac{1 \cdot 2 + 4 \cdot 4 + 1 \cdot 5}{1 + 4 + 1} = \frac{2 + 16 + 5}{6} = \frac{23}{6} = 3.83 \quad (2)$$

$$t_2 = 4 \quad (3)$$

$$t_3 = 3 \quad (4)$$

$$t_4 = \frac{r_1 o_4 + r_2 m_4 + r_3 p_4}{r_1 + r_2 + r_3} = \frac{1 \cdot 2 + 4 \cdot 4 + 1 \cdot 6}{1 + 4 + 1} = \frac{2 + 16 + 6}{6} = \frac{24}{6} = 4 \quad (5)$$

$$t_5 = \frac{r_1 o_5 + r_2 m_5 + r_3 p_5}{r_1 + r_2 + r_3} = \frac{1 \cdot 1 + 4 \cdot 3 + 1 \cdot 6}{1 + 4 + 1} = \frac{1 + 12 + 6}{6} = \frac{19}{6} = 3,16 \quad (6)$$

$$t_6 = \frac{r^1 o^6 + r^2 m^6 + r^3 p^6}{r^1 + r^2 + r^3} = \frac{1 * 2 + 4 * 4 + 1 * 4}{1 + 4 + 1} = \frac{2 + 16 + 4}{6} = \frac{22}{6} = 3.66 \quad (7)$$

* Note If only “m” is marked in the table, the formula is not used, but only the value for “m” is considered. 654
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Overall Expected Value: 656

$$tn = \frac{1}{n} \sum_{i=1}^n t_i \quad (8)$$

n is total number of experts

$$tn = \frac{1}{7} * (3,83 + 4 + 3 + 4 + 3,16 + 3,66 + 4) = 3.6 \text{ years} \quad (9)$$

Dispersion for Each Expert (Mean Square Deviation from the Arithmetic Mean): 657

$$\delta_i^2 = \frac{(p_i - o_i)^2}{r_4} \quad (10)$$

$$r_4 \text{ is constant, } r_4 = 36 \quad (11)$$

$$\delta_1^2 = \frac{(p_1 - o_1)^2}{r_4} = \frac{(5 - 2)^2}{36} = \frac{9}{36} = 0.25 \quad (12)$$

$$\delta_2^2 = \frac{(p_2 - o_2)^2}{r_4} = \frac{(0 - 0)^2}{36} = 0 \quad (13)$$

$$\delta_3^2 = \frac{(p_3 - o_3)^2}{r_4} = \frac{(0 - 0)^2}{36} = 0 \quad (14)$$

$$\delta_4^2 = \frac{(p_4 - o_4)^2}{r_4} = \frac{(6 - 2)^2}{36} = \frac{16}{36} = 0.444 \quad (15)$$

$$\delta_5^2 = \frac{(p_5 - o_5)^2}{r_4} = \frac{(6 - 1)^2}{36} = \frac{25}{36} = 0.694 \quad (16)$$

$$\delta_6^2 = \frac{(p_6 - o_6)^2}{r_4} = \frac{(4 - 2)^2}{36} = \frac{4}{36} = 0.111 \quad (17)$$

$$\delta_7^2 = \frac{(p_7 - o_7)^2}{r_4} = \frac{(0 - 0)^2}{36} = 0 \quad (18)$$

Total Dispersion: 658

$$\delta_n^2 = \frac{1}{n} * \left[\sum_{i=1}^n \delta_i^2 + \sum_{i=1}^n (t_i - t_n)^2 \right] \quad (19)$$

$$\delta_n^2 = \frac{1}{n} * \left[\delta_1^2 + \delta_2^2 + \delta_3^2 + \delta_4^2 + \delta_5^2 + \delta_6^2 + \delta_7^2 \right] + (t_1 - t_n)^2 + (t_2 - t_n)^2 + (t_3 - t_n)^2 + (t_4 - t_n)^2 + (t_5 - t_n)^2 + (t_6 - t_n)^2 + (t_7 - t_n)^2 \quad (20)$$

$$\delta_n^2 = \frac{1}{7} * \left[(0,25 + 0 + 0 + 0,444 + 0,694 + 0,111 + 0) + (3,83 - 3,6)^2 + (4 - 3,6)^2 + (3 - 3,6)^2 + (4 - 3,6)^2 + (3,16 - 3,6)^2 + (3,66 - 3,6)^2 + (4 - 3,6)^2 \right] \quad (21)$$

$$\delta_n^2 = \frac{1}{7} * [1.499 + 0.053 + 0.16 + 0.36 + 0.16 + 0.193 + 0.036 + 0.16] = \frac{1}{7} * 2.621 = 0.375 \quad (22)$$

$$\delta_n = \sqrt{0.375} = 0.612 \quad (23)$$

Probability Values:

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$$\gamma = \frac{t_i - t_n}{\delta_n} \quad (24)$$

t is referenced year 2024 having value 0, 2025 value is 1, 2026 value is 2

$$y_{2024}: \frac{0 - 3.6}{0.612} = \frac{-3.6}{0.612} = -5.88 \quad (25)$$

$$y_{2025}: \frac{1 - 3.6}{0.612} = \frac{-2.6}{0.612} = -4.24 \quad (26)$$

$$y_{2026}: \frac{2 - 3,6}{0,612} = \frac{-1,6}{0,612} = -2,61 \quad (27)$$

$$y_{2027}: \frac{3 - 3.6}{0.612} = \frac{-0.6}{0.612} = -0.980 \quad (28)$$

$$y_{2028}: \frac{4 - 3.6}{0.612} = \frac{0.4}{0.612} = 0.653 \quad (29)$$

$$y_{2029}: \frac{5 - 3.6}{0.612} = \frac{1.4}{0.612} = 2.28 \quad (30)$$

$$y_{2030}: \frac{6 - 3.6}{0.612} = \frac{2.4}{0.612} = 3.9 \quad (31)$$

$$y_{2031}: \frac{7 - 3.6}{0.612} = \frac{3.4}{0.612} = 5.5 \quad (32)$$

$$2024: P = 1 - (0.5 + 0.499) = 1 - 0.999 = 0.001 \quad (33)$$

$$2025: P = 1 - (0.5 + 0.499) = 1 - 0.999 = 0.001 \quad (34)$$

$$2026: P = 1 - (0.5 + 0.4955) = 1 - 0.9955 = 0.0045 \quad (35)$$

$$2027: P = 1 - (0.5 + 0.3365) = 1 - 0.8365 = 0.1635 \quad (36)$$

$$2028: P = 0.5 + 0.2420 = 0.742 \quad (37)$$

$$2029: P = 0.5 + 0.4885 = 0.9885 \quad (38)$$

$$2030: P = 0.5 + 0.4986 = 0.9986 \quad (39)$$

$$2031: P = 0.5 + 0.4999 = 0.9999 \quad (40)$$

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