



OLESEA PLOTNIC • MIHAELA TOFAN
(EDITORS)

Challenges, Processes, and Policies for a Circular Economy that Works for Consumers

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Olesea Plotnic, Mihaela Tofan

(editors)

**Challenges, Processes, and Policies
for a Circular Economy that Works for Consumers**

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2025

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UNDERSTANDING THE CONSUMER PERSPECTIVE IN CIRCULAR SYSTEMS: EXPLORING THE COMPLEXITY OF TRANSITION TO A CIRCULAR ECONOMY

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Abstract

This study addresses the critical yet underexplored role of consumers in the transition toward a circular economy, a shift necessitated by intensifying environmental degradation and resource scarcity. Despite the proliferation of academic literature on the circular economy, existing research often conceptualizes consumers as passive recipients rather than as dynamic agents capable of catalysing or impeding systemic change. To bridge this gap, the study employs a systematic literature review methodology, synthesizing insights from 156 screened academic articles to map the multidimensional interactions between consumers and other stakeholders within circular ecosystems. The analysis integrates the Multi-Level Perspective (MLP) and Stakeholder Theory, enabling a nuanced examination of how consumer behaviours interact with niche innovations, established market regimes, and broader policy landscapes. Findings reveal that increased consumer adoption of circular practices at the micro level stimulates business innovation and market expansion, while at the meso level, collaborative value creation and infrastructure development reinforce consumer participation. At the macro level, growing consumer demand incentivizes policy support and infrastructural investment, creating a feedback loop that accelerates systemic change. The study identifies leverage points for effective consumer engagement, such as targeted education, behavioural incentives, and multi-stakeholder collaboration, and offers practical implications for policymakers, businesses, and civil society. By reframing consumers as active co-creators, this study advances theoretical and practical understanding of their pivotal role in circular economy transitions, providing a comprehensive framework for future research and policy development.

Keywords: *circular economy; consumer engagement; multi-level perspective; stakeholder theory.*

JEL Classification: Q56

1. INTRODUCTION

The accelerating depletion of natural resources and mounting environmental degradation have brought the limitations of the traditional linear economic model – take, make, dispose – into sharp relief, necessitating a fundamental shift toward

more sustainable paradigms. The circular economy (CE) has emerged as a compelling alternative, aiming to decouple economic growth from resource consumption by promoting the continual use, reuse, and regeneration of materials and products (Nguyen *et al.*, 2023). In this context, the role of consumers has gained increasing attention, as their choices and behaviours are pivotal in driving or hindering the adoption and diffusion of circular practices across markets and societies.

Despite the growing body of literature on circular economy strategies, the majority of research has historically focused on supply-side innovations, business models, and policy frameworks, often relegating consumers to the role of passive recipients of circular solutions (Carreira *et al.*, 2023; Vidal-Ayuso *et al.*, 2023). This perspective overlooks the complex, multidimensional ways in which consumers actively shape the success or failure of circular transitions through their purchasing decisions, use patterns, and end-of-life product management (Duarte *et al.*, 2024). Recent studies underscore a persistent gap between consumers' positive attitudes toward circularity and their actual engagement in circular behaviours, with barriers such as insufficient information, limited accessibility, and inadequate economic incentives impeding widespread adoption. This disconnect highlights the need for a more nuanced understanding of consumers not merely as end-users, but as dynamic agents whose actions, motivations, and interactions with other stakeholders can catalyse or constrain systemic change.

The problem, therefore, lies in the lack of comprehensive frameworks that capture the full spectrum of consumer roles within circular ecosystems and elucidate how their behaviours interact with innovations at the micro (individual and niche), meso (organizational and regime), and macro (policy and societal) levels. Without such frameworks, policymakers and practitioners risk designing interventions that fail to address the root causes of consumer inertia or resistance, ultimately limiting the effectiveness of circular economy initiatives. Addressing this gap is critical, as evidence suggests that consumer engagement is not only necessary for the operationalization of circular business models but also for driving market shifts, influencing policy, and normalizing sustainable consumption patterns.

To respond to this challenge, the present study adopts a systematic literature review methodology, screening and synthesizing insights from 156 academic articles to map the multidimensional interactions between consumers and other stakeholders in circular ecosystems. Methodologically, the review is guided by the integration of the Multi-Level Perspective (MLP) (Geels, 2004) and Stakeholder Theory (Freeman *et al.*, 2010), which together provide a robust theoretical lens for analysing how consumer behaviours interact with niche innovations, established market regimes, and broader policy landscapes. The MLP framework allows for the identification of systemic barriers and leverage points across different levels of the circular transition, while Stakeholder Theory unpacks

the conflicts, collaborations, and co-creation processes among consumers, businesses, policymakers, and civil society actors.

The findings reveal that consumers play a tri-dimensional role in the circular economy: as customers making product choices, as users influencing the longevity and maintenance of goods, and as end-of-life product holders determining the fate of materials post-consumption. At the micro level, increased consumer adoption of circular practices – such as purchasing durable, repairable, or second-hand products – stimulates business innovation and market expansion, reinforcing positive feedback loops through social proof and word-of-mouth. At the meso level, collaborative value creation and infrastructure development – such as repair networks, sharing platforms, and co-design initiatives – enhance accessibility and normalize circular behaviours. At the macro level, growing consumer demand incentivizes policy support and infrastructural investment, creating a societal shift that accelerates the normalization of circular economy principles. However, the study also identifies persistent barriers, including the dominance of price-quality considerations, convenience, and information deficits, which must be addressed through targeted education, behavioural incentives, and multi-stakeholder collaboration.

Theoretically, this research advances the field by reframing consumers as active co-creators in circular ecosystems, rather than passive recipients, and by providing an integrative framework that links individual behaviours to systemic change through the lenses of MLP and Stakeholder Theory. Practically, the study offers actionable recommendations for policymakers, businesses, and civil society, the development of transparent information systems, and the alignment of policy incentives with consumer motivations. These contributions are intended to inform the design of more effective interventions that can bridge the gap between consumer intention and action, thereby accelerating the transition to a circular economy.

The remainder of the article is structured as follows. The next section reviews the relevant literature on the circular economy and consumer engagement. This is followed by a detailed account of the methodology. The subsequent section presents the preliminary results and discussion, mapping the multidimensional roles of consumers and identifying leverage points for effective engagement. The article concludes with a synthesis of theoretical and practical implications, limitations, and directions for future research.

2. LITERATURE BACKGROUND

The linear economic model, characterized by its "take-make-dispose" paradigm, has precipitated unprecedented environmental degradation, resource depletion, and climate instability (Geissdoerfer *et al.*, 2017). In response, the circular economy (CE) has emerged as a transformative framework that redefines production and consumption systems by prioritizing resource efficiency, waste

minimization, and regenerative design (Ahmadov *et al.*, 2025). Unlike linear systems, CE aims to decouple economic growth from finite resource extraction through strategies such as reuse, repair, remanufacturing, and recycling (Blomsma *et al.*, 2019). This shift is not merely an environmental imperative but a socioeconomic necessity, as global waste generation is projected to exceed 3.4 billion metric tons annually by 2050, exacerbating landfill pollution and greenhouse gas emissions (World Bank, 2021).

Academic consensus underscores CE's potential to mitigate climate change, enhance resource security, and foster innovation. Moreover, CE principles are increasingly integrated into policy frameworks, such as the European Green Deal, which mandates member states to adopt circular strategies to achieve carbon neutrality (European Commission, 2020). Despite these advancements, the transition remains uneven, with systemic barriers persisting across industries and geographies. A critical lacuna in current research lies in understanding the role of human agency – particularly consumers – in driving or inhibiting CE transitions (Bucur, 2023).

Consumers are central to CE ecosystems, yet their agency has historically been underestimated in both academic literature and practice. Traditional CE scholarship has focused disproportionately on supply-side innovations, such as closed-loop manufacturing and industrial symbiosis, while relegating consumers to passive recipients of circular products (Carreira *et al.*, 2023; Vidal-Ayuso *et al.*, 2023). This oversight is paradoxical, given that consumer decisions directly influence material flows at every lifecycle stage – from purchasing durable goods to participating in sharing economies and proper waste segregation (Duarte *et al.*, 2024).

Behavioural barriers – including lack of awareness, economic disincentives, and infrastructural limitations – hinder widespread consumer engagement. For example, convenience-driven consumption habits and perceived hygiene risks deter participation in product-service systems like clothing rentals (Bucur, 2023). Additionally, informational asymmetries persist: eco-labelling and transparency mechanisms often fail to communicate the environmental benefits of circular products effectively (Geissdoerfer *et al.*, 2017). Nevertheless, emerging evidence suggests that targeted interventions, such as behavioural nudges and financial incentives, can amplify consumer adoption. In Sweden, deposit-return schemes for beverage containers achieved a 90% recycling rate by aligning economic rewards with environmental action (Lacey & Rutqvist, 2015). Such examples underscore the untapped potential of consumer-centric CE strategies.

Existing CE literature provides robust insights into technological and regulatory dimensions but inadequately addresses the sociopolitical dynamics of consumer engagement (Ahmadov, 2025). First, while studies acknowledge consumers as "co-creators" in circular value chains, their interactions with other stakeholders – businesses, policymakers, NGOs – remain underexplored (Heikkinen *et al.*, 2023). For instance, collaborative platforms enabling consumer

feedback loops in product design are rare, despite their potential to enhance circularity (Blomsma *et al.*, 2019). Second, the temporal and spatial dimensions of consumer behaviour are neglected. Cross-cultural analyses reveal significant disparities: European consumers prioritize product longevity, whereas Asian markets emphasize cost-effectiveness, complicating global CE standardization (Govindan *et al.*, 2018).

Theoretical frameworks capable of bridging these gaps are scarce. Most CE models, such as the Ellen MacArthur Foundation's "butterfly diagram," focus on material flows rather than human behaviours. This reductionist approach overlooks the multilevel complexities of consumer decision-making, which operates within nested systems of individual preferences, institutional norms, and macroeconomic policies (Geels, 2004). To address this, scholars advocate integrating the MLP and Stakeholder Theory – two complementary lenses that collectively illuminate the interplay between micro-level actions and systemic change (Blomsma *et al.*, 2019; Heikkinen *et al.*, 2023).

The MLP, rooted in transition studies, conceptualizes societal change as the outcome of interactions across three tiers: niches (innovative experiments), regimes (dominant practices), and landscapes (exogenous trends) (Geels, 2002). Applied to CE transitions, MLP elucidates how consumer-driven niches – such as repair cafés or clothing swaps – challenge incumbent regimes (e.g., fast fashion) by normalizing circular behaviours (Blomsma *et al.*, 2019). Landscape pressures, such as climate policies or raw material shortages, further destabilize regimes, creating windows of opportunity for niche innovations to scale (Geels, 2011).

However, MLP's structural focus risks oversimplifying the agency of individual actors. Stakeholder Theory complements this by examining how diverse actors – consumers, firms, governments – collaborate or conflict in value creation processes (Freeman, 1984). In CE contexts, stakeholders often pursue divergent interests: consumers prioritize affordability, businesses seek profitability, and regulators enforce compliance (Heikkinen *et al.*, 2023). Successful CE transitions thus depend on aligning these interests through co-design, transparency, and shared incentives. For instance, blockchain-enabled traceability systems in the textile industry have bolstered consumer trust in recycled materials by verifying sustainability claims (Bocken *et al.*, 2016).

The integration of MLP and Stakeholder Theory offers a holistic framework to analyse CE transitions. MLP identifies systemic leverage points – such as policy reforms or niche upscaling – while Stakeholder Theory unpacks the relational dynamics enabling or constraining collective action (Ahmadov *et al.*, 2025). Together, they provide a roadmap for fostering consumer agency across micro, meso, and macro levels. At the micro level, educational campaigns can address knowledge gaps; at the meso level, multi-stakeholder partnerships can co-create circular infrastructure; and at the macro level, regulatory frameworks can

internalize environmental costs, incentivizing sustainable consumption (Geissdoerfer *et al.*, 2017).

3. METHODOLOGY

This study employed a systematic literature review (SLR) methodology to synthesize existing academic knowledge on consumer roles in CE transitions, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor and transparency. The review integrated the MLP and Stakeholder Theory as analytical frameworks to examine interactions between consumers, businesses, and policymakers across micro, meso, and macro levels.

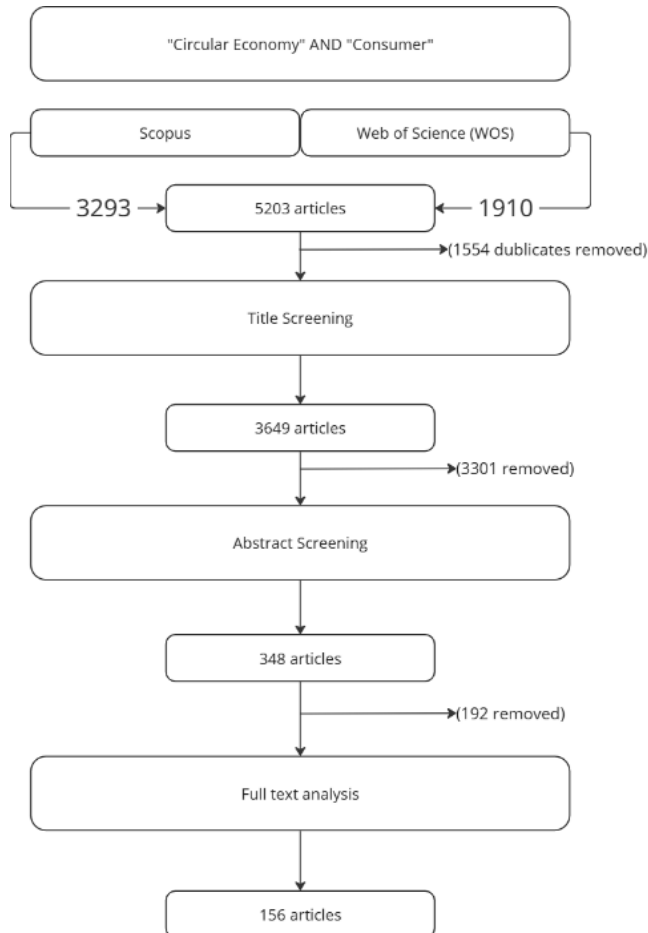


Figure 1. Systematic Literature Review Flow Diagram
Source: Author's own

The figure 1 illustrates the stepwise selection process for the systematic literature review on the intersection of the circular economy and consumer research. The initial database search using the terms "Circular Economy" AND "Consumer" yielded a total of 5,203 articles – 3,293 from Scopus and 1,910 from Web of Science. After removing 1,554 duplicates, 3,649 unique articles remained for title screening. This phase excluded 3,301 records, leaving 348 articles for abstract screening. Following the exclusion of 192 articles at this stage, 156 articles were subjected to full-text analysis and ultimately included in the final review. This transparent and rigorous process ensures that only the most relevant and high-quality academic studies inform the synthesis of consumer roles in circular economy transitions

4. RESULTS AND DISCUSSION

At the micro level, the adoption of circular practices by consumers serves as a critical driver for business innovation and market expansion. As recent studies have shown, consumer choices and behaviours – shaped by personal values, knowledge, habits, price sensitivity, perceived product quality, and social influence – play a decisive role in stimulating firms to develop and improve circular offerings (Dentchev *et al.*, 2018; Shevchenko *et al.*, 2023). When consumers opt for circular products or services, they not only create immediate demand but also send strong market signals that encourage businesses to invest in innovation, expand product accessibility, and enhance the overall value proposition of circular solutions (Nguyen *et al.*, 2023; Vidal-Ayuso *et al.*, 2023).

Positive consumer experiences and the spread of word-of-mouth further reinforce these dynamics, normalizing circular consumption and creating social proof that encourages broader uptake (Perez-Castillo & Vera-Martinez, 2021). This aligns with the MLP, which positions individual behaviours and niche innovations as foundational to systemic transitions (Geels, 2002; UNIDO, 2024). Stakeholder Theory complements this by framing consumers as active co-creators who directly engage with other actors – such as businesses and NGOs – to shape new practices and values within the system (Heikkinen *et al.*, 2023).

However, persistent barriers remain. Awareness and knowledge gaps, limited economic incentives, and accessibility issues continue to constrain consumer participation in circular models. Overcoming these challenges requires targeted education, behavioural nudges, and the design of products that are modular and repairable, thereby empowering consumers to participate meaningfully in the circular economy (Sabbaghi & Behdad, 2018).

At the meso level, the interplay between consumers and circular business models (CBMs) becomes more pronounced. As more consumers engage with CBMs – such as product-service systems, rental schemes, and sharing platforms – businesses are incentivized to expand and refine their circular offerings (Bocken *et al.*, 2016; Scholz *et al.*, 2016). This creates a virtuous cycle: improved offerings

make circular options more attractive and accessible, which in turn encourages greater consumer participation (Carreira *et al.*, 2023).

Social acceptance and the normalization of circular practices are crucial at this stage. The availability of CBMs, supportive social norms, effective marketing, and a conducive retail environment all contribute to reinforcing both consumer behaviour and business innovation. Collaborative value creation – where firms, consumers, and NGOs co-design solutions – emerges as a key mechanism for driving regime adaptation and shifting established market practices (Heikkinen *et al.*, 2023).

Stakeholder Theory highlights the importance of these partnerships, noting that consumer engagement can pressure businesses to innovate and align their strategies with evolving social expectations (Blomsma *et al.*, 2019). Policy advocacy, such as campaigns for repair rights, and the development of local infrastructure (e.g., repair cafés, sharing platforms) further facilitate this transition (UNIDO, 2024). Yet, challenges persist in the form of marketing communication gaps and limited accessibility to repair and reuse infrastructure, which can hinder the broader diffusion of circular practices.

At the macro level, growing consumer demand for circular products exerts pressure on governments and institutions to strengthen supportive policies and invest in enabling infrastructure (Nguyen *et al.*, 2023). Systemic policy mixes – combining regulatory frameworks, economic incentives, and infrastructural investments – are increasingly recognized as essential for scaling circular economy principles across societies (European Commission, 2020).

Societal shifts in attitudes, driven by consumer advocacy and behaviour, can accelerate the normalization of circular economy principles at the macro level. As cultural norms evolve and cross-sector coalitions form, there is greater alignment of incentives among governments, industry, and NGOs to support circular transitions (UNIDO, 2024). The MLP framework identifies these landscape pressures – such as policy reforms, technological advancements, and cultural change – as central to destabilizing incumbent regimes and opening pathways for systemic transformation (Geels, 2004).

However, the effectiveness of macro-level interventions depends on their ability to address context- and sector-specific barriers. For instance, in regions where CBM infrastructure is lacking, initial policy focus must be on building availability and access, while in more mature contexts, shifting social norms and individual behaviours becomes paramount. Stakeholder Theory emphasizes the need for cross-sector collaboration and the alignment of diverse interests to ensure that policy and infrastructure upgrades translate into meaningful changes in consumer behaviour and systemic outcomes (Heikkinen *et al.*, 2023).

A key insight emerging from this analysis is the presence of strong feedback loops across all three levels. At the micro level, consumer adoption of niche innovations pressures firms to mainstream circular options, which in turn

normalizes sustainable habits (Blomsma *et al.*, 2019). At the meso level, consumer engagement leads businesses to expand and improve their offerings, further increasing participation and reinforcing the cycle of innovation and adoption (Scholz *et al.*, 2016). At the macro level, consumer demand prompts policy and infrastructure upgrades, enabling more circular behaviour and reinforcing systemic change.

These findings underscore the necessity of integrated, multi-level strategies for advancing the circular economy. Policymakers, businesses, and civil society must coordinate efforts to address barriers and leverage points at each level, ensuring that interventions are mutually reinforcing and contextually appropriate (UNIDO, 2024; Nguyen *et al.*, 2023).

5. CONCLUSION

This study has sought to illuminate the pivotal and multidimensional role of consumers in the transition toward a circular economy, integrating insights from the MLP and Stakeholder Theory to provide a nuanced understanding of how consumer behaviours interact with business innovation, policy, and systemic change. The findings underscore that consumers are not merely passive recipients of circular solutions but active agents whose choices, advocacy, and participation can catalyse shifts across micro, meso, and macro levels of the circular ecosystem (Shevchenko *et al.*, 2023; Dentchev *et al.*, 2018). At the micro level, consumer adoption of circular practices stimulates business innovation and market expansion, reinforcing positive feedback loops through social proof and word-of-mouth. At the meso level, engaged consumers drive the evolution of circular business models, influence policy advocacy, and contribute to the normalization of sustainable consumption patterns. At the macro level, collective consumer demand incentivizes policy reform, infrastructure investment, and the alignment of societal norms with circular economy principles (Nguyen *et al.*, 2023; Vidal-Ayuso *et al.*, 2023).

Despite these promising dynamics, several persistent barriers must be addressed to fully realize the transformative potential of consumer engagement. Awareness and knowledge gaps, limited accessibility to circular options, and insufficient economic incentives remain significant obstacles. The literature also highlights the need for systemic approaches that combine targeted education, behavioural nudges, and supportive policy frameworks to empower consumers and facilitate meaningful behavioural change. Moreover, the transition to a circular economy requires robust stakeholder collaboration, as the interdependence between consumers, businesses, governments, and civil society is essential for joint value creation and the scaling of circular innovations (Bocken *et al.*, 2018; Geissdoerfer *et al.*, 2017).

There are, however, notable limitations to this research. The systematic literature review, while comprehensive, is constrained by the predominance of

studies from high-income and European contexts, potentially underrepresenting the perspectives and challenges faced in the Global South. The exclusion of grey literature, while ensuring academic rigor, may omit valuable practical insights from industry and policy practice. Additionally, the evolving and context-specific nature of consumer engagement in circular transitions suggests that findings may not be universally generalizable, and further empirical research is needed to capture diverse consumer experiences and sectoral variations.

Future research should prioritize the development of context-sensitive interventions and policy toolkits that address the specific barriers and motivations of different consumer segments. Longitudinal and cross-cultural studies are needed to deepen understanding of how consumer engagement evolves over time and across regions. Furthermore, interdisciplinary approaches that integrate behavioural science, design thinking, and digital innovation hold promise for unlocking new pathways to consumer empowerment and systemic change.

References

- 1) Ahmadov, T., Durst, S., Gerstlberger, W., & Kraut, E. (2025). *SMEs on the way to a circular economy: insights from a multi-perspective review*. *Management Review Quarterly*, 75(1), 289–322. <https://doi.org/10.1007/s11301-023-00380-2>
- 2) Blomsma, F., Pieroni, M., Kravchenko, M., Pigosso, D. C. A., Hildenbrand, J., Kristinsdottir, A. R., Kristoffersen, E., Shabazi, S., Nielsen, K. D., Jönbrink, A. K., Li, J., Wiik, C., & McAloone, T. C. (2019). *Developing a circular strategies framework for manufacturing companies to support circular economy-oriented innovation*. *Journal of Cleaner Production*, 241. <https://doi.org/10.1016/j.jclepro.2019.118271>
- 3) Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). *Product design and business model strategies for a circular economy*. *Journal of Industrial and Production Engineering*, 33(5), 308–320. <https://doi.org/10.1080/21681015.2016.1172124>
- 4) Bucur, L.-M. (2023). *Exploring the Role of Consumers in Promoting a Circular Economy: Increasing Awareness and Engagement*. *Proceedings of the International Conference on Business Excellence*, 17(1), 38–47. <https://doi.org/10.2478/picbe-2023-0006>
- 5) Carreira, R. J., Ferreira, J. V., & Ramos, A. L. (2023). *The Consumer's Role in the Transition to the Circular Economy: A State of the Art Based on a SLR with Bibliometric Analysis*. In *Sustainability* (Vol. 15, Issue 20). <https://doi.org/10.3390/su152015040>
- 6) Dentchev, N., Rauter, R., Jóhannsdóttir, L., Snihur, Y., Rosano, M., Baumgartner, R., Nyberg, T., Tang, X., van Hoof, B., & Jonker, J. (2018). Embracing the variety of sustainable business models: A prolific field of research and a future research agenda. *Journal of Cleaner Production*, 194, 695–703. <https://doi.org/10.1016/j.jclepro.2018.05.156>
- 7) Duarte, N., Pereira, C., Grzywińska-Rapca, M., Kulli, A., & Goci, E. (2024). Consumers' knowledge and decisions on circularity: Albanian, Polish, and Portuguese perspectives. *Environment, Development and Sustainability*. <https://doi.org/10.1007/s10668-024-05077-4>

- 8) European Commission. (2020). A new circular economy action plan for a cleaner and more competitive Europe. Brussels: European Commission.
- 9) Freeman, R. E. (1984). Strategic management: A stakeholder approach. Pitman.
- 10) Freeman, R. E., Harrison, J. S., Wicks, A. C., Parmar, B. L., & De Colle, S. (2010). Stakeholder theory: The state of the art.
- 11) Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6–7), 897–920. <https://doi.org/10.1016/j.respol.2004.01.015>
- 12) Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, 1(1), 24–40. <https://doi.org/10.1016/j.eist.2011.02.002>
- 13) Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- 14) Govindan, K., & Hasanagic, M. (2018). A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. *International Journal of Production Research*, 56(1–2), 278–311. <https://doi.org/10.1080/00207543.2017.1402141>
- 15) Heikkinen, A., Kujala, J., & Blomberg, A. (2023). Outlining Stakeholder Engagement in a Sustainable Circular Economy BT - Stakeholder Engagement in a Sustainable Circular Economy: Theoretical and Practical Perspectives (J. Kujala, A. Heikkinen, & A. Blomberg, Eds.; pp. 1–15). Springer International Publishing. https://doi.org/10.1007/978-3-031-31937-2_1
- 16) Lacy, P., & Rutqvist, J. (2015). Waste to wealth: The circular economy advantage (Vol. 91). Springer.
- 17) Nguyen, T. T., Grote, U., Neubacher, F., Rahut, D. B., Do, M. H., & Paudel, G. P. (2023). Security risks from climate change and environmental degradation: implications for sustainable land use transformation in the Global South. *Current Opinion in Environmental Sustainability*, 63, 101322. <https://doi.org/10.1016/j.cosust.2023.101322>
- 18) Perez-Castillo, D., & Vera-Martinez, J. (2021). Green behaviour and switching intention towards remanufactured products in sustainable consumers as potential earlier adopters. *Asia Pacific Journal of Marketing and Logistics*, 33(8), 1776–1797. <https://doi.org/10.1108/APJML-10-2019-0611>
- 19) Sabbaghi, M., & Behdad, S. (2018). Consumer decisions to repair mobile phones and manufacturer pricing policies: The concept of value leakage. *Resources, Conservation and Recycling*, 133, 101–111. <https://doi.org/10.1016/j.resconrec.2018.01.015>
- 20) Scholz, J., & Smith, A. N. (2016). Augmented reality: Designing immersive experiences that maximize consumer engagement. *Business Horizons*, 59(2), 149–161. <https://doi.org/10.1016/j.bushor.2015.10.003>
- 21) Shevchenko, T., Saidani, M., Ranjbari, M., Kronenberg, J., Danko, Y., & Laitala, K. (2023). Consumer behavior in the circular economy: Developing a product-centric framework. *Journal of Cleaner Production*, 384, 135568. <https://doi.org/10.1016/j.jclepro.2022.135568>
- 22) UNIDO. (2024). Circular economy and consumer engagement: Policy and practice. United Nations Industrial Development Organization.

- 23) Vidal-Ayuso, F., Akhmedova, A., & Jaca, C. (2023). The circular economy and consumer behaviour: Literature review and research directions. *Journal of Cleaner Production*, 418, 137824. <https://doi.org/https://doi.org/10.1016/j.jclepro.2023.137824>.
World Bank. (2021). *What a waste 2.0: A global snapshot of solid waste management to 2050*. World Bank Publications.

A SYSTEMATIC REVIEW OF THE LITERATURE ON SUSTAINABLE BUSINESS MODELS IN RESTAURANTS, ZERO FOOD WASTE PRACTICES, AND CONSUMER AWARENESS

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Abstract

The study uses a systematic literature review technique to examine prior studies on sustainable restaurant business models and consumer behavior. We searched the Web of Science database using terms such as "sustainable restaurant models," "consumer awareness," "zero food waste," and "sustainable dining." The inclusion criteria focused on articles published during the last decade to ensure that the review covered the latest advancements and trends in the area. We located, analyzed, and categorized publications on our topic into themes related to sustainable business practices, zero-waste restaurant policies, and consumer behavior.

The studies compiled in the review also highlight recurring trends, difficulties, and how consumer awareness affects sustainable restaurant decisions. Numerous studies indicate that consumer education, together with effective marketing, must exist to promote zero-

food waste behaviors. Furthermore, restaurants that emphasize sustainability by efficiently utilizing resources and serving eco-friendly food tend to attract more ecologically sensitive customers. The results of the study show that raising consumer awareness through focused instruction and transparent marketing can have a substantial effect on consumer behavior, thus increasing demand for environmentally friendly restaurants and helping the sector minimize food waste.

Keywords: Sustainable restaurant models; consumer awareness; consumer behavior; zero food waste; Prisma; literature review; sustainability marketing.

JEL Classification: Q56

1. INTRODUCTION

Rising environmental issues and shifting consumer demands have brought increasing pressure on the worldwide food and hospitality sector to adopt sustainable practices in recent years. The effects of global warming and the resulting decline in biodiversity provide two major concerns for the hotel sector (Epstein, 2018). The diverse activities within food systems significantly affect the environment, many of which are inherently linked to the utilization of natural resources (Westhoek, Ingram, Van Berkum, Özay, & Hajer, 2016). The food sector, encompassing a diverse array of participants from small local enterprises to prominent multinational corporations with established brands, constitutes the largest economic sector in numerous locations, including the EU (Underwood, et al., 2013). Therefore, it can be concluded that there is a strong competition in the market among food sector businesses. A business would typically want to be cost-efficient in highly competitive and globalizing marketplaces, which frequently results in the externalization of environmental costs (Westhoek, Ingram, Van Berkum, Özay, & Hajer, 2016). On the other hand, food and hospitality companies are under stress from stakeholders (i.e., customers and competitors) as a result of the ongoing environmental concerns (Sun & Nasrullah, 2024). The food and hospitality industry has been forced to go green due to these strict environmental measures (Sun & Nasrullah, 2024).

With their efforts to reduce food waste and adopt sustainable business models, restaurants have become one of the industry's most important areas in promoting eco-friendly behavior and lessening their influence on the environment. Demand for dining experiences that reflect sustainable ideals is rising along with consumer awareness of environmental challenges.

By systematically reviewing studies conducted over the last ten years, this paper seeks to investigate the relationship between customer behavior and a restaurant's sustainable policies. In this respect, it highlights issues of importance, including resource efficiency, zero-waste initiatives, and consumer education. This study also looks for ways to help restaurants lessen their environmental effect while influencing customer decision-making and sustainable dining practices.

The topic of this paper is related to the 2030 Agenda for Sustainable Development (United Nations, 2015) and to the Sustainable Development Goals (SDGs), presented in Figure 1.



Figure 1. The 17 Sustainable Development Goals (SDGs)
(Source United Nations, 2015)

Specifically, the issues examined in this paper are related to the following SDGs:

SDG 12: Responsible Consumption and Production

SDG 2: Zero Hunger - through reduction of food waste and improved food security

SDG 13: Climate Action - since reducing food waste cuts down greenhouse gas emissions

SDG 3: Good Health and Well-being – by promoting consumer awareness of sustainable and healthy food choices.

2. METHODOLOGY

We employed a systematic approach for the study selection in order to find relevant papers about Sustainable Business Models in Restaurants, Zero Food Waste Practices, and Consumer Awareness. Furthermore, the systematic literature review was based on the Prisma 2020 standards and recommendations (Page *et al.*, 2021).

2.1. Search approach

The Web of Science Core Collection database, which is regarded as the most trustworthy database (Ding, Rousseau, & Wolfram, 2014), was chosen for this study's research purposes. After filtering the data from Web of Science Core Collection for keywords: "sustainab*" OR "restaurant*" OR "model*" AND

"consumer*" OR "awareness*" AND "zero*" OR "food*" OR "waste*" AND "sustainab*" OR "dining*" for the period 2015 till 2025 only in English Language and in the field of Economics, Business and Management remained 63 publications. As seen in Figure 2, we removed a total of 11 papers after screening due to duplicate records. Whereas 26 papers were excluded due to the ineligibility issues. Finally, a sample of 26 papers was included in the study.

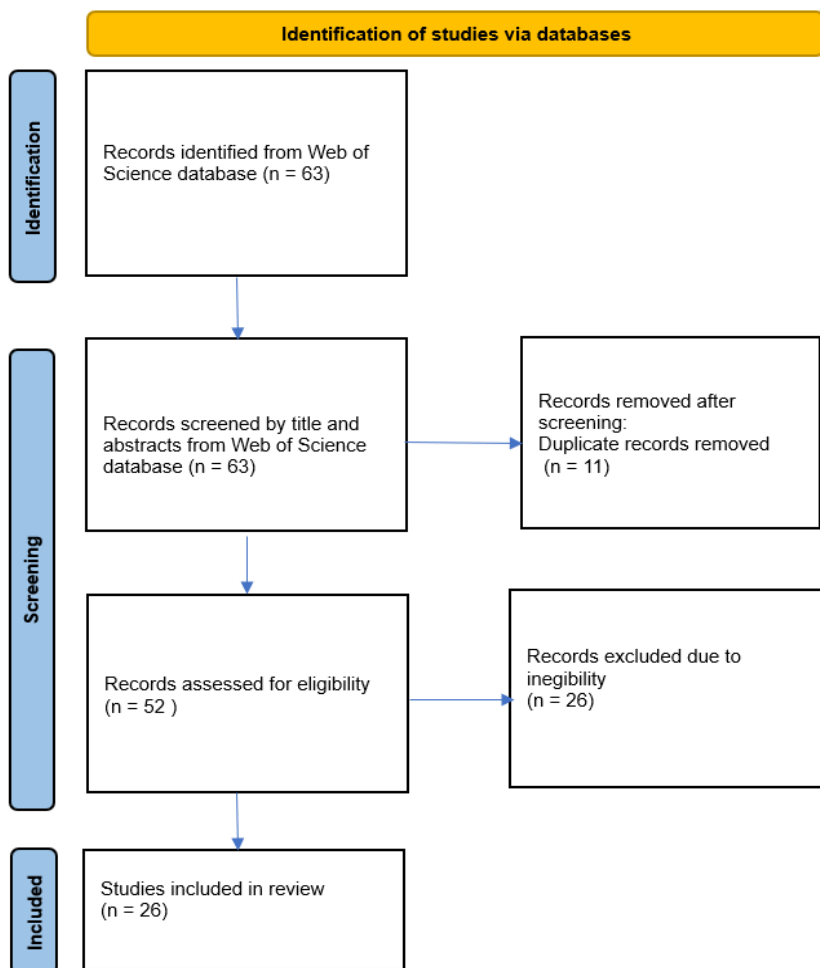


Figure 2. Paper collection flow strategy (adapted from PRISMA 2020; Page *et al.*, 2021)

3. RESULTS

The final sample of 28 papers has been subjected to a content analysis. For each article in the sample, the following elements were exported in Microsoft Excel: Table 1 contains the following information: (1) author(s), (2) year of publication, (3) title, (4) research type, (5) research methodology, and (6) key findings. In addition to helping us produce descriptive statistics, this technique provided us with a broad understanding of the structure and evolution of the literature.

As can be seen in table 1, from 26 studies included in the sample, 24 were qualitative studies (12 were systematic literature reviews; 9 were literature review; 2 were case studies analyses and 1 was survey typed), whereas 2 were quantitative studies (1 was survey-type and 1 was survey typed and Structural Equation Modeling).

Table 1. Overview of all articles used in the systematic literature review

Authors	Publication Year	Article Title	Research Type	Research Methodology	Key findings
Kuasoski, M; Doliveira, SLD	2023	Sustainability transition in the agrifood system: a systematic review focused on food loss and waste	Qualitative	Systematic Literature Review	Understanding the features of sustainability transitions, particularly in the context of agri-food systems (AFS), has proven to be made possible by agent-based modeling (ABM).
Jacob-John, J; D'Souza, C; Marjoribanks, T; Singaraju, S	2023	Sustainable Development Goals: a review of SDG 12.3 in food supply chain literature	Qualitative	Systematic Literature Review	There is a need for the Reduction of Food Loss and Waste (FLW), as a result of non-sustainable consumption and production, in order to achieve SDG 12.3. Academic research does not address the factors that motivate and hinder FLW reduction.
Bourke, BC; Mccarthy, MB; Mccarthy, SN	2024	Behavioural Factors Influencing Consumer Acceptance of Sustainable Healthy Food: A Review and	Qualitative	Systematic Literature Review	Theory of Planned Behaviour predominates in the literature, which reveals a prevalence of cognitive/motivational theories and conceptions on Food-

Authors	Publication Year	Article Title	Research Type	Research Methodology	Key findings
		Research Agenda			based dietary and sustainability recommendations
da Silva, ADS; da Silva, WV; da Silva, LSCV; da Cruz, NJT; Su, ZH; da Veiga, CP	2025	Interdependence between supply chains and sustainable development: global insights from a systematic review	Qualitative	Systematic Literature Review	Supply chains and sustainable development are closely related. Environmental sustainability is the main theme, and in order to fully address the challenges of global sustainability, it is recommended that circular economy principles be more fully integrated and that food supply chains receive special attention.
Pramudika, GF; Astanti, RD; Ai, TJ	2024	Energy Issues in Sustainable Retailing: A Systematic Literature Review	Qualitative	Systematic Literature Review	Articles related to sustainable retailing are grouped into four clusters, with the following characteristics: 1) energy issues related to food waste; 2) energy issues related to cooled storage; 3) energy issues related to general energy issues and energy efficiency, including green models in retail buildings; and 4) energy issues related to transportation in retail.
Kim, J; Rundle-Thiele, S; Knox, K	2019	Systematic literature review of best practice in food waste reduction programs	Qualitative	Systematic Literature Review	According to the study, the majority of food waste programs rely on non-voluntary methods and lack essential social marketing components. However, programs that use the marketing mix and behavior change theory are more successful, suggesting that future food waste

Authors	Publication Year	Article Title	Research Type	Research Methodology	Key findings
					reduction initiatives could use more effective voluntary strategies.
Santos, PHA; Martins, RA	2021	Food Waste and Performance Measurement Systems: A Systematic Review of the Literature	Qualitative	Systematic Literature Review	Few articles focus on performance measurement systems for the whole supply chain, with a particular emphasis on sustainability
Hariyani, D; Mishra, S	2023	Barriers to the adoption of integrated sustainable-green-lean-six sigma-agile manufacturing system (ISGLSAMS): a literature review	Qualitative	Systematic Literature Review	The integrated sustainable-green-lean-six sigma-agile manufacturing system (ISGLSAMS) provides a solid platform for meeting both the customers' variety needs and business sustainability requirements, but due to various barriers are not able to be fully implemented.
Tiwari, P; Panicker, S	2017	Sustainability Balanced Scorecard as a Framework for Performance Measurement in Facility Management - A Literature Review	Qualitative	Systematic Literature Review	By creating, putting into practice, and upholding sustainable facility practices, the facility manager can create long-lasting value for the company with the right financial and strategic planning tools.
Singh, A; Trivedi, A	2016	Sustainable green supply chain management: trends and current practices	Qualitative	Systematic Literature Review	Particular attention must be paid to waste management, closed-loop supply chain management, and reverse logistics in order to attain environmental sustainability.
Florence, ES; Fleischman, D; Mulcahy, R; Wynder, M	2022	Message framing effects on sustainable consumer behaviour: a	Qualitative	Systematic Literature Review	Using a combination of two message frames, such as positive-negative and self-other, is more effective in

Authors	Publication Year	Article Title	Research Type	Research Methodology	Key findings
		systematic review and future research directions for social marketing			encouraging environmentally sustainable behavior than using a single frame.
Ghose, A; Chandra, B	2020	Models for Predicting Sustainable Durable Products Consumption Behaviour: A Review Article	Qualitative	Literature Review	Consumers' confidence, environmental attitude, values, past experience, consumers' willingness, social pressure, perceptions, and feelings also influence consumers' purchase intention and behaviour towards sustainable product consumption.
White, K; Habib, R; Hardisty, DJ	2019	How to SHIFT Consumer Behaviors to be More Sustainable: A Literature Review and Guiding Framework	Qualitative	Literature Review	Psychological factors: Social influence, Habit formation, Individual self, Feelings and cognition, and Tangibility encourage pro-environmental behaviors.
Jones, P; Comfort, D; Hillier, D	2016	Interpretations of The Concept of Sustainability Amongst the UK's Leading Food and Drink Wholesalers	Qualitative	Analyses of Case Studies	The leading food and drinks wholesalers' commitments to sustainability are principally driven by business imperatives, as by any fundamental concern to maintain the viability and integrity of natural and social capital.
Taucean, IM; Ivascu, L; Miclea, S; Negrut, M	2019	Synergies between lean and sustainability: a literature review of concepts and tools	Qualitative	Literature Review	There is compatibility and synergy between lean and sustainability, because waste elimination will benefit both the companies and the environment.
Palazzo, M; Vollero, A	2021	A systematic literature review of food sustainable supply chain management	Qualitative	Literature Review	The main research directions in food sustainable supply chain management (FSSCM) considering the opportunities in

Authors	Publication Year	Article Title	Research Type	Research Methodology	Key findings
		(FSSCM): building blocks and research trends			neglected emerging countries.
Gurralla, KR; Hariga, M	2022	Key Food Supply Chain Challenges: A Review of the Literature and Research Gaps	Qualitative	Literature Review	Advanced technologies and optimization models are the most predominant tools for addressing Food Supply Chain challenges. Food loss and waste, coordination, globalization, resilience, robustness, and food-security challenges are one of the identified research gaps.
Chandra, S; Verma, S	2023	Big Data and Sustainable Consumption: A Review and Research Agenda	Qualitative	Literature Review	Businesses deploy Big Data to create sustainable consumer experiences, predict consumer buying patterns, design and alter business models, and create nudges for sustainable consumption, while consumers are forcing businesses to develop green operations and supply chains to reduce the latter's carbon footprint.
Bahrololoum, S; Kermani, MMM; Koohzadi, F	2022	Ecopreneurs and agricultural waste management	Qualitative	Case studies analyses	The innovative potential of ecopreneurs encourages startups that create the new jobs needed to address the environmental problems and increased food demands.
Sharma, AP	2021	Consumers' purchase behaviour and green marketing: A synthesis,	Qualitative	Literature Review	The concern for eco-environment, eco-labelling, past experiences, and perceived usefulness

Authors	Publication Year	Article Title	Research Type	Research Methodology	Key findings
		review and agenda			have been identified as major influencers of green consumer behaviour. Lack of environmental knowledge, price, perceived associated risks, organizational image, trust, and willingness to pay has been identified as barriers of consumers towards green products.
Prakash, G	2018	Review of the food processing supply chain literature: a UK, India bilateral context	Qualitative	Literature Review	The UK researchers have addressed vertical integration, coordination, safety, competitiveness and transparency and information technology. Indian researchers have focused on issues such as consumer perceptions, retail format choice, organic, health and wellness products.
Gursoy, ÖB; Akbas, I	2024	Can Sustainability Reporting Make a Difference: A Qualitative Analysis on Sustainability Reports of BIST Listed Agri-Food Companies in Turkey	Qualitative	Survey typed	The agri-food sector is lagging in sustainability reporting compared to other sectors. Companies are more ready to comply with issues that are legally regulated. Environmental problems are more addressed than social and economic sustainability standards.
Wang, HJ	2017	Determinants of consumers' purchase behaviour towards green brands	Quantitative	Survey typed and Structural Equation Modeling	The purchase intentions are positively associated with purchase behaviour and mediate the impacts of green perceived quality, green perceived value, information costs

Authors	Publication Year	Article Title	Research Type	Research Methodology	Key findings
					saved, and green perceived risk on purchase behaviour.
Bigliardi, B; Filippelli, S	2022	A review of the literature on innovation in the agrofood industry: sustainability, smartness and health	Qualitative	Literature Review	Benefits deriving from the adoption of digital technologies, the ever-increasing involvement of consumers in health and environmental issues, and the introduction of the open innovation concept in the agrofood industry.
Fenta, Y; Singh, M; Gautam, RK	2024	Antecedents of consumers' green product purchase intention: an insight from Ethiopia	Quantitative	Survey typed and Structural Equation Modeling	Attitude, subjective norms, and perceived behavioural control had a direct and environmental knowledge indirectly impacted the intention to make green purchases
Maesano, G; Carra', G; Peri, I	2019	How do Consumers Perceive Sustainable Wine? A Review	Qualitative	Systematic Literature Review	Consumers have positive perceptions regarding sustainable wine and a willingness to pay a price premium, though the awareness about the broad concept of sustainability is still vague.

The sample included 26 articles published between 2015 till 2025. Figure 3 shows the distribution of the articles over the years. The highest number of studies in the sample was published in 2019, 2021, 2022, 2023, and 2024 (four studies), followed by 2021 (three studies). Additionally, two studies on our sample were published in 2016 and 2017, whereas our sample included one study from 2018, 2020, and 2025. No studies from 2015 were included in the sample.

Based on our systematic literature review, we try to synthesize the literature and aim to accomplish the research paper goal by investigating the relationship between customer behavior and a restaurant's sustainable policies.

Industrialization and economic progress had unfavorable effects, most notably resource depletion and environmental problems (da Silva *et al.*, 2025). Food waste is a major problem for the environment, communities, and society worldwide, wasting both financial and material resources (Gustavsson, Cederberg, Sonesson, Van Otterdijk, & Meybeck, 2011). Food waste disposed in

landfills is thought to be responsible for 8% of global warming (FAO, 2015).

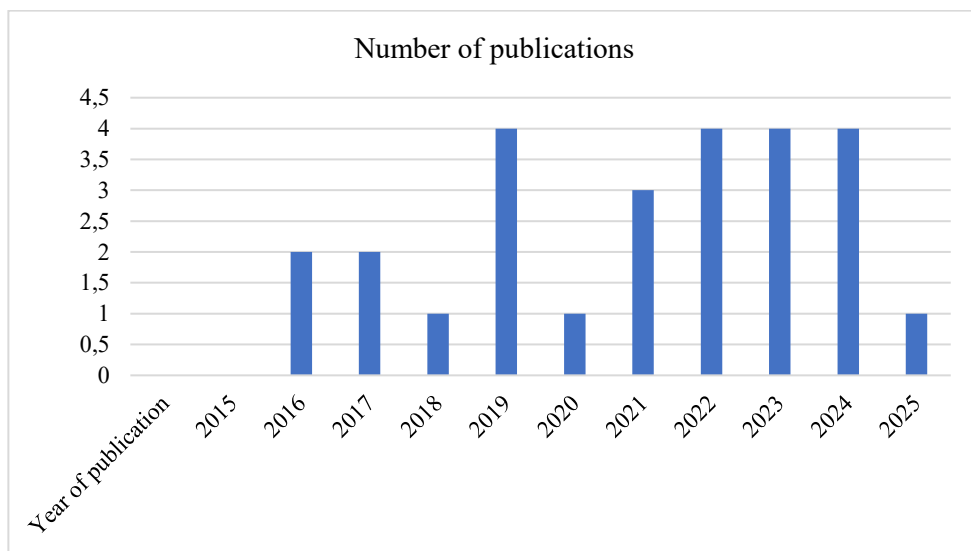


Figure 3. Annual studies distribution

Source: Authors

It seems counterintuitive that over a billion tonnes of food are wasted annually that could be used to feed the ten percent of people who are starving and living in extreme poverty (Jacob-John, D'Souza, Marjoribanks, & Singaraju, 2023). In such situations, the use of qualitative methods to reduce food losses and waste is essential. In this case, Lean, Six-Sigma, and Lean Six-Sigma can be applied. Lean and sustainability are compatible and work well together because reducing waste will help businesses and the environment (Tăucean, Ivaşcu, Micle, & Nergut, 2019). In their literature review paper Hariyani & Mishra (2023), pointed out that although the integrated sustainable-green-lean-six sigma-agile manufacturing system (ISGLSAMS) offers a strong foundation for satisfying the diverse needs of consumers and corporate sustainability standards, it is unable to be completely implemented due to a number of obstacles.

According to Wen *et al.* (2018), half of China's food waste is produced by the country's foodservice industry. The reasons for this issue can be numerous. According to Sakaguchi, Pak, & Potts (2018), who investigated how restaurant owners in the USA saw FLW from a legal standpoint, whereas the majority of restaurants avoid donating food because of a "unfounded fear of the legal liability," which contributes to FLW. Food retail firms and restaurants face a number of sustainability-related problems, including consumerism, food waste, energy efficiency, and carbon emissions from retail transportation (Pramudika, Astanti, & The Jin, 2024). In light of food shortages, reducing food loss and waste

(FLW) due to non-sustainable production and consumption is necessary to meet SDG 12.3 (Alonso-Adame, Van Meensel, Marchand, Van Passel, & Farahbakhsh, 2024). According to Alonso-Adame *et al.* (2024), the forces that drive and hinder FLW reducing are not examined sufficiently in academic research

The demand for healthful foods has grown recently. Although food-based dietary guidelines offer professional advice on what to eat, few people follow them, and few of them incorporate sustainability considerations (Bourke, McCarthy, & Sinéad). Sustainable consumer behavior is sometimes referred to as pro-environmental or ecologically responsible behavior (Florence, Fleischman, Mulcahy, & Wynder, 2022). The sense of moral obligation is a strong determinant for environment-friendly behaviour (Ghose & Chandra, 2020).

Kim, Rundle-Thiele, & Knox (2019) discovered in their systematic literature study that social marketing elements are not fully used in food waste programs. In addition they found that utilizing the social marketing elements of behavioral change, theory, and marketing mix increased program effectiveness, suggesting that voluntary techniques may be employed more frequently in the future (Kim, Rundle-Thiele, & Knox, 2019). Reducing food waste is seen as something that requires the engagement of all actors throughout the supply chain in restaurants and other food stores.

By systematically reviewing the literature Santos & Martins (2021) found that performance measuring systems for the entire supply chain, with a focus on sustainability, are not often covered in the articles of their research sample. The main fields of study for food sustainable supply chain management (FSSCM), is underserved by developing nations (Palazzo & Vollero, 2022). Singh & Trivedi (2016) in their review of the literature found that during the past ten years, researchers and practitioners have become more interested in the topic of sustainable green supply chain management and that there is a universal need to achieve sustainability through the adoption of greener practices. The facility manager is the one who visualizes the entire process in the organization and often turns out to be the advocate for sustainable and green practices (Tiwari & Panicker, 2017). In order to attain environmental sustainability, particular attention must be paid to waste management, closed-loop supply chain management, and reverse logistics (Singh & Trivedi, 2016).

The most common tools for tackling issues in the food supply chain are optimization models and advanced technology (Gurralla & Hariga, 2022). Customers are more likely to act environmentally friendly when the message or context makes use of the following psychological elements: “*social influence, habit development, individual self, feelings and cognition, and tangibleness*” (White, Habib, & Hardisty, 2019). Accurate demand forecasting has the greatest potential to reduce food waste since it avoids overproduction of meals and oversupply of food items, which lowers the likelihood of spoiling (Jonesa, Comfortb, & Hillier, 2016; Filimonau, Fidan, Alexi, Dragoev, & Marinova, 2019).

Among the identified study gaps are issues related to food loss and waste, coordination, globalization, resilience and robustness, and food-security (Gurralla & Hariga, 2022). Consumers are pressuring businesses to create green supply chains and operations to lessen their carbon footprint, whereas, businesses are using big data to create sustainable consumer experiences, forecast consumer purchasing patterns, design and modify business models, and create nudges for sustainable consumption (Chandra & Verma, 2023). Green consumer behavior has been found to be significantly influenced by perceived utility, historical experiences, eco-labelling, and environmental concern. Consumer obstacles to green products have been identified as lack of environmental awareness, price, perceived dangers, corporate image, trust, and willingness to pay (Sharma, 2021). Ecopreneurs' creative potential supports new businesses that generate the new jobs required to solve environmental issues and rising food demands (Bahrololoum, Mahmood, & Koohzadi, 2022).

By reviewing the literature, Prakash (2018) compared the literature in UK and India. He found that UK researchers in the literature focus on Information technology, safety, competitiveness, transparency, vertical integration, and coordination whereas Indian researchers have been concentrated on topics including organic, health and wellbeing, and consumer attitudes (Prakash, 2018). When it comes to sustainability reporting, the agri-food industry is trailing behind other sectors (Gürsoy & Akbaş, 2024). According to Bigliardi & Filippelli (2022), agrofood industry can benefit from the adoption of digital technologies and the introduction of the open innovation concept.

The benefits of green perceived risk, green perceived quality, green perceived value, and information costs saved on purchase behavior are all mediated by purchase intentions, which are positively correlated with purchase behavior (Wang, 2017). The intention to make green purchases was influenced indirectly by environmental knowledge and directly by attitude, subjective norms, and perceived behavioral control (Fenta, Singh, & Gautam, 2024). Although consumers' understanding of the general notion of sustainability is still lacking, they have favorable opinions about sustainable products such as wine and are willing to pay more for it (Maesano, Carra, & Peri, 2019).

4. CONCLUSIONS

Based on our systematic literature review we can conclude that there is scarcity in the literature regarding sustainable restaurants and zero food waste policies. Most of the literature of our sample speaks about the consumer awareness on sustainability, natural resource use and insufficiency and for the environmental issues.

References

- 1) Alonso-Adame, A., Van Meensel, J., Marchand, F., Van Passel, S., & Farahbakhsh, S. (2024). Sustainability transitions in agri-food systems through the lens of agent-based modeling: a systematic review. *Sustainability Science*, 19, 2101–2118. doi:10.1007/s11625-024-01551-0
- 2) Bahrololoum, S., Mahmood, M., & Koohzadi, F. (2022). Ecopreneurs and agricultural waste management. *Journal of Global Entrepreneurship Research*, 12, 47-51.
- 3) Bigliardi, B., & Filippelli, S. (2022). A review of the literature on innovation in the agrofood industry: sustainability, smartness and health. *European Journal of Innovation Management*, 26(6), 589-611.
- 4) Bourke, B. C., McCarthy, M. B., & Sinéad, N. (a.d.). Behavioural Factors Influencing Consumer Acceptance of Sustainable Healthy Food: A Review and Research Agenda. *International Journal of Consumer Studies*, 48:e13078, 1-28.
- 5) Chandra, S., & Verma, S. (2023). Big Data and Sustainable Consumption: A Review and Research Agenda. *Vision*, 27(1), 11–23.
- 6) da Silva, A. S., Vieira, W., da Silva, L. C., Nicholas, J., Su, Z., & da Veiga, C. P. (2025). Interdependence between supply chains and sustainable development: global insights from a systematic review. *Review of Managerial Science*, 19, 931–962.
- 7) Ding, Y., Rousseau, R., & Wolfram, D. (2014). Measuring scholarly impact. Zurich, Switzerland: Springer.
- 8) Epstein, M. J. (2018). *Making Sustainability Work: Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts*. New York, NY, USA: Routledge.
- 9) Fenta, Y., Singh, M., & Gautam, R. K. (2024). Antecedents of consumers' green product purchase intention: an insight from Ethiopia. *Cogent Business & Management*, 11(1), 1-19. doi:10.1080/23311975.2024.2361865
- 10) Filimonau, V., Fidan, H., Alexi, J., Dragoev, S., & Marinova, D. D. (2019). Restaurant food waste and the determinants of its effective management in Bulgaria: An exploratory case study of restaurants in Plovdiv. *Tourism Management Perspectives*, 32, 2211-9736. doi:10.1016/j.tmp.2019.100577
- 11) Florence, E. S., Fleischman, D., Mulcahy, R., & Wynder, M. (2022). Message framing effects on sustainable consumer behaviour: a systematic review and future research directions for social marketing. *Journal of Social Marketing*, 12(4), 23-652. doi:10.1108/JSOCM-09-2021-0221
- 12) Ghose, A., & Chandra, B. (2020). Models for Predicting Sustainable Durable Products Consumption Behaviour: A Review Article. *Vision*, 24(1), 81-89.
- 13) Gurralla, K. R., & Hariga, M. (2022). Key Food Supply Chain Challenges: A Review of the Literature and Research Gaps. *Operations and Supply Chain Management*, 15(4), 441 - 460.
- 14) Gürsoy, Ö. B., & Akbaş, I. (2024). Can Sustainability Reporting Make A Difference?: A Qualitative Analysis on Sustainability Reports of BIST Listed Agri-Food Companies in Turkey. *Ege Academic Review*, 24(2), 233-248. doi:10.21121/eab.1342188

- 15) Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). *Global Food Losses and Food Waste*. Rome: FAO.
- 16) Hariyani, D., & Mishra, S. (2023). Barriers to the adoption of integrated sustainable-green-lean-six sigma-agile manufacturing system (ISGLSAMS): a literature review. *Benchmarking: An International Journal*, 30(9). doi:10.1108/BIJ-10-2021-0585
- 17) Jacob-John, J., D'Souza, C., Marjoribanks, T., & Singaraju, S. (2023). Sustainable Development Goals: a review of SDG 12.3 in food supply chain literature. *Benchmarking: An International Journal*, 30(9), 3465-3481. doi:10.1108/BIJ-12-2021-0736
- 18) Jonesa, P., Comfortb, D., & Hillier, D. (2016). Interpretations of The Concept of Sustainability Amongst The UK's Leading Food and Drink Wholesalers. *Market-Tržište*, 28(2), 213-229.
- 19) Kim, J., Rundle-Thiele, S., & Knox, K. (2019). Systematic literature review of best practice in food waste reduction programs. *Journal of Social Marketing*, 9(4), 447-466.
- 20) Maesano, G., Carra, G., & Peri, I. (2019). How do consumers perceive sustainable wine? A review. *Calitatea*, 20(2), 351-357.
- 21) Page, M. J., McKenzie, J. E., Bossuyt, P. M., Hofmann, T., Mulrow, C., Shamseer, L. et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *British Medical Journal*. doi:10.1136/bmj.n71
- 22) Palazzsprino, M., & Vollero, A. (2022). A systematic literature review of food sustainable supply chain management (FSSCM): building blocks and research trends. *The TQM Journal*, 34(7), 54-72. doi:10.1108/TQM-10-2021-0300
- 23) Prakash, G. (2018). Journal of Advances in Management Research. 15(4), 457-479.
- 24) Pramudika, G. F., Astanti, R. D., & The Jin, A. (2024). Energy Issues in Sustainable Retailing: A Systematic Literature Review. *Operations and Supply Chain Management*, 17(3), 152 - 164.
- 25) Sakaguchi, L., Pak, N., & Potts, M. D. (2018). Tackling the issue of food waste in restaurants: options for measurement method, reduction and behavioral change. *Journal of Cleaner Production*, 180, 430-436.
- 26) Santos, P. A., & Martins, R. A. (2021). Food waste and performance measurement systems: a systematic review of the literature. *RAE-Revista de Administração de Empresas (Journal of Business Management)*, 61(5), 1-24.
- 27) Sharma, A. P. (2021). Consumers' purchase behaviour and green marketing: A synthesis, review and agenda. *International Journal of Consumer Studies*, 45(6), 1217-1238. doi:10.1111/ijcs.12722
- 28) Singh, A., & Trivedi, A. (2016). Sustainable green supply chain management: trends and current practices. *Competitiveness Review*, 26(3), 265-288. doi:10.1108/CR-05-2015-0034
- 29) Sun, J., & Nasrullah, A. (2024). Green transition in the hospitality industry: The influence of market forces and customer dynamics on sustainable performance in the digital era. *Heliyon*, 10(8), 1-17. doi:10.1016/j.heliyon.2024.e29563
- 30) Tăucean, I. L., Ivaşcu, L., Micle, S., & Nergut, M. (2019). Synergies between lean and sustainability: a literature review of concepts and tools. *Quality-Access to Success*, 20 (S1), January 201, 20, 559-564.

- 31) The Food and Agriculture Organization of the United Nations (FAO). (2015). *The state of food insecurity in the world 2015*.
- 32) Tiwari, P., & Panicker, S. (2017). Sustainability Balanced Scorecard as a Framework for Performance Measurement in Facility Management - A Literature Review. *Pacific Business Review International*, 10(1), 121-127.
- 33) Underwood, E., Baldock, D., Aiking, H., Buckwell, A., Dooley, E., Frelih-Larsen, A. *et al* (2013). *Technology options for feeding 10 billion people. Synthesis report: Options for sustainable food and agriculture in the EU*. Brussels: Brussels Science and Technology Options Assessment (STOA), European Parliament.
- 34) United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. Gjetur March 11, 2025, nga UN Department of Economic and Social Affairs: <https://sdgs.un.org/2030agenda>
- 35) Wang, H.-J. (2017). Determinants of consumers' purchase behaviour towards green brands. *The Service Industries Journal*, 37:13-14, , DOI:, 37(13-14), 896-918. doi:10.1080/02642069.2017.1365140
- 36) Wen, Z., Hu, S., De Clercq, D., Bruce Beck, M., Zhang, H., Fei, F., & Liu, J. (2018). Design, implementation, and evaluation of an Internet of Things (IoT) network system for restaurant food waste management. *Waste Management*, 26-38. doi:10.1016/j.wasman.2017.11.054
- 37) Westhoek, H., Ingram, J., Van Berkum, S., Özay, L., & Hajer, M. (2016). *Food Systems and Natural Resources*. UNEP. Gjetur April 2, 2025
- 38) White, K., Habib, R., & Hardisty, D. J. (2019). How to SHIFT Consumer Behaviors to be More Sustainable: A Literature Review and Guiding Framework. *Journal of Marketing*, 83(3), 22-49.

PACKAGING WASTE GENERATION AND RECYCLING IN THE EU: TRENDS, TARGETS, AND INSIGHTS FOR A CIRCULAR ECONOMY

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Abstract

The increasing generation of packaging waste in the European Union, driven by sustained economic growth and intensifying consumerism, has raised significant environmental concerns. Despite the expanding volume of packaging waste, recycling rates have not kept pace with this growth, posing a serious challenge to the EU's sustainability ambitions. In response, the EU has transitioned from the long-standing Packaging and Packaging Waste Directive (94/62/EC) to the more rigorous Packaging and Packaging Waste Regulation (PPWR). It establishes binding recycling targets of 65% by 2025 and 70% by 2030, aiming to significantly enhance recycling performance and resource efficiency. This research aims to map the trends between packaging waste generation and recycling rates in the EU-27, identify disparities across Member States, and evaluate their alignment with the PPWR targets. A quantitative analysis was conducted combining trend analysis, correlation analysis, and cluster analysis, using Eurostat data: Packaging waste by waste management operations and Recycling rates of packaging waste for monitoring compliance with policy targets, by type of packaging in the period 2011-2022. The results show that packaging waste generation in the EU-27 reached 83.4 million tonnes in 2022, with growth of 18.7%, while the recycling rate improved by only 1.9 percentage points compared to 2011. At the EU level, the recycling rate targets for 2025 and 2030 have already been achieved; however, the goal of reducing overall packaging waste remains unmet. The findings underscore persistent disparities in recycling performance across EU members and highlight the need for intensified efforts and policy interventions, especially in lagging countries. This study contributes to a clearer understanding of the trajectory of EU Member States toward circular economy goals and the challenges that remain in achieving uniform compliance with EU-wide environmental standards.

Keywords: *Recycling rates, PPWR compliance, circular economy, waste prevention, cluster analysis*

JEL Classification: Q53, C38

1. INTRODUCTION

The growth of the EU's packaging waste is largely driven by economic progress, changing consumer lifestyles, and the rapid increase in online shopping, creating a pressing environmental concern. Packaging is a multidisciplinary field that spans multiple business areas and processes. Beyond its material components, it serves crucial logistical functions, including product protection, transportation efficiency, storage convenience, information dissemination, and sales facilitation. Its role extends across the entire product lifecycle, highlighting its importance in modern consumption and distribution systems. Packaging is not only functional but also strategic. It plays a pivotal role in the marketing mix by serving as a tool for communication and brand differentiation. As Mason (1958) observed, packaging is more than a container; it is a strategic element influencing consumer perceptions and behaviors. Effective packaging balances functionality with aesthetics, enhancing product utility while appealing to consumer preferences. This dual role underscores the necessity of aligning packaging design with marketing objectives to maximize impact in competitive markets. Packaging is ubiquitous, with households accumulating waste from nearly every purchase. While commonly associated with product wrapping, packaging encompasses much more. According to its definition, the packaging includes “the totality of operations whose basic purpose is to protect the product, make it suitable for transport or storage, or contain it (Vuk *et al.*, 2023). However, the increasing volume of packaging waste presents significant sustainability challenges. The growing demand for packaging, driven by consumption patterns and e-commerce expansion, strains natural resources and contributes to environmental degradation. Consequently, there is an urgent need for a circular approach that minimizes waste, maximizes resource efficiency, and promotes sustainable consumption.

The European Union has long recognized the environmental impact of packaging waste and has responded with regulatory measures aimed at sustainability. The EU Packaging Directive was introduced as part of a comprehensive European strategy to improve waste management and reduce environmental impacts. Initially established through Directive 94/62/EC, it aimed to harmonize national regulations, setting baseline recycling and recovery requirements to encourage waste minimization and recycling improvements (European Union, 1994). Over time, the directive evolved to address emerging challenges, drawing on earlier national initiatives such as Netherlands' Dutch Packaging Covenant of 1993 and Denmark's 1996 report on transport packaging waste (Ingram, 1999). Subsequent amendments, including Directive 2004/12/EC, enhanced its effectiveness in promoting recycling and reducing landfill dependency (European Union, 2004). In 2018, Directive 2018/852 introduced ambitious recycling and recovery targets, aligning packaging practices with sustainability goals (European Commission, 2018). Directive 2019/904 further emphasized reducing plastic pollution and marine litter by targeting single-use

plastics (Ragonnaud, 2023). The European Commission's 2022 proposal represents the latest regulatory advancement, focusing on enhancing circularity, packaging design, and recycling rates. Building on these developments, the proposed Packaging and Packaging Waste Regulation (PPWR) seeks to replace the current directive framework with directly applicable rules, further harmonizing EU efforts and setting binding targets to reduce packaging waste and boost reuse and recyclability (European Commission, 2022a).

The study goals are:

- To map the trends in packaging waste generation and its material-specific composition in the EU-27 from 2011 to 2022.
- To analyze recycling rates of packaging waste by material category (paper, plastic, wood, metal, and glass) over the same period and examine the correlation between the packaging waste generation and recycling performance.
- To assess disparities in packaging waste management performance among EU member states through a cluster analysis based on 2022 data, and their alignment with the PPWR targets.

Despite the growing body of research on packaging waste and recycling, there remains a notable gap in comprehensive, multi-dimensional analyses that track both packaging waste generation and recycling performance over time across all 27 EU Member States. Existing studies often concentrate on specific materials, particularly plastics and focus on a limited number of countries, or assess the effects of individual policy measures. However, few provide a holistic overview that captures long-term trends, highlights cross-national disparities, and evaluates collective progress toward the binding targets established by the Packaging and Packaging Waste Regulation. This study addresses that gap by offering an integrated assessment that combines temporal, spatial, and policy-oriented dimensions.

The findings provide valuable insights into the effectiveness of current policies and highlight areas for improvement to achieve sustainability goals. By exploring the dynamics of packaging waste and recycling within the EU, this paper contributes to the ongoing discourse on circular economy practices and sustainable development.

The structure of the paper is as follows: after the introduction, Section 2 reviews relevant literature on circular economy and packaging waste, recycling and regulation. Section 3 outlines the methodology, including data sources and analytical methods. Section 4 presents the results, while Section 5 discusses the findings in the context of EU policy targets. Finally, Section 6 concludes with implications for policy and future research directions.

2. BACKGROUND

2.1. Circular economy

Economic development and environmental sustainability are inherently linked. Historically, rapid economic growth has often been associated with increased environmental degradation. As industries expanded and consumption surged, natural resources were exploited at unprecedented rates, leading to pollution, habitat destruction, and climate change. This pattern of economic progress, primarily driven by the linear "take-make-dispose" model, proved unsustainable as it disregarded the environmental costs of waste and resource depletion (Van Buren *et al.*, 2016; Galvão *et al.*, 2018; Masi *et al.*, 2018). The concept of a circular economy (CE) emerged as a transformative solution to these environmental challenges. Unlike the traditional linear economy, the circular model focuses on minimizing waste, extending product life cycles, and regenerating natural systems.

The origins of circular economy thinking can be traced back to the late 20th century, but it gained formal recognition and widespread attention in the 1970s and 1980s (Geissdoerfer *et al.*, 2017). One of the earliest conceptual frameworks was developed by Kenneth Boulding (1966), who envisioned the economy as a "closed loop" system similar to natural ecosystems. The concept gained traction in the 1970s with the Club of Rome's 1972 report "The Limits to Growth", highlighting the dangers of continued economic growth without considering environmental limits (Park *et al.*, 2023). The term itself became more established in the 1990s and early 2000s as sustainability and resource efficiency became global priorities (Ghisellini *et al.*, 2016).

The modern interpretation of the circular economy, however, was shaped significantly by the Ellen MacArthur Foundation, founded in 2010 (MacArthur, 2013), which popularized the concept and advocated for system-level change. CE frameworks emphasize:

- **Resource efficiency:** Designing products for reuse, remanufacturing, and recycling.
- **Waste minimization:** Transforming waste into valuable inputs for new products.
- **Systemic innovation:** Integrating sustainable practices throughout the supply chain.
- **Economic resilience:** Reducing dependency on finite resources by closing material loops.

Today, the circular economy is considered a pivotal strategy to decouple economic growth from environmental degradation. It addresses the root causes of waste and pollution while fostering innovation and sustainable business practices. Governments, industries, and environmental organizations increasingly recognize

the circular economy as essential for achieving long-term sustainability and combating climate change (Sarangi, 2023).

By promoting circular principles, economies aim to transition from wasteful linear systems to resilient and regenerative models, fostering both environmental protection and sustainable economic development (Kandpal *et al.* 2024).

2.2. Packaging waste, recycling and regulation

At the end of the 20th century, the concept of environmental packaging design emerged as a response to growing concerns about the ecological impacts of packaging waste and resource consumption (Brydson, 1999; Soroka, 1999). This approach views packaging as an essential intermediary between the product and the environment, aiming to minimize their interaction. Packaging serves to shield the product from environmental influences while simultaneously protecting the environment from the potential harmful effects of the product (Lydekaityte and Tambo, 2020). However, this beneficial effect only persists while the product remains within the packaging (Rundh, 2016). The environmental burden arises from both the production of packaging materials and their transformation into waste after use. The primary goal of environmental packaging design is to ensure that packaging materials fulfill their protective role while minimizing environmental impacts throughout their entire life cycle (Keoleian and Menerey, 1994; Svanes *et al.*, 2010; Boz, Korhonen and Koelsch Sand, 2020).

The emphasis on sustainable practices in packaging logistics has significantly progressed over the years. Initial work by Gray and Guthrie, (1990) addressed ethical issues surrounding eco-friendly packaging. This was expanded by later research, such as Murphy, Poist and Braunschweig (1994), who examined environmental management in logistics, and Szymankiewicz (1993), who discussed the difficulties of adopting green practices. Recovery involves the process of reclaiming materials, components, or energy from packaging waste, either partially or fully, and reintegrating them into the production process (Kutz, 2007). This can be achieved through material recovery, incineration for energy production, or biodegradation under aerobic or anaerobic conditions (Demirbas, 2011; Hermann *et al.*, 2011). Recyclable packaging materials encompass a wide range of items, including glass (of all colours), paper, aluminium foil, take-away containers, aluminium cans, tin and steel cans, PET, and HDPE (Marshall, 2007; Coles and Kirwan, 2011).

Environmental packaging regulations establish general requirements based on principles aimed at reducing environmental impacts, including prevention, reuse, and recycling (Marshall 2007). Key prevention elements include reducing the weight of packaging, minimizing the use of multiple packaging layers, implementing refill systems, optimizing both the quantity and characteristics of packaged products, avoiding the use of hazardous or harmful substances, and researching alternative packaging materials (Yam, 2010).

On September 28, 1976, the Organisation for Economic Co-operation and Development (OECD) issued its first recommendation for establishing a comprehensive waste management policy among European Union Member States. This marked the first coordinated effort to address waste management at the EU level (Vuk, Szűcs and Bauerné Gáthy, 2023). Subsequently, in 1991, Germany introduced the first specific legislation targeting packaging waste, guided by principles aimed at minimizing future waste generation, ensuring the use of environmentally friendly materials, and reducing packaging weight and volume (Brisson, 1993).

A significant milestone came with the adoption of Directive 94/62/EC on December 20, 1994, which took effect in EU Member States by June 30, 1996. This directive set forth rules for managing packaging and packaging waste, aiming to harmonize national measures while enhancing environmental quality by preventing and reducing the impact of packaging waste (Malinauskaite, Jouhara and Spencer, 2017). The directive's core objective was to promote prevention, reuse, and recycling while minimizing environmental harm (European Union, 1994). Implementation of the EU Packaging Waste Directive has highlighted the tension between harmonization and flexibility across Member States, with national differences, such as those between the UK and Germany, reflecting varied applications of economic instruments in environmental policy (Bailey, 1999). Central to the Packaging Directive are the recycling quotas that each Member State must achieve within a specified time frame (Avogadro and Ragaini, 1994). Directive 75/442/EEC outlined the fundamental aspects of waste management and treatment for all waste types, emphasizing the prevention of waste generation and its hazardousness, as well as prioritizing waste recovery. By June 30, 2001, Member States were required to recover at least 50% and up to 65% by weight of packaging waste. Additionally, 25% to 45% of all packaging material had to be recycled, with a minimum of 15% per material type (European Parliament and Council, 1995).

Following June 30, 2001, recycling quotas were increased, mandating that by 2006, at least 60% to 75% of packaging waste by weight must be recovered, and 55% to 70% of all packaging materials recycled. When the EU expanded in 2004, the new Member States were required to comply with the amended directive. Belgium, Germany, Luxembourg, Austria, and the Czech Republic successfully met the increased 60% minimum target. However, Cyprus and Malta struggled with both packaging recycling and environmental management (García-Álvarez and Moreno, 2018).

The next amendment, Directive (EU) 2018/852, introduced updated measures to further reduce packaging waste and encourage reuse, recycling, and other recovery methods (European Commission, 2018). It emphasized preventing packaging waste generation and promoting circular economy practices rather than relying on final disposal. This directive applies to all types of packaging placed

on the EU market, regardless of material or the sector involved, including industrial, commercial, household, and service packaging (Ragonnaud, 2023).

The rules, originally established in the Packaging and Packaging Waste Directive (Directive 94/62/EC), are now governed by a new regulation proposed by the European Commission under document COM/2022/677 on 30 November 2022, as part of the European Green Deal and the Circular Economy Action Plan (European Commission, 2022). Building on these early contributions, the Packaging and Packaging Waste Regulation (PPWR) aims to move the EU closer to a more circular and sustainable packaging system (Matlhare, Monnapule, 2024). The proposal underwent legislative review and was formally adopted by the European Parliament and the Council on 19 December 2024 as Regulation (EU) 2025/40 (European Parliament and Council, 2024). It was published in the Official Journal on 22 January 2025 and entered into force on 11 February 2025, with general application beginning 18 months later, on 11 August 2026. Packaging and Packaging Waste Regulation (PPWR), sets out requirements for packaging placed on the EU market, along with measures for packaging waste prevention and management.

Article 43, Prevention of packaging waste states:

1. Each Member State shall reduce the packaging waste generated per capita, as compared to the packaging waste generated per capita in 2018 as reported to the Commission in accordance with Decision 2005/270/EC, by at least:

- (a) 5 % by 2030;
- (b) 10 % by 2035;
- (c) 15 % by 2040.

PPWR further in Article 52, Recycling targets and promotion of recycling, established long-term targets for packaging recycling rates.

1. Member States shall take the necessary measures to achieve the following recycling targets covering the whole of their territory:

2025	2030
65 % by weight of all packaging waste	70 % by weight of all packaging waste
50 % of plastic	55 % of plastic
25 % of wood	30 % of wood
70 % of ferrous metals	80 % of ferrous metals
50 % of aluminium	60 % of aluminium
70 % of glass	75 % of glass
75 % of paper and cardboard	85 % of paper and cardboard

3. DATA AND METHODOLOGY

The data used in this study are obtained from the Eurostat database, which provides comprehensive information on packaging waste generation, and

recycling rates as reported by EU countries, in accordance with Commission Decision 2005/270/EC. The reported data typically becomes available approximately 20 months after the end of the reference year. Packaging is defined as any material used to contain, protect, handle, deliver, or present goods. It encompasses a wide range of items such as glass bottles, plastic containers, aluminium cans, food wrappers, timber pallets, and drums. Packaging waste can arise from diverse sources, including supermarkets, retail outlets, manufacturing industries, households, hotels, hospitals, restaurants, and transport companies (*Statistics | Eurostat*, 2024). The recycling rates are calculated as the total quantity of recycled materials divided by the total quantity of generated packaging waste, with certain exceptions. The dataset titled "Recycling rates of packaging waste for monitoring compliance with policy targets, by type of packaging (env_waspacr)" includes "Adjusted recycling rates" for specific materials, such as plastic and wood. These adjusted rates are defined in line with Article 6 of Directive 94/62/EC and Article 6b(1) of Decision 2005/270 (*Statistics | Eurostat*, 2024).

For the purpose of this research, Eurostat indicators for packaging waste generation per capita and recycling rates of packaging waste by categories are used. The analysis covers the period from 2011 to 2022 for all EU member states. The chosen indicators and time period enable a comprehensive assessment of trends in packaging waste generation and recycling, reflecting the progress made toward meeting EU policy targets. The selected indicators are presented in Table 1:

Table 1. Eurostat indicators for packaging waste generation per capita and recycling rates of packaging waste by categories

Packaging waste by waste management operations [env_waspac]:	Recycling rates of packaging waste for monitoring compliance with policy targets, by type of packaging [env_waspacr]
Generation of packaging waste (kg per capita)	Recycling rates for packaging waste (%)
Paper and cardboard packaging generated (kg per capita)	Recycling rates for packaging waste - Paper and cardboard packaging (%)
Plastic packaging generated (kg per capita)	Recycling rates for packaging waste – plastic packaging (%).
Wooden packaging generated (kg per capita)	Recycling rates for packaging waste – wooden packaging (%)
Metal packaging generated (kg per capita)	Recycling rates for packaging waste – glass packaging (%)
Glass packaging generated (kg per capita)	Recycling rates for packaging waste – metal packaging (%).

To achieve the research objectives, this study applies a set of quantitative methods. Trend analysis is used to examine developments in packaging waste generation and recycling rates across EU-27 Member States from 2011 to 2022,

highlighting general patterns and growth tendencies. Growth rates are calculated to assess increases in waste generation across five main material categories: paper and cardboard, plastic, wood, metal, and glass. Comparative analysis between countries complements the trend evaluation, identifying variations in national performance.

Correlation analysis is used to evaluate the strength and direction of the linear relationship between the two variables: packaging waste generation per capita and recycling rate of packaging waste in the period 2011-2022 in EU (27). Its primary purpose is to determine whether, and to what extent, changes in one variable are associated with changes in another. This technique enables the identification of underlying patterns and associations that may indicate whether increased waste generation aligns with improved recycling performance or highlights inefficiencies in waste management systems.

Cluster analysis is an exploratory, interdependence-based statistical technique used to classify a set of observations, such as countries, into distinct groups, or clusters, based on shared characteristics. A key strength of this method lies in its unsupervised nature: unlike methods such as discriminant analysis, cluster analysis does not require pre-defined groups. Instead, it uncovers natural groupings within the data based solely on patterns of similarity. The main objective of cluster analysis is to segment a dataset into a small number of mutually exclusive and internally homogeneous groups (Hair *et al.*, 2010). That is, entities within a cluster are highly similar to one another, while entities across clusters differ significantly. In the context of packaging waste generation and recycling rates, cluster analysis offers a robust way to detect patterns across EU member states. By reducing the complexity of a dataset, such as 27 EU countries, into a few well-defined clusters, we can simplify interpretation, highlight commonalities, and draw more focused conclusions. A hierarchical cluster analysis using Ward's method was conducted to classify EU member states into five distinct groups based on two key indicators for 2022: packaging waste generation per capita and the recycling rate of packaging waste. To determine the optimal number of clusters, an Analysis of Variance (ANOVA) test was conducted to evaluate whether the means of the key clustering variables significantly differed across clusters. This configuration provides a robust and meaningful classification of EU member states, enabling a nuanced assessment of their progress toward packaging waste reduction and recycling goals in line with EU sustainability directives. Countries grouped into the same cluster exhibit similar behaviors or performance levels related to the circular economy, making it easier to identify common challenges, best practices, or policy needs. This type of analysis has been widely adopted in previous studies on environmental and sustainability metrics, including those by (Mathrani *et al.*, 2023; Claudio, Quiroga and Poza, 2024), who have used clustering to inform policy decisions and circular economy performance. Mathrani *et al.* (2023) demonstrated its usefulness in

examining Sustainable Development Goal (SDG) indicators by identifying groups of countries with similar sustainability characteristics. Similarly, Claudio, Quiroga and Poza (2024) employed clustering techniques to assess circular economy performance, highlighting its potential to inform evidence-based policy decisions through the identification of shared challenges and opportunities among countries.

4. RESULTS

The results of this study are presented in three main sections. The first, Trends and Correlations between Packaging Waste Generation and Recycling in the EU-27, analyzes the evolution of packaging waste and recycling rates from 2011 to 2022 and explores the relationship between these indicators. The second, Disparities in packaging waste management across EU members in 2022: Cluster Analysis and PPWR Alignment, identifies groups of countries based on packaging waste and recycling rate indicators, revealing substantial disparities in meeting the targets set by the PPWR. The third section shifts focus to a critical reflection on compliance with PPWR targets, questioning whether achieving the 2025 and 2030 recycling rates is sufficient. It highlights that even countries meeting the targets may still generate larger volumes of non-recycled packaging waste compared to others that have not yet reached the recycling thresholds.

4.1. Trends and Correlations between Packaging Waste Generation and Recycling in the EU-27

In 2022, the total packaging waste generated across the European Union (EU-27) reached approximately 83.4 million tonnes, underscoring the significant environmental footprint of packaging materials in modern economies. Paper and cardboard remained the most prevalent waste category, contributing 34.0 million tonnes or 40.8% of the total. This dominance reflects the continued preference for paper-based solutions, particularly in sectors emphasizing recyclability and environmental sustainability. Plastic packaging was the second largest contributor, generating 16.1 million tonnes or 19.4% of the total. Despite increasing regulatory and consumer pressure to reduce plastic use, its considerable share reveals the ongoing dependency on plastics, especially in food and consumer goods packaging. Glass followed with 15.7 million tonnes, representing 18.8%, due to its extensive use in the beverage and preserved food industries. Wooden packaging accounted for 13.3 million tonnes or 16.0%, primarily associated with transport and storage systems. In contrast, metal packaging made up just 4.1 million tonnes, representing 4.9% of the total waste, reflecting its limited use and higher recyclability rates. All other packaging materials combined amounted to a marginal 0.2%, indicating their relatively minor role in the EU packaging landscape. Overall, the data illustrate a clear hierarchy in material usage, with paper and cardboard leading due to their perceived environmental benefits, and

metal and other materials contributing the least. These trends not only shows consumption patterns but also point to key areas where circular economy initiatives must be intensified to mitigate the growing volume of packaging waste.

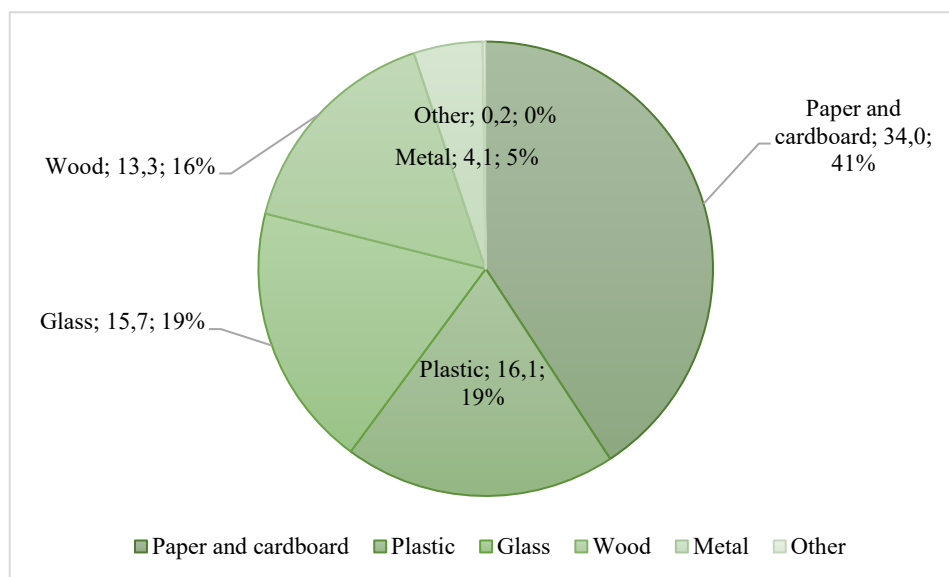


Figure 1. Packaging waste generated by a packaging material mill. tons, EU (27), 2022
Source: Eurostat (online data code: env_waspac)

Between 2011 and 2022, the generation of packaging waste per capita exhibited a consistent upward trend, marking an overall increase of 18.67% from 157.2 to 186.5 kg per capita. This growth of packaging waste generation in the EU reflects evolving consumer behaviors and an intensified demand for packaging, particularly driven by economic growth. Among the various packaging categories, plastic packaging showed the most significant growth, increasing by 27.30% from 28.4 to 36.1 kg per capita, highlighting its continued dominance despite global initiatives aimed at reducing plastic waste. Paper and cardboard packaging followed with a growth of 19.41%, rising from 63.7 to 76.0 kg per capita, indicating an increased focus on sustainable packaging solutions. Wood packaging recorded an increase of 17.98%, from 25.3 to 29.8 kg per capita, although some fluctuations were observed, particularly between 2017 and 2018. Glass packaging waste displayed moderate growth of 16.58%, increasing from 30.0 to 35.0 kg per capita, reflecting stable but gradual expansion. Meanwhile, metal packaging remained the smallest category in terms of waste generation, with a modest increase of 5.54%, from 8.7 to 9.1 kg per capita, suggesting a preference for lighter and more flexible alternatives over time (fig.2).

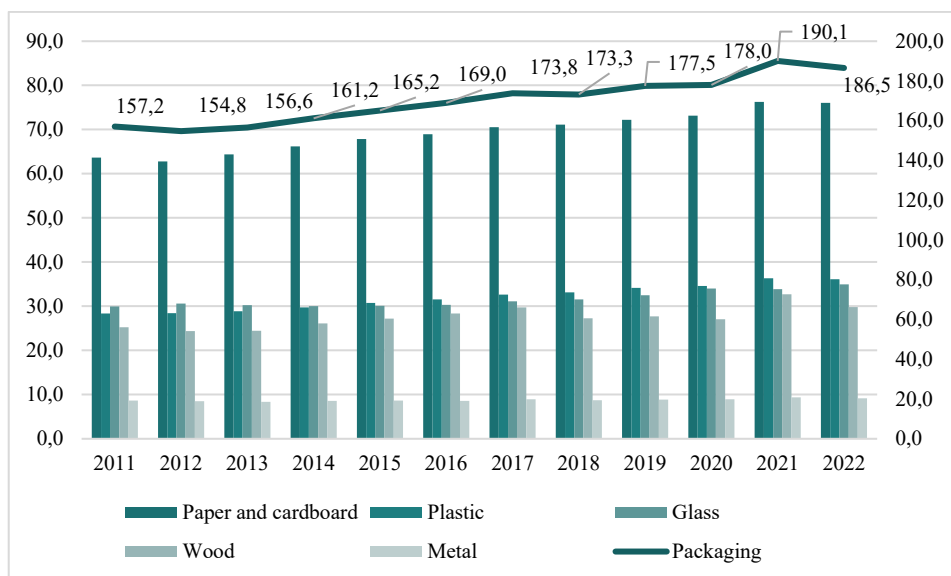


Figure 2. Packaging waste generated per capita, by packaging material, EU (27), 2011–2022

Source: Eurostat (online data code: env_waspac)

The overall recycling rate of packaging waste has remained relatively stable, fluctuating between 64.2% in 2011 and 65.4% in 2022. The plastic packaging waste recorded the most significant increase in recycling rates, growing from 35.6% in 2011 to 40.7% in 2022, marking an increase of 5.1 percentage points. Although this growth is notable, it still falls short of the EU target of 50% by 2025, indicating a significant gap that needs to be addressed to meet policy goals. Wooden packaging experienced a moderate decrease in recycling rates, falling from 36.6% in 2011 to 34.2% in 2022. The 2025 target of 25% and the 2030 target of 30% have already been met. However, maintaining and further improving this performance will be crucial for long-term compliance. Metallic packaging (including ferrous metals and aluminum) showed a slight increase from 75.7% in 2011 to 76.9% in 2022. Despite the small growth, the recycling rate for metallic packaging already meets the 2025 targets of 70% for ferrous metals and 50% for aluminum, indicating strong performance in this category. However, the 2030 target of 80% for ferrous metals and 60% for aluminum will require additional efforts to ensure continued progress. Glass packaging maintained a stable recycling rate throughout the period, with a minor fluctuation from 72.3% in 2011 to 75.6% in 2022. The 2025 target of 70% and 2030 of 75% has already been achieved. Paper and cardboard packaging, which represents the largest share of packaging waste, maintained consistently high recycling rates, ranging from 82.7% in 2011 to 83.2% in 2022. These rates comfortably meet the 2025 target of

75% and are approaching the 2030 target of 85%, highlighting the effectiveness of paper recycling systems compared to other materials. In conclusion, while some categories like metals, glass, and paper have either met or are close to meeting the 2025 targets, plastic packaging remains a critical challenge. Reaching the 2030 targets will require significant improvements, particularly in recycling plastic and maintaining the momentum in other categories (Fig.3).

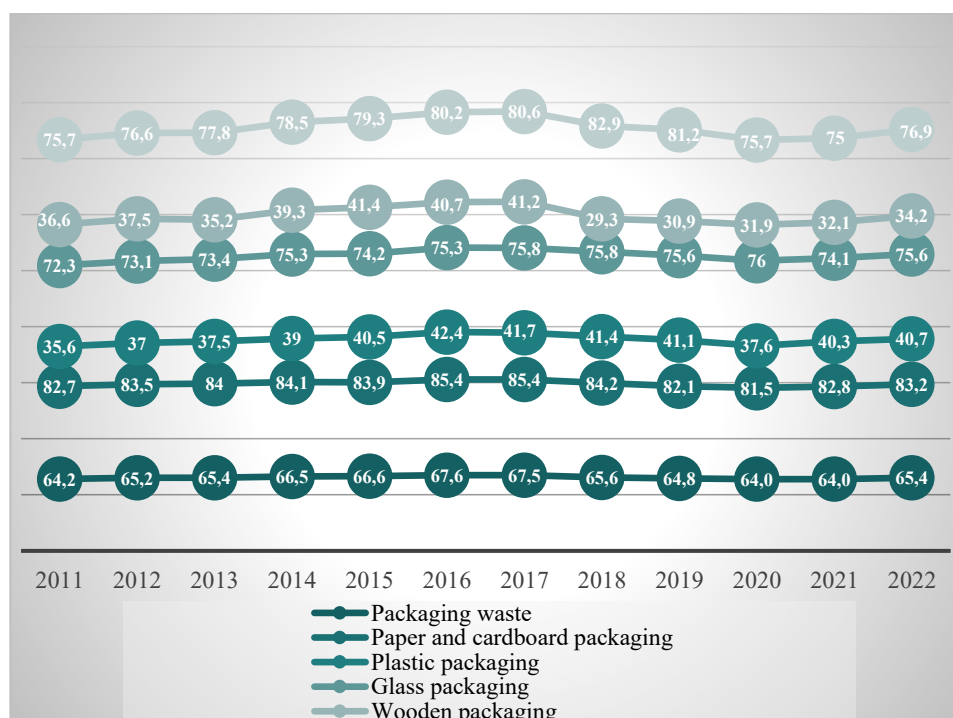


Figure 3. Recycling rates of packaging waste in %, by packaging material, EU (27), 2022

Source: Eurostat (online data code: env_waspr)

To assess the evolving dynamics of packaging waste in the EU, we analyzed the growth in packaging waste generation alongside changes in recycling rates by material type between 2011 and 2022. During this period, packaging waste increased across all material categories, reflecting rising consumption and expanding logistics demands. Overall, total packaging waste in the EU rose by 18.7% over the decade, whereas the overall recycling rate increased by just 1.9 percentage points. The most pronounced growth was observed in plastic packaging waste, which surged by 27.3%, followed by paper and cardboard (+19.4%), wood (+18.0%), and glass (+16.6%). In contrast, metal packaging waste exhibited the most modest increase, rising by only 5.5%. However, the

progress in recycling rates did not keep pace with the growth in waste generation. While plastic recycling rates improved notably by 14.3 percentage points, indicating efforts to address plastic pollution, the recycling rates for paper and cardboard (+0.6%) and metal (+1.6%) showed only marginal improvement. Alarming, wood recycling experienced a significant decline of 6.6 percentage points, suggesting setbacks in material recovery systems. Glass recycling saw a modest improvement of 4.6 percentage points, despite a considerable rise in waste volume. This growing disparity signals that while waste generation continues to climb, recycling systems are not advancing at a comparable pace. The findings underscore the urgency for enhanced material-specific strategies and investment in recycling infrastructure to bridge this gap and meet the EU's circular economy goals (Fig.4).

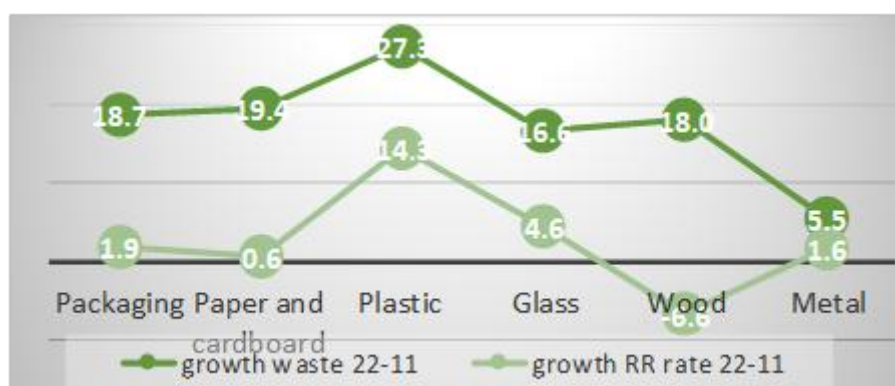


Figure 4. Growth of packaging waste generation and recycling rates of packaging waste in %, EU (27), 2011-2022

Source: Eurostat (online data code: env_waspr)

The correlation matrix offers insights into the relationship between packaging waste generation and recycling rates across material categories in the EU (Table 2). The data shows that total packaging waste generation is highly and positively correlated with waste generation from individual materials such as paper and cardboard, plastic, and metal. These strong correlations (e.g., 0.9938 between total packaging and paper and cardboard, and 0.9921 between total packaging and plastic) suggest that as overall packaging waste increases, waste from each material type tends to increase in tandem. This is expected, given the dominant share of these materials in the total packaging composition. However, a different pattern emerges when analyzing the relationship between packaging waste generation and recycling rates. The overall correlation between packaging waste and its corresponding recycling rate is negative and insignificant (-0.2164), indicating that higher packaging waste generation is not associated with better recycling performance. In fact, in most cases, there appears to be a weak or even

inverse and insignificant relationship between generation and recycling, particularly for paper and cardboard (-0.2730), metal (-0.24826), and wood (-0.14316). This suggests that increased material use does not necessarily lead to improved recycling outcomes, and in some cases, may strain the recycling infrastructure. Positive but insignificant is correlation between glass generation and recycling (0.46336). One exception is the positive and significant correlation between plastic packaging waste and its recycling rate (0.56), indicating that higher plastic waste generation might be somewhat aligned with improved recycling performance, potentially due to policy interventions or technological investments targeting plastic recycling. Additionally, RRPlastic shows moderate to strong positive correlations with other recycling indicators, such as RRGlass (0.7056) and RRMetal (0.6830), implying that recycling capacities may be integrated or supported by common systems or frameworks across materials in certain member states. In contrast, recycling rates for wooden packaging exhibit negative and insignificant correlations with most variables, including a strong negative correlation with glass (-0.6246) and plastic (-0.5314) waste generation. This reflects the unique challenges or limited prioritization associated with wood recycling in the EU context. Furthermore, RRMetallic packaging appears to be largely uncorrelated with overall packaging waste (correlation of -0.0230), suggesting its recycling is driven by factors independent of total waste volumes, perhaps due to its specialized collection systems or economic value.

The data show that higher generation levels are not accompanied by higher recycling rates, and in several instances, the relationship is either weak or negative. The only moderate exception is observed in the case of plastic, where a positive and statistically significant correlation indicates a partial alignment between generation and recycling capacity.

Table 2. Correlation analysis between the growth in packaging waste generation and the growth in recycling rates by category at the EU level (2011–2022)

	Packaging	RRPackag	Paper and	RRPaper a	Plastic	RRPlastic	Glass	RRGlass p	Wood	RRWoode	Metal	RRMetallic
Packaging	1											
RRPackag	-0.21637	1										
Paper and	0.993832	-0.1926	1									
RRPaper a	-0.27304	0.904848	-0.27145	1								
Plastic	0.992135	-0.2353	0.995989	-0.31289	1							
RRPlastic	0.569431	0.588878	0.583727	0.486449	0.560007	1						
Glass	0.879134	-0.498	0.88126	-0.55346	0.902938	0.20314	1					
RRGlass p	0.60571	0.323706	0.663775	0.104974	0.656721	0.705564	0.463364	1				
Wood	0.895547	0.036614	0.861559	0.040646	0.840029	0.661108	0.631575	0.453527	1			
RRWoode	-0.47737	0.742075	-0.48876	0.648899	-0.53137	0.059837	-0.62462	-0.19826	-0.14316	1		
Metal	0.928091	-0.36914	0.892088	-0.36904	0.895608	0.342947	0.851816	0.362348	0.877998	-0.42966	1	
RRMetallic	-0.02301	0.612477	0.018158	0.529349	0.011283	0.682946	-0.30231	0.521805	-0.01099	0.032433	-0.24826	1

Source: Author calculation

4.2. Disparities in packaging waste management across EU members in 2022: Cluster Analysis and PPWR Alignment

Figure 5 shows packaging waste generation per capita across EU countries for 2011, 2018, and 2022, illustrating the trends over the observed period and highlighting disparities among Member States. The graph demonstrates substantial differences in packaging waste generation across countries, reflecting diverse consumption patterns and waste management practices. In 2022, Ireland generated the highest packaging waste per capita at 233.84 kg, followed by Italy (232.36 kg) and Germany (226.94 kg). On the opposite end, Bulgaria generated the least packaging waste at 78.75 kg per capita, with Romania (127.21 kg) and Greece (104.95 kg) also among the lowest. Compared to 2011, when Germany and Italy already recorded high levels of packaging waste at 205.37 kg and 195.99 kg per capita, respectively, Ireland continued to increase generation of packaging waste, reflecting a consistent upward trend. Conversely, countries like Bulgaria and Romania remained low throughout the period, emphasizing a persistent disparity between Western and Eastern European countries. When comparing 2022 data to the 2018 baseline, the most significant growth was observed in Romania (58.1%), Greece (38.3%), and Slovenia (23.8%), while some countries managed to reduce their packaging waste per capita. The most notable reductions were recorded in Estonia (-9.4%), Luxembourg (-6.8%), France (-3.6%), and Sweden (-2.1%), while Germany showed a slight decrease of -0.2%. According to the PPWR, Member States should reduce packaging waste generation per capita by at least 5% by 2030 compared to 2018 levels. Based on current trends, only Estonia, Luxembourg, and France have achieved reductions compared to 2018. Sweden and Germany have also decreased from 2018, while most other countries are still increasing their packaging waste generation. The overall increase in packaging waste generation in most Member States, driven by intensified consumption and e-commerce growth, indicates that significant efforts are required to reverse this trend and comply with waste prevention objectives.

A hierarchical cluster analysis using Ward's method was conducted to classify EU member states into five distinct groups based on two key indicators for 2022: packaging waste generation per capita and the recycling rate of packaging waste. The aim was to identify performance patterns and categorize countries according to their alignment with the PPWR objectives. To determine the optimal number of clusters, an Analysis of Variance (ANOVA) test was conducted to evaluate whether the means of the key clustering variables significantly differed across clusters. The results confirmed that the five-cluster solution produced statistically significant differences in mean values of both packaging waste per capita ($p < 0.01$) and recycling rates across clusters ($p < 0.05$). The resulting clusters show substantial disparities among member states and offer insight into targeted policy interventions.

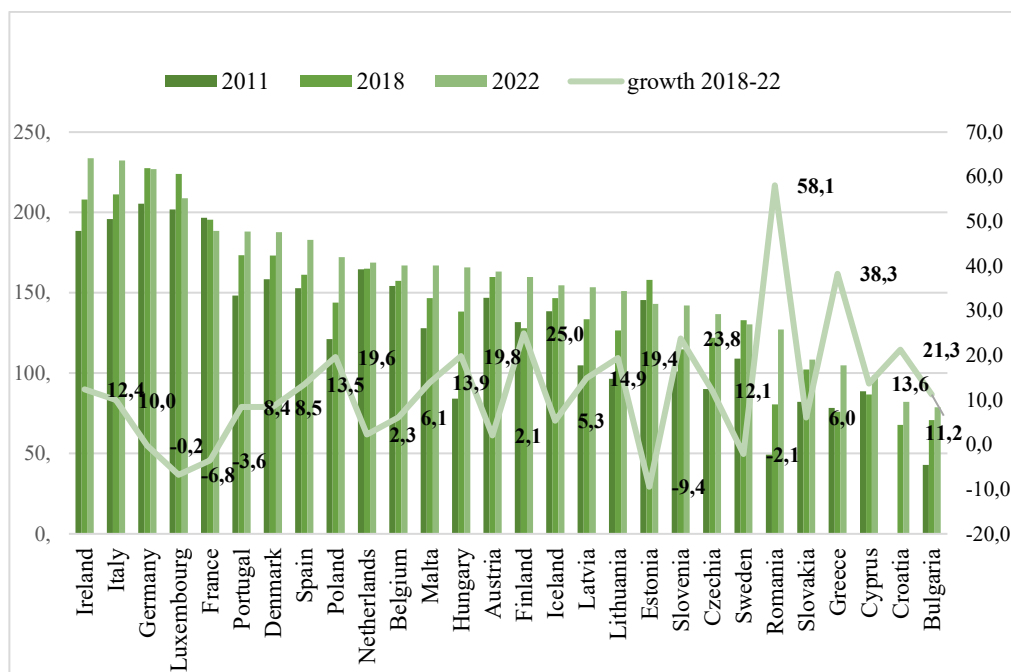


Figure 5. Packaging waste generated per capita, EU countries, 2011, 2018, 2022, and growth 2022-2018

Source: Eurostat (online data code: env_waspac)

Note: Data for Poland are from 2019 and Czechia and Romania 2021

Cluster 1 High Performers includes: Belgium, Denmark, Spain, France, the Netherlands, Austria, Portugal, and Finland. These countries show relatively high recycling rates (average: 69.7%, range: 61.1%–80.4%) and moderate levels of packaging waste per capita (average: 175.8 kg, range: 159.9–188.5 kg). Most members of this group have already met 2030 PPWR recycling target of 70%: Belgium (80.4%), Netherlands (75.2%), and Finland (73.5%), while Spain (69.4%), France (67.2%), Austria (66.2%) and Denmark (64.9%) meet the 2025 target of 65%. In this group, only Portugal (61.1%) does not meet the PPWR targets.

Cluster 2 Transitional Countries with Low Waste consists of: Bulgaria, Greece, Croatia, Cyprus, Romania, and Slovakia. This group is characterized by low packaging waste per capita (average: 100.0 kg, range: 78.8–127.2 kg) but lower average recycling rates (average: 55.7%, range: 38.3%–72.2%). Only Slovakia (72.2%) and Cyprus (69.5%) meet the 70% target, while countries like Romania and Greece fall significantly short.

Cluster 3 Balanced Performers comprises: Czechia, Estonia, Latvia, Lithuania, Slovenia, and Sweden. These are middle performers, with moderate

levels of waste (average: 142.8 kg, range: 130.3–153.4 kg) and recycling rates (average: 65.1%, range: 58.3%–73.0%). Some members of this cluster meet or closely approach the PPWR 2030 target: Estonia (73%), Czechia (69.1%), and Sweden (66.9%).

Cluster 4 High Waste, Good Recycling includes: Germany, Ireland, Italy, and Luxembourg. This group is characterized by the highest levels of packaging waste per capita (average: 225.5 kg, range: 208.9–233.8 kg) alongside good recycling performance (average: 66.5%, range: 61.7%–71.9%). Italy (71.9%) and Germany (68.5%) meet the PPWR 2025 and 2030 targets, but their high waste generation suggests room for improvement in prevention measures.

Cluster 5 Lagging Behind includes: Hungary, Malta, and Poland. These countries are characterized by moderate packaging waste per capita (average: 168.3 kg, range: 165.8–172.2 kg) and low recycling rates (average: 44.0%, range: 31.8%–55.5%), indicating serious challenges in aligning with the PPWR targets and a pressing need for systemic improvements.

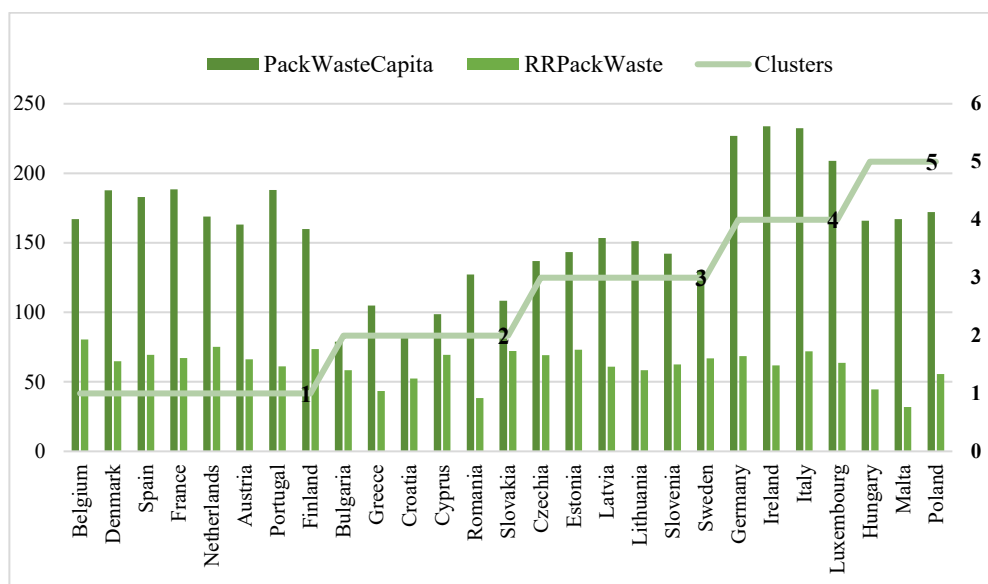


Figure 6. Hierarchical cluster analysis, 2022.

Source: Author calculation

4.3. Discussion: Beyond Recycling Rates – The Significance of Non-Recycled Packaging Waste

The analysis of packaging waste generation and recycling trends in the EU-27 from 2011 to 2022 reveals a widening gap in their growth. Packaging waste has grown at a significantly faster rate than recycling rates, with no clear correlation between the two. This raises critical questions about the adequacy of

current policy targets, such as those set in the Packaging and Packaging Waste Regulation, specifically, the goal of reducing packaging waste by 5% compared to 2018 levels, and achieving recycling rates of 65% by 2025 and 70% by 2030.

The cluster analysis identified five distinct country groups based on packaging waste generation and recycling performance. Of particular interest is Cluster 4, which consists of countries with high levels of packaging waste generation and relatively high recycling rates. Despite meeting or exceeding EU targets for recycling rates, these countries still produce substantial volumes of non-recycled packaging waste in absolute terms. This stands in contrast to Cluster 2, which is composed of countries with lower packaging waste generation and moderate to low recycling rates, which ultimately generate less non-recycled packaging waste per capita.

This underscores a key limitation in using recycling rates alone as performance indicators. While recycling rates are often presented as the key metric for evaluating progress toward a circular economy, they can present an incomplete picture when assessed in isolation. A country may meet or exceed recycling targets, yet still contribute disproportionately to environmental degradation if its overall packaging waste generation is high. The analysis of non-recycled packaging waste per capita, derived by subtracting the recycled share from total packaging waste generation, offers a more nuanced and accurate reflection of circularity performance. This approach reveals important disparities. For example, Germany and Ireland report relatively strong recycling rates of 68.5% and 61.7%, respectively. However, due to very high levels of packaging waste per capita (226.94 kg and 233.84 kg), these countries still generate 71.5 kg and 89.6 kg of non-recycled packaging waste per capita, among the highest in the EU. In contrast, countries such as Bulgaria (58.3% recycling rate, 78.75 kg total packaging waste per capita) and Croatia (52.4% recycling, 82.17 kg total) have significantly lower non-recycled waste outputs of just 32.8 kg and 39.1 kg per capita, respectively. This suggests that higher recycling rates alone do not necessarily translate into lower environmental pressure from packaging waste.

In conclusion, evaluating non-recycled packaging waste per capita offers a more nuanced and accurate measure of a country's environmental performance regarding packaging waste. It highlights the need for comprehensive strategies that address both waste reduction and recycling efficiency to achieve sustainable waste management goals.

This insight supports a shift in analytical and policy focus, from relative improvements in recycling to absolute reductions in non-recycled waste. The PPWR targets, while important, may need to be complemented by stricter waste prevention measures, such as caps on per capita packaging waste or incentives for reusable and refillable systems. Without this pivot, high-performing recyclers that generate even higher amounts of packaging waste may inadvertently undermine the EU's broader circular economy goals.

Therefore, shifting the focus from "how much is recycled" to "how much is not" may offer a more actionable and policy-relevant insight into the circularity of EU economies. It supports the argument that prevention and waste reduction must take precedence in the waste hierarchy, aligned with the core principles of the circular economy. Achieving the 2025 and 2030 PPWR targets will not only require improving recycling infrastructure but also reducing the absolute volumes of packaging placed on the market, especially in high-income, high-consumption member states.

5. CONCLUSIONS

The goal of this research was to map the trends between packaging waste generation and recycling rates in the EU-27, identify disparities across Member States, and evaluate their alignment with the Packaging and Packaging Waste Regulation (PPWR) targets. At the EU-27 level, packaging waste generation reached 83.4 million tonnes in 2022, with paper and cardboard (40%) leading, followed by plastic (19%), glass (18%), wood (17%), and metal (6%). The trend shows a consistent 18.7% increase in packaging waste generation over the 2011–2022 period, while recycling rates improved by only 1.9 percentage points.

According to the PPWR, Member States should reduce packaging waste generation per capita by at least 5% by 2030 compared to 2018 levels. Based on current trends, only Estonia, Luxembourg, and France have achieved reductions compared to 2018. Sweden and Germany have also decreased from 2018, while most other countries are still increasing their packaging waste generation.

The cluster analysis confirms significant disparities in packaging waste generation and recycling performance across EU member states and highlights distinct country groupings that reflect varying levels of progress toward the PPWR targets. High-performing countries such as Belgium, the Netherlands, Finland, and Spain have already met or are very close to meeting both the 2025 and 2030 recycling targets, combining efficient recycling systems with relatively moderate packaging waste levels. In contrast, despite low per capita waste, transitional countries like Bulgaria, Romania, and Greece exhibit insufficient recycling rates, revealing structural challenges. Balanced performers such as Czechia, Estonia, and Sweden display encouraging signs of progress, with several members approaching or achieving the 70% recycling rate threshold. Meanwhile, countries like Germany and Italy in the high-waste but good-recycling cluster demonstrate strong recycling systems but require targeted waste prevention strategies to address excessive waste generation. Finally, Hungary, Malta, and Poland, identified as laggards, face critical challenges, with high packaging waste and poor recycling rates, underscoring the need for comprehensive policy and infrastructure reforms.

This disparity raises critical questions about the effectiveness of the existing EU policy framework, particularly whether the PPWR targets reducing packaging

waste by 5% compared to 2018 levels and achieving recycling rates of 65% by 2025 and 70% by 2030, are sufficient indicators for addressing the core challenges of packaging waste management. Notably, while some countries have achieved recycling targets, they still produce large volumes of non-recycled waste. High-performing recyclers like Germany and Ireland continue to generate higher absolute quantities of non-recycled packaging waste compared to low-waste countries such as Bulgaria and Croatia, underscoring the need for a shift in focus from recycling rates to absolute waste reduction.

Overall, while the EU has made progress in meeting recycling targets, packaging waste prevention remains a critical gap. To achieve a truly circular economy, future efforts must prioritize both recycling improvements and significant reductions in packaging waste generation at both the EU and national levels.

References

- 1) Avogadro, A. and Ragaini, R.C. (eds) (1994). *Technologies for Environmental Cleanup: Toxic and Hazardous Waste Management*. Dordrecht: Springer Netherlands. Available at: <https://doi.org/10.1007/978-94-017-3213-0>.
- 2) Bailey, I. (1999). Flexibility, Harmonization and the Single Market in EU Environmental Policy: The Packaging Waste Directive, *JCMS: Journal of Common Market Studies*, 37(4), pp. 549–571. Available at: <https://doi.org/10.1111/1468-5965.00196>.
- 3) Boulding, K. (1966). *The Economics of the Coming Spaceship Earth (historical) - Encyclopedia of Earth*.
- 4) Boz, Z., Korhonen, V. and Koelsch Sand, C. (2020). Consumer Considerations for the Implementation of Sustainable Packaging: A Review, *Sustainability*, 12(6), p. 2192. Available at: <https://doi.org/10.3390/su12062192>.
- 5) Brisson, I. (1993). Packaging waste and the environment: economics and policy, *Resources, Conservation and Recycling*, 8(3), pp. 183–292. Available at: [https://doi.org/10.1016/0921-3449\(93\)90026-C](https://doi.org/10.1016/0921-3449(93)90026-C).
- 6) Brydson, J.A. (1999). *Plastics materials*. Elsevier. Available at: https://books.google.com/books?hl=en&lr=&id=OlgSAEZYmmoC&oi=fnd&pg=P1&dq=Brydson,+1999&ots=CJH_9dZ_Np&sig=col-AsfwL5Dqt9eSeSyTUziEts (Accessed: 17 March 2025).
- 7) Claudio-Quiroga, G. and Poza, C. (2024). Measuring the circular economy in Europe: Big differences among countries, great opportunities to converge, *Sustainable Development*, 32(5), pp. 4707–4725. Available at: <https://doi.org/10.1002/sd.2925>.
- 8) Coles, R. and Kirwan, M.J. (2011). *Food and beverage packaging technology*. John Wiley & Sons. Available at: [https://books.google.com/books?hl=en&lr=&id=Kf8CEQAAQBAJ&oi=fnd&pg=PR13&dq=Recyclable+packaging+materials+encom+pass+a+wide+range+of+items,+including+glass+\(of+all+colours\),+paper,+aluminium+foil,+take-away+containers,+aluminium+cans,+tin+and+steel+cans,+PET,+and+HDPE+&ots=m-5gtKhWAL&sig=raoow1-jEZT7dl68-x1NQ2EB3gA](https://books.google.com/books?hl=en&lr=&id=Kf8CEQAAQBAJ&oi=fnd&pg=PR13&dq=Recyclable+packaging+materials+encom+pass+a+wide+range+of+items,+including+glass+(of+all+colours),+paper,+aluminium+foil,+take-away+containers,+aluminium+cans,+tin+and+steel+cans,+PET,+and+HDPE+&ots=m-5gtKhWAL&sig=raoow1-jEZT7dl68-x1NQ2EB3gA) (Accessed: 17 March 2025).

- 9) Demirbas, A. (2011). Waste management, waste resource facilities and waste conversion processes, *Energy Conversion and Management*, 52(2), pp. 1280–1287.
- 10) European Commission (2022). Proposal for a Regulation of the European Parliament and of the Council on packaging and packaging waste. COM(2022) 677 final, 2022/0396 (COD).
- 11) European Commission (2018). *Proposal for a Regulation of the European Parliament and of the Council on Packaging and Packaging Waste*.
- 12) European Commission (2022a). *Revision of the Packaging and Packaging Waste Directive*.
- 13) European Parliament and Council (2024). REGULATION (EU) 2025/40 on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC. Official Journal of the European Union.
- 14) European Parliament and Council (1995). Directive 94/62/EC, *Journal of Environmental Law*, 7(2), pp. 323–337. Available at: <https://doi.org/10.1093/jel/7.2.323>.
- 15) European Union (1994). *Council Directive 94/62/EC, on Packaging and Packaging Waste*, pp. 10–23.
- 16) European Union (2004). *Directive 2004/12/ec of the European parliament and of the council of 11february 2004*.
- 17) Galvão, G.D.A. *et al.* (2018). Circular economy: Overview of barriers, *Procedia Cirp*, 73, pp. 79–85.
- 18) García-Álvarez, M.T. and Moreno, B. (2018). Environmental performance assessment in the EU: A challenge for the sustainability, *Journal of Cleaner Production*, 205, pp. 266–280.
- 19) Geissdoerfer, M. *et al.* (2017). The Circular Economy—A new sustainability paradigm? *Journal of cleaner production*, 143, pp. 757–768.
- 20) Ghisellini, P., Cialani, C. and Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems, *Journal of Cleaner Production*, 114, pp. 11–32. Available at: <https://doi.org/10.1016/j.jclepro.2015.09.007>.
- 21) Gray, V. and Guthrie, J. (1990). Ethical issues of environmentally friendly packaging, *International Journal of Physical Distribution & Logistics Management*, 20(8), pp. 31–36.
- 22) Hair, J.F. *et al.* (2010). *Multivariate data analysis: A global perspective* (Vol. 7). Upper Saddle River, NJ: Pearson.
- 23) Hermann, B.G. *et al.* (2011). To compost or not to compost: Carbon and energy footprints of biodegradable materials' waste treatment, *Polymer degradation and stability*, 96(6), pp. 1159–1171.
- 24) Ingram, V. (1999). *Joint Environmental Policy Making in the EU The Packaging Waste Case*.
- 25) Kandpal, V. *et al.* (2024). Circular Economy Principles: Shifting Towards Sustainable Prosperity, in Kandpal, V. *et al.*, *Sustainable Energy Transition*. Cham: Springer Nature Switzerland (Circular Economy and Sustainability), pp. 125–165. Available at: https://doi.org/10.1007/978-3-031-52943-6_4.

- 26) Keoleian, G.A. and Menerey, D. (1994). Sustainable Development by Design: Review of Life Cycle Design and Related Approaches, *Air & Waste*, 44(5), pp. 645–668. Available at: <https://doi.org/10.1080/1073161X.1994.10467269>.
- 27) Kutz, M. (ed.) (2007). *Environmentally Conscious Materials and Chemicals Processing*. 1st edn. Wiley. Available at: <https://doi.org/10.1002/9780470168219>.
- 28) Lydekaityte, J. and Tambo, T. (2020). Smart packaging: definitions, models and packaging as an intermediary between digital and physical product management, *The International Review of Retail, Distribution and Consumer Research*, 30(4), pp. 377–410. Available at: <https://doi.org/10.1080/09593969.2020.1724555>.
- 29) MacArthur, E. (2013). Towards the circular economy, *Journal of industrial ecology*, 2(1), pp. 23–44.
- 30) Malinauskaitė, J., Jouhara, H. and Spencer, N. (2017). Waste prevention and technologies in the context of the EU Waste Framework Directive: lost in translation?, *European Energy and Environmental Law Review*, 26(3). Available at: <https://kluwerlawonline.com/journalarticle/European+Energy+and+Environmental+Law+Review/26.3/EELR2017009> (Accessed: 17 March 2025).
- 31) Marshall, J. (2007). Packaging unwrapped, *New Scientist*, 194(2598), pp. 37–41.
- 32) Masi, D. et al. (2018). Towards a more circular economy: exploring the awareness, practices, and barriers from a focal firm perspective, *Production Planning & Control*, 29(6), pp. 539–550. Available at: <https://doi.org/10.1080/09537287.2018.1449246>.
- 33) Mason, W.R. (1958). A theory of packaging in the marketing mix, *Business Horizons*, 1(3), pp. 91–95. Available at: [https://doi.org/10.1016/0007-6813\(58\)90082-X](https://doi.org/10.1016/0007-6813(58)90082-X).
- 34) Mathrani, A. et al. (2023). Clustering analysis on sustainable development goal indicators for forty-five asian countries, *Sci*, 5(2), p. 14.
- 35) Matlhare, Monnapule (2024). *EU Packaging and Packaging Waste Regulation - A New Dawn or A Fading Twilight?*.
- 36) Murphy, P.R., Poist, R.F. and Braunschweig, C.D. (1994). Management of environmental issues in logistics: current status and future potential, *Transportation journal*, pp. 48–56.
- 37) Park, J., Cuervo-Cazurra, A. and Montiel, I. (2023). Chapter 2: The evolution of sustainability concerns over business activities: from local to cross-national to global, in. Available at: <https://www.elgaronline.com/edcollchap/book/9781802207040/book-part-9781802207040-7.xml> (Accessed: 16 March 2025).
- 38) Ragonnaud, G. (2023). Revision of the Packaging and Packaging Waste Directive, *European Parliamentary Research Service* [Preprint]. Available at: <https://bioplasticsnews.com/wp-content/uploads/2023/10/PPWD-Revision.pdf> (Accessed: 17 March 2025).
- 39) Rundh, B. (2016). The role of packaging within marketing and value creation, *British Food Journal*, 118(10), pp. 2491–2511.
- 40) Sarangi, U. (2023). CIRCULAR ECONOMY AND ITS IMPLICATIONS IN ACHIEVING THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS AND 2030 AGENDA, *International Journal of Legal Studies (IJOLS)*, 14(2), pp. 481–497.
- 41) Soroka, W. (1999). Paper and paperboard, *Embelm and H. Embelm (Eds.)*, pp. 95–112.

- 42) Eurostat (2024). Available at: https://ec.europa.eu/eurostat/databrowser/view/cei_pc050/default/table?lang=en&category=cei.cei_pc (Accessed: 17 March 2025).
- 43) Svanes, E. *et al.* (2010). Sustainable packaging design: a holistic methodology for packaging design, *Packaging Technology and Science*, 23(3), pp. 161–175. Available at: <https://doi.org/10.1002/pts.887>.
- 44) Szymankiewicz, J. (1993). Going green: The logistics dilemma, *Logistics Information Management*, 6(3), pp. 36–43.
- 45) Van Buren, N. *et al.* (2016). Towards a circular economy: The role of Dutch logistics industries and governments, *Sustainability*, 8(7), p. 647.
- 46) Vuk, A., Szűcs, I. and Bauerné Gáthy, A. (2023). Packaging waste and recycle in EU, *International Review of Applied Sciences and Engineering*, 14(3), pp. 402–412. Available at: <https://doi.org/10.1556/1848.2023.00615>.
- 47) Yam, K.L. (2010). *The Wiley Encyclopedia of Packaging Technology*. John Wiley & Sons.

CONSUMER AWARENESS AND BEHAVIOURAL DYNAMICS IN THE CIRCULAR ECONOMY OF THE REPUBLIC OF MOLDOVA IN THE CONTEXT OF SUSTAINABLE TRANSITION

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Abstract.

The circular economy is a crucial model for transitioning towards sustainability, yet its success largely depends on consumer awareness and behavioural dynamics. This study examines consumer behavior in the Republic of Moldova regarding circular economy principles, focusing on awareness levels, motivations, and barriers to adopting circular practices. The research employs a quantitative methodology, utilizing a structured questionnaire administered to a representative sample, combined with an advanced analysis of psychological and behavioural factors. To introduce an innovative dimension, the study integrates psychometric models such as perceived behavioural control and proposes a circular economy readiness index to assess consumer preparedness for sustainable behaviour. Additionally, an A/B testing experiment is conducted to evaluate the effectiveness of different behavioural messages (environmental, economic, social) in influencing consumer attitudes. Complementary to this, behavioural clustering analysis is applied to segment Moldovan consumers based on their engagement in circular economy practices, thus identifying distinct consumer profiles. The findings reveal that, while there is an increasing openness towards the circular economy, significant discrepancies exist between declared intentions and actual behaviours. These gaps are influenced by factors such as insufficient infrastructure, the high costs of sustainable alternatives, and the limited impact of awareness campaigns. The study also highlights the importance of a tailored approach in promoting circular economy principles through messages adapted to the socio-cultural context of the Republic of Moldova. The conclusions provide valuable insights for developing more effective public policies, designing evidence-based awareness campaigns, and refining circular marketing strategies. This research contributes to the existing literature by combining advanced quantitative methods and

behavioural psychology to deepen the understanding of the transition towards a sustainable economic model.

Keywords: *circular economy, consumer behaviour, behavioural models, sustainable transition.*

JEL Classification: Q56, D12, Q01, D91, M31

1. INTRODUCTION

The circular economy (CE) is increasingly being conceptualised as a viable model for sustainable development, offering an alternative framework to the traditional linear "produce-use-dispose" paradigm. It promotes maintaining the value of products, materials and resources in the economy for as long as possible, concomitant with reducing waste and primary resource use (Geissdoerfer *et al.*, 2017; Niculescu, 2025; Toma & Corețchi, 2024). The transition to CE requires a systemic conversion, involving both supply-side actors – producers, designers, distributors – and demand-side actors – primarily consumers (Kirchherr *et al.*, 2017; European Environment Agency [EEA], 2022).

In the literature, there is growing evidence that the success of a circular model depends not only on technological innovations and institutional regulations, but also on consumers' ability to understand, accept and incorporate sustainable behaviours into their daily lives (Maitre-Ekern & Dalhammar, 2019). However, empirical research shows that public awareness of CE remains low and consumers are not sufficiently familiar with the concept, especially in Eastern European countries (Kirchherr *et al.*, 2017; Georgescu *et al.*, 2025; Pascal, 2025).

In the Republic of Moldova, circular economy remains an emerging concept, present more at the level of political discourse and pilot initiatives, rather than as a widespread practice in society. According to an analysis conducted by the National Institute for Economic Research (Popa *et al.*, 2022), the penetration of circular principles in consumption behaviour is low, affected by a lack of infrastructure, economic incentives and a weak culture of sustainability. Although Moldova has signed several international commitments on sustainable development and aligned with the European Green Pact, the concrete implementation of CE strategies is still at an early stage (Ministry of Environment RM, 2023).

In order to understand the psychological mechanisms underlying the pro-environmental behaviour of Moldovan consumers, this research adopts the Theory of Planned Behavior (TPB) model formulated by Ajzen (1991) as its theoretical foundation. According to TPB, the intention to adopt a behaviour is influenced by attitudes, perceived social norms and perceived behavioural control (PBC). In the CE context, this model provides a relevant framework to analyse to what extent individual, social and contextual factors determine consumers' willingness to adopt sustainable behaviours (Yuriev *et al.*, 2018).

The literature outlines five key dimensions influencing circular behaviour: economic factors (perceived costs and benefits), environmental information and education, infrastructure availability, social influences and personal values (EEA, 2022; European Commission, 2020a). In Moldova, recent survey evidence (Rusu, 2022) suggests that the main motivation for pro-environmental behaviours is economic, followed by concern for family health and influence of community norms. However, behaviours such as recycling, repairing objects or buying second-hand products are still perceived as difficult or uncomfortable, reflecting low behavioural control.

Against this background, the present research aims to systematically assess the level of behavioural and cognitive readiness of Moldovan consumers towards the circular economy, exploring attitudes, motivations, perceived barriers and the influence of different types of sustainable messages. The project integrates quantitative (standardised questionnaire applied to a representative sample) and qualitative (thematic analysis of open-ended responses) methods in order to outline a complete psychosocial profile of the circular consumer in the Republic of Moldova.

As there are so far no extensive studies on Moldovan consumers' perceptions of the circular economy, this research contributes to filling a significant epistemological gap. At the same time, its results can be used as a basis for tailored public policies (e.g. environmental education campaigns, financial incentive mechanisms) as well as social marketing strategies capable of stimulating the behavioural transformation necessary for the circular transition. Involving consumers in this process is essential for achieving sustainable development goals, and understanding the motivations and obstacles from a Moldovan contextual perspective provides useful benchmarks for institutional, economic and educational actors.

2. METHODOLOGY

The present study was based on the use of a complex questionnaire, structured to comprehensively capture the perceptions, motivations and behaviours of Moldovan consumers in relation to the transition to the circular economy. The research was conducted in the first half of 2025, in a context in which public interest in sustainability is visibly growing, but in which, according to recent data, the level of public engagement in circular actions remains fragmented and dependent on a number of contextual and cultural factors (Popa *et al.*, 2022).

The research instrument integrated both quantitative items, designed based on models validated in the international literature (Ajzen, 1991; Kirchherr *et al.*, 2017), and open-ended questions, aimed at capturing the motivational nuances and subjective perceptions of respondents. The targeted dimensions included awareness and familiarity with the circular economy, as measured by self-

perceptions of knowledge about concepts such as recycling, reuse or waste minimisation, as well as attitudes towards individual responsibility in adopting sustainable practices. At the same time, the research sought to highlight the barriers perceived by participants in applying pro-environmental behaviours – difficulties associated with poor infrastructure, perceived high costs or lack of information – but also possible solutions formulated from an individual perspective that can guide future public policy interventions.

Another key aspect was to explore the frequency of self-reported circular behaviours, such as recycling household waste, reusing goods, repairing objects, consuming environmentally friendly products or reducing the use of disposable items, all of which were correlated with perceptions of behavioural control and self-efficacy – relevant theoretical dimensions in the TPB model (Ajzen, 1991). The respondents' readiness and intention to actively support the transition to the circular economy, even when assuming changes in daily habits, was also investigated.

To test the responsiveness of consumers to different persuasive strategies, the questionnaire included an applied mini-experiment in which participants were successively exposed to three types of visual messages, each centred on a distinct motivational dimension: environmental benefit, personal economic advantage and positive community impact. The effectiveness of these messages was assessed by self-reporting the perceived level of motivation, complemented by brief qualitative reflections on the emotional and rational relevance of the received content – an increasingly used method of investigation in contemporary research on sustainable behaviour (Lisenco, 2024).

The questionnaire was distributed electronically via the Google Forms platform, ensuring complete confidentiality of responses. The sample was obtained through the convenience method, mainly formed by distributing the link in social and academic networks with the support of the researchers involved. In total, 352 valid questionnaires were collected, providing a solid basis for exploratory analysis. The socio-demographic profile of the respondents reveals a predominance of highly educated individuals: almost half of the participants hold doctoral or postdoctoral degrees, a significant proportion have bachelor or master degrees, and a smaller proportion have secondary school or vocational education. The gender distribution was relatively balanced, with a slight female predominance, and the age structure reflected a balanced coverage of the adult and mature segments of the population.

In terms of financial status, the data suggest a concentration of respondents in the middle and above-middle income categories, although about one-fifth of participants chose not to report this information. This demographic structure of the sample indicates a predominantly urban and educated orientation, characteristics associated in the literature with a higher likelihood of engaging in sustainable behaviours (EEA, 2022; Rusu, 2022). This methodological peculiarity

is important to keep in mind at the stage of data interpretation and generalisation of conclusions.

The analysis of the sample structure reveals a relatively balanced representation in terms of demographics, with a slight preponderance of people with higher education. This can be interpreted as a reflection of a higher interest in the topics of sustainability and civic engagement among the educated segment of the population – a result that is also in line with the findings of other research conducted at the national level (Gribincea, 2024). In terms of familiarisation with the circular economy, the data indicate that the majority of respondents are at a medium or high level of knowledge (score ≥ 3), suggesting a relative penetration of the concept in the Moldovan public discourse. However, about 15% of the sample report a pronounced lack of knowledge (scores of 1 or 2), reflecting a systemic problem of communication and information dissemination among certain social groups – a barrier also frequently signalled in the literature (Kirchherr *et al.*, 2017; Georgescu *et al.*, 2025).

For quantitative data processing, Likert items were numerically coded from 1 to 5, representing extremes of disagreement/agreement or behavioural frequency. For analytical purposes, part of these scores were recoded on a symmetric scale from -2 to +2, where the neutral value (3 - 'indifferent') was transformed to 0. This procedure allows a more intuitive interpretation of the averages: positive values indicate a tendency towards approval or adoption, while negative values signal resistance or rejection. The approach was inspired by the methodology used in studies of pro-environmental attitudes in transitional contexts (Yuriev *et al.*, 2018).

In parallel, open-ended qualitative responses were subjected to thematic content analysis using an inductive approach to identify emerging themes. This allowed the classification and quantification of proposals related to the promotion of circular behaviours (e.g. Coding was carried out by two independent researchers to ensure inter-coder validity and the categories identified were then statistically quantified (e.g. percentage of respondents mentioning each theme).

A central element of this research was the construction of a composite index of individual readiness for the circular economy. This index was defined as the sum of the scores on four core items: (1) intention to adopt circular behaviours, (2) active engagement in outreach, (3) behaviours already exhibited, and (4) personal perception of readiness for the circular transition. Each item was rated on a scale from 1 to 5, resulting in a total score between 4 and 20. The index thus constructed allows a synthetic assessment of respondents' behavioural and cognitive readiness for the changes needed in a circular economy – a method also used in international research on participatory sustainability (Oberholzer *et al.*, 2021).

The results were statistically analysed by means, distributions and proportions, and significant differences between demographic groups (gender, age, education level) were tested by comparisons of means (t-test, ANOVA) and

proportions (chi-square), depending on the nature of the variables. The interpretations obtained were correlated with the theoretical hypotheses formulated in the introductory framework (Ajzen, 1991) and with the results obtained in the literature, including studies applied in the Republic of Moldova (Popa *et al.*, 2022; Rusu, 2022).

This integrative approach – quantitative and qualitative – allows not only to measure circular behaviours, but also to understand the motivations and subjective bottlenecks of Moldovan consumers. Therefore, the proposed analysis is in line with international methodological standards and responds to the urgent need for empirical substantiation of public policies for ecological transition in a country still at the beginning of this process.

3. RESULTS

Assessing the level of public awareness and familiarity with the concepts and practices of the circular economy (CE) is an essential step in understanding societal readiness for the transition to sustainable patterns. The data obtained from the present study reveal that, in the case of the Republic of Moldova, there is a relatively solid perceptual base regarding the concept of CE, but with important variations according to age, educational level and professional experience.

To the question "To what extent have you heard of and understand the concept of circular economy?", a significant percentage of the respondents – approximately 66.5% – indicated an above average level of familiarity. The most frequent answer was "4" ("somewhat familiar"), selected by almost half of the participants (Fig. 2), suggesting that most of them have been exposed to the basic concepts of CE, albeit in an informal manner (Țurcan *et al.*, 2021). About 17% declared themselves "very familiar" (score 5), while at the opposite pole were about 8% who had not heard of the concept at all and another 8% who had only vaguely heard of it. These data indicate a partial and heterogeneous awareness, typical of a socio-economic context in which CE is still in its institutional emergence phase (Popa *et al.*, 2022).

The detailed analysis by age group shows that the 36-45 age group has the highest average level of familiarity (mean score ~4.36), followed by the 46-55 age group (~4.07). In contrast, younger respondents (18-35 years) report a significantly lower level of familiarity (mean ~3.0), which can be explained by a lower exposure to institutional contexts (jobs, vocational training) in which the CE has been promoted. The elderly (>56 years) also show an intermediate level of familiarity (mean ~3.39), possibly influenced by limited access to up-to-date information sources. Thus, it is hypothesised that middle age, correlated with active professional involvement, is a favourable factor for exposure to circular concepts (Ministry of Environment RM, 2024).

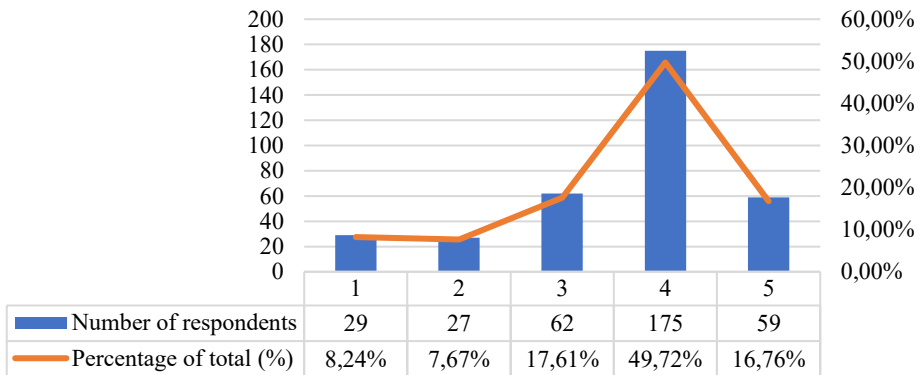


Figure 1. Level of familiarisation with circular economy practices and sources of information about the concept.

Source: Diagram by the authors, based on data collected in the study on consumer behaviour towards the circular economy (2025)

Education level was also found to be a significant predictor of familiarity. Respondents with higher education, especially those working in higher education or research, had significantly higher scores, confirming the link between educational capital and access to sustainability concepts (Georgescu *et al.*, 2025; Prisac & Pop, 2024). This correlation is in line with other European studies highlighting that high educational attainment is a strong determinant of pro-environmental behaviours (EEA, 2022).

To get a more nuanced picture of the degree of practical internalisation of the circular economy, a separate question on familiarity with concrete practices associated with CE was introduced: "How familiar are you with circular economy practices such as recycling, reusing or repairing products?". The distribution of responses reflected a general trend towards higher levels of familiarity, with 36% of respondents declaring themselves "very familiar" (score 5) and a further 40% selecting score 4. Only 5% of participants said they were not at all familiar with such practices.

These results could suggest a "practice without conceptualisation", in the sense that individuals are already resorting to some circular actions (recycling, reuse of packaging, repair), but without explicitly associating them with the circular economy paradigm. Thus, there is a dissonance between the theoretical recognition of the term and the practical application of the related principles, a phenomenon also observed in other studies conducted in Eastern Europe (Kirchherr *et al.*, 2017).

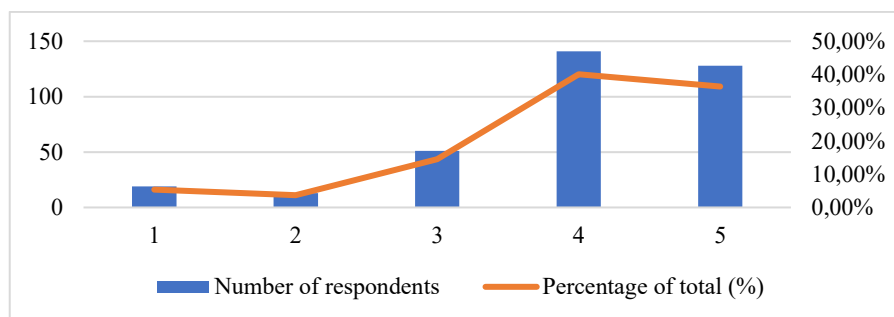


Figure 2. Level of familiarisation with circular economy practices such as recycling, reusing or repairing products

Source: Authors' diagram based on data collected in the study on consumer behaviour towards the circular economy (2025)

It is important to note that certain circular behaviours - such as reusing bags or selective collection – have become more common in the Moldovan public space, partly due to environmental education initiatives carried out in schools and universities, but also under the influence of European regulations transmitted through pre-accession programmes. However, deep internalisation of the CE concept as part of a responsible consumer culture is far from widespread.

In the conceptual architecture of the transition to the circular economy (CE), the level of familiarity of consumers with the principles and practices of the circular economy model becomes a key predictor of the internalisation of sustainable behaviours. In particular, in emerging contexts such as the Republic of Moldova, public understanding of the circular economy dimension not only reflects the maturity of the national environmental discourse, but is also an indirect indicator of the effectiveness of formal and informal education mechanisms, as well as the thematic penetrability in the sphere of social communication (EEA, 2022; Kirchherr *et al.*, 2017).

The data obtained following the application of the survey instrument indicate a significantly concentrated distribution in the upper range of the familiarity scale (Figure 2), with more than 60% of respondents reporting scores of 4 and 5, corresponding to a high degree of exposure or practical experience in recycling, reuse or repair. This finding can be interpreted as reflecting an emerging form of ecological capital, as conceptualised in Bourdieu's theoretical conceptualisations, in which familiarity with circular norms and practices is a distinguishing element among the urban educated population (Sârbu, 2022; Perciun *et al.*, 2022; Plotnic & Praporșic, 2024).

From the perspective of information dissemination, the analysis of the sources through which respondents first came into contact with the notion of CE reveals a central role of the formal education system. Thus, about 19% of the participants identify university or pre-university education as the primary vector

of conceptual exposure. This empirical reality validates the hypothesis that universities can act as agents of systemic change, contributing to the ecological socialisation of new generations by including sustainability content in the curriculum (Putregai, 2024; Diaconu, 2025).

In second place is the generalist media (14%), indicating a still timid but noticeable presence of the circular theme in the public space. The low presence of the digital medium – in particular the Internet (3%) and social networks (less than 3%) – as primary sources of information can be explained by a different perception of the legitimacy of sources: respondents tend to favour institutionalised or socially validated sources over informal or perceived as ephemeral ones (Ganea, Trushkina, & Țîrlea, 2022). Only 2.8% stated that they had no previous exposure to the concept of CE, signalling a relatively high degree of terminological penetration, although the complexity and depth of understanding remain to be investigated.

3.1. Value structures and behavioural motivations - from awareness to intention

Following the analysis, we explored the axiological dimension of consumers' relationship to the circular economy by asking them to express their degree of agreement with a series of evaluative statements. The responses highlight a normative climate deeply favourable to the adoption of pro-environmental behaviours, shaped around the principles of individual responsibility and the internalisation of the social utility of environmental actions (Figure 3).

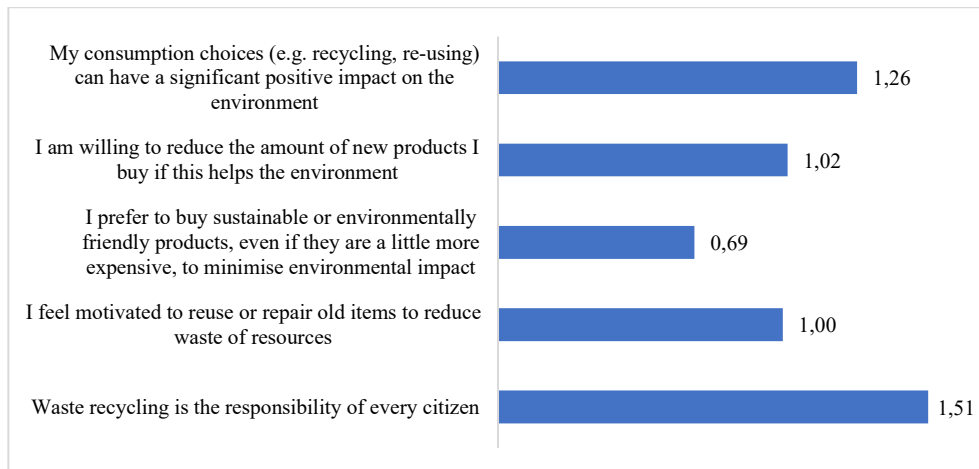


Figure 3. Respondents' level of agreement with statements on pro-environmental behaviour in the context of the circular economy

Source: Authors' chart based on data collected in the study on consumer behaviour towards the circular economy (2025)

The statement "Recycling is the responsibility of every citizen" obtained an average score of +1.51 (on a -2:+2 scale), configuring an almost hegemonic consensus on the moral imperative of individual waste management. This trend is congruent with the recent literature on the greening of social norms in post-communist Eastern Europe (Georgescu *et al.*, 2025).

Behaviours such as repairing or reusing products (+1.00), reducing consumption (+1.02) and positive perceptions of the impact of personal choices (+1.26) support the idea of a normative horizon favourable to behavioural change. In contrast, the willingness to pay a higher price for environmentally friendly products scored significantly lower (+0.69), suggesting that the economic factor still functions as an instrumental rationality filter (Diaconu, 2025).

The results suggest that, despite a still underdeveloped institutional infrastructure, there is a significant declarative willingness to engage in circular behaviours, to the extent that they are supported by favourable external conditions and persuasive strategies tailored to the socio-cultural context (Perciun *et al.*, 2022). This dynamic can form the basis for the development of integrated communication campaigns with the potential to transform latent predispositions into manifest and sustainable behaviours.

While the literature emphasises the importance of a positive normative orientation for a successful transition to the circular economy (EEA, 2022; Kirchherr *et al.*, 2017), the application of these principles in practice depends on a range of cognitive, structural and motivational factors. Our research results highlight an interesting convergence between favourable attitudes towards sustainable behaviours and perceived systemic difficulties in adopting them in everyday life, reflecting the intention-action divide – an issue extensively theorised in the planned behaviour model (Ajzen, 1991).

The aggregated attitudinal values (Figure 3) show that respondents declaratively adhere to pro-environmental norms, with a notable consensus on individual responsibility for recycling (+1.51), reuse and responsible consumption. This profile is comparable with the results of recent national surveys (Diaconu, 2025; Gribincea, 2024), which signal an emergence of a green civic ethos among the educated population, especially the young urban segment. However, the willingness to pay an additional price for green products (+0.69) suggests the persistence of economic constraints as a decision filter (Ganea *et al.*, 2022; Georgescu *et al.*, 2025).

In terms of perceived barriers (Figure 4), the data clearly highlights the lack of infrastructure as the main barrier, with an average score of 4.19/5. This finding aligns with the European literature which argues that lack of easy access to circular options undermines voluntary participation even by those willing to contribute (EEA, 2022; Perciun *et al.*, 2022). In Moldova, difficulties related to separate waste collection, lack of repair centres and absence of effective systems

to reward green behaviour constitute major systemic limitations (Ministry of Environment RM, 2023).

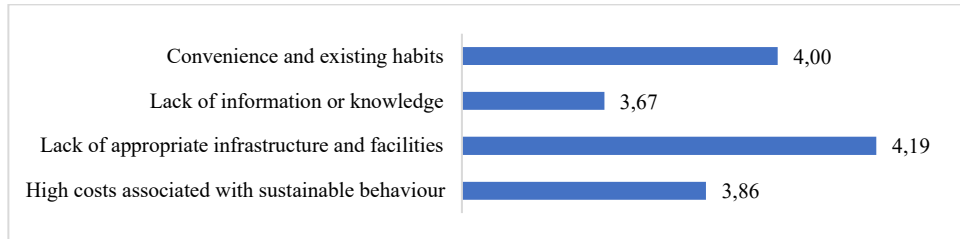


Figure 4. Attitudes, perceived barriers and suggested solutions on sustainable behaviour (aggregated results)

Source: Authors' diagram based on data collected in the study on consumer behaviour towards the circular economy (2025)

The second major barrier identified is resistance to behavioural change and the convenience of existing habits (4.00/5). This 'cognitive inertia', associated with everyday automatisms – such as throwing waste in one container or a preference for disposable products – is often more difficult to change than lack of knowledge per se (Thøgersen, 2013). Although the majority of respondents state that they 'know what they should do', putting it into practice is inhibited by the lack of concrete facilities and the absence of accessible alternative routines.

The high costs associated with green products (3.86/5) and lack of information (3.67/5) complete the picture of perceived barriers. Although the latter is perceived as a relatively less severe barrier, it remains significant in the context of the lack of systematic environmental education in schools or effective institutionalised communication campaigns (Putregai, 2024; Ganea *et al.*, 2022).

3.2. Motivational profiles – between value idealism and economic pragmatism

The thematic analysis of the responses to the open-ended questions confirms the existence of a motivational duality among respondents. The majority justify engaging in sustainable behaviours either by intrinsic motivations – such as the desire to live in a healthy and safe environment for themselves and their children – or by economic rationales – in particular the desire to reduce expenditure by reusing or avoiding waste. Mentions such as "care for the future", "money saved" or "I was brought up to care for the environment" outline two distinct psychosocial segments: an idealistic, value-based one and a pragmatic, instrumental one (Rusu, 2022).

The presence of family values, early education and an informally formed environmental consciousness suggest a positive internalisation of sustainability norms in certain social groups. At the same time, the almost complete absence of references to social conformity, external rewards or injunctive norms imposed by

the community indicate a relatively low level of social ecological pressure - which limits the potential for behavioural spread through mimicry (Ajzen, 1991; Steg & Vlek, 2009).

Based on these findings, it can be argued that the Moldovan public exhibits an encouraging degree of 'readiness' for the circular transition, but its manifestation is contingent on the existence of structural facilities, supportive policies and coherent value narratives in the public space. Strengthening the existing ecological capital requires coordinated systemic interventions in which education, infrastructure and economic incentives act synergistically.

Research results indicate that economic barriers are a major constraint to the adoption of circular behaviours among Moldovan consumers. The high costs associated with sustainable products and services – such as the higher prices of green goods, the expense of repair services or upfront investments in green technologies – are rated as a significant impediment, with an average score of 3.86 on a scale of 1 to 5. This result reflects converging findings in the international literature, which emphasise that factors such as price and affordability are key determinants in consumer decision-making (EEA, 2022; Schröder *et al.*, 2018).

This perception is also supported by research conducted in the Republic of Moldova, which indicates a pragmatic reluctance towards the costs associated with green products, especially among low-income population segments (Diaconu, 2025; Rusu, 2022). Thus, although many consumers express agreement in principle with sustainability, the practical implementation of circular choices is often limited by objective financial constraints. This discrepancy between declarative attitudes and actual behaviour is also documented in studies by Kirchherr *et al.* (2017), who identify the 'green intention-action gap' as one of the major challenges for circular policies.

Seemingly counterintuitively, the lack of information and knowledge is perceived as the least severe of the barriers analysed, yet scores 3.67. This result can be interpreted in terms of the profile of the sample, which is predominantly made up of highly educated people already familiar with the sustainability discourse. At the same time, some of the respondents emphasised that, although they do not experience informational difficulties, the general public might be more vulnerable to confusion about correct circular practices – especially in the absence of coherent environmental education campaigns (Ganea, Trushkina & Țîrlea, 2022).

It is relevant to note that the perception of barriers is influenced more by age-related variables than by gender. While there were no significant differences between men and women, respondents in the over 56 age group rated infrastructural and routine-related barriers as more salient, which may be associated with poorer behavioural adaptability and reduced exposure to recent environmental initiatives (Sârbu, 2022; Perciun *et al.*, 2022).

3.3. Perceived solutions to overcome barriers – a participatory approach

Based on the answers to the final open-ended question, we extracted a set of solutions proposed by the participants to facilitate the transition towards circular behaviours. These have been summarised thematically in Figure 5, reflecting a coherent spectrum of interventions that can be subsumed under the three pillars of behavioural change: awareness, infrastructure and public policy.

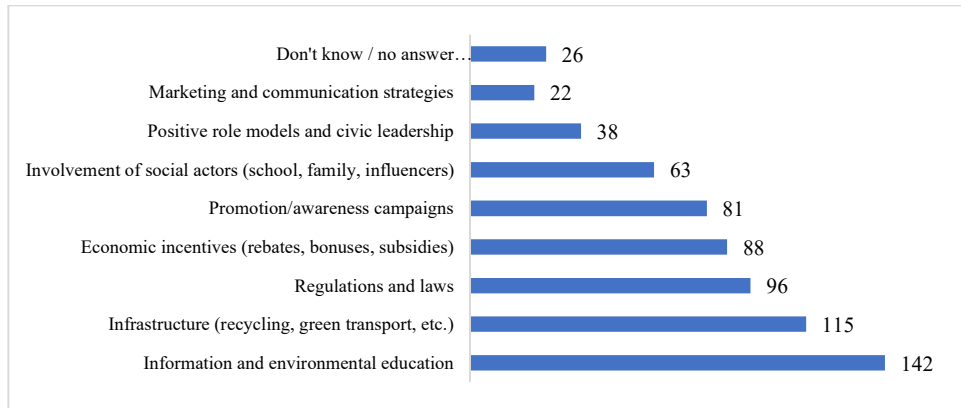


Figure 5. Perceived solutions to facilitate sustainable consumption behaviour in the Republic of Moldova

Source: Diagram by the authors, based on data collected in the study on consumer behaviour towards the circular economy (2025)

The most frequently mentioned solution (around 40% of respondents, equivalent to 142 mentions) is to step up environmental information and education programmes. Participants called for education initiatives in schools, universities, local communities and through the media, arguing that the process of behavioural change starts with an understanding of the individual's impact on the environment. This priority is in line with international and European literature emphasising the role of education in enhancing sustainable behaviour (OECD, 2024; EEA, 2022; UNEP, 2025), but also with recent Moldovan initiatives promoted through the National Environmental Strategy (Ministry of Environment, 2022).

The second major category of proposed solutions (115 mentions) concerns the development of infrastructure for selective collection, recycling and reuse. This includes requests for the extension of the network of recycling containers, the creation of local repair and reuse centres and the improvement of sanitation services. These aspects confirm that adequate infrastructure is perceived as a key enabler of circular choices, as argued by Batista *et al.* (2018), who highlight the interdependence between environmental infrastructure and consumer behaviour.

A third direction of intervention indicated by respondents relates to public regulation and policy. A total of 96 respondents called for coercive and

incentivising legislation, such as mandatory separate waste collection, bans on single-use plastic products, or economic policies such as "pay-what-you-throw". Another 88 respondents supported the implementation of economic incentives – tax rebates, subsidies for circular products or rewards for pro-environmental behaviour – to mitigate the financial barriers identified above. These recommendations converge with European good practices, which point to the effectiveness of a combination of legislative measures and financial instruments in accelerating the green transition (Saulītis *et al.*, 2024; Yin *et al.*, 2021).

A recurring element in participants' qualitative responses concerns the identification of concrete solutions to accelerate the transition towards sustainable consumption behaviour. Thus, 81 respondents made proposals for more attractive and effective public awareness campaigns, suggesting the involvement of persuasive tactics such as interactive community events (e.g. greening actions), innovative media spots, and appealing to opinion leaders – public figures, local influencers or ambassadors of green behaviour (Ganea, Trushkina, & Țîrlea, 2022). Another 63 mentions underline the need to involve key social actors – schools, family, media - in the early formation of environmental norms, an idea in line with the international literature on early education as a vector for internalising sustainability values (Gribincea, 2024).

Promoting tangible positive examples, through narrative strategies and inspirational storytelling, was mentioned by 38 participants, while 22 highlighted the role of sustainable marketing in transforming circular products into 'aspirational' and 'trendy' alternatives – observations that resonate with global trends on the greening of the consumer imaginary (Prothero *et al.*, 2011; European Commission, 2020b).

Only around 7% of respondents did not offer any suggestions, indicating a high level of cognitive engagement with circular issues. Overall, these results confirm the existence of a systemic perception of change – with respondents recognising the interdependence between infrastructure, education, regulations and incentives, in an approach consistent with circular governance principles (Loorbach *et al.*, 2017). At the same time, there is a favourable attitude towards state and local government intervention to support the consumer, which provides a basis of legitimacy for proactive and participatory eco-social policies (Perciun *et al.*, 2022; Mies & Gold, 2021).

3.4. Reported circular consumption practices and perceptions of behavioural control

The applied dimension of the research included the assessment of the self-reported frequency of specific circular economy behaviours. Figure 4 (top) summarises data on the adoption of five circular practices in everyday life: reusing packaging, avoiding single-use products, repairing items, second-hand/environmentally friendly shopping and recycling waste.

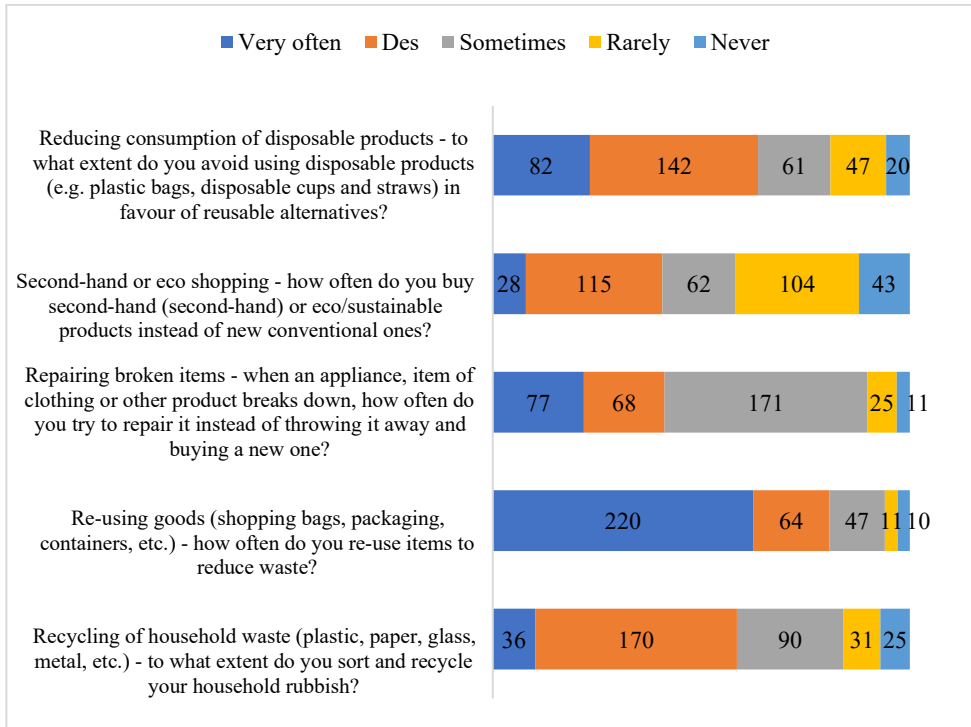


Figure 6. Frequency of adoption of circular economy behaviours and perception of behavioural control

Source: Authors' diagram based on data collected in the study on consumer behaviour towards the circular economy (2025)

Re-use of goods (bags, jars, packaging) is the most commonly practised behaviour, mentioned as "often" or "very often" by around 80.7% of respondents. This behaviour has strong socio-cultural roots, stemming from an ethos of thrift inherited from the Soviet period, but is increasingly also supported by current environmental beliefs (Diaconu, 2025). Gender differences are notable: women tend to show a higher frequency in reuse (66.5% stating that they practice this behaviour very often) compared to men (56.6%), reflecting a continuity in domestic roles in which women manage household resources (Popa *et al.*, 2022).

Avoidance of disposable products (such as disposable plastic or disposable cutlery) is common for 63.6% of respondents. A more constant involvement is observed from women, who are more sensitive to the environmental implications of household waste (Rusu, 2022). The male segment includes both an active core (37% say they always avoid disposables) and a significant passive extreme (~12% do not do so at all).

In terms of recycling household waste, approximately 58.5% of respondents report that they do it frequently, while ~16% rarely or never recycle. These results

reflect the infrastructural deficiencies reported in other studies (Ministry of Environment RM, 2023), especially in rural or peri-urban areas, where selective collection services are uneven or absent. Gender-differentiated analysis reveals a slight superiority of women in consistent recycling – a finding in line with the literature on gender and environmental behaviours (Iordachi, 2024; Șavga *et al.*, 2023).

Repairing broken items is a practice endorsed by about 90% of participants, with over 40% indicating that they do it frequently. This is evidence of do-it-yourself cultural capital that supports product longevity – an essential component of the circular economy (Bocken *et al.*, 2016). Men more often report technical repairs, and women in the area of textiles and light maintenance - reflecting both traditional labour distributions and informally acquired skills.

In contrast, the behaviour with the lowest adoption rate is second-hand or green shopping. Only 8% of respondents say they do it very often, and over 40% admit to doing it infrequently or not at all. In contrast to other behaviours, a trend reversal prevails here: men are more likely to buy second-hand products, which can be correlated with a more pragmatic approach to consumption or with experiences related to purchases of electronics, cars, etc. (Putregai, 2024).

The dimension of perceived behavioural control (Figure 4, bottom) indicates a high degree of self-efficacy: more than 70% of the participants believe that they have the knowledge and ability to act in a circular way. However, only 45% feel fully able to adapt their daily routines in a sustainable way, suggesting a gap between intention and implementation – an aspect well documented in the theory of planned behaviour (Ajzen, 1991; Yuriev *et al.*, 2020).

The empirical data obtained confirms the existence of a significant gap between declarative intention and actual behaviour, a phenomenon often documented in the sustainability literature (Ajzen, 1991; Bamberg & Möser, 2007). Although respondents show favourable attitudes towards circular economy values, their translation into concrete behaviours is filtered through structural factors such as access to recycling infrastructure, availability of green products on the market and local logistical support (Diaconu, 2025; Perciun *et al.*, 2022). However, the results indicate a relatively high degree of participation in circular behaviours – especially in terms of reuse, waste avoidance and adoption of responsible consumption practices – suggesting a functional emergence of circular culture in educated urban environments in the Republic of Moldova (Ganea *et al.*, 2022).

3.5. Self-efficacy and perceived behavioural control - premises for action

A key dimension investigated was the level of Perceived Behavioral Control (PBC), defined as an individual's perception of the ease or difficulty of adopting pro-environmental behaviours (Ajzen, 1991). Figure 4 (bottom) summarises the distribution of responses to the items on this dimension.

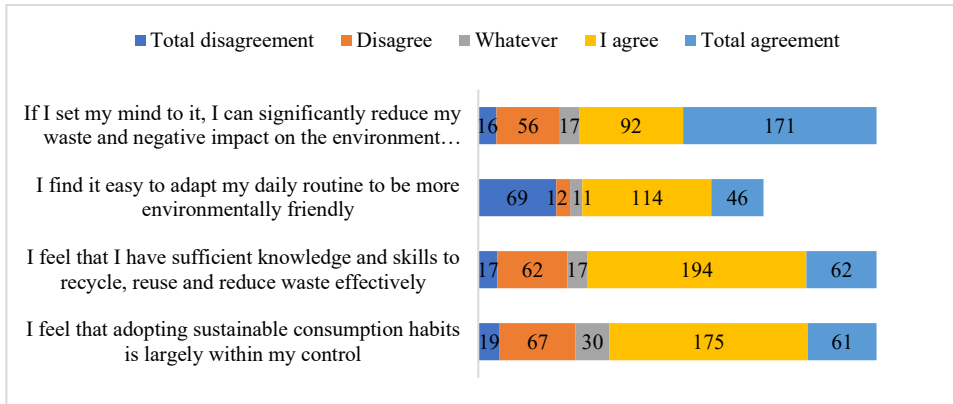


Figure 7. Perceived behavioural control over circular actions

Source: Diagram drawn by the authors, based on data collected in the study on consumer behaviour towards the circular economy (2025)

The majority of respondents (74.7%) agreed or strongly agreed with the statement: 'If I set my mind to it, I can significantly reduce my waste and negative environmental impact through my actions', reflecting a robust level of self-efficacy. This perception is a key catalyst for sustainable behaviour according to validated theoretical models (Yuriev *et al.*, 2020).

At the same time, 72.7% reported having sufficient knowledge and skills to recycle, reuse and reduce waste efficiently. This finding indicates the relative effectiveness of educational campaigns targeting the educated urban segment, as well as an increased autonomous capacity to internalise and apply environmentally friendly behaviours (Gribincea, 2024).

In terms of sense of control over the implementation of sustainable habits, 67% stated that these behaviours are "mostly under my control", while 24% expressed some degree of distrust in their own ability to act. These results highlight the persistence of perceived systemic barriers, such as insufficient infrastructure or time and resource limitations, also identified in other indigenous research (Sârbu, 2022).

The statement about the ease of integrating sustainable routines into daily life obtained a below expected level of agreement (45.5%), while 31.5% expressed a neutral position. This behavioural ambivalence reflects the adaptive difficulties frequently reported in studies of resistance to change in the sustainability sphere (Steg & Vlek, 2009).

3.6. Circular readiness index: integrated assessment of transition potential

To operationalise the concept of "behavioural readiness for the circular transition", a composite Circular Economy Readiness Index was developed, consisting of four components: declarative intention, current circular behaviours,

level of information and perceived self-efficacy. The average score obtained by the sample was 15.75 out of 20, equivalent to 78.7% of the maximum potential – a high level of readiness for transition, at least among the educated segment (Ganea *et al.*, 2022).

The distribution of this index highlights significant gender and age differences: women had a higher mean score (~16.99) than men (~13.93), and seniors (56+) outperformed the 46-55 group, possibly due to a post-career value conversion towards environmental concerns (Rusu, 2022). These results support the hypothesis that socio-demographic factors significantly influence the predisposition towards circular behaviours (Georgescu *et al.*, 2025).

3.7. Receptivity to sustainable messages – testing the impact of motivational framing

An innovative contribution of the research is the comparative evaluation of the effectiveness of pro-sustainable messages according to the motivational framing strategy: ecological, economic and community. The results support the hypothesis that community anchored messages generate the strongest attitudinal mobilisation: more than 82% of the respondents rated this type of message positively. The favourable emotional impact is also demonstrated by the content of the qualitative responses – e.g. "I feel motivated knowing that I can influence others", which reflects the activation of collective prosocial values (Cialdini *et al.*, 1990).

Economic-based messages generated a polarised response – attractive to one segment but perceived as insufficiently relevant or even cynical by others. This ambivalence has also been documented in international studies on motivational crowding-out in environmental communication (Bolderdijk *et al.*, 2013). In contrast, the environmental message, although value resonant, was assessed as less mobilising, possibly due to narrative saturation and high familiarity with this type of discourse (EEA, 2022).

Gender-differentiated analysis reveals an increased receptivity of women to all three messages, especially the economic one, contrary to traditional stereotypes. This may be associated with increased responsibility in household budget management and sensitivity to consumption efficiency (Diaconu, 2025).

The study confirms that among the urban educated public in the Republic of Moldova, the level of circular readiness is high and the perception of self-efficacy is at favourable levels. At the same time, the effectiveness of motivational framing varies significantly depending on the psychosocial profile of consumers, suggesting the need for differentiated communication strategies. In the long term, removing structural barriers - infrastructure, accessibility, time – will be essential to transform intention into systemic sustainable behaviour.

4. DISCUSSION

The empirical results of the study provide a comprehensive overview of the current state of circular behaviour in the Republic of Moldova, illustrating both the individual readiness for change and the systemic constraints that prevent sustainable behaviour from materialising. Overall, the educated and informed urban segment is distinguished by a high level of environmental awareness and a favourable attitude towards circular economy principles, in line with European trends that cognitive elites often act as catalysts for behavioural change (EEA, 2022; Georgescu *et al.*, 2025).

However, the comparative analysis of intention and actual behaviour highlights a significant discrepancy – well documented in the literature as the 'attitude-behaviour gap' (Kollmuss & Agyeman, 2002). Although respondents declare strong intentions in favour of circular practices (e.g. recycling, reuse, buying second-hand products), actual actions do not always reflect this motivation. In our case, less than 60% of participants say they recycle frequently, and less than 50% purchase circular products – figures that indicate latent structural and motivational barriers. These findings are supported by indigenous research that reveals a polarisation between declarative environmental consciousness and practical possibilities for implementation, especially in the post-Soviet urban context (Ganea *et al.*, 2022).

Among the causes of this gap are recurrent infrastructural inadequacies. The selective collection system in the Republic of Moldova is fragmented and geographically limited, and the logistic chains required for industrial reuse or recycling remain incipient (Ministry of Environment RM, 2023; Galanton, 2024). The lack of access to appropriate facilities (e.g. repair centres, second-hand markets) creates a 'behavioural opportunity gap' – a phenomenon also mentioned in EEA reports (2022), which highlight that mere individual cannot compensate for the absence of supporting infrastructure.

This mismatch between intention and opportunity is also explicable in terms of the model of planned behaviour (TPB), where perceived behavioural control (PBC) is crucial for converting intention into action (Ajzen, 1991). Even if respondents positively evaluate their ability to act sustainably, the absence of appropriate material conditions diminishes objective control, blocking the manifestation of behaviour.

A second block relates to perceptions of cost. Many consumers associate green or repairable products with higher prices, which, in a context of low purchasing power, becomes a notable impediment. Diaconu (2025) demonstrated, in a study applied to the Moldovan wine sector, that perceived economic viability is a key determinant of sustainable consumption decisions. Also, research by Perciun *et al.* (2023) shows that without interventions such as subsidies, VAT rebates or buy-back schemes, circular options will remain marginal in the preferences of Moldovan consumers.

Pricing policies – as a tool for economic nudging – are essential to tip the balance in favour of desired behaviours (OECD, 2024). In this respect, measures such as tax facilitation for repairs or penalising disposable products can create a framework conducive to structural change.

On the psycho-behavioural dimension, the study highlights the difficulty of changing established routines. Sustainable consumption often involves additional cognitive and logistical effort, which discourages transition without appropriate incentives. This rigidity is a phenomenon documented in numerous research studies (Thøgersen & Ölander, 2003) and reflects a resistance to changing implicit action patterns.

Interestingly, messages with a communitarian character had the greatest motivational impact, suggesting that normative influences play a catalytic role. According to TPB, subjective norms – perceptions of what others do or approve of – can amplify or inhibit environmental behaviour (Ajzen, 1991). In this case, campaigns that valorise sustainable behaviours as community norms ('what we do, together') could have a disproportionately positive impact.

An often overlooked dimension, but highlighted in this study, is the gender difference in predisposition towards circular behaviours. Women showed a higher involvement in recycling, plastic reduction and reuse of packaging, while men were more active in behaviours related to durable and technological goods (e.g. second-hand purchases). These results are congruent with international literature indicating an association between gender roles and sustainable consumption patterns (Hunter *et al.*, 2004; Zelezny *et al.*, 2000). In the Moldovan context, where the responsibility for household resource management often falls on women, it is logical that women are more receptive to messages on waste reduction.

Therefore, communication campaigns need to be differentiated and gender-sensitive: for example, messages about financial savings may be more effective for women, while messages about community contribution may be more attractive to men - in line with empirically observed differences in motivation.

An important issue is the representativeness of the results. Although the current sample is predominantly urban and educated, which may induce a selection bias, the identification of a 'critical core' of sustainable consumers is of utmost relevance. This segment – made up of informed, active and engaged individuals – can play the role of early adopters in the diffusion of circular innovation (Rogers, 2003). Public policies can capitalise on this potential by directly involving these actors in local networks, pilot projects and community initiatives.

The convergence of the findings with the international literature validates the usefulness of the study in outlining policy directions for Moldova: (1) investments in circular infrastructure, (2) large-scale environmental education campaigns, (3) economic incentives for sustainable behaviours, and (4) social proof soft interventions (EEA, 2022; Kirchherr *et al.*, 2017).

The message that had the greatest impact – the one focused on community benefit – suggests a clear direction for public communication: framing circular behaviours as acts of collective responsibility. This approach is in line with research indicating the effectiveness of social and identity-framed messages in driving sustainable behaviour change (Schultz *et al.*, 2007).

5. LIMITATIONS OF THE STUDY

Interpretation of the results presented above must be undertaken with epistemological caution, given a number of limitations inherent in the research design. Firstly, the sample analysed reflects predominantly the perspective of an educated, urbanised and relatively young segment. This overlap between the educational capital and the urbanisation of the respondents' space of origin implies a possible overestimation of the real level of awareness and involvement in circular practices at the scale of the entire Moldovan population (Popa *et al.*, 2022; Gribincea, 2024). Thus, vulnerable groups – especially those in rural settings or those with limited access to infrastructure – may exhibit significantly lower levels of ecological self-efficacy and sustainable motivation (Ganea, Trushkina, & Țirlea, 2022).

Second, the use of the self-report method raises the issue of social desirability, a well-documented phenomenon in the psychosocial literature (Paulhus, 1991). Even if the instrument was administered anonymously and phrased in neutral language, it is plausible that some responses may reflect a form of virtue signalling, which may distort the accuracy of the measurement of actual behaviours (Yuriev *et al.*, 2020). For example, the frequency of recycling or reuse may be reported more optimistically than is actually the case.

Another critical issue concerns the hypothetical nature of the motivational experiment: the intention to act sustainably, expressed following exposure to a message, cannot be directly equated with actual behaviour (Ajzen, 1991). Thus, the results should be interpreted as indices of emotional and cognitive sensitivity to particular types of communicative stimuli, not as empirical validation of their effectiveness in real contexts. Field experiments measuring observable behaviours would be needed to validate the effectiveness of interventions (Saulītis *et al.*, 2024).

Also, observed demographic correlates – in particular differences by age group or gender – should be treated with analytical reserve, given the possible collinearity effect between socio-demographic variables (e.g. age and educational attainment).

6. APPLICATIVE IMPLICATIONS AND FUTURE RESEARCH DIRECTIONS

Despite these limitations, the results obtained provide a number of relevant contributions both from a public policy perspective and for sustainability practitioners and the scientific community. At the operational level, the data suggest that the educated urban population in the Republic of Moldova shows a high level of receptivity towards circular infrastructures and initiatives. Therefore, investments in selective collection systems, repair centres or reuse platforms would benefit from an increased take-up rate (Diaconu, 2025; European Commission, 2020b).

At the same time, the results can guide push-pull policies: on the one hand, reinforcing the educational dimension (information campaigns, integration of CE in curricula), and on the other hand, creating economic incentives (e.g. guarantee schemes for packaging, tax deductions for circular firms, green subsidies) aimed at reducing the perceived cost barrier (OECD, 2024).

Non-governmental actors – from environmental organisations to community movements – can capitalise on the insights generated by message testing. Thus, messages with community or collaborative content (e.g. "together we succeed", "be a positive role model") were found to be most effective in activating motivation (Figure 3). This result is consonant with other research conducted in the region (Dulgheru, 2023), which shows that appeals to solidarity and collective responsibility have a higher mobilising power than purely technical or environmental ones.

From a business perspective, the evidence suggests latent demand for circular products and services. Companies interested in sustainable innovation could respond effectively by expanding the supply of sustainable goods, repair services or collaborative consumption platforms (Llorente-González & Vence, 2020). Marketing communication should be tailored to the psychosocial profile of Moldovan consumers – balancing the community impact component with personal economic benefits, and avoiding overly prescriptive or moralising tone (Yin *et al.*, 2021).

On the scientific dimension, the study highlights the need to deepen the analysis of circular behaviours through longitudinal investigations, multivariate analyses and focused qualitative research. Exploring cultural values and social capital as predictors of sustainable engagement remains an important area of research – aspects little studied in the Eastern European space. Also, extending research to rural segments, as well as developing rigorous experimental protocols (e.g. A/B tests with actual behavioural measurement) would allow for a more robust validation of theoretical models such as TPB and CEBM (Bocken *et al.*, 2016).

7. CONCLUSIONS

The present study provides a substantial empirical contribution to the understanding of Moldovan consumers' behaviour in the transition to the circular economy. By combining quantitative and qualitative methods, the research paints a complex picture of awareness levels, attitudes and motivations, as well as perceived barriers and contextual limitations. In essence, the urban educated segment of the Moldovan educated population proves to be in favour of the circular transition – both in terms of cognitive level of understanding and declared readiness to act.

However, the gap between intentions and actual behaviour persists, explained by structural (infrastructure, prices), cultural (stigma associated with second-hand) and psychological (perception of control) factors. Thus, the transition to CE should not be thought of exclusively in technical or regulatory terms, but as a complex process of social and cultural transformation, in which consumers play a central role – but which requires systemic support to be fully realised.

In this context, the message spontaneously expressed by one of the participants – "Together we can make it happen" – takes on an emblematic value: only through co-responsibility between authorities, the private sector and citizens can genuine and sustainable circularity be achieved. Our study provides a solid starting point for this joint endeavour.

Bibliography

- 1) Ajzen, I. (1991). The theory of planned behaviour. *Organisational Behavior and Human Decision Processes*, 50(2), 179-211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- 2) Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, 27(1), 14-25. <https://doi.org/10.1016/j.jenvp.2006.12.002>
- 3) Batista, L., Bourlakis, M., Smart, P., Maull, R., & Dewick, P. (2018). supply chain operations for a circular economy. *production Planning & Control*, 29(6), 419-424. <https://doi.org/10.1080/09537287.2018.1449267>
- 4) Bocken, N. M. M. P., De Pauw, I., Bakker, C., & Van Der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, 33(5), 308-320. <https://doi.org/10.1080/21681015.2016.1172124>
- 5) Bolderdijk, J. W., Steg, L., Geller, E.S., Lehman, P. K., & Postmes, T. (2013). Comparing the effectiveness of monetary versus moral motives in environmental campaigning. *Nature Climate Change*, 3(4), 413-416. <https://doi.org/10.1038/NCLIMATE1767>
- 6) Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp063oa>
- 7) Cialdini, R. B., Reno, C. A., & Kallgren, R. R. (1990). A focus theory of normative behaviour: Recycling the concept of norms to reduce littering in public places.

- Journal of Personality and Social Psychology*, 58(6), 1015-1026. <https://doi.org/10.1037/0022-3514.58.6.1015> <https://doi.org/10.1037/0022-3514.58.6.1015>
- 8) Diaconu, C. (2025). *Development of the circular business model in the wine sector of the Republic of Moldova* (Doctoral thesis, Technical University of Moldova). Chisinau, Republic of Moldova.
- 9) Dulgheru, V. (2023). Innovative business models in the circular economy. *Intellectus*, (2), 73-80. <https://doi.org/10.56329/1810-7087.23.2.08>
- 10) European Commission (2020a). *A new Circular Economy Action Plan* (COM(2020) 98 final). Publications Office of the European Union. https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en
- 11) European Commission (2020b). *Circular economy action plan: For a cleaner and more competitive Europe*. Directorate-General for Environment. https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en
- 12) European Environment Agency (2022, 17 May). *Enabling consumer choices for a circular economy* (EEA Briefing No. 7/2022). European Environment Agency. <https://www.eea.europa.eu/publications/influencing-consumer-choices-towards-circularity>
- 13) Galanton, N. (2024). The circular supply chain: a paradigm shift towards sustainable resource management. *European Vector*, (1), 70-77. <https://doi.org/10.52507/2345-1106.2024-1.15>
- 14) Ganea, V., Trushkina, N., Țirlea, M. R., & Birca, I. (2022). Circular economy - a perspective model for the Republic of Moldova. *Strategic Universe*, (4/52), 53-68.
- 15) Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). *The Circular Economy - A new sustainability paradigm?* *Journal of Cleaner Production*, 143, 757-768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- 16) Georgescu, L. P., Fortea, C., Antohi, V.M., Balsalobre-Lorente, D., Zlati, M. L., & Barbuta-Misu, N. (2025). Economic, technological and environmental drivers of the circular economy in the European Union: A panel data analysis. *Environmental Sciences Europe*, 37, Art. 76. <https://doi.org/10.1186/s12302-025-01119-4>
- 17) Gribincea, C. (2024). Determining the national circular economy model in the tourism sector. In *Science, education, culture*. Ed. 1, Vol. 1, pp. 112-115. ISBN 978-9975-83-295-3.
- 18) Hunter, L. M., Hatch, A., & Johnson, A. (2004). *Cross-national gender variation in environmental behaviours*. *Social Science Quarterly*, 85(3), 677-694. <https://doi.org/10.1111/j.0038-4941.2004.00239.x>
- 19) Iordachi, V. (2024). Sustainable financing of the business environment in the Republic of Moldova: Challenges and solutions. *Journal of Research on Trade, Management and Economic Development*, 11(1[21]), 7-21. <https://doi.org/10.59642/JRTMED.1.2024.01> <https://doi.org/10.59642/JRTMED.1.2024.01>
- 20) Kirchherr, J., Reike, D., & Hekkert, M. (2017). *Conceptualising the circular economy: An analysis of 114 definitions*. *Resources, Conservation & Recycling*, 127, 221-232. <https://doi.org/10.1016/j.resconrec.2017.09.005>
- 21) Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environmental Education Research*, 8(3), 239-260. <https://doi.org/10.1080/13504620220145401>

- 22) Lisenco, V. (2024). Sustainable economy and effective environmental governance: Key principles and global best practices. *Moldovan Journal of International Law and International Relations*, 2(19), 52-64. <https://doi.org/10.61753/1857-1999/2345-1963/2023.19-2.04> <https://doi.org/10.61753/1857-1999/2345-1963/2023.19-2.04>
- 23) Llorente-González, L. J., & Vence, X. (2020). *How labour-intensive is the circular economy? A policy-orientated structural analysis of the repair, reuse and recycling activities in the European Union. Resources, Conservation and Recycling*, 162, Article 105033. <https://doi.org/10.1016/j.resconrec.2020.105033>
- 24) Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability transitions research: Transforming science and practice for societal change. *Annual Review of Environment and Resources*, 42, 599-626. <https://doi.org/10.1146/annurev-environ-102014-021340>
- 25) Maitre-Ekern, E., & Dalhammar, C. (2019). Towards a hierarchy of consumption behaviour in the circular economy. *Maastricht Journal of European and Comparative Law*, 26(3), 394-420. <https://doi.org/10.1177/1023263X19840943> <https://doi.org/10.1177/1023263X19840943>
- 26) Mies, A. & Gold, S. (2021). Mapping the social dimension of the circular economy. *Journal of Cleaner Production*, 329, 129736. <https://doi.org/10.1016/j.jclepro.2021.128960>
- 27) Milošević, I., Plotnic, O., Stanković, Z., Tick, A., & Buzdugan, A. (2025, February 14-16). *Circular economy as a strategic imperative for fostering sustainability and consumer engagement (K02140)*. In R. Mitoula (Ed.), Book of Abstracts - 2nd Open-Air Cities International Conference: Local and Regional Sustainable Development and Urban Reconstruction. Harokopio University of Athens. ISBN 978-618-618-87070-3-0.
- 28) Ministry of Environment & Environment Agency. (2023, 17 November). *Report of the National Conference "Circular Economy in the Republic of Moldova"*.
- 29) Ministry of Environment of the Republic of Moldova. (2024). *National Determined Contribution 3.0 (CNDD-3.0)*. Chisinau. https://mediu.gov.md/sites/default/files/Documente%20atasate%20Advance%20Pagines/MD_NDC_3.0_RO_31.12.2024_final.pdf
- 30) Niculescu, G. (2025). Resource crisis and circular economy - a sustainable approach for the future. In *Sensitive and controversial issues of contemporary society* (Conference organised in Chisinau, 25-26 October 2024, pp. 222-229). Chisinau: CEP UPSC. ISBN 978-9975-48-237-0.
- 31) Oberholzer, S., Sachs, S. (2023). Engaging Stakeholders in the Circular Economy: A Systematic Literature Review. In: Kujala, J., Heikkinen, A., Blomberg, A. (eds) *Stakeholder Engagement in a Sustainable Circular Economy*. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-31937-2_3 https://doi.org/10.1007/978-3-031-31937-2_3
- 32) Organisation for Economic Co-operation and Development (OECD) (2024). *Monitoring progress towards a resource-efficient and circular economy*. OECD Publishing. <https://doi.org/10.1787/3b644b83-en>
- 33) Pascal, M. (2025). Consumer rights and obligations in the circular economy. *Anale Științifice ale Academiei "Stefan cel Mare" a MAI of the RM: Științe Juridice*,

- (Supplement), 13-24. "Stefan cel Mare" Academy "Stefan cel Mare" of the MAI of the RM. ISSN 1857-0976.
- 34) Paulhus, D. L. (1991). *Measurement and control of response bias*. In J. P. Robinson, P. R. Shaver & L. S. Wrightsman (Eds.), *Measures of personality and social psychological attitudes* (pp. 17-59). Academic Press. <https://doi.org/10.1016/B978-0-12-590241-0.50006-X>
 - 35) Perciun, M., Caramizi, A., & Iurcu, L. (2022) *Annual scientific report on the development of the mechanism for the formation of circular economy in the Republic of Moldova (2020-2023)*. National Agency for Research and Development.
 - 36) Plotnic, O., & Praporșic, V. (2024, May 17-18). *Legal adaptation strategies for unforeseen events in the circular economy through the integration of resilience and material reuse*. In *European Financial Resilience and Regulation* (pp. 256-270). Iași: "Alexandru Ioan Cuza" University of Iași. ISBN 978-606-714-891-6; ISSN 3044-8689.
 - 37) Popa, Viorica & Ceban, Alexandru & Popa, Nicolae, 2022. "Circular Economy - Sustainable Development Between Present And Future," *Journal of Financial and Monetary Economics*, Centre of Financial and Monetary Research "Victor Slavescu", vol. 10(1), pages 291-307, October.
 - 38) Prisac, I., & Pop, I. G. (2024). redefining sustainable development in the context of transdisciplinary paradigm. *Studia Universitatis Moldaviae. Economic and Communication Sciences Series*, 11(3), 67-75. [https://doi.org/10.59295/sum11\(3\)2024_11](https://doi.org/10.59295/sum11(3)2024_11)
 - 39) Prothero, A., Dobscha, S., Freund, J., Kilbourne, W. E., Kilbourne, W. E., Luchs, M. G., Ozanne, L. K., & Thøgersen, J. (2011). *Journal of Public Policy & Marketing*, 30(1), 31-38. <https://doi.org/10.1509/jppm.30.1.31>
 - 40) Putregai, V. (2024). *Circular economy: strategies for sustainable development*. In *Technical-Scientific Conference of Students, Master's and Doctoral Students* (Vol. III, pp. 2024-2027). Technical University of Moldova.
 - 41) Rogers, E. *Diffusion of innovations* (5th ed.). Free Press. 576 p.
 - 42) Rusu, Elena, 2022. Circular Economy - Zero Waste Strategy for The Communities of The Republic of Moldova, *Journal of Financial and Monetary Economics*, Centre of Financial and Monetary Research "Victor Slavescu", vol. 10(1), pages 319-324, October.
 - 43) Saulītis, A., Silkāne, V., & Gaile, G. A. (2024). *Nudging pro-environmental behaviour in a subsidised waste recycling system: A field experimental study*. *Journal of Environmental Psychology*, 99, 102416. <https://doi.org/10.1016/j.jenvp.2024.102416>
 - 44) Sârbu, O. (2022). Transition to circular economy as a factor of sustainable development. In *Cadastre and Law: Proceedings of the scientific conference, 30 September - 1 October 2021, Maximovca* (Vol. 55, pp. 100-103). Chisinau, Republic of Moldova: State Agrarian University of Moldova. ISBN 978-9975-64-271-2; 978-9975-64-328-3.
 - 45) Schröder, P., Anggraeni, K., & Weber, U. (2018). the relevance of circular economy practices to the sustainable development goals. *Journal of Industrial Ecology*, 23(1), 77-95. <https://doi.org/10.1111/jiec.12732>

- 46) Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007, May). The constructive, destructive, and reconstructive power of social norms. *Psychological Science*, 18(5), 429-434. <https://doi.org/10.1111/j.1467-9280.2007.01917.x> <https://doi.org/10.1111/j.1467-9280.2007.01917.x>
- 47) Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, 29(3), 309-317. <https://doi.org/10.1016/j.jenvp.2008.10.004>
- 48) Savga, L., Ivanov, T., Perciun, R., & Iordachi, V. (2023). The co-operative and the circular economy: Embracing collaboration towards sustainability. *Journal of Research on Trade, Management and Economic Development*, 10(1), 7-21. <https://doi.org/10.59642/JRTMED.1.2023.01>
- 49) Thøgersen, J. (2023). Cheltenham, UK: Edward Elgar Publishing. ISBN 978-1-80392-450-2 (print); 978-1-80392-452-6 (ebook)
- 50) Toma, V., & Corețchi, B. (2024). Waste as an energy resource: challenges and opportunities in Moldova's circular economy. In *Promotion of social and economic values in the context of European integration*, 7th edition, Chisinau, 6-7 December 2024, pp. 26-34. Chisinau: Tipografia "Pulsul Pieței". ISBN 978-9975-3611-4-9.
- 51) Țurcan, I., & Ciloci, R. (2021). *The circular economy in the vision of young people in the Republic of Moldova*. In *Competitiveness and sustainable development in the context of European integration* (3rd Economic International Conference, pp. 110-114), Chisinau, Chisinau: Tehnica-UTM. Retrieved from <https://repository.utm.md/handle/5014/18381>
- 52) United Nations Environment Programme (2025, 19 February). Youth Programmes & Initiatives. UNEP. <https://www.unep.org/youth>. <https://www.unep.org/youth>
- 53) Yin, M., Tayyab, S. M.U., Xu, X.-Y., Jia, S.-W., & Wu, C.-L. (2021). The investigation of mobile health stickiness: The role of social support in a sustainable health approach. *Sustainability*, 13(4), art. 1693. <https://doi.org/10.3390/su13041693>
- 54) Yuriev, A., Boiral, O., Francoeur, V., & Paillé, P. (2018). Overcoming the barriers to pro-environmental behaviours in the workplace: A systematic review. *Journal of Cleaner Production*, 182, 379-394. <https://doi.org/10.1016/j.jclepro.2018.02.041>
- 55) Yuriev, A., Dahmen, M., Boiral, O., Paillé, P., & Guillaumie, L. (2020). Pro-environmental behaviours through the lens of the theory of planned behaviour: A scoping review. *Resources, Conservation & Recycling*, 155, 104660. <https://doi.org/10.1016/j.resconrec.2019.104660>
- 56) Zelezny, L. C., Chua, P. P., & Aldrich, C. (2000). Elaborating on gender differences in environmentalism. *Journal of Social Issues*, 56(3), 443-457. <https://doi.org/10.1111/0022-4537.00177>

INNOVATIONS IN FOOD PRODUCT DESIGN: LIFE CYCLE OPTIMIZATION FOR SUSTAINABLE CONSUMPTION IN THE REPUBLIC OF NORTH MACEDONIA

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Abstract

Global challenges related to the sustainability of the food sector require innovative approaches to reduce negative environmental impacts and improve efficiency in food production and consumption. This paper analyzes innovations in food product design in the Republic of North Macedonia through optimization of their life cycle, with a focus on sustainability and resource efficiency.

The research includes an analysis of current practices in the Macedonian food industry, including the stages of raw material selection, processing, packaging, distribution and waste management. Special emphasis is placed on the use of local and organic ingredients, eco-friendly packaging and strategies for reducing food waste. Through life cycle assessment (LCA) methods and environmental impact analyses, challenges and opportunities for advancing the circular economy in the food sector are identified.

The results show that, although there is an increased interest in sustainable food practices in North Macedonia, there are significant challenges, such as the limited availability of eco-friendly packaging materials, insufficient consumer awareness and poor implementation of waste reduction strategies. The paper offers recommendations for strengthening sustainability in the sector by supporting domestic producers, investing in green technologies and educating consumers about eco-conscious consumption.

Keywords: *innovation, life cycle, sustainable consumption, food industry.*

JEL Classification: Q56, Q18, L66

1. INTRODUCTION

The agri-food industry is of strategic importance for the development of the economy of each country. Agri-food products represent a significant group of products because the safety and security of human health depend on them. In order to develop this industry, it is necessary to restructure it towards modern trends and permanently improve it by introducing modern technologies.

Ecological production of agri-food products emphasizes quality and safety, avoiding the use of additives that are harmful to human health.

The environmental sustainability of the agri-food industry implies the maximum use of renewable energy sources, the maintenance of the genetic diversity of agro-ecosystems and the protection of the environment, the reduction of all types of pollution

that may be a consequence of production, as well as production in accordance with environmental standards.

All this in order to achieve the goals of agri-food producers and gain appropriate profits, as well as active action in order to raise consumer awareness of purchasing ecological agri-food products and promote their benefits.

Agri-food producers should provide consumers with healthy food options and reliable nutritional information. At the same time, the development of the agri-food industry assumes industrial production aimed at satisfying the increasingly sophisticated needs and desires of consumers, with an emphasis on innovation, quality, a high level of food hygiene and standards for food safety and a healthy environment. The choice of food affects the environment and people's health and quality of life. The production, transportation, processing, storage, sale and preparation of food are processes that use a lot of natural resources (such as land, water and nutrients) and energy, and involve a large number of people.

Choosing food from limited resources or from unsustainable production systems (such as when eating certain types of wild fish) can cause the extinction of animal species and the destruction of natural habitats. In addition, food production irreversibly consumes huge amounts of energy and resources, since globally, one third of all food produced is lost or wasted every year. Although it is not so simple, this amount of food can feed hungry people. The development of agriculture contributes to the development of agri-food production systems. Each change brings with it new advantages and challenges and an increasing diversity and complexity of the agri-food system. To this end, it is necessary to analyze the drivers of change, as well as the challenges and contemporary trends faced by producers, consumers and policymakers in the agri-food sector. In modern conditions, increasing attention is paid to environmental protection and the production of high-quality, environmentally sound agri-food products that are increasingly in demand on the world market. Today's orientation of modern agri-food production is aimed at the economical, productive and competitive production of healthy, high-quality and safe food, in conditions of an ecologically clean and healthy environment, without or with minimal permitted use of chemical agents and increased use of organic fertilizers and biological agents for the protection of plants and animals in agricultural production, as well as without added ingredients in the process of their processing and preparation. In the future, proper business operations will not be possible without the application of new technologies due to the growth of the need for healthy food and profitability of companies in the agri-food industry, because if we look at the global level, the number of people is constantly increasing, while the arable land is constantly decreasing and air pollution is increasingly observed as a result of climate change.

The global food industry is experiencing a fundamental transformation driven by the urgent need for sustainability, technological progress and changed consumer habits. As a key sector directly affected and impacted by climate change, the food system faces an imperative to redesign its production models towards the principles of a circular economy. This challenge is particularly relevant for the Republic of North Macedonia,

where economic realities and an underdeveloped infrastructure for sustainable waste management create unique obstacles, but also opportunities for innovation.

The focuses on the critical role of food product design in optimizing their life cycle, with a particular focus on:

Modern challenges related to climate change and environmental degradation are transforming the global food industry, imposing an imperative for a transition to sustainable production and consumption models. In this context, innovations in food product design emerge as a key factor for optimizing their life cycle and reducing environmental damage. The Republic of North Macedonia, although facing economic and infrastructural constraints, shows increased sensitivity to these issues, which creates fertile ground for the implementation of circular economy principles in the food sector.

This study aims to explore the possibilities for promoting sustainability throughout the entire life cycle of food products – from the selection of raw materials, through production processes, to packaging and waste management. The focus is on:

1. Analysis of the current state of the environmental sustainability of the food industry – Analysis of the strategic importance of the sector and its potential for transition to green technologies, increased use of renewable energy sources and preservation of biodiversity (Bojkovska, 2021).

2. Identification of innovative solutions for efficient waste management - Examination of the "zero waste" model and its applicability in the local context, including innovative approaches (Camilleri, 2021).

3. Consumption trends – Assessment of the awareness and readiness of Macedonian consumers to adopt sustainable food practices, including economic barriers.

4. Policy frameworks – Critical review of existing regulations and the need for harmonization with European standards to support green innovations, especially in light of the EU's Farm to Fork (F2F) Strategy.

The study is based on the assumption that the optimal combination of technological innovation, consumer awareness and adequate policy measures can significantly reduce the environmental burden of the country's food sector.

2. LITERATURE REVIEW

The concept of sustainable food product design has emerged as a crucial framework for addressing the growing environmental challenges of the food industry. It draws on several interrelated research areas, including life cycle assessment (LCA), circular economy principles, food waste reduction, eco-design, and consumer behavior. These approaches provide valuable tools for rethinking how food products are developed, produced, and delivered, and they are increasingly relevant for the evolving food sector in North Macedonia.

Recent studies emphasize that the transition to a circular economy represents a key pathway for transforming the food industry into a more sustainable system (Geissdoerfer *et al.*, 2017). According to the European Commission (2020), moving from a linear to a circular model involves redesigning production processes to minimize

losses, integrating waste streams as raw materials in new production cycles, and developing innovative packaging with improved recyclability.

In the Macedonian context, research has identified both challenges and opportunities in implementing these principles. A 2022 study by the Ministry of Agriculture revealed that only 18% of enterprises have formal procedures for food waste management. The main obstacles include high initial investments (reported by 72% of surveyed enterprises), lack of knowledge (58%), and complex administrative procedures (45%). Similarly, a UNDP comparative study (2019) found that North Macedonia lags behind the regional average in investments in green technologies (0.8% of GDP compared to 1.5% in the Western Balkans) and offers only two higher education programs related to the circular economy.

These findings suggest that the existing potential for circular practices is still underutilized, yet they also indicate a growing interest among Macedonian companies, especially as EU-driven regulatory harmonization begins to shape the market. The central challenge remains finding a balance between economic feasibility and environmental responsibility within the constraints of a relatively small domestic market.

Alongside circular economy principles, Life Cycle Assessment (LCA) has become a well-established methodology for evaluating the environmental impacts of food products at every stage of their life cycle. Global research shows that food production contributes substantially to greenhouse gas (GHG) emissions, land use, and water consumption (Poore & Nemecek, 2018). Applying LCA helps identify environmental “hotspots” in production where targeted improvements can bring significant sustainability benefits. Studies have found that the production phase typically accounts for 40–60% of the total environmental impact (Notarnicola *et al.*, 2017), packaging contributes 15–30% (Wikström *et al.*, 2019), while distribution and storage are particularly critical for products with short shelf lives (Verghese *et al.*, 2015).

In the Republic of North Macedonia, however, the use of LCA remains very limited. Local producers face several challenges in adopting this approach, such as limited access to specialized software, the absence of local environmental data, and the high costs of certification. Regional studies from the Western Balkans also suggest that local food systems often carry a higher carbon footprint due to outdated agricultural techniques, inefficient logistics, and high levels of food waste. Introducing LCA methodologies on a national scale could provide valuable insights for both policymakers and businesses, enabling them to identify inefficiencies, improve resource use, and ultimately reduce the environmental impact of the Macedonian food sector.

The circular economy model is increasingly recognized as a key strategy for sustainable food production. According to Kircher *et al.* (2017), circular economy principles aim to minimize waste, extend the life cycle of products, and increase resource efficiency.

According to FAO (2021), around one-third of all food produced globally is lost or wasted, which creates serious economic, environmental, and social consequences.

The economic costs are estimated at approximately 1.2 trillion USD annually, while food waste is responsible for 8–10% of global greenhouse gas emissions. At the same time, this loss occurs in a world where about 821 million people continue to suffer from chronic hunger, making the issue both ethically and practically urgent.

To address these challenges, the food industry has increasingly been adopting principles of sustainable production and consumption. These efforts include sustainable sourcing practices such as organic farming and regenerative agriculture, which aim to protect soil health and biodiversity.

Companies are also investing in eco-friendly packaging solutions, including biodegradable and compostable materials that reduce plastic pollution. Another important area is waste valorization, where food waste is converted into bioenergy, animal feed, or other valuable byproducts, thereby closing the loop within production systems. Product innovation has also gained momentum, with alternative proteins and plant-based food innovations offering opportunities to reduce the environmental footprint of diets.

A number of innovative solutions have already demonstrated their potential to significantly cut food waste. For example, converting waste oils into biodiesel can reduce waste by up to 40% (Budžaki *et al.*, 2018). Digital redistribution platforms such as the ResQ Club app help redirect surplus food to consumers at reduced prices, achieving waste reductions of 15–25%. Smart packaging technologies, including biodegradable films with freshness indicators, can extend shelf life and lower waste by 30–50%. These examples show that innovation plays a critical role in reducing food losses while simultaneously creating new economic opportunities within the food sector.

Table 1. Innovative solutions

Solution	Example	Waste reduction potential
Waste processing into biofuel	Biodiesel production from waste oils (Budžaki <i>et al.</i> , 2018)	to 40%
Digital redistribution platforms	ResQ Club APP	15-25%
Smart packaging	Biodegradable films with freshness indicators	30-50%

While circular economy strategies are gaining popularity globally, their implementation in North Macedonia remains limited due to insufficient infrastructure and regulatory support.

Reports from the European Environment Agency (EEA, 2022) suggest that North Macedonia lags behind EU member states in recycling rates and sustainable food production practices. Strengthening local policies and fostering industry cooperation could improve the integration of the circular economy in the food sector.

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Food waste is a major sustainability challenge, contributing to resource depletion and environmental degradation. According to the Food and Agriculture Organization (FAO, 2021), approximately one-third of all food produced globally is wasted, leading to unnecessary carbon emissions and economic losses. Effective strategies for reducing food waste include:

- Improving the efficiency of the food supply chain to minimize losses during transportation and storage.
- Raising consumer awareness through educational campaigns.
- Encouraging businesses to adopt zero waste policies by repurposing surplus food.

In the Republic of North Macedonia, data on food waste is scarce and waste management systems are underdeveloped. The absence of strict regulations to reduce food waste and inadequate incentives for businesses to adopt sustainable practices hinder progress in this area. The majority of food waste in North Macedonia ends up in landfills, rather than being composted or repurposed. Policy interventions and public-private partnerships are key to improving the country's food waste management system.

Consumer awareness and willingness to pay for sustainable food products are key determinants of market success. Studies show that consumer demand for organic, locally produced and environmentally friendly food products is increasing globally (Aschemann-Witzel *et al.*, 2019).

However, research indicates that in North Macedonia, sustainable food consumption remains in its early stages of development. Several factors contribute to this situation, including a general lack of awareness about how food choices affect the environment, as well as high price sensitivity among consumers, who often perceive sustainable food products as expensive. Additionally, the limited availability of environmentally friendly alternatives on local markets further restricts the adoption of more sustainable consumption patterns.

These findings are in line with global studies (Grunert, 2019) that highlight the need for: clear and standardized eco-labels, full transparency in the supply chain and targeted educational campaigns.

Government policies play a key role in facilitating sustainable innovation in the food sector. The European Union's Green Deal and Farm to Fork Strategy provide strong policy frameworks for the transition to sustainable food systems (European Commission, 2020). However, as an EU candidate country, North Macedonia faces significant challenges in aligning its regulations with European Union standards. Notable gaps include weak enforcement of environmental regulations within the food production sector, a lack of financial incentives for businesses investing in sustainable

innovations, and the absence of a comprehensive national strategy to promote circular economy principles specifically for the food industry.

A comparative review of regulatory frameworks shows that the EU's Farm to Fork Strategy (2020) and the Single-Use Plastics Directive (2019) have contributed to a measurable 12% reduction in food waste between 2015 and 2020, primarily through stricter sustainability requirements and incentives for innovation in product design and packaging. In contrast, North Macedonia's National Waste Management Plan (2020–2030) and National Strategy for Sustainable Development (2009–2030) have so far produced limited impact due to weak institutional enforcement and lack of targeted measures to promote sustainable product design across the food sector.

Table 2. Comparative Analysis of Regulatory Frameworks for Sustainable Food Systems

Country	Key Policies	Results
EU	• Farm to Fork Strategy (2020) • Single-Use Plastics Directive (2019)	12% waste reduction (2015-2020)
North Macedonia	• National Waste Management Plan (2020-2030) • National Strategy for Sustainable Development (2009-2030)	Limited results due to weak institutional control

Source: Author's analysis based on European Commission (2020), Ministry of Agriculture, Forestry and Water Management (2022) and Ministry of Environment and Physical Planning (2020)

Key obstacles to effective implementation include (Bojkovska *et al.*, 2023):

- Fragmented institutional framework;
- Lack of financial incentives;
- Misalignment between national and local policies.

This literature review confirms the need for an integrated approach that combines technological innovation, consumer education and political support for an effective transformation towards a sustainable food system in North Macedonia.

Strengthening regulatory frameworks and providing financial and technical support to food producers could significantly boost the adoption of sustainable food design practices in North Macedonia.

The review of existing literature highlights the growing importance of sustainable food production and the need for systemic changes to optimize the life cycle of food products. While global research provides valuable frameworks and strategies, North Macedonia lags behind in implementation due to regulatory, infrastructure and consumer-related challenges. This study aims to bridge these gaps by analyzing local industrial practices, assessing environmental impacts using LCA, and proposing context-specific strategies to improve sustainable food product design. By integrating findings from scientific research, policy analysis and industry insights, this study will provide practical recommendations for food producers, policymakers and consumers in North Macedonia, facilitating the transition to a more circular and sustainable food system.

3. RESEARCH METHODOLOGY

This research employs a *qualitative Life Cycle Assessment (LCA)* to evaluate the environmental, economic, and social implications associated with food products in North Macedonia. Departing from the conventional quantitative LCA framework outlined by ISO 14040/44, the qualitative approach emphasizes contextual understanding, systemic challenges, and stakeholder insights throughout each phase of the product life cycle. The research adopts a multi-method qualitative strategy, integrating stakeholder interviews, consumer surveys, policy analysis, and thematic coding to facilitate triangulation and ensure the validity of findings.

Data were collected through secondary sources, including reports from FAO, UNDP, World Bank, and national agencies, as well as peer-reviewed literature on sustainable food systems. Key life cycle stages – raw material extraction, processing, packaging, distribution, and end-of-life – were analyzed using qualitative indicators such as greenhouse gas emissions, water and energy usage, land occupation, and waste generation. Insights were further validated through expert consultations and field observations in local production facilities. The analysis contrasts animal-based and plant-based systems to identify opportunities for sustainable transformation within the national context.

A total of 15 semi-structured interviews were conducted with key actors in the food system, including food producers, policymakers, non-governmental organizations, and academic researchers. Interviewees were selected through purposive sampling to capture a broad range of perspectives on sustainable food production. The interviews explored perceived barriers and opportunities at each stage of the food product life cycle – raw material sourcing, processing, packaging, distribution, and end-of-life management. Guiding questions included:

- „What are the main environmental concerns in raw material sourcing?”
- „How does infrastructure limit sustainable processing?”
- „What innovations or practices have emerged to address food waste or packaging challenges?”

Interviews were recorded, transcribed, and coded using thematic analysis to identify recurring themes and contextual insights.

To assess consumer awareness, attitudes, and behavior regarding sustainable food consumption, a stratified sample of 300 respondents was surveyed. The stratification was based on age group, geographic location (urban/rural), and economic status to ensure demographic representativeness. Data were collected via structured questionnaires administered both online and in person. The survey instrument addressed consumer preferences related to eco-friendly packaging, sustainable product attributes, and willingness to pay a premium for such products. Descriptive and inferential statistical methods were used to analyze the data, identifying significant correlations and trends relevant to sustainable consumption behaviors.

Additionally, focus group discussions were conducted with selected participants to further explore motivations and barriers influencing purchasing decisions related to sustainability.

4. RESULTS AND DISCUSSION

This section presents the key findings of the study, which encompass a qualitative life cycle assessment (LCA) of selected food products, consumer attitudes towards sustainable food options, and insights derived from industry stakeholders. The interpretation of results is situated within the broader context of current sustainability trends and policy frameworks relevant to the Republic of North Macedonia.

Globally, the agri-food sector is responsible for approximately 25% of total greenhouse gas (GHG) emissions. Significant reductions can be achieved through improved management practices, the development of ecosystem services, and the integration of renewable energy sources, all while ensuring food security. Digital innovations and sustainable practices are increasingly recognized as catalysts for green transformation, especially in reducing waste – one of the sector's most pressing challenges.

The qualitative LCA focuses on identifying environmental impacts, systemic challenges, and improvement opportunities across all phases of the food product life cycle, from raw material extraction to end-of-life management.

The choice between animal-based and plant-based food production systems has significant implications for environmental sustainability, resource efficiency, and local economic development.

Animal-based production systems such as meat and dairy are highly resource-intensive, contributing significantly to methane emissions, consuming large amounts of water, and requiring extensive land use that can lead to land degradation.

Livestock production is a significant source of methane (CH₄) emissions, with average levels estimated at approximately 25 kg CO₂-equivalent per kilogram of beef (FAO, 2023). In addition to its climate impact, livestock requires substantial water resources, with an average water footprint of around 15,000 liters per kilogram of meat, reflecting a high degree of resource intensity. Moreover, about 30% of global agricultural land is dedicated to grazing, which poses considerable risks of land degradation, particularly in cases of overgrazing and inadequate pasture management.

Plant-based alternatives offer a more sustainable option, with significantly lower environmental impacts and strong potential for local production in North Macedonia.

Plant-based proteins, including lentils and legumes, demonstrate significantly reduced resource intensity, generating emissions that are on average ten times lower and requiring five times less water compared to meat production. Furthermore, the agro-climatic conditions in North Macedonia are highly favorable for the cultivation of crops such as organic lentils and sunflowers, creating opportunities to strengthen local production and decrease dependence on imports.

Shifting towards more plant-based alternatives could therefore play a crucial role in reducing environmental pressures while fostering sustainable agricultural growth in North Macedonia.

Processing plays a crucial role in shaping the overall energy demand, efficiency, and sustainability of food production, and the contrasts between animal-based and plant-based products are particularly evident.

In the case of **animal-based products**, processing is highly energy intensive, with procedures such as pasteurization and meat processing requiring approximately 2.5 kWh per kilogram of product. The reliance on outdated equipment in many facilities further exacerbates inefficiencies, while insufficient sanitary infrastructure poses risks of contamination and product loss.

By contrast, **plant-based products** benefit from more energy-efficient technologies. Advanced methods such as extrusion and fermentation, although requiring specialized equipment, demonstrate roughly 30% higher energy efficiency compared to conventional meat processing. Furthermore, the processing of plant-based foods generates primarily biodegradable residues, which can be repurposed for composting and thus support circular economy principles.

Overall, plant-based processing not only ensures greater energy efficiency but also contributes to more sustainable and circular production practices when compared to traditional animal-based systems.

Packaging represents a critical aspect of food production sustainability, with current practices in North Macedonia heavily dependent on plastics.

More than 70% of food packaging is composed of conventional plastic materials, while the recycling rate remains below 15% (EKO-SKOP, 2023), indicating a substantial environmental burden. However, innovative alternatives are emerging, including the use of compostable materials such as polylactic acid (PLA) derived from corn starch.

These solutions provide a promising pathway to mitigate the environmental impacts traditionally associated with food packaging and to advance more sustainable practices in the sector.

Distribution remains a critical stage in the food supply chain, where inefficiencies significantly affect both sustainability and economic performance.

In North Macedonia, fragmentation of the market and limited coordination across supply chains result in an estimated 20% loss of food products before they reach consumers (UNDP, 2022). Furthermore, the underdevelopment of cold chain infrastructure not only compromises food quality but also increases energy consumption by approximately 35% compared to European Union standards.

These shortcomings highlight the dual challenge of reducing environmental impacts while improving the economic efficiency of food distribution systems.

End-of-Life (Waste Management) represents a major challenge in the food system, particularly due to the large share of organic waste. In North Macedonia, around 40% of household waste is biodegradable, yet the absence of industrial composting facilities severely constrains opportunities for recovery and recycling. This shortcoming not only exacerbates environmental pressures but also leads to significant economic losses. Food loss alone is estimated to cost the Macedonian economy approximately €300 million annually (World Bank, 2021), emphasizing the urgent need for comprehensive strategies and policies aimed at reducing waste and improving resource efficiency.

Based on the findings, the following key strategies are proposed to support the sustainable transformation of the food system in North Macedonia:

1. **Promotion of Plant-Based Alternatives:** Economic incentives should be introduced to encourage the production of local legumes, lentils, and other vegan products that offer environmental and nutritional advantages.
2. **Modernization of Processing Infrastructure:** Investment in energy-efficient equipment and the adoption of clean technologies across the supply chain are essential to improve productivity and reduce carbon footprints.
3. **Policy Interventions:** The introduction of mandatory recycling standards and a plastic packaging tax could drive systemic change and align national practices with EU directives.
4. **Public Awareness and Education:** National campaigns are needed to promote waste reduction, sustainable consumption, and circular economy principles among consumers.

This analysis demonstrates that a systemic approach – integrating technological innovation, supportive policy frameworks, and informed consumer behavior – is necessary to achieve long-term sustainability in North Macedonia’s food system.

Life Cycle Assessment of Food Products



Key insights:

- Livestock production generates significant environmental impacts
- Dairy and meat products have a large carbon footprint
- Plant-based alternatives are generally more sustainable
- Digital tools help to optimize waste and resource efficiency

Figure 1. Life Cycle Assessment Stages and Key Sustainability Insights for Food Products

Source: Adapted from various LCA stage diagrams (MDPI’s REAMIT LCA tool), modified by the author

This figure 1 illustrates the main stages of the life cycle assessment (LCA) of food products – ranging from raw material extraction to end-of-life disposal – alongside key insights. It highlights the significant environmental impacts associated with livestock production, the high carbon footprint of dairy and meat products, the comparative sustainability of plant-based alternatives, and the role of digital tools in enhancing efficiency and reducing waste.

Sustainable Innovations:

Plant-based alternatives demonstrate considerable potential to reduce the environmental impact of food systems. Supporting local production and fostering the development of innovative plant-based food products are essential steps toward achieving sustainability goals.

Infrastructure Improvement:

Strengthening logistics, expanding recycling capacities, and enhancing energy efficiency in food processing should be prioritized as core areas for investment and modernization.

Policy and Education:

Robust policy support for green practices, including subsidies for sustainable agriculture, alongside targeted consumer education on environmentally responsible choices, are critical components for enabling systemic transformation across the food value chain.

To gain insights into consumer awareness, preferences, and willingness to pay for sustainable food products, a structured survey was conducted among a representative sample of 300 respondents. The study aimed to assess current attitudes and behaviors within the context of environmental responsibility and sustainable food production.

The survey results provide a detailed picture of the variability in consumer knowledge and awareness regarding sustainable food products. The findings are of particular relevance for shaping public health policies, marketing strategies, and sustainable agricultural models.

Distribution of Awareness Levels Table 2. reveals that more than two-thirds of the surveyed population (65.8%) possess at least a basic understanding of sustainability in the context of food consumption, while 34.2% report having no awareness of the concept.

Table 3. Consumer Awareness Levels of Sustainable Food Consumption Practices

Awareness Level	Percentage (%)	Interpretation
Highly Aware	18.2%	A small but influential group actively purchasing eco-certified products.
Moderately Aware	47.6%	A key target segment for awareness campaigns – familiar with the concept, but inconsistent in behavior.
Not Aware	34.2%	Indicates the need for structured educational interventions.

Source: Survey results

The research uncovered several important insights into consumer attitudes and behaviors regarding sustainable products, with the key findings and implications summarized as follows: statistical analysis revealed a significant correlation ($p < 0.05$) between higher levels of formal education and greater awareness of environmental certifications, suggesting education as a critical factor in fostering sustainable consumer behavior; the results indicate a distinct segmentation in the consumer base, where 18.2% can be categorized as "early adopters" willing to pay a premium for sustainable options, while nearly half (47.6%) represent "potential converts" who require clearer

communication and product labeling to fully engage; and qualitative data from focus groups revealed skepticism towards eco-labels, with concerns about “greenwashing” (misleading environmental claims), underscoring the need for standardized, transparent certification schemes. These findings underscore the critical role of policy interventions and marketing strategies in supporting the transition towards a sustainable food industry in North Macedonia.

The analysis of consumer willingness to pay premium prices for sustainable food products is based on a representative sample of 300 respondents surveyed using a structured questionnaire designed to assess attitudes toward sustainable consumption. The data were analyzed using descriptive statistics and chi-square (χ^2) tests to determine statistical significance.

Table 4. Willingness to Pay a Premium for Sustainable Food Products

Willingness Level	Percentage Distribution (%)	Statistical Significance (p-value)
Up to 10% price premium	41.5%	<0.01
Up to 20% price premium	22.3%	<0.05
Unwilling to pay any premium	36.2%	—

Source: Survey results

The analysis of consumers’ willingness to pay for sustainable food products revealed distinct patterns of price sensitivity and environmental commitment, summarized as follows:

- **Dominant Preference for Moderate Premiums.** Approximately 41.5% of respondents indicated a willingness to pay up to a 10% price premium for sustainable food products. This segment represents a statistically significant majority ($\chi^2=32.1$, $df=2$, $p<0.01$), suggesting moderate premiums are broadly acceptable in the general population.

- **High Environmental Awareness Segment.** A further 22.3% of participants expressed readiness to pay up to a 20% premium. This group closely correlates with the "highly aware" consumers identified in the awareness analysis ($r=0.67$, $p<0.05$), highlighting the role of environmental consciousness in purchasing behavior.

- **Price-Sensitive Consumers**

Notably, 36.2% of respondents were unwilling to pay any premium. This segment correlates negatively with income levels ($r=-0.71$, $p<0.01$), underscoring the influence of economic constraints on sustainable consumption choices.

The **analysis of stakeholder perceptions** regarding barriers and strategic approaches to sustainable food production was based on qualitative interviews with 15 key actors from the food sector in the Republic of North Macedonia. The participants represented a diverse range of perspectives, including the food industry (47%), public institutions (27%), academia (13%), and non-governmental organizations (13%). This composition ensured a balanced understanding of the challenges and opportunities perceived across different sectors involved in shaping sustainable food systems, thereby strengthening the validity and comprehensiveness of the analysis.

The empirical findings reveal several systemic constraints that continue to impede the transition toward sustainable production models. Foremost among these are the high transformation costs, which were identified as the most pressing economic barrier by 80% of respondents. This observation is consistent with existing industry data indicating that the shift to sustainable practices typically entails significantly higher capital expenditures – estimated at 30–45% above conventional investment levels. For small and medium-sized enterprises (SMEs), the financial burden is exacerbated by protracted payback periods, which frequently extend between six and eight years.

Table 5. Hierarchy of Systemic Constraints

Challenge	Key Findings	Correlation with Existing Data
High transformation costs	Identified as a dominant issue by 80%	Aligned with industry data on capital investment
Lack of political support	73% cited regulatory uncertainty	Supported by policy document analysis
Limited market demand	65% noted price sensitivity as a barrier	Consistent with consumer survey findings

Source: Author's own work

In addition to economic barriers, regulatory challenges also play a substantial role. A lack of coherent political support, coupled with regulatory uncertainty, was highlighted by 73% of participants and corroborated through the analysis of relevant policy documents. Although subsidies for sustainable practices are formally available, their administration remains inconsistent across different sectors. Moreover, the absence of standardized and transparent criteria for environmental certification not only generates confusion among producers but also undermines the overall credibility of such certification schemes.

Finally, market-related limitations further constrain the scaling of sustainable production. While survey data indicate a relatively high declared willingness to pay for sustainable alternatives (63.8%), actual consumer purchasing behavior falls considerably short, with estimates ranging between 35% and 40%. This discrepancy is further aggravated by the limited availability of sustainable products within mainstream retail channels, which restricts consumer access and, in turn, slows down the broader diffusion of sustainable consumption patterns.

In light of the identified barriers, **several strategic approaches** are recommended to facilitate the transition toward sustainable production in the food sector. From a financial perspective, the establishment of targeted funds dedicated to green investments is essential in order to reduce the burden of initial transformation costs. Complementary to this, the development of innovative financial instruments – such as green bonds and sustainability-linked loans or mortgages – could provide enterprises with more flexible and accessible means of financing sustainability-oriented initiatives.

At the policy level, greater alignment between national sustainability standards and EU regulatory frameworks is required to minimize regulatory uncertainty and foster coherence across markets. Furthermore, the integration of mandatory sustainability criteria within public procurement processes would not only stimulate

demand for sustainable products but also create exemplary market practices that can be emulated by private sector actors.

Market-based incentives have the potential to significantly strengthen the uptake of sustainable products. Enhancing distribution infrastructure would ensure that sustainable alternatives gain broader penetration within mainstream retail channels, thereby improving consumer access. Equally important is the introduction of scientifically validated eco-labels, designed with clear and transparent messaging. Such labeling systems could play a pivotal role in building consumer trust while simultaneously addressing the risks of greenwashing, which remain a key obstacle to market credibility.

The stakeholder recommendations related to the strategic approaches for advancing sustainable food production are derived from structured interviews conducted with 15 key stakeholders representing industry, government, academia, and non-governmental organizations. The collected data were systematically analyzed through content analysis, frequency quantification, and cross-sectoral comparison, allowing for the identification of strategic priorities that are broadly supported across stakeholder groups.

Among the proposed measures, **financial incentives** emerged as the most widely endorsed strategy, receiving support from 85% of participants. Stakeholders emphasized the role of subsidies, tax reductions, and loan guarantees in lowering the costs of transition, with the potential to achieve a 15–25% reduction in investment expenditures and to significantly shorten payback periods.

Technological innovation was also highlighted as a critical pathway, supported by 78% of respondents. Within this domain, three priority areas were identified: energy efficiency (52%), circular production models (26%), and the adoption of biodegradable packaging solutions (22%). Collectively, these innovations are expected to reduce energy consumption by approximately 30% and cut production waste by up to 50%.

In addition, **educational campaigns** were considered essential by 70% of stakeholders. Targeted at both consumers and producers, such initiatives – implemented through media channels, educational institutions, and digital platforms – are projected to increase public awareness by 25% and raise consumer willingness to pay for sustainable alternatives by an estimated 15% within a three-year period.

Finally, **regulatory strengthening** was supported by 65% of participants. Proposed measures included the introduction of stricter emission limits, enhanced organic waste management systems, and binding waste reduction targets of up to 25% annually. Such interventions were viewed as necessary to complement financial and market-based measures, thereby creating a more coherent framework for sustainable food production.

The findings of the **Life Cycle Assessment (LCA)** conducted in this study underscore the considerable environmental advantages of plant-based alternatives when compared to conventional animal-based products. Plant-based options demonstrate between 45-60% lower carbon emissions, three to five times lower water consumption, and a reduction of 50-70% in land use. These outcomes provide a robust scientific foundation for advocating dietary shifts and production realignments toward

more resource-efficient systems. Additional opportunities to reduce the environmental footprint, estimated at 15-25%, can be realized through optimized packaging strategies. Biodegradable materials show the potential to reduce plastic waste by up to 80%, while reuse systems can achieve efficiency improvements of 30-40%. Together, these measures highlight both the scientific rationale and the practical feasibility of interventions aimed at lowering the ecological impacts of agri-food production and consumption.

Stakeholder consultations with policymakers, industry representatives, and sustainability experts further emphasized the urgent need for regulatory reforms that can reinforce the transition to sustainable agri-food systems. Participants pointed to three domains where targeted action would have the greatest effect. Horizontal measures such as binding Life Cycle Assessment standards, harmonized environmental labeling schemes, and the introduction of a carbon tax above €20 per ton of CO₂-equivalent were identified as critical steps toward establishing a coherent regulatory foundation. In parallel, sector-specific measures in food processing and agriculture were highlighted as essential. For the food processing sector, improved energy efficiency and optimized waste management were considered priorities, while in agriculture the focus lay on the transition to organic farming practices and sustainable management of water resources. Finally, strengthening institutional capacities was seen as indispensable for long-term progress. The establishment of a National Center for Sustainable Agriculture would provide coordination in research, training, and innovation, while the creation of an independent ecological certification authority would help secure transparency and credibility in sustainability claims.

If implemented in an integrated manner, these horizontal measures, sector-specific actions, and institutional reforms would form a coherent policy framework capable of accelerating the shift to sustainable agri-food systems. By aligning regulatory action with scientific evidence and stakeholder priorities, such a framework would deliver clear and measurable benefits for businesses, consumers, and the environment alike.

5. CONCLUSION

This research provides evidence-based insights into the environmental, economic, and social dimensions of sustainable food production in North Macedonia. By applying an integrative methodology that combined Life Cycle Assessment (LCA), consumer surveys, and stakeholder interviews, several key findings have emerged. The LCA results confirm the substantial environmental advantages of plant-based alternatives, which demonstrate between 45% and 60% lower carbon emissions, markedly reduced water consumption, and significantly less land use compared to conventional products. Additional reductions in environmental impact can be achieved through innovative packaging solutions, particularly the use of biodegradable materials and reuse systems.

At the market level, the findings reveal both opportunities and persistent challenges. While a majority of consumers (63.8%) express willingness to adopt sustainable alternatives, price sensitivity continues to act as a major barrier to actual purchasing behavior. The establishment of a standardized and transparent eco-labeling system was identified as essential for building consumer trust and reducing uncertainty.

The analysis further highlights a number of structural barriers to sustainable transformation. High upfront costs represent a major obstacle, particularly for small and medium-sized enterprises, while the lack of coordinated policy incentives limits the effectiveness of existing initiatives. Moreover, fragmented infrastructure within sustainable agriculture and food processing continues to constrain the scalability of innovative practices.

Despite these challenges, the research identifies several strategic directions for systemic transformation. On the policy level, harmonized sustainability standards, comprehensive financial incentive programs such as subsidies and tax relief, and the establishment of a national coordinating body for sustainable food policy could provide a coherent framework for progress. From an industrial perspective, investments in circular production models, the development of localized short supply chains, and the deployment of energy-efficient technologies would help to align production processes with sustainability goals. Equally important is consumer engagement, which can be strengthened through targeted education and awareness campaigns, credible eco-labeling systems, and the promotion of partnerships between producers and consumers.

The transition toward a sustainable food system in North Macedonia is a complex but achievable objective that requires a holistic approach. While this study identifies significant barriers, it also outlines practical opportunities for systemic change through synergies across policy, industry, and consumer sectors, strategic investments in critical technologies and infrastructure, and the establishment of inclusive decision-making mechanisms. Future research should continue to explore the economies of scale in sustainable production, assess the impacts of implemented policy measures, and monitor long-term trends in consumer behavior.

References

- 1) Bojkovska, K. (2021). *Marketing strategies for export of agri food products on foreign markets*. Bitola: Faculty of Biotechnical Sciences, pp. 43-47.
- 2) Bojkovska K. et.al. (2023). *Circular economy – global concept for sustainability*, Macedonian Science Society, Bitola, pp. 51-70
- 3) Braun, V. & Clarke, V. (2006). 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, 3(2), pp. 77–101.
- 4) Budžaki, S. et al. (2018). 'Cost analysis of biodiesel production from waste cooking oil', *Fuel*, 222, pp. 394–408.
- 5) Camilleri, M.A. (2021). *Strategic corporate communication in the digital age*. Bingley: Emerald Publishing Limited, pp. 45-68.
- 6) European Commission (2020). *Farm to Fork Strategy: For a Fair, Healthy and Environmentally-Friendly Food System*. COM (2020) 381 final. Brussels.
- 7) European Environment Agency (EEA) (2022). *Circular Economy in the Western Balkans: State of Play*. EEA Report No 15/2022. Copenhagen.
- 8) Food and Agriculture Organization (FAO) (2021). *The State of Food and Agriculture: Making Agrifood Systems More Resilient*. Rome: FAO.
- 9) Geissdoerfer, M. et al. (2017). 'The Circular Economy – A new sustainability paradigm?', *Journal of Cleaner Production*, 143, pp. 757–768.
- 10) Grunert, K.G. (2019). 'Sustainability in the Food Sector: A Consumer Behaviour Perspective', *International Journal on Food System Dynamics*, 10(3), pp. 195–205.

- 11) Kircher, M. *et al.* (2017). *Transition Towards a Circular Bioeconomy: Forestry and Forest-Based Industries*. Joensuu: European Forest Institute, pp. 20-35.
- 12) Ministry of Agriculture, Forestry and Water Economy, North Macedonia (2022). Report on Food Waste Management Practices. Skopje.
- 13) Ministry of Environment and Physical Planning (2020): National Waste Management Plan (2020-2030), https://www.moepp.gov.mk/wp-content/uploads/2020/10/Nacrt-SOZS-NPUO_14.10.2020_v02.pdf
- 14) Ministry of Environment and Physical Planning (2010): National Strategy for Sustainable Development (2009-2030), <https://www.moepp.gov.mk/wp-content/uploads/2014/12/Nacionalna-Strategija-za-Odrziv-Razvoj-vo-RM-NSSD-Del-1.pdf>
- 15) 13. Notarnicola, B. *et al.* (2017). '*Environmental impacts of food consumption in Europe*', Journal of Cleaner Production, 140, pp. 753–765.
- 16) Poore, J. and Nemecek, T. (2018). '*Reducing food's environmental impacts through producers and consumers*', Science, 360(6392), pp. 987–992.
- 17) United Nations Development Programme (UNDP) (2019). *Comparative Analysis of Green Technology Investments in the Western Balkans*. New York: UNDP.
- 18) Verghese, K. *et al.* (2015). '*Packaging's role in minimizing food waste in the supply chain*', Packaging Technology and Science, 28(7), pp. 603–620.
- 19) Wikström, F. *et al.* (2018). '*Packaging strategies that save food: a research agenda for 2030*', Journal of Industrial Ecology, 23(15), pp. 532-540. DOI: 10.1111/jiec.12769.

ADAPTING GREEN PUBLIC PROCUREMENT FOR A CIRCULAR ECONOMY: CHALLENGES, PROCESSES, AND POLICIES IN PORTUGAL

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Abstract

Green public procurement (GPP) is a strategic approach that enables government entities to acquire goods and services while prioritizing sustainability and minimizing environmental impact. By integrating environmental and social criteria into procurement processes, GPP fosters responsible consumption and production patterns, essential for advancing a circular economy.

This paper examines the evolution and implementation of GPP in Portugal, analyzing the extent to which environmental criteria are embedded in procurement strategies. It explores the key challenges and opportunities associated with the transition to a circular economy through public procurement, identifying gaps and potential improvements in policy and practice. A critical assessment of current legislation and policy frameworks is provided, evaluating their effectiveness in driving sustainability, resource efficiency, and waste reduction.

The study offers an overview of the current state of GPP in Portugal and its long-term implications for circular economy objectives. It concludes with policy recommendations to enhance the effectiveness of green procurement practices, ensuring they contribute to a more resource-efficient and consumer-friendly circular economy.

Keywords: *Green Public Procurement; Public Administration; Portugal; Policy*

JEL Classification: K32

1. INTRODUCTION

Green public procurement refers to practices and policies for the acquisition of goods and services by government entities with a focus on sustainability and reducing environmental impact. This approach aims to integrate environmental and social criteria into public procurement processes, promoting more sustainable and responsible practices. Considering the importance of the topic described, this paper examines the evolution and implementation of green public procurement in Portugal in the legal context, analyzing how government entities in Portugal are integrating environmental criteria into the processes of acquiring goods and services, highlighting the implications, challenges and associated opportunities.

The main elements associated with green public procurement include the integration of environmental criteria in the supplier selection and evaluation processes, considering the life cycle of products or services. Furthermore, it encourages preference for environmentally certified products and services, demonstrating the commitment to sustainable practices. Prioritizing energy efficiency when choosing products and services aims to reduce the consumption of natural resources. Green public procurement also stimulates sustainable innovation, favoring products and services with a lower environmental impact.

Additionally, social responsibility is incorporated, including responsible social practices in the selection of suppliers, with special attention to working conditions and respect for human rights. We intend to analyze the current legislation and policies that guide green public procurement in Portugal, evaluating their impact on promoting sustainability and mitigating environmental impact. This study aims to provide a comprehensive overview of the current state of green public procurement in Portugal and its implications for long-term sustainability. Finally, recommendations are presented to improve the effectiveness of green public procurement policies and practices in Portugal as a means of resolving complex political challenges.

2. METHODOLOGY

To conduct this research, the methodology employed uses a mixed approach that combines documentary research, content analysis, and case studies.

Documentary Research includes a Literature Review covering the search for existing academic literature on green public procurement, sustainability in public procurement, and social responsibility practices. It also involves the analysis of Legislation and Policies, where laws, regulations, and policies guiding green public procurement in Portugal were collected and examined, including government documents, official reports, and guidelines from regulatory bodies.

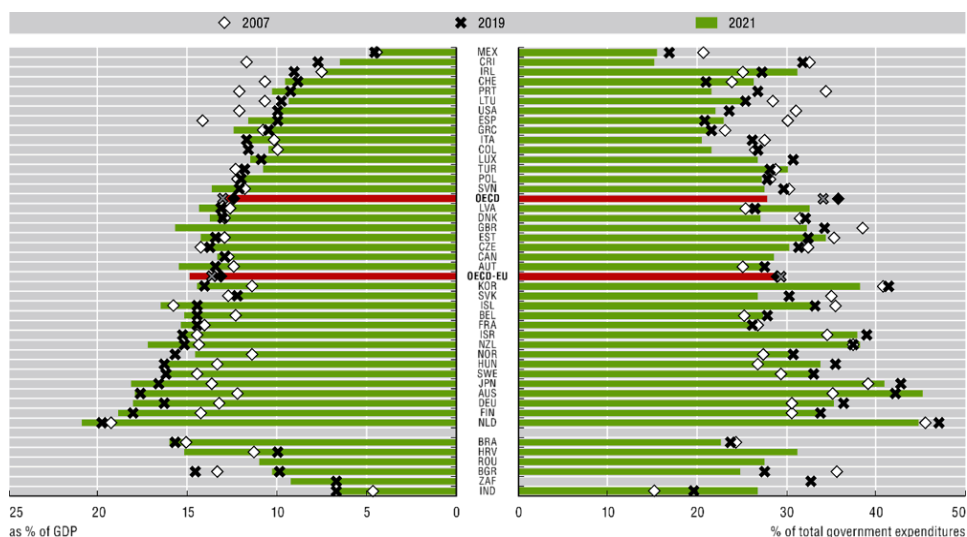
Content analysis was based on the evaluation of environmental and social criteria, analyzing how these criteria can be integrated into green public procurement processes in Portugal. This analysis includes the review of tender documents and procurement contracts published on the Portal Base.

Regarding case studies, this will be further explored in subsequent research. It aims to select representative cases by choosing various government entities that have implemented green public procurement practices for detailed study. In the future, interviews and questionnaires are planned to gain insights into practical implementation, challenges, and opportunities.

3. THE SIZE OF PUBLIC PROCUREMENT

The results are analyzed in 3 parts, namely: the size of public procurement, evolution of the legal framework for public procurement in Portugal, and the lowest price.

Over the past decade, public procurement spending as a percentage of GDP has risen notably across the OECD, going from 11.8% in 2007 to 12.9% in 2021. In recent years, there has been an additional increase in public procurement's GDP share. Specifically, in OECD-EU countries, it grew from 13.7% in 2019 to 14.8% in 2021, largely attributed to the Recovery and Resilience Facility (RRF), a key element of Europe's recovery strategy that has stimulated public investment (OCDE 2023).



Source: OECD National Accounts Statistics (database). StatLink <https://stat.link/gq15r6>

Figure 1. General government procurement spending as a percentage of GDP and total government expenditures, 2007, 2019 and 2021

States and public administrations are consumer organizations of varied goods and services and they are at a European level among the entities with more purchase power. European Union (EU) estimates that public authorities expend annually about 16% of the Gross Domestic Product (GDP) purchasing goods and services, a situation that besides the financial costs also involves environmental costs (Mira 2011). Reconsidering contracting authority as a means to direct that purchasing power for the acquisition of ecological products and services, which will contribute to reduce the environmental impact and to a sustainable economic development has been a major concern of the EU. Besides the general aim of

reducing the environmental impact resulting from the consumption of public services, contracting authority has also an important role in the European Union Strategy for Sustainable Development (Mira 2011).

Green public procurement is the public purchasing of products and services that are less environmentally damaging when taking into account their whole life cycle. Countries increasingly use GPP to achieve secondary policy objectives in the area of environmental protection. The OECD has been a forerunner in encouraging the development of Green public purchasing policies (OCDE 2019).

Public procurement is used across all spending functions, from health to environmental protection, public order and economic affairs. As in previous years, Portugal spends more on Health and Economics affairs while spends only 4,3% in Environmental protection.

Table 1. General government procurement spending by function as percentage of total procurement spending, 2021

Country	General public services	Defence	Public order and safety	Economic affairs	Environmental protection	Housing and community amenities	Health	Recreation, culture and religion	Education	Social protection
Austria	11.5	1.3	2.6	20.7	1.2	0.6	40.7	3.4	8.1	10.0
Belgium	11.8	2.1	2.1	12.8	2.9	1.1	47.6	2.6	6.5	10.5
Costa Rica	4.6	0.0	7.6	12.2	3.9	3.6	39.5	1.2	17.0	10.4
Czech Republic	7.9	3.1	4.1	22.3	5.1	3.0	36.7	4.6	9.0	4.1
Denmark	14.4	5.1	2.7	9.0	1.2	0.6	36.5	4.7	10.9	14.8
Estonia	8.8	9.7	4.2	18.9	3.0	2.6	27.5	6.3	14.3	4.7
Finland	22.2	3.8	2.0	12.2	0.6	1.4	24.7	3.6	11.3	18.2
France	7.2	5.9	2.6	12.5	4.1	3.4	41.9	4.1	5.9	12.3
Germany	11.2	3.9	3.1	9.1	1.9	1.0	42.9	3.2	6.5	17.1
Greece	15.1	8.7	1.6	15.1	4.4	1.7	38.4	3.3	7.1	4.6
Hungary	15.0	4.2	2.8	29.7	3.5	2.3	20.5	8.2	10.5	3.4
Iceland	10.0	0.5	4.0	18.8	2.6	2.2	27.0	9.0	18.0	7.8
Ireland	4.6	0.8	4.0	13.4	2.3	5.1	39.1	3.5	8.5	18.6
Israel	5.8	18.4	2.9	11.1	2.6	2.0	28.3	4.2	13.7	11.0
Italy	12.4	4.2	3.5	13.4	6.8	2.6	43.7	3.9	4.3	5.2
Japan	6.3	3.4	1.8	15.2	5.2	1.8	45.1	1.4	6.5	13.2
Korea	5.6	11.4	2.9	15.3	4.0	6.3	32.2	2.8	12.9	6.6
Latvia	6.4	12.2	4.9	20.7	2.4	5.2	26.1	4.5	13.3	4.3
Lithuania	7.0	8.4	3.5	18.3	3.5	4.3	32.1	5.6	11.5	5.9
Luxembourg	13.2	1.4	2.9	21.4	4.6	2.2	23.6	5.0	7.8	17.9
Netherlands	5.5	3.0	3.5	11.3	4.6	1.4	35.3	3.2	8.3	23.7
Norway	10.0	7.8	2.6	21.9	3.8	3.7	27.4	4.6	9.4	8.9
Poland	5.3	5.7	4.6	26.7	2.7	3.6	32.1	5.6	10.0	3.7
Portugal	11.9	2.4	3.1	20.2	4.3	4.0	37.0	4.8	8.3	4.0
Slovak Republic	9.4	4.6	3.9	23.2	4.0	2.7	39.6	3.4	7.1	2.1
Slovenia	10.0	3.2	3.3	23.3	3.1	3.5	33.7	5.0	10.4	4.7
Spain	9.7	3.5	2.8	16.1	6.4	2.8	33.7	5.1	10.9	9.0
Sweden	9.7	5.2	2.9	13.5	2.2	2.7	23.7	3.6	15.3	13.2
Switzerland	21.4	5.5	5.5	14.8	3.9	1.5	6.7	2.8	18.2	19.7
United Kingdom	3.1	9.7	6.2	11.8	3.6	2.6	37.9	2.2	9.2	13.8
United States	10.7	20.2	6.4	21.9	0.0	2.4	16.3	1.6	16.4	4.1
OECD	9.2	9.9	4.2	16.4	2.7	2.4	31.9	2.7	10.7	9.8
OECD-EU	10.2	4.2	3.1	13.7	3.6	2.2	39.0	3.9	7.6	12.5
Bulgaria	7.3	7.2	4.0	13.8	5.7	8.4	37.4	2.8	10.8	2.6
Croatia	8.9	2.5	5.2	23.5	3.7	4.5	33.5	4.7	9.8	3.7
Romania	9.1	5.3	2.6	29.5	4.3	8.3	27.5	4.0	6.1	3.4

Source: OECD National Accounts Statistics (database); Eurostat Government Finance Statistics (database). StatLink <https://stat.link/lptwg7>

4. THE EVOLUTION OF THE LEGAL FRAMEWORK FOR PUBLIC PROCUREMENT IN PORTUGAL

The Portuguese initiatives are based on European Directives. It started in 2007, as a guide, until becoming mandatory criteria.

The National Strategy for Ecological Public Procurement, approved by Resolution of the Council of Ministers no. 65/2007, of May 7, for the period 2008-2010, constituted a relevant guiding instrument, with a significant impact on the national purchasing system (SNCP), in the integration of environmental criteria in framework agreements for transversal categories of goods and services and,

consequently, in the contracting processes triggered by public entities (PRESIDÊNCIA DO CONSELHO DE MINISTROS 2023).

In 2016, the National Strategy for Ecological Public Procurement 2020 (ENCPE 2020) was defined, approved by Resolution of the Council of Ministers no. 38/2016, of July 29, which now has a more comprehensive and effective impact, covering a greater number of acquisition procedures and enhancing their application to entities under direct and indirect administration of the State, the State's business sector and, also, on a voluntary basis, the autonomous administration and other legal entities governed by public law.

One of the main tasks of ENCPE 2020 was the adaptation to the national context of the manuals referring to the priority products and services covered by this strategy, through the constitution of thematic and interdisciplinary working groups created for this purpose, which constituted the bases for the introduction of criteria ecological in public acquisitions of products, services and public works contracts, operationalizing ecological public contracting (CPE) within the scope of the activity carried out by public administration.

More recently, in the amendment to the public procurement law promoted by Law no. 30/2021, of May 21, a greater and more adequate integration of environmental considerations into public procurement procedures was introduced.

Specifically, the changes envisaged in the most relevant Portuguese public procurement law ensured the provision of conditions for the execution of contracts and factors for evaluating proposals in line with the fundamental concerns of the CPE and which go further than previously established, namely in subject of:

- a) Environmental sustainability, in particular with regard to transport time and availability of the product or service, especially in the case of perishable products;
- b) Energy efficiency, in particular, energy supply;
- c) Promotion of the circular economy and short distribution circuits, ensuring efficiency in the use of materials and the reduction of environmental impacts;
- d) Use of products from organic production.

5. THE LOWEST PRICE

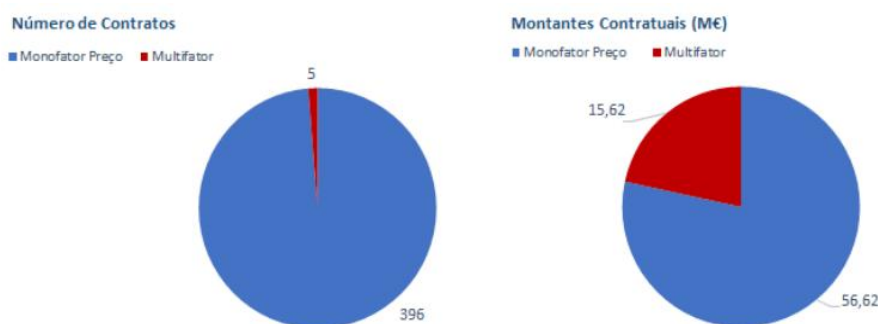
Various stages of the public procurement and the implementation procedure can become more ecological (Gomes & Caldeira, 2017):

- (i) Decision to hire
- (ii) Method of contracting
- (iii) Object of the contract
- (iv) Type of pre-contractual procedure to be adopted
- (v) Characteristics of economic operators
- (vi) Technical specifications
- (vii) Analysis (and exclusion) of proposals

- (viii) Variant proposals
- (ix) Evaluation of proposals
- (x) Execution of the contract

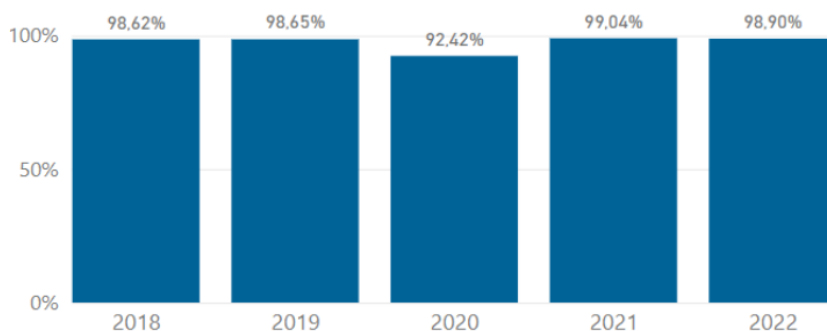
In this article we will only emphasize the aspect of evaluating proposals. The principle “best value for money” is fundamental. This increases the competition, but the most sustainable solutions are not the cheapest. The modalities of awarding criteria are two: single-factor and multifactor. The single-factor is the lowest price.

According to the report on public procurement in Portugal in 2022 (Instituto dos Mercados Públicos 2023). In a sample of tender procedures (based on the advertisement) and whose contracts were celebrated in 2022, it was found that 98.8% only had price as an evaluation factor in their awarding method. These contracts corresponded to 78.4% of contractual amounts.



Source: Portal Base (October 2023)

Figure 2. Type of award in open procedures (public and limited competitions)



Source: Portal Base (October 2023)

Figure 3. Percentage of the number of contracts in which the single factor price or cost had preponderance majority

In 2023, the trend observed in previous years continued, which points to timid representation in the use of the multifactor modality.

Even in a multifactor modality, the price factor is relevant. Comparing the procedures in which the proposal assessment factor was only price, with other procedures in which the price factor, was not the only assessment factor, the price represented more than half of the weighting. We conclude that in 98.9% of the tender procedures, price was the determining and majority weighting factor (Instituto dos Mercados Públicos 2023).

6. CONCLUSIONS

Public procurement has evolved into a strategic tool for governments seeking to achieve economic efficiency while promoting social and environmental well-being. It has become a critical instrument of administrative action to meet collective needs, significantly impacting national budgets.

Initially, public procurement was viewed with skepticism due to concerns about potential disruptions to the principles of competition and transparency enshrined in procurement law. However, the European Union's increasing commitment to combating global warming, with public authorities expected to lead by example, has made public procurement particularly receptive to the integration of eco-criteria throughout its various stages and implementation procedures.

The main obstacles that lead states not to exploit the full potential of these contracts were (Rodrigues 2014):

- Limited environmental criteria established for products/services – and when these exist, they are often insufficient for their dissemination;
- Insufficient information on calculating the cost of the entire product cycle and the relative costs of environmentally friendly products/services;
- Insufficient awareness of the benefits of environmentally friendly products and services;
- Uncertainty about the legal possibilities of including environmental criteria in specifications;
- Lack of political support and consequently limited resources for the implementation and promotion of green public procurement (especially better training);
- Lack of a coordinated exchange of best practices and information between regions and local authorities.

References

- 1) Gomes, C. A.& Caldeira, M. (2017). Green Public Procurement: An Ecologic (r)Evolution. *Revista Da AGU* 14 (4): 44–80. www.icjp.pt. [Accessed 12.06.2025].
- 2) Instituto dos Mercados Públicos, do Imobiliário e da Construção. (2023). *Relatório Anual 2022: Contratação Pública Em Portugal*. Lisboa. www.base.gov.pt.

- 3) Mira, M. E. (2011). *Gestão Ambiental na Administração Publica Central Portuguesa. Mestrado Em Cidadania Ambiental e Participação*. Lisboa: Universidade Aberta. <https://doi.org/http://hdl.handle.net/10400.2/1899>. [Accessed 12.06.2025].
- 4) OCDE (2019). *Reforming Public Procurement*. OECD Public Governance Reviews. OECD. <https://doi.org/10.1787/1de41738-en>. [Accessed 12.06.2025].
- 5) OCDE (2023). *Government at a Glance 2023*. Government at a Glance. OECD. <https://doi.org/10.1787/3d5c5d31-en>. [Accessed 12.06.2025].
- 6) PRESIDÊNCIA DO CONSELHO DE MINISTROS (2023) *Estratégia Nacional Para as Compras Públicas Ecológicas 2030 – ECO360*. 1a série, n.o 30. Diário da República.
- 7) Rodrigues, C. S. M. (2014). *Entre a Contratação Pública Ecológica e a Contratação Pública Sustentável-Compreender o Presente, Transpor o Futuro*. Coimbra: Universidade de Coimbra. <https://hdl.handle.net/10316/28443>. [Accessed 12.06.2025].

THE CHALLENGE OF RAISING PUBLIC AWARENESS FOR THE DEVELOPMENT OF A CIRCULAR ECONOMY IN GEORGIA

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Abstract

In recent decades, the issue of human economic activity, which involves the consumption of natural resources on an annual basis whilst reducing the resources available for future use, has become increasingly salient. This dynamic is detrimental to the environment, ecology and the economy, and consequently raises the issue of transitioning from a linear economy to a circular economy.

The paper discusses the policy developed for the development of the circular economy in the European Union, the action plan based on this policy and its significance not only for the EU Member States, but also for the countries on the way to rapprochement with the EU, including Georgia.

Since signing the Association Agreement with the European Union in 2014, Georgia has taken steps in a number of areas to bring its country in line with European standards and legislation in the areas of environmental protection, climate change and others. Georgia is embarking on an accelerated path of transition to a circular economy, which requires the joint participation of many stakeholders - government agencies at all levels, the business sector, academia, investors and consumers.

Based on official documents of the European Union and Georgia, as well as studies conducted by different sectors, the article discusses several examples of the legislative framework necessary for the development of the circular economy in order to raise public awareness, different measures taken in response to the existing needs in this direction, their results and recommendations for further actions.

Keywords: *circular economy; public awareness; sustainable development; environmental policy; European Union; Georgia*

JEL Classification: *Q56, Q58, O13, K32, D83*

1. INTRODUCTION

In recent decades, the issue of human economic activity has become relevant, as it annually increases the number of natural resources consumed while reducing resources intended for the future. Such dynamics damage the environment, ecology, and economy raises the question of transitioning from a linear economy to a circular economy.

Against the backdrop of today's economic and environmental challenges, the circular economy is widely regarded as one of the most effective models for the sustainable use of resources and waste minimization. However, the successful implementation of this model depends heavily on public awareness. In Georgia, the concept of the circular economy is still in its infancy, and public knowledge of it is limited. This is precisely why raising public awareness is one of the most important prerequisites for developing this model. "The circular economy requires technological innovation and behavioral changes in society" (Geissdoerfer *et al.*, 2017).

Informing and educating society in this direction is critically important, as the circular economy requires changes at both the individual behavior and business practice levels. Several important details should be highlighted in this regard: It is essential to address existing societal challenges and manage change at the consumer level. A circular economy involves maximizing the use of resources and recycling to minimize waste. In order to achieve this, consumers need to know how to reduce waste, select sustainable products and participate in recycling; Encouraging businesses – An informed society creates demand for environmentally responsible products, which compels businesses to shift to circular models; Cultural transformation - Raising public awareness creates new social norms and values based on the smart use of resources and environmental protection; Low level of awareness among the population – Many citizens still do not have a full understanding of the concept of the circular economy and its benefits; Lack of education in schools and universities – this topic is rarely included in formal education. Naturally, these are issues that require considerable effort. This paper examines the steps taken in this direction in Georgia, the results achieved and future tasks for developing the country's circular economy.

Since signing the Association Agreement with the European Union in 2014, Georgia has made significant progress in aligning its legislation with EU standards and has embarked on a proactive journey towards integration with the EU. As the 'Association Agreement' is implemented, raising awareness of European values and rules among the population has become particularly relevant. This is important for approaching European standards and improving living standards.

As in other countries, it is important to assess how public knowledge and behaviour influence the development of the circular economy in Georgia, and how consumer changes and social norms and values are formed.

2. ASSOCIATION AGREEMENT AND ENVIRONMENTAL COMMITMENTS

The “Association Agreement between Georgia and the European Union”, signed in 2014, is an ambitious and innovative “new generation” agreement. It includes a Deep and Comprehensive Free Trade Area (DCFTA) component, as well as important concrete mechanisms for rapprochement with the European Union. For Georgia, the Association Agreement with the EU establishes a new legal framework for cooperation between the two sides and allows for closer collaboration in all priority areas (Association Agreement between Georgia and the European Union, 2014).

The Association Agreement addresses environmental issues, among other things. In the field of environmental policy and climate change, it includes the following key commitments:

Legislation harmonisation: Georgian legislation is moving closer to EU environmental directives and regulations. This includes the regulation of waste management, air and water pollution, and the protection of biodiversity and other environmental issues.

Developing sustainable development strategies: Georgia is responsible for developing and implementing national strategies and action plans on climate change, energy efficiency, and the circular economy.

Institutional capacity building: Georgia is responsible for strengthening the relevant institutional and administrative capacity to ensure the implementation of existing legislation.

Specific commitments to the circular economy include:

Improving the waste management system in line with relevant EU directives. Georgia has improved its waste management system to include waste reduction, recycling and reuse; Harmonisation of regulations and standards: Georgian legislation has been brought closer to EU technical regulations and standards to facilitate the implementation of the circular economy's principles; Promotion of sustainable production and consumption: Georgia has developed policies and strategies that promote sustainable production and consumption.

Thus, the Association Agreement is an important tool for Georgia in developing its circular economy. This includes harmonising legislation, developing strategies, and strengthening institutional capacities. Fulfilment of the Association Agreement's obligations contributes to Georgia's circular economy development. Promoting economic growth: Adopting circular economy principles promotes efficient use of resources and the development of new business models; Improving the environment: Improving waste management and reducing pollution improves the environment. Enhancing social well-being: Implementing sustainable development strategies enhances social well-being and job creation.

3. DEVELOPMENT OF THE CIRCULAR ECONOMY IN GEORGIA AND RAISING PUBLIC AWARENESS

The Georgian government has introduced legislative changes based on EU environmental and economic policy principles. These reforms aim to improve waste management, increase resource efficiency, and raise environmental standards.

The government has also set up agencies and mechanisms to develop and implement circular economy policies. These agencies have contributed to the development of sustainable development strategies and their effective implementation.

Since 2014, when the Ministry of Environment and Agriculture of Georgia began implementing the principles of the circular economy, it has organised awareness-raising campaigns and meetings with politicians, NGOs and business representatives. The second stage involved assessing the country's potential for implementing the circular economy and identifying priority sectors in which circular models could be implemented most effectively. The third stage involved developing a circular economy strategy.

Georgia is actively establishing partnerships to learn from the experience of more advanced countries and implement circular approaches, with the aim of becoming a leading regional player. The Government of Sweden and the Swedish International Development Agency (SIDA) currently provide the main assistance to Georgia. The first step in developing a circular economy is raising awareness. The activities implemented by the Union of Nature Researchers of Georgia "Orchis" are of particular interest in this regard. This programme provides stakeholders with recommendations on how to accelerate the implementation of circular model principles at different levels of economic activity (Prasek *et al.*, 2022). „Orchis”, a non-governmental, non-profitable organization that was founded in 1997 with the aim to protect environment and involvement in elaboration and implementation of environmental protection measures to create better and safer environment for society. „Orchis” actively promotes an accelerated transition to a green economy in Georgia. This involves promoting and implementing environmental, social and corporate governance, green finance and green procurement practices, while taking into account international best practices. “Orchis” believes that, by working closely with the government, the business sector, financial institutions, the Academy of Sciences and other relevant stakeholders, civil society can play an important role in the green transformation process and the implementation of circular economy principles at various levels of economic activity.

„Orchis” projects form the basis for the accelerated implementation of the circular economy. They are also important for fulfilling the commitments undertaken under the Association Agreement with the European Union, as well as

for inclusion in the European Green Deal process. This, in turn, ensures the implementation of the sustainable development agenda.

As part of this project, “Orchis” has planned lectures and training sessions on environmental degradation and human health, waste management and sustainable development goals, and biodiversity and climate change adaptation issues at various higher education institutions in 2023. One of the first events took place at Sulhan Saba Orbeliani University, where presentations on the following topics were given to students and faculty: „Environmental Pollution and Human Health”, „Sustainable Waste Management: Challenges and Development Prospects”, and 'Biodiversity, Climate Change, and Sustainable Development'. These discussions aroused great interest and prospects for future cooperation in the field of environmental protection and the circular economy were outlined ("Orchis" Green Transformation).

“Orchis” educational activities and campaigns are an effective means of achieving the Sustainable Development Goals. These goals have a broad scope, addressing the interconnected elements of sustainable development: economic growth, social inclusion, and environmental protection. In this context, raising awareness among the general public, including university students, is important. Protecting biodiversity, addressing climate change and ensuring proper waste management and care for human health are important components without which the SDGs cannot be achieved. Notably, “Orchis” is supported by the Georgian Ministries of Environment and Agriculture, Education and Science, Economy and Sustainable Development, and Regional Development and Infrastructure, as well as receiving financial support from the Government of Sweden.

4. LEVEL OF PUBLIC AWARENESS OF CIRCULAR ECONOMY IN GEORGIA

The Circular Economy Awareness Programme, developed by “Orchis”, provides basic information on the circular economy and circular business models, as well as financing opportunities. It also offers guidance to various stakeholder groups, including policymakers, financial institutions, and project promoters, on accelerating the adoption of circular economy principles at different levels of economic activity. Launched in November 2019, the programme featured an international circular economy expert and eight one-day conferences for various target groups. Notably, all conferences were attended by Members of Parliament, senior civil servants at central and local levels, and private sector representatives. Key issues discussed at the conferences included general information on circular economic transition pathways, the legacy of the industrial era, current trends, and the challenges and opportunities they present. Other topics covered included a comparison of linear and circular approaches, circular economy business models, and information on EU circular economy policies. These include the initial 2015 circular economy package and the new Circular Economy Action Plan adopted in

2020. Two books on the circular economy have been published, as well as several thematic articles in the journal. Environmental education is crucial for the development of the circular economy. Back in 2014, the Centre for Environmental Information and Education, supported by the German Society for International Cooperation (GIZ), conducted a small study which assessed environmental education in formal and non-formal sectors in Georgia, identifying achievements and requirements.

A study entitled “Assessing of Environmental Education and Awareness in Georgia” at the National Level was conducted in 2022. It was carried out by the Institute for Social Studies and Analysis (ISSA), at the initiative of the Centre for Environmental Information and Education, and with the support of the United Nations Development Programme (UNDP) and the Government of Sweden (Assessing the level of environmental Education and Awareness in Georgia, 2022).

According to the survey, the majority of respondents (an average of 60 per cent) rarely or never read environmental information or discuss environmental issues with others. Furthermore, although the majority of both urban and rural residents rarely read environmental information or discuss environmental issues, a higher proportion of rural residents than urban residents never or rarely read environmental information (64 per cent in rural areas versus 60.5 per cent in urban areas). Additionally, it is noteworthy that the proportion of individuals seeking information on significant environmental issues increases with educational attainment (30.5% of individuals with secondary education and 42% of individuals with higher education always or often receive such information) (Level of Environmental Information and Education in Georgia, 2022).

In recent years, activities aimed at promoting both formal and non-formal environmental education have been based on the Third National Environmental Action Programme, as well as objectives and goals defined by international agreements. Notable efforts include changes to the national textbook accreditation standards, which now incorporate sustainability principles; these principles have been reflected in all primary-level textbooks. In 2020, a supplementary textbook titled “*Environmental and Agricultural Education in Schools*” was published. A teacher training process has begun, and educational programs in vocational education have been updated accordingly.

Environmental education is a continuous process, and it is essential to implement consistent and uninterrupted actions, as the level of environmental education and awareness remains a challenge to this day.

Environmental awareness was identified as one of the key challenges in the thematic inquiry report by the Environmental Protection and Natural Resources Committee of the Parliament of Georgia, titled “*The Current Situation in the Field of Municipal Waste*.” The lack of education and awareness is also highlighted by the findings of various studies conducted under different projects on specific

environmental issues. Notably, the 2020 monitoring report of the project "*Clean Region – The Road to Europe*" emphasized this problem.

According to experts, environmental education should be prioritised at state level to encourage behavioural change regarding environmental issues. We agree with this, as the current situation is hindering the development of the circular economy and recycling infrastructure.

Studies in the Georgian environmental sector also indicate that public awareness is lacking due to a combination of insufficient information dissemination and infrastructural problems. For instance, many people do not understand the importance of correctly analysing and sorting waste, which results in lower recycling rates. In addition, the lack of recycling facilities and insufficient information campaigns at state level hinder population involvement and behavioural change. It can be said that raising awareness among Georgian citizens is one of the biggest challenges to developing a circular economy.

These results confirm that, to successfully implement the circular economy, it is necessary to develop and implement intensive education and communication programmes that reach different groups, from schoolchildren to professionals and civil society. According to other authors who have conducted research in both Georgia and other countries, social change and raising awareness are important conditions for the systematic implementation and sustainability of the circular economy (Geissdoerfer *et al.*, 2017).

These are clearly issues that require a great deal of work. The question arises: what can be done to raise awareness? The most effective methods are information campaigns through the media and social networks, the development of educational programmes for schools and universities, partnerships with local authorities and businesses, and pilot projects at a community level, such as markets for renewable materials and the development of environmental education centres and platforms. Various social media pages that provide information about the circular economy have proved interesting in this regard, including details of educational events and information about the nature and importance of the circular economy.

As part of our research into the study of the research question, we conducted a quantitative study. Two hundred respondents aged 18–25 were interviewed. The results showed that up to 85% of respondents were familiar with the Facebook page "Tene", which is active in protecting the environment from plastic waste and informing the public about its harmful effects. The page explains how the "Tene" bin helps us to recycle plastic so that we can use recycled plastic productively. Respondents are well aware of the importance of recycling plastic, protecting the environment from harmful substances, and making use of recycled plastic in other products. However, only a small proportion confirm that they participated in "Tene's" campaign, which offered a USB cable instead of a plastic bottle (Phone chargers in exchange for plastic bottles, 2021). Respondents are well aware of the importance of recycling plastic, protecting the environment from harmful

substances, and repurposing recycled plastic. However, only a small proportion confirm that they participated in Tene's campaign, which offered a USB cable instead of a plastic bottle.

In Georgia, knowledge of the circular economy is largely confined to environmental organisations, academic institutions, and specific business sectors. For ordinary citizens, the concept is often unfamiliar or is only associated with recycling.

In April 2021, a survey was conducted to investigate the level of awareness of the circular economy in society. Of the 80 respondents from different age groups, three-quarters were female and one-quarter were male. Half of the respondents were aware of the circular economy, while the other half were not. However, 90% of respondents felt that planning for a circular economy was inevitable. Interestingly, many respondents had heard of Georgian enterprises that had adopted the principles of the circular economy.

Clearly, the most effective way to address existing issues is to educate the population about the importance and effectiveness of the circular economy. Over the past few decades, various eco-friendly organisations and platforms working on circular economy principles have been established around the world, and events have been held to share experiences and expertise (Dolidze, 2021).

Strengthening Georgia's circular economy through resource efficiency and cleaner production' is of great interest to businesses. Resource Efficient and Cleaner Production (RECP) enables companies to implement comprehensive, continuous, preventive environmental strategies for their processes, products, and services, thereby improving efficiency and reducing risks to people and the environment. In short, RECP helps companies minimise the environmental impact of their operations, reduce their use of resources and increase their productivity.

Georgia has more than 41,000 manufacturing companies, 85 per cent of which are small and 9 per cent of which are medium-sized (Strengthening the circular economy in Georgia through resource-efficient and clean production, 2024). EU4Environment has shown that Georgian businesses are interested in achieving sustainability by reducing energy, material and water consumption and contributing to a cleaner environment. As material and energy costs are a significant part of production costs, inefficient use of natural resources not only wastes money, but also significantly contributes to climate change and environmental degradation. The EaP GREEN and EU4Environment programmes developed environmental, health and safety recommendations and proposed them to companies based on their specific needs, resources, capacities and priorities. Awareness raising activities were also carried out, national service providers were trained, and guidelines on RECP (Strengthening the circular economy in Georgia through resource-efficient and clean production, 2024).

Enterprises demonstrated a deep understanding of the role, purpose and benefits of the RECP methodology among their senior management. However,

while a few companies retained their original RECP-trained teams, most experienced rapid staff turnover. This emphasises the need for continuous practical training combined with awareness-raising activities to ensure the consistent application of lessons learnt from RECP.

Georgia's experience shows that international cooperation programmes have played a crucial role in generating demand for knowledge and services that were previously unavailable in industries promoting RESP and the circular economy over the last decade. Entrepreneurs are increasingly interested in participating in programmes that provide their industries with training and technical assistance. They are also motivated by the expected benefits and success stories of RECP demonstration companies. However, it remains important to strengthen the capacity of institutions implementing circular economy projects to disseminate relevant knowledge of the circular economy to society (Strengthening the circular economy in Georgia through resource-efficient and clean production, 2024).

An interesting document in terms of raising public awareness is the “*Food Waste Management Concept*,” which clearly outlines the transition to a more structured and scalable level of FLW (Food Loss and Waste) management, both at the decision-making and public awareness levels. This concept paves the way for international standards and best practices. The issue has become even more relevant following the adoption of the *Food Loss and Waste Reduction and Food Storage Law* by the Parliament of Georgia on October 4, 2023.

In this regard, alongside all other steps, awareness-raising campaigns are crucial. Initiatives are being developed at the national level for the public, especially schools, consumers, and primary producers, to help them understand the environmental and socio-economic impacts of food loss and waste. These campaigns aim to promote sustainable behaviors, including responsible purchasing, proper storage, and waste reduction practices.

Producer-focused campaigns are underway, with efforts to raise awareness among primary producers in collaboration with local activity groups. This will help reduce FLW and improve FLW management practices at the production level. It is important that the Ministry of Environmental Protection and Agriculture, the National Food Agency, local self-governments, the private sector, and civil society organizations ensure the implementation of awareness-raising and training programs about the significance of FLW reduction. The involvement of international organizations and donors is also essential, as they support targeted awareness campaigns aimed at strengthening the culture of FLW reduction in Georgia. While the concept is well-structured and aligned, it is designed for the period from 2025 to 2028. Therefore, it is currently impossible to assess the outcomes.

Access to a clean and healthy environment is one of the basic human rights enshrined in the Georgian Constitution. However, the production and import of plastic in Georgia has increased by 71% over the last decade, which has had a

direct impact on environmental pollution. There has been particular growth in the production and import of single-use plastic products. Around 93% of these products end up as waste in coastlines and illegal landfills.

In response to this challenge, the non-governmental organisation CENN (Caucasus Environmental NGO Network), supported by the United Nations Development Programme (UNDP) and Norway and in partnership with the Ministry of Environmental Protection and Agriculture, implemented the “Reducing Plastic Pollution in Georgia” project in 2024. The project consists of four main components: sectoral training on the circular economy; campaigns for businesses and schools; educational activities for schoolchildren, including green camps; and a large-scale media campaign on reducing plastic waste. As part of the project, meetings have been held to offer participating companies and organisations advice on business sustainability. The project is also collaborating with schools to develop a plastic prevention programme (Khidureli, 2024).

5. CONCLUSION

Although Georgia has made significant progress in environmental protection and tackling climate change,

The development of the circular economy depends heavily on public knowledge and behaviour. Public knowledge of circular economy principles is a key factor in its successful implementation. People who are familiar with these principles (e.g. waste reduction, resource reuse and recycling) are more likely to choose environmentally responsible products. In other words, they are empowered to make the right choices. Public initiatives emerge as a result of this knowledge, raising awareness and shaping values and demand. Behaviour directly changes the market, reducing resource wastage and contributing to economic growth.

References

- 1) Dolidze, T., Benefits of implementing circular economy principles. [online] Available at: <https://geoeconomics.ge/?p=13464> [Accessed 04.05.2025].
- 2) Geissdoerfer, M., Savaget, P., Bocken, N. M. P. and Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143.
- 3) Khidureli, S., End plastic pollution in Georgia. (2024). Web page. [online] Available at: <https://bm.ge/news/proeqti-shevamsirot-plastmasit-dabindzureba-saqartveloshidaitsyo-ras-gegnavs-cenn-i-kampaniis-farglebshi> [Accessed 05.05.2025].
- 4) Prasek, D., Chelidze, M., Pavliashvili, S. and Kimeridze, M. (2022). Assessment of the circularity level of the Georgian economy.
- 5) "Orchis" - Green Transformation. Web page. [online] Available at: <https://unglobalcompact.ge/sustainability-spotlight/orqisis-mwvane-transformacia/> [Accessed 04.05.2025].
- 6) Assessing the level of environmental Education and awareness in Georgia, (Research Analytical Report). (2022). [online] Available at: <https://georgia.un.org/en/254717->

- assessing-level-environmental-education-and-awareness-georgia [Accessed 03.05.2025].
- 7) Association Agreement between Georgia and the European Union. (2014). Web page. [online] Available at: <https://matsne.gov.ge/ka/document/view/2496959?publication=0> [Accessed 05.05.2025].
 - 8) Environmental and Agricultural Education in Schools (2020). [online] Available at: <https://www.eiec.gov.ge/Ge/EducationalResources> [Accessed 03.05.2025].
 - 9) "Orchis" - Green Transformation. Web page. [online] Available at: <https://unglobalcompact.ge/sustainability-spotlight/orqisis-mwvane-transformacia/> [Accessed 04.05.2025].
 - 10) Phone chargers in exchange for plastic bottles. (2021). [online] Available at: <https://at.ge/2021/07/17/damteni/> [Accessed 03.05.2025].
 - 11) Report 2024, Ministry of Environmental Protection and Agriculture of Georgia. Web page. [online] Available at: <https://mepa.gov.ge/Ge/Reports> [Accessed 03.05.2025].

COMPENSATION FOR ECONOMIC LOSSES: PERSPECTIVES AND AMBIGUITIES

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Abstract

This paper examines the complex legal framework surrounding compensation for economic losses, focusing on the balance between fundamental rights and tort liability. The study analyzes the application of the proportionality test in cases where fundamental rights conflict with general interests, particularly in disputes involving dignity rights versus freedom of expression. Through examination of European case law and Moldovan Civil Code provisions, the research explores the distinction between direct and indirect economic damages, and the emerging recognition of purely economic losses as compensable harm. The paper investigates the "rule of exceptions" that traditionally limits compensation for pure economic losses and examines evolving judicial approaches to financial harm in commercial relationships. The analysis reveals significant ambiguities in determining when economic losses should be compensated, particularly in cases involving informational services and contractual relationships. The research contributes to understanding the evolving landscape of tort liability and economic damage compensation in European legal systems.

Keywords: *economic losses, tort liability, fundamental rights, proportionality test, compensation*

JEL Classification: K13, K41

1. LEGAL REASONING AND THE BALANCING TEST

The resolution of legal disputes is generally done through judicial reasoning in the form of a syllogism, where the major premise is the applicable legal norm, the minor premise is the factual situation, and the conclusion, contained in the court's judgment, is the sanction or the effect of the norm upon the established facts. In the case of disputes concerning fundamental rights, a different type of syllogism is applied, called the "balancing test", or the test of proportionality of

conflicting rights, particularly when one or more rights are in conflict with the general interest. The court performs a balancing of the specific circumstances of the civil case.

Criteria for assessing the "balancing" process or the exercise of the proportionality test in case of conflicting rights must rely on the reasoning specific to the engagement of tort liability, according to the provisions of Articles 1998-1999 of the Civil Code of the Republic of Moldova.

A tort action based on the violation of a fundamental right, such as the right to dignity, allegedly violated through the intentional dissemination of false information, must be weighed against the corresponding rights of the persons who caused the damage to dignity, claiming that they themselves were exercising a fundamental right – the right to freedom of expression.

Under Article 2003 of the Civil Code, "The obligation to repair damage is excluded if it was caused in order to protect fundamental values in a democratic society, especially if the damage was caused through the disclosure of information via mass media." According to Article 3 of the Constitution of the Republic of Moldova, "Human dignity, his rights and freedoms, the free development of the human personality, justice and political pluralism are supreme values and are guaranteed."

2. EUROPEAN COURT STANDARDS AND PROPORTIONALITY

In analyzing the protection of the private life of the Claimants, the European Court of Human Rights considered the following factors: contribution to a debate of general interest; the notoriety of the person concerned; the subject of the report; the prior behavior of the person concerned; the content, form, and repercussions of the publication (*Fuchsman v. Germany*, para. 34).

When resolving such disputes, the court must apply the balancing of the proportionality of the competing rights. The negative effects that may result from the press-related tort shall not constitute a measure of the damage caused to the Claimant, but will serve as arguments to weigh the scale in favor of either freedom of expression or the right to dignity.

From the perspective of European case law regarding special torts, we support the position of Professor Ion Deleanu, who argued that "Objective liability must be acknowledged; not as a speculative or sterile legal fiction, but as the only solution in certain circumstances" (Deleanu, 2005, p. 298).

3. RELATIONSHIP BETWEEN TORT AND CONTRACTUAL LIABILITY

According to Article 1999 of the Civil Code of the Republic of Moldova, the relationship between tortious and contractual liability is governed by the principle of subsidiary applicability of tort liability, under the following provisions: (1) The

provisions of this chapter apply also to damage caused in contractual relationships, except in cases where legal provisions regarding non-performance of obligations apply; (2) The provisions of this chapter do not apply where their application contravenes other legal provisions; (3) The provisions of this chapter do not preclude the application of legal remedies on other legal grounds.

The wording of Article 1399 of the Civil Code prior to the 2019 amendments expressly referred to liability between contracting parties and stipulated that: "The provisions of this chapter shall also apply to damage caused in contractual relationships, except in situations where provisions regarding the liability of the debtor for non-performance of the contract and special regulations for certain contractual relationships apply."

3.1. Theoretical Foundations in Moldovan Legal Science

The scientific analysis of the correlation between tort liability and contractual liability, as well as with other similar institutions, was developed for the first time in the legal science of private law of the Republic of Moldova by Dr. Andrei Bloşenco in the work entitled "Tort Civil Liability" (Bloşenco, 2002). This work is of special interest to civil legal science as it analyzes the theory and practice of civil liability before the adoption of the Civil Code of the Republic of Moldova on 06.06.2002. Based on the analysis, and using comparative legal methods, the author predicted the development of civil liability institutions, including bodily injury converted into biological damage, recreational damage later categorized as non-pecuniary damage, aesthetic damage as a component of biological damage, damage to the affective personality which became part of moral damage in law, and damage to social personality involving violations of non-patrimonial personal rights such as honor, dignity, reputation, name, and commercial name.

At the level of pecuniary damage, which may manifest as actual damage and loss of profit, the same author supports and develops the legal grounds and conditions for the recovery of lost benefits. This perspective might also affect the areas from the field of climate change (Plotnic, 2020).

4. INDIRECT MATERIAL DAMAGE AND CAUSAL LINKS

Regarding the possibility of recovering indirect material damage, Dr. Andrei Bloşenco held in his reference work that "it should not be compensated, as there is no sufficient causal link between the wrongful act and this damage" (Bloşenco, 2002, p. 56). Unfortunately, in his work on civil liability or in other reference works, there is no doctrinal analysis of what constitutes a "sufficient causal link" that would justify the exclusion of the possibility to recover indirect damages.

In practice, the legislator excluded special regulations for certain contractual relationships as exceptions from the application of tort law provisions to wrongful acts. The logic behind this exclusion lies in the appearance, at legislative and sub-legislative level, of various named and unnamed contractual types, for which

adequate mechanisms of liability suited to the legal essence of the contractual or quasi-contractual construction have not been developed.

5. PURELY ECONOMIC LOSSES: RECOGNITION AND COMPENSATION

The study of the category of purely economic losses shows that these should be considered compensable damage, even in the absence of initial personal or property damage. In this context, the legal term "pure/exclusive" in judicial determinations plays a crucial role, as it strictly defines the financial losses of the injured party.

It should be considered that if economic losses are related to minor damage to health or property, then they are classified as "indirect economic damage" and must be compensated by the liable person without specific restrictions, in accordance with paragraph 3 of Article 19 of the Civil Code of the Republic of Moldova.

In the scientific evaluation of the grounds for recovery of economic damage, one may ask: Why are purely economic losses compensated to a lesser extent than physical/material damages that are explicitly listed in Article 19 of the Civil Code? In response, it should be noted that indirect economic damage is compensable in European legal systems, regardless of the source of the damage – intentional or negligent behavior, or actions subject to strict liability. All this illustrates a European legal trend to recognize financial losses as a category eligible for compensation as economic damages.

5.1. The Rule of Exceptions

Legal literature discusses cases of limiting compensation for pure economic losses, commonly referred to as the "rule of exceptions." Professor Willem H. Van Boom notes that: "Today, pure economic losses are probably the central problem in the expansion of tort law. In some countries, they are associated with uncontrolled and unpredictable compensation demands, which could become limitless. These arguments have been used as reference points against compensating pure economic losses and have supported the development of the 'rule of exceptions' in doctrine, aimed at keeping the gate open selectively" (Van Boom, 2004, p. 3).

6. COMMERCIAL RELATIONS AND ECONOMIC DAMAGE

Commercial economic relations are highly complex from the perspective of the interweaving of the legal, economic, and patrimonial interests of the participants in these relationships. From this perspective, it is natural to conclude that causing damage to the interest of one participant in the commercial relationship can spread directly or indirectly to the interests of various other

subjects involved in the relationship, by reducing the economic assets' potential to generate capital gains in the form of income.

These circumstances and the conditions of mutual influence on the economic interests of the subjects of commercial relations fall within the magnitude of the potential of each participant in these relations, which can be disrupted by the harmful actions of their counterpart. The size of the economic potential of an asset can be measured by the asset's capacity to bring certain benefits/income to its owners or beneficiaries. This potential value is usually set by the holders in the market price of the asset, which is why the potential compensation for purely financial damage tends to double the amount of material damage compensation.

Conversely, in certain situations, the economic interests of contractual parties, arising from the provision of informational services, are not dependent on any material assets held by the asset holders. In the absence of the possibility to compensate exclusively economic losses, the injured party who suffers damage to a right or interest loses the right to compensation for those economic losses.

7. EUROPEAN JURISPRUDENTIAL APPROACHES

The distinction between "indirect" financial losses caused by minimal material damage and "pure" (or exclusively) financial losses, which may arise without any damage to the person or their property, has been recognized only at the level of the jurisprudence of European countries. These jurisdictions consider the essential link between economic damage and material/patrimonial damage sustained primarily by the injured person. Thus, European courts may rule that in the absence of material/patrimonial damage, it is impossible to claim economic/financial damage.

However, this rule concerning the priority of compensating patrimonial and economic damage categories is not uniformly applied across European courts. Some courts may decide that losses caused by low-quality informational services are not "exclusive" – that is, strictly financial – but rather "indirect," and therefore qualify as compensable under the law by the responsible party.

Therefore, we observe a lack of positive legislative argumentation regarding the factor that determines the "order of succession" in applying liability for the provision of substandard informational services and the causation of financial losses depending on the presence of patrimonial damage. In such situations, the rationale behind the rule must be analyzed – that is, the idea that in the absence of actual material/patrimonial damage, the "rule of exceptions" applies, which excludes liability for financial losses. Conversely, the existence of actual patrimonial damage can serve as a precondition for engaging liability for financial losses, i.e., pure financial damage.

What is certain is that the rule establishing the order in which liability arises for causing financial losses depending on the existence of patrimonial damage is aimed at limiting the number of potential lawsuits based on such grounds. It

maintains a positive level of deterrence for potential perpetrators of this type of harm.

8. CONCLUSIONS

The analysis of compensation for economic losses reveals significant complexity in balancing fundamental rights with tort liability principles. The proportionality test emerges as a crucial tool for courts when adjudicating conflicts between dignity rights and freedom of expression. The evolution from traditional tort concepts to recognition of purely economic losses reflects broader changes in European legal systems toward acknowledging financial harm as compensable damage.

The distinction between direct and indirect economic damages, while theoretically sound, creates practical challenges in determining compensation eligibility. The "rule of exceptions" serves as a necessary limitation mechanism but requires careful application to avoid unfair outcomes. Future legal development should focus on establishing clearer criteria for determining sufficient causal links and developing more precise standards for evaluating purely economic losses in commercial relationships.

The research demonstrates that while European legal systems are moving toward greater recognition of economic losses, significant ambiguities remain in determining when such losses should be compensated, particularly in cases involving informational services and complex commercial relationships.

REFERENCES

- 1) Bloşenco, A. (2002). *Răspunderea civilă delictuală*. Chişinău: Arc.
- 2) Deleanu, I. (2005). *Ficţiunile juridice*. Bucureşti: ALL Beck.
- 3) Platonic Olesea, Popescu Lucia (2022). Climate change and sustainable development: issues for international trade system, European Finance, Business and Regulation. Challenges of Post-Pandemic Recovery. Proceedings of the International Conference EUFIRE 2022, 313
- 4) Van Boom, W. H. (2004). *Pure Economic Loss. A Comparative Perspective*. In: W. H. Van Boom, H. Koziol and C. A. Witting, eds., *Pure Economic Loss - A Comparative Perspective*. Wien/N.Y.: Springer, pp. 1-15.

UNRAVELING CIRCULAR ECONOMY DYNAMICS IN THE EU: A BAYESIAN NETWORK ANALYSIS

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Abstract

This study applies Bayesian Network (BN) modelling to assess changes in the interdependencies among key Circular economy (CE) indicators across two timeframes: 2012-2016 and 2017-2021. Using data from EURUSTAT monitoring framework, we analyse how variables such as material footprint, material import dependency, and private investment in Circular Economy interact over time. Structure learning is conducted separately for each period, followed by posterior updates based on selected evidence. The results reveal a temporal shift in material sourcing. While high material consumption in the earlier period is primarily supported by domestic resources, the later period showed increased dependency on imported materials under similar conditions. Furthermore, high private investment in Circular economy does not automatically reduce material import dependency and may coincide with higher external reliance, suggesting delayed impacts or structural limitations.

Keywords: *Bayesian networks, Circular economy and Sustainability, EU Circular Economy Policy, Circular economy indicators, Material Import Dependency*

JEL Classification: Q01, Q56, Q32

1. INTRODUCTION

The depletion of natural resources, a growing population, and the alarming levels of pollution – byproducts of a linear, wasteful consumption model – have made the transition to a circular economy imperative. The world's largest economies, which are largely responsible for perpetuating this wasteful consumption model, must now lead to transition to a circular economy. Rather than stemming from altruism, this move was the direct consequence of the need of a sustainable development which is unattainable under the wasteful consumption pattern of the linear economy.

A linear economy is a traditional economic model based on a “take-make-dispose” approach where natural resources are extracted, used to produce goods and discarded as waste. Circular Economy on the other hand, is designed to minimize waste and make the most of resources by keeping products, materials,

and components in use for as long as possible. The three principles called as 3Rs that the circular economy is based are reduce, reuse and recycle.

Enabling the transition from a linear to a circular economy requires significant changes in policies and regulations. As Alberich, Pansela and Hartley (2023) state, the shift toward a circular economy has become the central focus for governments, major corporations, and advocacy groups (Ekins *et al.*, 2019; Kircherr, Reike and Hekkert, 2017; Murray, Skene and Haynes, 2017). In this context, China emerged as an early leader on the global stage. In 2005, the State Council of China issued an official directive promoting the circular economy. This was followed by the enactment of the Circular Economy Promotion Law in 2015 (Zhao, 2020). On the hand, the European Union has also acknowledged that the transition to a circular economy is crucial for achieving sustainability, which has been followed by the enactment of key policy milestones, as illustrated in the timeline presented in Figure 1. To fast-track Europe's shift from a linear to a circular model European Union launched the Circular Economy Action Plan. The aim of the plan was to boost competitiveness, support economic growth and faster employment opportunities. To measure the progress towards the goals a dedicated monitoring framework was launched in 2018, focusing on five core areas: production and consumption, waste management, secondary raw materials, competitiveness and innovation, and global sustainability and resilience. These developments laid the foundation for the European Green Deal, adopted by the European Parliament in 2019 as a blueprint for sustainable growth across the EU. In line with this strategy in 2020 the Circular Economy Action plan was updated, emphasizing sustainable product design, reuse, and recycling to improve resource efficiency and minimize waste generation.



Figure 1. Major circular economy milestones relevant to the EU

Monitoring the transition toward a circular economy (CE) requires a systematic approach that captures the complex relationships between resource use, waste generation, economic activity, and sustainability outcomes. The European Commission's CE monitoring framework provides a structured dataset to evaluate progress across EU member states. This framework encompasses a wide range of indicators including material footprint, resource productivity, waste generation, recycling rates, circular material use, greenhouse gas emissions, employment, investment, patents, and GDP per capita. Understanding the interrelationships between circular economy indicators is essential for designing

effective policy interventions. Indicators in a CE system are expected to be interconnected and the strength and nature of the relationships between the indicators may reflect the system's internal coherence. Addressing this need, Cinicioglu (2025) investigated the probabilistic dependency structure among CE indicators across EU countries, using data from the EUROSTAT database. The study focused on three dimensions: production and consumption, competitiveness and innovation, and global sustainability and resilience.

These analytical efforts align with broader policy goals: over the past decade, circular economy policies within the European Union have aimed to facilitate systemic transformation across multiple sectors. A critical next step is to evaluate the actual impact of these measures—specifically, whether they have driven meaningful change and to what extent they have influenced CE performance across member states. There exist various studies that questions the effectiveness of the CE practices. Georgescu *et al.* (2025) apply a multiple linear regression model with fixed effects panel data to examine the factors influencing the efficiency of the circular economy transition in the EU. Sanz-Torró (2025) uses Data Envelopment Analysis and the Sequential Malmquist Index to analyse the effectiveness of the national CE polices across EU and to identify the items of circularity that need improvement.

In this study, we follow the convention of Cinicioglu (2025) and use Bayesian networks (BNs) to explore the dependency structure of CE indicators. These indicators can be naturally interrelated due to underlying economic and material flows. However, the emergence of a stronger and more coherent dependency structure over time may signal the systemic effect of CE policies. To explore this, we learn Bayesian network structures from data provided by the EU Monitoring Framework across two time periods: 2012–2016 and 2017–2021. This comparison allows us to assess how the relationships between indicators have evolved and to infer the potential influence of CE policies on the internal coherence of the system.

The remainder of this paper is structured as follows: Section 2 outlines the Bayesian network methodology, the dataset and the CE indicators used in this study. Section 3 presents the comparative analysis of the BNs learned across different timeframes. Section 4 concludes with a discussion of the main results and key findings.

2. METHODOLOGY & DATA SET

2.1. Bayesian networks

Bayesian networks are acyclic probabilistic graphical networks where each node represents a variable and each arc represents the probabilistic dependency between the variables. In a BN if there is an arc going from a node to another, the node at the end of the arc is called the child node, and the node from which the

arc originates is called the parent node. As represented in Equation (1) given below each variable in a Bayesian network (BN) possess a probability distribution given its parents and the product of these probability distributions constitute the joint probability distribution of the network.

$$P(X_1, \dots, X_N) = \prod_{i=1}^N P(X_i | Pa(X_i)) \quad (1)$$

A simplistic BN with three variables A , B and C is given in Figure 2. Here the variables A and B have no parent variables in the network and are therefore represented with their marginal distributions $P(A)$ and $P(B)$. Variable C , on the other hand, is the child variable of both A and B and as can be seen in the network its probability distribution $P(C|A, B)$ is conditioned on its parents.

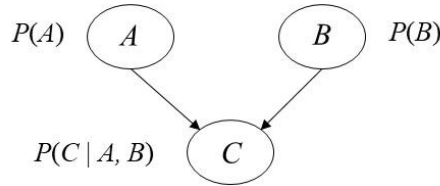


Figure 2. An illustrative Bayesian network with three variables

There exist two different layers of the BNs, one where the graphical structure is given and which represents the probabilistic dependency structure between the variables and the second are the parameters of the network which are the conditional probability distributions that the variables do possess. Both the graphical and the computational layer can be based on expert knowledge or be learned from data directly using the existing structure and parameter learning algorithms. These algorithms typically rely on statistical independence tests or on the optimization of a network scoring function

The structure of a BN can be Bayesian networks offer a probabilistic modelling framework capable of identifying dependencies among these variables and quantifying their interactions. Unlike conventional statistical techniques, BNs allow for scenario analysis and uncertainty quantification, making them particularly useful for sustainability assessments. Moreover, the ability to model non-linear relationships, the inference capability through Bayesian updating offers a flexible structure which is not limited to a single output variable. The use of BNs extends to a wide set of different areas from targeted advertising (Cinicioglu and Shenoy, 2016) to healthcare Kyrimi *et al.* (2025), competitiveness and innovation analysis (Cinicioglu, Önsel and Ülengin, 2012; Cinicioglu *et al.*, 2017) and geopolitical risk Bozcu and Cinicioglu (2023). In this work we will use BNs to analyse the changing dependency structure of the selected CE indicators obtained

from the European Monitoring Framework. Both the network structure and also the parameters will be learned from data using the Bayesian search (Cooper and Herskovitz, 1992; Heckerman, 1995) and Expectation Maximization (EM) algorithm respectively. The following section describes the set of CE indicators used to learn the BNs.

2.2. Data Set

The set of indicators used to learn the BNs is derived from the EU Monitoring Framework for CE which consists of five thematic sections with a total of eleven statistical indicators capturing the key dimensions of circular economy. In this study seven different CE indicators are selected based on the availability across a 10-year period (2012-2021) and for 27 EU countries. The selected CE indicators (Eurostat, 2024 a-f) are as follows: From the Production & Consumption thematic section: Material footprint (pc020) and generation of plastic packaging waste per capita (pc050). From the competitiveness & Innovation section: two variables from cie012, gross investment in tangible goods and value added at factor costs in recycling, repair and reuse and rental & leasing. From the global sustainability and resilience thematic section: Patents related to recycling and secondary raw materials (gsr 010) and Material import dependency (gsr 030). This 10-year data set is divided in two to be analysed across the two five-year periods, 2012-2016 and 2017-2021 in order to see the effect of the EU CE policies and regulations on the dependency structure of the CE indicators. In total the data set includes 270 observations for seven CE indicators (variables), 135 for each 5-year timespan. Before the BN learning is applied on the data set, all the variables are discretized with four equal-width intervals, showing the different states of each variable. Here, though the variables are the same CE indicators, the fact that they belong to different time frames results in variations in the underlying data distributions. Consequently, the discretized intervals (states) of each variable may differ across the two time periods. These states should be interpreted as data-driven levels specific to each timeframe, reflecting the variable's behaviour within that particular period. Therefore, these states should be considered as the levels of that variable. In the following section we present and analyse the BNs learned from this discretized data sets for the two different timeframes.

3. COMPARATIVE ANALYSIS ON BAYESIAN NETWORKS

The purpose of this analysis is to examine how the dependency structure between the circular economy indicators has evolved over time. To this end, two distinct BNs are learned, each corresponding to a different five-year period. Figure 3 presents these networks: The one on the left-hand-side was learned from data covering the 2012-2016 period and the BN on the RHS is learned from the following second five-year time frame, 2017-2021. We observe that the BN belonging to the first five year is showing a denser set of arcs compared to the one

on RHS learned from the time frame 2017-2021. Though this observed difference may suggest a potential shift in the interdependencies among circular economy indicators over time, one should keep in mind that a score-based algorithm is used for structure learning and an analysis based on the number and direction of arcs may be misleading. A score-based algorithm typically balances model fit with complexity and adopts to the data characteristics each time independently. Therefore, we will restrict our analysis to the changes in the marginal and conditional probabilities of the variables in the network. Notice that the marginal probabilities of the variables present in the network can directly be read from the BN given in Figure 3. Though no big differences are realized at first glance, one should keep in mind that for some of the variables the discretized intervals (states) of each variable does differ. For example, the variable “plastic packaging generations per capita” exhibits a clear upward trends over the years. In the BN corresponding to the 2012-2016 period (LHS), the highest state levels s3 and s4 correspond to value ranges of 41-54 and 54 and above, respectively. In contrast, in the 2017-2021 BN (RHS), the same states s3 and s4 cover the higher ranges of 44-59 and 59 and above, reflecting an increasing consumption over time.

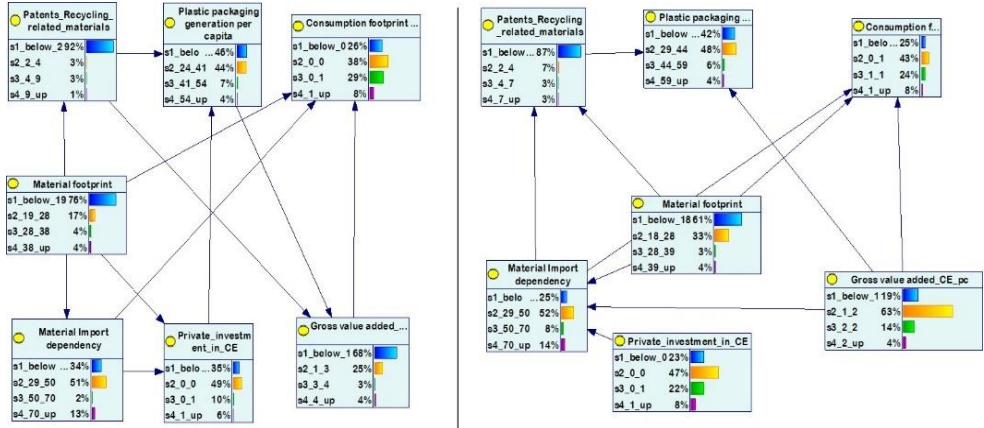


Figure 3. Structure of the Bayesian networks learned from two distinct time frames: 2012-2016 (LHS) and 2017-2021 (RHS)

In Figure 4 below we present the updated posterior probabilities of the BNs after observing the same evidence $P(\text{Material Footprint} = s_4)$ across the two different time frames. In the EUROSTAT Monitoring framework the variable “Material footprint” refers to the annual total raw material consumption per inhabitant. In the updated BN corresponding the time frame 2012-2016 we see that although the raw material consumption is in its highest level, the material import dependency seems to be largely unaffected. Material import dependency refers to the ratio of imports over direct material inputs. A reasonable conclusion

from this result is that, during the earlier 5-year timeframe (2012-2016), the observed increase in material consumption is primarily met through domestic resource extraction. By contrast, the later 5-year timeframe (2017-2021) the same evidence leads to an increase of about 18% for the higher levels of states (s2, s3, s4) on material import dependency. This suggests a growing reliance on external resources among EU countries. This trend highlights an important concern: for many countries, rising level of material consumption are increasingly associated with external dependence, potentially generating both environmental and strategic vulnerabilities.

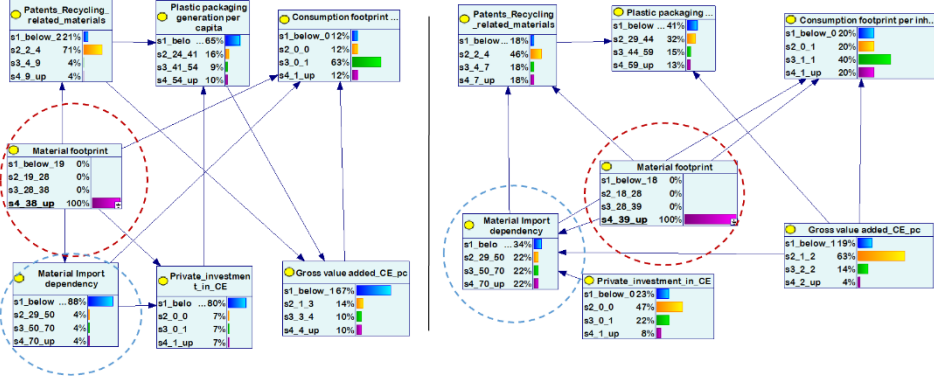


Figure 4. Updated posterior BNs for the same evidence: $P(\text{Material Footprint} = s4)$ across two time frames: 2012-2016 (LHS) and 2017-2021 (RHS)

As the next step of our analysis, we observe the effect of observing the evidence for the highest level of the variable “Private investment in CE”. “Private investment in CE” refers to cie012, which has its full name as “Private investment and Gross Added Value Related to Circular Economy Sectors”. This indicator assesses the financial investments and value added by the private sector entities actively engaged in CE activities. It reflects the economic output of industries dedicated to sustainability, recycling and material reuse. During the first 5-year period when the highest level s4 for Private investment in CE is observed, the updated probabilities for Material Import Dependency show an upward trend. This trend becomes even more pronounced in the second five-year period, where after observing the highest level for Private Investment in CE the updated marginal probability of Material Import Dependency reaches to 46 % for its highest level of state s4. These results suggest that high investment in CE does not automatically lead to a reduction in material import dependency, particularly in short term. The following section presents the results and concludes the study.

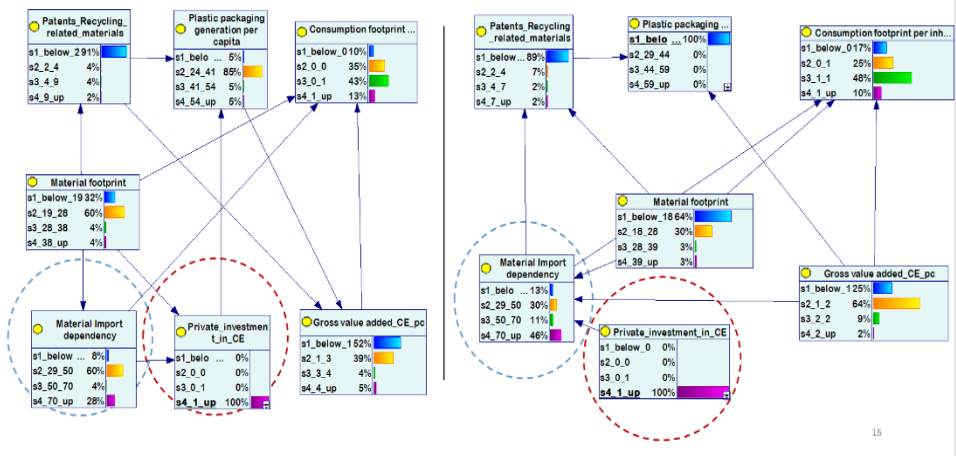


Figure 5. Updated posterior BNs for the same evidence: $P(\text{Private investment in CE} \mid \text{Material footprint \& Material Import Dependency} = s_4)$ across two time frames: 2012-2016 (LHS) and 2017-2021 (RHS)

4. CONCLUSIONS

In this study we applied a Bayesian network analysis on the selected Circular Economy indicators from European monitoring framework to investigate the evolving relationships over the two consecutive five-year periods (2012-2016 and 2017-2021) in EU countries. By comparing updated posterior probabilities in response to the same evidence, we captured shifts in dependency structures over time, particularly with regard to material import dependency and investment in circular economy initiatives.

Our findings reveal that while material consumption has increased over time, its sources have shifted from primarily domestic extraction in the earlier period to greater reliance on imported resources in the later years. Additionally, we find that higher levels of private investment in CE do not automatically translate into reduced material import dependency. In fact, in the more recent timeframe, increased investment is associated with higher import dependency, suggesting a potential time lag in the impact of CE measures, possible misalignments between investment focus and material substitution goals, or inherent structural constraints within domestic economies. These insights underline the importance of aligning circular economy strategies not only with sustainability targets but also with economic resilience and material self-sufficiency. Closing the gap between investment and material outcomes will require targeted policy action and continuous monitoring using robust, data driven methods.

References

- 1) Alberich, J.P., Pansera, M. and Hartley, S. (2023). Understanding the EU's circular economy policies through futures of circularity. *Journal of Cleaner Production*, 385, p. 135723.
- 2) Bozcu, G. and Çinicioglu, E.N. (2023). Ulusal güvenlik karar problemlerinde karşısalsal risk analizi: Doğu Akdeniz problemi örnek modelleme. *Ardahan Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 5(1), pp. 62–73.
- 3) Cinicioglu, E.N. (2025). The EU's probabilistic dependency structure towards the goal of a circular economy. *Sustainable Development, Culture, Traditions Journal*, 16(a), pp. 42–52.
- 4) Cinicioglu, E.N. and Shenoy, P.P. (2016). A new heuristic for learning Bayesian networks from limited datasets: a real-time recommendation system application with RFID systems in grocery stores. *Annals of Operations Research*, 244, pp. 385–405.
- 5) Cinicioglu, E.N., Önsel, Ş. and Ülengin, F. (2012). Competitiveness analysis of automotive industry in Turkey using Bayesian networks. *Expert Systems with Applications*, 39(12), pp. 10923–10932.
- 6) Cooper, G.F. and Herskovits, E. (1992). A Bayesian method for the induction of probabilistic networks from data. *Machine Learning*, 9, pp. 309–347.
- 7) Ekins, P., Domenech Aparisi, T., Drummond, P., Bleischwitz, R., Hughes, N. and Lotti, L. (2020). *The circular economy: What, why, how and where*.
- 8) Eurostat (2024a). Material footprint. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/cei_pc020_esmsip2.htm [Accessed 1 Feb. 2025].
- 9) Eurostat (2024b). Generation of plastic packaging waste per capita. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/cei_pc050_esmsip2.htm [Accessed 1 Feb. 2025].
- 10) Eurostat (2024c). Private investment, jobs and gross value added related to circular economy sectors. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/cei_cie011_esmsip2.htm [Accessed 1 Feb. 2025].
- 11) Eurostat (2024d). Patents related to waste management and recycling. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/cei_cie020_esmsip2.htm [Accessed 1 Feb. 2025].
- 12) Eurostat (2024e). Consumption footprint. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/cei_gsr010_esmsip2.htm [Accessed 1 Feb. 2025].
- 13) Eurostat (2024f). Material import dependency. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/cei_gsr030_esmsip2.htm [Accessed 1 Feb. 2025].
- 14) Georgescu, L.P., Fortea, C., Antohi, V.M., Balsalobre-Lorente, D., Zlati, M.L. and Barbuta-Misu, N. (2025). Economic, technological and environmental drivers of the circular economy in the European Union: a panel data analysis. *Environmental Sciences Europe*, 37(1), pp.1–30.
- 15) Heckerman, D., Geiger, D. and Chickering, D.M. (1995). Learning Bayesian networks: The combination of knowledge and statistical data. *Machine Learning*, 20, pp. 197–243.

- 16) Kirchherr, J., Reike, D. and Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, pp. 221–232.
- 17) Kyrimi, E., Mossadegh, S., Wohlgemut, J.M., Stoner, R.S., Tai, N.R. and Marsh, W. (2025). Counterfactual reasoning using causal Bayesian networks as a healthcare governance tool. *International Journal of Medical Informatics*, 193, p. 105681.
- 18) Murray, A., Skene, K. and Haynes, K. (2017). The circular economy: an interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics*, 140, pp. 369–380.
- 19) Sanz-Torró, V., Calafat-Marzal, C., Guaita-Martinez, J.M. and Vega, V. (2025). Assessment of European countries' national circular economy policies. *Journal of Environmental Management*, 373, p. 123835.
- 20) Zhao, Y. (2020). China in transition towards a circular economy: from policy to practice. *Journal of Property, Planning and Environmental Law*, 12(3), pp. 187–202.

LEGAL PERSPECTIVES ON LIABILITY FOR CONSULTANCY SERVICES

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Abstract

The paper analyzes the legal and economic implications of financial and consulting services under Articles 1391-1399 of the Civil Code, highlighting that third parties may use professional information for their own purposes. The presentation of false information or inadequate services can lead to economic damages for contracting parties and material losses for third parties. The concept of patrimonial and non-patrimonial damages (Article 19 of the Civil Code) is explored, emphasizing the role of the "rule of exceptions" in limiting compensation for purely economic damages. The paper also discusses the professional liability of notaries and lawyers, as well as the impact of audit and expert services, where third parties benefit from information without having the right to compensation, thereby avoiding increased costs for direct beneficiaries. The "rule of exceptions" is presented as an efficient mechanism for protecting the professional services market.

Keywords: *Patrimonial and non-patrimonial damages; Rule of exceptions; Financial and consulting services; Professional liability; Economic compensation; Audit*

JEL Classification: *K12, K13, K40*

1. INTRODUCTION

The substantive rules of the obligation to provide information in consumer contracts have been established at the level of case law in *the Cofinoga case* (ECJ, 2004, pp. 1-157) and are reduced to ensuring market transparency as a means of guaranteeing equal conditions of competition between undertakings and, subsequently, the protection of the consumer who is given the opportunity to choose between offers according to his interests and the ability to assume contractual obligations. The requirement of transparency is satisfied by the completeness, clear, unequivocal and correct nature of the information subject to the obligation.

With the entry into force of the new Romanian Civil Code, the obligation to inform and advise was seen as specific to professionals when they are in legal relationships with non-professionals (Orga-Dumitriu, 2013, p. 196).

Distinguished civil experts have concluded that most of the obligations of professionals fall under the obligations of means, prudence and diligence, without excluding the possibility that some of them are obligations of result (Stoica, 2013, p. 20-25; Puie, 2017, p. 15-16).

Academician Liviu Pop, in the analysis of the pre-contractual obligations regarding the exchange of reciprocal and unilateral data and information, mentions that they must, as a rule, cumulatively meet three conditions: they must be complete, clear and correct (Pop, 2023, p. 202). In developing these conditions, the author emphasizes that the information must be clear, unambiguous, correct, and up-to-date (Pop, 2023, pp. 213-214).

At the same time, with reference to the obligation to cooperate, it is shown that it creates the premises and conditions necessary to comply with the obligation of pre-contractual and contractual information, which is, in fact, an expression of the general obligation of the contracting parties to act in good faith (Pop, Popa and Vidu, 2020, p. 335). Thus, the necessary framework is created for the promotion and compliance with other obligations complementary to good faith, such as the obligation of sincerity, the obligation of advice, the obligation of prudence and the obligation of coherence.

Persons who professionally deal with the collection and processing of information relating to the legal regime established in Articles 1391–1399 of the Civil Code, providing financial and consultancy services, must accept that third parties, who do not have direct contractual relations with them, may also use this data or information for their own purposes. The presentation of unrealistic information, the provision of inappropriate advice or services may be grounds for the termination of the contract for the provision of financial and advisory services. For the contracting parties, this resolution can generate economic damages, and for third parties – strictly material damages (Boilă, 2012, p. 204).

Given the structure of the legal framework for the classification of damages as defined in Article 19, paragraph (1) of the Civil Code, *“Under the conditions of the law, a person whose right or legally recognized interest is harmed may request full compensation for the material and non-material damage thus caused,”* it becomes clear to see that the legislator make distinct uses of the terms “material” and “non-material” damages. Furthermore, on paragraphs (2) and (3), *“Material damages include the expenses that the injured party has incurred or will incur in restoring the infringed right or legally recognized interest, the destruction or damage of their property (actual damage), as well as the lost profit resulting from the violation (lost profit). Non-material damages (moral damages) include physical and psychological suffering, and the reduction in quality of life. In case of health injury, non-material damage also includes the loss or impairment of a bodily capacity (biological damage).”* Considering the damage category, this can be viewed or applied only through the lens of economic damage. A similar conclusion may be drawn from the provisions of Article 1998, paragraph (1) of

the Civil Code: *"The person who acts unlawfully and with fault towards another is obliged to repair the material damage, and in the cases provided by law, also the moral damage caused by action or omission."*

Specialized legal literature analyzes the cases in which compensation for strictly economic damages is limited, known as the **rule of exceptions** (to the recovery of such damages).

2. LEGAL FRAMEWORK OF PROFESSIONAL LIABILITY

The typology of the damage, regulated in art. 19 para. (1) of the Civil Code, provides: "Under the law, the person injured in one of his rights or in an interest recognized by law may request full compensation for the pecuniary and non-pecuniary damage thus caused" (Terzea, 2021, p. 137). The legislator uses the phrase of pecuniary and non-pecuniary damage, detailed in para. (2) and para. (3): "The expenses that the injured person has incurred or will bear for the restoration of the right or interest recognized by the law, the destruction or deterioration of his property (actual damage), as well as the lost profit as a result of the violation of the right or interest recognized by law (lost profit) are considered pecuniary damage. Non-pecuniary damage (moral damage) is considered to be physical and mental suffering, as well as a decrease in the quality of life. In the case of damage to health, non-pecuniary damage also includes the loss or reduction of a capacity of the human body (biological damage)" (Boilă, 2012, p. 204).

This regulation can be viewed and applied from the perspective of economic damage. A similar conclusion results from the provisions of art. 1998 para. (1) Civil Code: "The one who acts towards another unlawfully, with guilt, is obliged to repair the pecuniary damage, and in the cases provided for by law, also the moral damage caused by action or omission" (Boilă, 2012, p. 204).

The literature analyzes the cases of limitation of the payment of strictly economic damages, known as the "rule of exceptions" (Van Boom, 2004, p. 3). Professor Willem H. Van Boom mentions that strictly economic damages are probably the central problem of modern tort liability. In some countries, they are associated with uncontrolled and unpredictable compensation requirements, which has led to the development of the exception rule to restrict access to such compensation.

Notarial and legal consultancy services are usually offered for a single person or for a small circle of third parties, indicated as beneficiaries in the contracts. Under these circumstances, third parties may request from lawyers or notaries compensation for the economic damages resulting from the poor quality provision of services by liberal professionals (Pop, Popa & Vidu, 2020, p. 335). The fees charged by notaries and lawyers must include both the costs of professional liability insurance, as well as the "quality guarantee payment" and the price of the right to obtain financial compensation for inadequate services.

3. THE RULE OF EXCEPTIONS

The economic analysis of other categories of services, such as audit and expertise services, has another characteristic of them: third parties, such as investors, are allowed to benefit in a commercial interest from the information presented by auditors and experts in acts drawn up at the request of those who commissioned and paid for them (Schwartz, 1995, p. 103). If the information developed in the context of consultancy, audit and expertise contracts becomes accessible to third parties, the direct beneficiary of the information, a party to the contracts under which the expert reports and/or expert conclusions were prepared, may not request payment from third parties for any benefits obtained by them from the use of this information for their own purposes. In such situations, the "rule of exceptions" becomes an effective tool in annihilating the influences of external factors on the professional services market (Van Boom, 2004, p. 3).

The plaintiffs, in the person of third parties to the consultancy, audit and expertise contracts, will not be able to rely on compensation for purely economic losses, as this would lead to an increase in expenses for those who actually pay for the professional services (Boilă, 2012, p. 204, Plotnic, 2024, p. 257). The effectiveness of the application of the 'exception rule' is an important advantage, but the key is that third parties must pay the cost of professional services in order to fully benefit from the right to material compensation for non-quality services.

By reason of the fact that typically, notarial and legal consultancy services are offered to a single person or a very limited circle of third parties, expressly indicated as beneficiaries in the contracts, third parties are entitled to request compensation from lawyers or notaries for economic damages resulting from the provision of low quality services by liberal professionals. The price of the services offered by notaries and lawyers must include the cost of professional liability insurance. The largest share of the price of the services offered by notaries and lawyers should represent the "payment for quality assurance" as well as the price paid for the right to obtain compensation for the provision of substandard services.

The economic analysis of other types of services, such as audit and expert consultancy, reveals a different characteristic, out of the perspective that third parties – for instance, investors – are allowed to commercially benefit from the information presented by auditors and experts in documents prepared at the request of those who commissioned and paid for them. In case the information produced under the process of audit and expert consultancy contracts becomes accessible to third parties, the immediate beneficiary/purchaser of the information, as a party to the contracts under which the expert reports or conclusions were elaborated, cannot claim payment from third parties for the possible benefits those third parties might have obtained from using the information for their own purposes.

In such situations, the "rule of exceptions" becomes an effective instrument to annihilate the influence of external factors on the professional services market.

As a third-party, the claimants in relation to the contracting parties of audit and expertise consultancy contracts, will not be able to claim compensation for purely economic losses, simply because that this would lead to increased external costs for those who actually pay for the professional services. The effectiveness of the “rule of exceptions” in such cases represents an advantage, but not an important one. The essential element in this context is the ideal alternative proposed to third parties, that they will be forced to pay for the professional services in order to fully benefit from the right to obtain material compensation for poor quality service provision.

4. MEDICAL LIABILITY TOWARDS THIRD PARTIES

The doctor must try to express himself, as much as possible, in a way that is understandable to the patient and understand that it is not only a barrier of expression or language, but often also a cultural barrier. Different beliefs and customs encourage people to express their pain differently: either exaggeratedly or by enduring it with stoicism. Depending on his own conceptions, the doctor can be misled by these differences in expression. Therefore, it is necessary to follow all the steps in his activity of prevention, diagnosis and treatment, since, in the event of a harmful or detrimental result for the patient, he will be able to demonstrate that he has not treated his patients with ease, indifference or carelessness and will not be found guilty (Simion, 2010, p. 98).

Questions are also raised regarding the cases in which the breach of professional obligation by the medical professional indirectly causes damage to an interested third party:

1. When a male patient has been informed that the vasectomy has been successfully performed and that he will no longer have to use contraceptives, he follows the doctor's advice, but the partner becomes pregnant;
2. When the doctor is contacted by an insurance company or a commercial company, in order to assess the health status of the future insured/employee; based on the information provided by the doctor incorrectly, the person in question concludes the insurance policy or the employment contract, but subsequently causes substantial damages to the insurer/employer due to his or her poor health;
3. When the doctor is contacted by the future insured/employee and, based on positive medical recommendations, he concludes the insurance policy or the employment contract, but subsequently causes damage to the insurer or employer due to his real state of health.

Third parties interested in the described relationship between doctors and patients (the partner who becomes pregnant without wishing it, the insurer or the employer who bears the appropriate compensation) are outside direct legal relations with the doctors. However, through their professional actions of

informing them, the intermediate link – the patient – makes decisions in direct legal relations with interested third parties, based on the veracity and relevance of the information and data received.

Patients' decisions in relation to third parties are ensured by the professional recommendations of doctors, which are not simple reports about facts, but conclusions that can be framed, at least, in the format of a therapeutic standard or based on individual analyses and research (Simion, 2010, p. 161). The laws of European countries establish that the economic damage caused by intentional actions is subject to reparation. By the exclusion method, it is concluded that the economic damage caused by unintentional, i.e. reckless actions (fault), is not amenable to reparation (Terzea, 2021, p. 137).

In the case of determining the level of civil liability for damages caused by intentional and reckless actions, little attention is paid to the subjective element of the crime, since both forms of guilt are regulated by the general rules of civil liability, without detailing the particularities. According to art. 20 of the Civil Code, para. (1) and (2), the act is committed intentionally if the person realized the harmful nature of his action or inaction, foresaw the consequences and consciously desired or accepted them. It is committed out of recklessness if the person realized the harmful nature, but easily considered that the consequences could be avoided, or did not realize it, although he should and could have foreseen it (Pop, Popa, & Vidu, 2020, p. 335).

5. INTENTIONAL CONDUCT VS. NEGLIGENCE IN ECONOMIC DAMAGE

The difference between the forms of guilt can only be observed if the recklessness serves as a direct basis for the occurrence of economic damage. The norm established in para. (4) Article 20 of the Civil Code of the Republic of Moldova does not expressly establish this fact, but, by its nature, it can be appreciated as such a ground, because it describes a profoundly negligent behavior, which goes beyond the pattern of wide fault. *Culpa brevis* is characterized by the law as "The act is committed due to gross negligence if the person committed it with a profound lack of prudence which, in the circumstances of the case, it was obvious that he had to prove" (Pop, Popa & Vidu, 2020, p. 335).

There are still opinions in the civil legal literature according to which the influence of the subjective factor of the perpetrator should not be neglected as an element of civil liability and that only the direct intention can serve as a basis for repairing economic damages (Boilă, 2012, p. 204).

Contemporary legal systems show a tendency to broaden the boundaries of compensation, starting from the idea that the rules of exceptions should not be viewed solely on the basis of the nature of the claimant's losses. It is increasingly recognized that the nature of losses is only one part of the complex system of

conditions for civil liability, a system that can determine when and how limitations can be applied (Van Boom, 2004, p. 3).

We support the idea that there are at least two causes that substantiate the possibility that the economic damage caused by intentional actions is compensable:

1. **Unpredictability and difficulty of prevention** – intentional actions causing harm are very difficult to foresee and prevent by the injured party, even if they represent a minority in actions for damages (Schwartz, 1995, p. 103). This situation creates problems in the procedures for the recovery of exclusive financial damages, from the perspective of the right to correlative legal actions.
2. **Situations of zero transfer to third parties** – even if the damage is caused to a person, he does not suffer social losses, because the profits are transferred to third parties. From an economic point of view, the size of the social losses caused by this person determines the size of the responsibility (Van Boom, 2004, p. 3).

It is important to follow the proper application of the rule of exceptions, in order to avoid double liability – both in favour of the first injured person and the subsequent one, for the same damage. In the calculation of the social damage, both the value of the "clean" damage and the value of the damage suffered by third parties must be included, referring to examples from the legal literature, such as the demolition of a building in which the tenants request compensation for the damages caused (Orga-Dumitriu, 2013, p. 196).

6. CONCLUSIONS

The most relevant cases of injury in medical matters are: diagnostic error, treatment error and failure to fulfill the obligations of information and counseling by medical professionals. Dr. Viorel Terzea cites recent French jurisprudence, which holds that failure to comply with the obligation to inform the medical staff entitles the patient to obtain damages for two distinct types of damages: the damage resulting from the loss of an opportunity – as a result of the fact that the patient could not opt for a less harmful therapeutic act or to give up that therapeutic act, if they had known all its implications – and the moral damage, as a result of the fact that the patient was unable to prepare psychologically for the consequences of the medical act (Terzea, 2021, p. 137).

As regards the primary obligation of the doctor to care for the patient, in most cases it has been assessed as an obligation of means. On the other hand, the obligations of security, information, counseling and maintenance of medical secrecy were considered obligations of result (Simion, 2010, p. 161). The lack of correct information or guidance on treatment, offered at the right time, can lead to the loss of the chance to avoid the occurrence of a tragedy.

In the specialized legal literature, it has been discussed whether informing the patient is an accessory obligation to care, without autonomy, which would prevent the establishment of a direct causal link with the loss of opportunity. The debate was stimulated by the solution offered by the French case-law in the *Terruche* case, pronounced by the Plenary Assembly of the Court of Cassation on 17 November 2001, which ruled on the professional liability of the doctor for the diagnostic error that prevented a pregnant woman from taking the decision to terminate her pregnancy, not being correctly informed about the risks (Pop, 2023, p. 202).

In order to substantiate medical civil liability, the precautionary principle, provided by Article 191 of the Treaty on the Functioning of the European Union, which establishes the legal obligation to reduce and even avoid, to an acceptable level, risks to life, health and the environment must also be taken into account (Orga-Dumitriu, 2013, p. 196).

Overall, the correct application of the 'exception rule' and the clear delineation between intentional and negligent conduct help to protect the balance between the interests of the contracting parties and third parties. It ensures the efficient functioning of the professional services market and protects against excessive liability.

References

- 1) Boilă, L.R. (2012). *The New Civil Code: Perspectives on Tort Liability*. Bucharest: C.H. Beck Publishing House, p. 204.
- 2) ECJ (2004). *C-264/02, Cofinoga Merignac SA v. Sylvain Sachithanathan*. Rec. 2004, p. 1-157, 4 March 2004.
- 3) Gary, T.S. (1995). The Economic Loss Doctrine in American Tort Law: Assessing the Recent Experience. In: Banakas, E.K., ed., *Civil Liability for Pure Economic Loss*. Dordrecht: Kluwer Law International, p. 103.
- 4) Orga-Dumitriu, G. (2013). *European contract law: realities, influences, scope*. Bucharest: C.H. Beck Publishing House, p. 196.
- 5) Pop, L. (2023). About the deontology of free negotiations for the formation of contracts. In: Baias, F.A., Neacșu, D., Bercea, L. and Nicolae, M. (coord.), *Progressive Contract Formation: Preliminary Acts and Contracts: Theoretical Aspects with Implications and Practical Applications*. Bucharest: Solomon Publishing House, pp. 202, 213-214.
- 6) Plotnic, O. (2024). *Legal adaptation strategies for unforeseen events in the circular economy through the integration of resilience and material reuse*, Book European Financial Resilience and Regulation 25 Years United under Euro – Proceedings of the International Conference EUFIRE-RE 2024, pp. 256-270
- 7) Pop, L., Popa, I.-F., & Vidu, S.I. (2020). *Civil law: obligations*. 2nd edition, revised and added. Bucharest: Universul Juridic Publishing House, p. 335.
- 8) Puie, O. (2017). *Civil contract treaty according to the Civil Code, the Code of Civil Procedure, the Tax Code, the Code of Fiscal Procedure, the Criminal Code and the Code of Criminal Procedure*. Bucharest: Universul Juridic Publishing House, pp. 15-16.

- 9) Schwartz, G.T. (1995). The Economic Loss Doctrine in American Tort Law: Assessing the Recent Experience. In: Banakas, E.K., ed., *Civil Liability for Pure Economic Loss*. Dordrecht: Kluwer Law International, p. 103.
- 10) Simion, R.M. (2010). *Malpraxisul medical: oportunitate sau realitate?* București: Humanitas, pp. 98, 161.
- 11) Stoica, V. (2013). Discussions regarding some obligations incumbent on professionals. *Romanian Journal of Business Law*, 7-8, pp. 20-25.
- 12) Terzea, V. (2021). *Contractual civil liability*. Bucharest: Solomon Publishing House, p. 137.
- 13) Van Boom, W.H. (2004). Pure Economic Loss: A Comparative Perspective. In: Van Boom, W.H., Koziol, H. and Witting, C.A., eds., *Pure Economic Loss – A Comparative Perspectives*. Vienna/New York: Springer, p. 3.

THE INTERPLAY BETWEEN ENVIRONMENTAL REGULATION, CLIMATE NEGOTIATIONS AND ECONOMIC DEVELOPMENT IN MOLDOVA: A PATHWAY TO SUSTAINABLE GROWTH

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Abstract

This article critically examines the dynamic interplay between environmental regulation, climate negotiations, and economic development in Moldova, with a focus on the role of legal frameworks in steering the country as a catalyst toward sustainable growth. Positioned at the intersection of environmental law and economic policy, this study aims to evaluate whether Moldova's legislative alignment with European Union environmental standards has effectively addressed ecological challenges while fostering economic resilience. Utilizing a qualitative methodology, the research adopts a juridical approach, employing a doctrinal analysis of Moldova's environmental legislation, including the Climate Law and the Environmental Liability Directive, complemented by case studies to assess implementation efficacy.

The findings reveal that Moldova's proactive approach to environmental legislation, inspired by EU standards, has established a robust foundation for integrating climate considerations into economic planning. However, systemic gaps in enforcement, public awareness, institutional capacity, and public participation undermine the transformative potential of these laws. The discussion highlights the dual role of environmental regulations: as a driver of innovation in green technologies and as a safeguard against unsustainable exploitation of natural resources. Moreover, the article underscores the importance of international cooperation in climate negotiations to enhance Moldova's adaptive capacity and access to green financing. By aligning national policies with global climate goals, Moldova can leverage its regulatory framework to attract investment in green technologies and foster innovation. This study concludes that Moldova must adopt a more adaptive regulatory framework that balances stringent environmental protections with economic flexibility. Strengthening compliance assurance mechanisms, enhancing inter-agency coordination, and fostering public-private partnerships are essential steps toward achieving Moldova's sustainable development goals. By embedding environmental law into its economic strategy, Moldova can position itself as a regional model for harmonizing ecological integrity with economic progress.

Keywords: *environmental regulation, climate negotiations, economic development, sustainable growth, Moldova, EU Standards, compliance assurance, climate law.*

JEL Classification; K 32

1. INTRODUCTION

Moldova stands at a pivotal crossroads, where the imperatives of environmental protection, international climate commitments, and the pursuit of economic development converge with unprecedented urgency. As the Republic of Moldova grapples with the legacies of its Soviet past and the aspirations of European integration, it faces the formidable challenge of forging a development trajectory that is both economically viable and environmentally sustainable. This challenge is magnified by Moldova's unique vulnerabilities: as one of Europe's poorest nations, it is acutely sensitive to the impacts of climate change, including extreme weather events, droughts, and soil degradation, which threaten both livelihoods and long-term growth prospects (Ciscar *et al.*, 2018).

The pressures on Moldova are multifaceted. On the one hand, the country is under increasing obligation to align its environmental regulatory frameworks with those of the European Union, particularly as it seeks closer political and economic ties through the EU Association Agreement and the Deep and Comprehensive Free Trade Area (DCFTA). These agreements require not only the adoption of stringent environmental standards but also a transformation in governance, transparency, and enforcement mechanisms. On the other hand, Moldova is an active participant in global climate negotiations, having ratified the Paris Agreement and committed to ambitious Nationally Determined Contributions (NDCs) aimed at reducing greenhouse gas emissions and enhancing climate resilience (UNFCCC, 2024). These international commitments place Moldova within a broader network of accountability, cooperation, and opportunity – but also expose it to the complexities and trade-offs inherent in global climate politics (Ciscar *et al.*, 2018).

At the heart of Moldova's sustainable development journey lies the evolving interplay between law, policy, and practice. The country's environmental legislation has undergone significant reform in recent years, with new laws on waste management, air quality, and biodiversity protection reflecting both domestic priorities and international obligations. However, the path from legal reform to effective implementation is fraught with obstacles, including limited institutional capacity, resource constraints, and competing economic interests. For a nation where agriculture remains a cornerstone of the economy, and where energy security is a persistent concern, the integration of environmental objectives into economic planning is not merely a technical exercise, but a fundamental test of political will and societal consensus.

This paper seeks to unravel the dynamic relationships between Moldova's environmental regulation, its role in international climate negotiations, and its broader economic development agenda. It will analyze how legal and policy choices made at the national level are influenced by – and in turn influence – international frameworks and market forces. The discussion will highlight both the synergies and tensions that arise as Moldova strives to meet the dual goals of

ecological integrity and economic advancement. Drawing on case studies, policy analysis, and comparative insights, the paper will assess the effectiveness of Moldova's current approach, identify gaps and opportunities, and propose pathways for harmonizing environmental stewardship with sustainable growth.

Ultimately, Moldova's experience offers valuable lessons for other transition economies facing similar dilemmas at the intersection of environmental governance, climate diplomacy, and economic modernization. By examining Moldova's journey, this paper aims to contribute to the broader discourse on how small states can leverage regulatory innovation, international cooperation, and inclusive policy-making to chart a resilient and prosperous future in an era of global environmental change (UNFCCC (2024).

2. MOLDOVA'S ENVIRONMENTAL AND ECONOMIC LANDSCAPE

Moldova, a landlocked country nestled between Ukraine to the north, east, and south and Romania to the west, occupies a unique geographic position in Eastern Europe. The nation's terrain is predominantly a hilly plain, carved by the meandering Prut and Dniester rivers, with uplands such as the Codri Hills and the Bălănești peak rising to 429 meters above sea level. The landscape is characterized by a network of river valleys, ravines, and gullies, while forested slopes and steppe regions add ecological diversity. This varied topography, combined with a continental climate, shapes both the country's natural resources and its environmental vulnerabilities.

Economically, Moldova remains one of Europe's most fragile states. Its economy is heavily reliant on agriculture, which employs a significant portion of the population and contributes substantially to GDP. However, Moldova's economic prospects have been hampered by a series of shocks in recent years. The European Commission's latest forecast projects a modest GDP growth of just 0.9% in 2025 (European Commission, 2024) a sharp downgrade from previous estimates, primarily due to a dramatic decline in agricultural output following severe summer droughts. The country faces persistent challenges such as high inflation, a widening fiscal deficit, and a negative trade balance, largely driven by its dependence on energy imports and a weak export base. Public debt is expected to rise, and economic recovery is closely tied to external financial support, particularly from the EU.

Moldova's environmental vulnerabilities are profound and multifaceted. According to global assessments, Moldova is considered the most climate-vulnerable country in Europe, with increasing temperatures and more variable rainfall patterns observed over the past century. The frequency and severity of natural hazards – such as droughts, floods, and late frosts – have escalated, causing significant economic and social disruption. For instance, the 2007 drought alone resulted in damages estimated at around USD 1 billion. Looking ahead, climate models predict further rises in mean temperature, more erratic precipitation, and

increased evapotranspiration, all of which threaten to reduce water availability and agricultural productivity. The National Climate Change Adaptation Strategy identifies agriculture, water resources, health, forests, energy, and transport as sectors at particular risk.

Resource management presents another critical challenge. Moldova's water resources are under growing pressure, with total availability projected to fall below demand within the next two decades. Surface and groundwater pollution – stemming from agricultural runoff, untreated wastewater, and industrial discharges – remains a persistent issue, especially in rural areas. Air pollution in urban centers and inadequate waste management systems further exacerbate public health risks and environmental degradation (European Commission, 2024).

Biodiversity loss and land degradation compound these challenges. The conversion of natural habitats for agriculture, unsustainable land use practices, and deforestation have led to declining ecosystem health and reduced resilience to climate shocks. While Moldova has made progress in forest regeneration and biodiversity conservation policies, enforcement gaps, limited institutional capacity, and insufficient financial resources hinder effective implementation.

In summary, Moldova's environmental and economic landscape is defined by a delicate balance between natural resource endowments and acute vulnerabilities. The interplay of geography, economic structure, and environmental risks underscores the urgent need for integrated policy responses that can safeguard ecological integrity while promoting sustainable development (EU4Climate, 2023).

3. THE EVOLUTION OF ENVIRONMENTAL REGULATIONS IN MOLDOVA

Since gaining independence in 1991, Moldova has embarked on a complex and often arduous journey to build a robust environmental regulatory framework capable of addressing the country's pressing ecological challenges while aligning with its broader political and economic aspirations. The early post-Soviet years were marked by a legacy of outdated legislation, weak institutions, and limited public awareness, which collectively hindered effective environmental governance. However, recognizing the critical importance of environmental protection for sustainable development, Moldova gradually undertook a series of legislative reforms aimed at modernizing its legal framework. These efforts gained significant momentum with the country's commitment to European integration, which necessitated harmonization with the EU's comprehensive environmental acquis – a body of laws and regulations that set high standards for air and water quality, waste management, biodiversity conservation, and climate change mitigation.

Moldova's alignment with EU environmental directives has been both a catalyst and a challenge (IEA) (2022). On the one hand, it has driven the adoption

of progressive laws and policies, such as the Law on Environmental Protection, the Waste Management Strategy, and the National Climate Change Adaptation Strategy, reflecting international best practices and obligations under multilateral environmental agreements. On the other hand, the process has exposed gaps in institutional capacity, regulatory enforcement, and inter-agency coordination. The country's environmental institutions – ranging from the Ministry of Environment to regional inspectorates – often face resource constraints, limited technical expertise, and political pressures that undermine their effectiveness. Moreover, enforcement remains inconsistent, with issues such as illegal logging, pollution violations, and non-compliance in industrial sectors persisting despite legal prohibitions (EU4Climate, 2023).

This evolving regulatory landscape reveals a broader tension at the heart of Moldova's sustainable development agenda: the need to reconcile ambitious environmental commitments with socio-economic realities and governance challenges. Understanding this evolution is essential not only to assess Moldova's current environmental governance but also to identify pathways for strengthening legal frameworks, enhancing institutional performance, and fostering a culture of compliance that can support the country's transition to a greener, more resilient future. This section delves into the historical trajectory of Moldova's environmental law, its ongoing alignment with EU and international standards, and the institutional dynamics that shape regulatory enforcement, offering critical insights into the opportunities and obstacles that define Moldova's environmental governance today.

Since independence, Moldova has progressively reformed its environmental legislation, moving from a Soviet-era framework characterized by limited enforcement and outdated norms toward a more comprehensive system that increasingly reflects European Union directives and global environmental commitments. Key milestones include the adoption of the foundational Law on Environmental Protection in 1993, which established environmental protection as a national priority and laid the groundwork for subsequent regulations on air quality, waste management, and biodiversity conservation. Over the past decade, Moldova has intensified efforts to transpose EU environmental acquis, including recent initiatives to implement the EU Environmental Liability Directive, which enshrines the “polluter pays” principle and mandates accountability for environmental damage.

Despite these legislative advances, Moldova's institutional framework faces significant challenges. The Ministry of Environment, along with agencies such as the Environmental Protection Inspectorate, is tasked with oversight and enforcement but struggles with limited financial and human resources, insufficient technical capacity, and coordination difficulties among various government bodies. These constraints often result in uneven application of environmental laws, with persistent issues like illegal logging, pollution from industrial and

agricultural sources, and inadequate waste management undermining regulatory goals. Moreover, the legal system is still evolving to incorporate new procedural requirements, such as enhanced Environmental Impact Assessment (EIA) processes that now integrate biodiversity considerations and strategic environmental assessments in line with international conventions. This complex regulatory evolution reflects Moldova's broader struggle to balance economic development imperatives with environmental sustainability. While alignment with EU standards opens access to funding, technical assistance, and markets, it also imposes stringent compliance demands that require robust governance and stakeholder engagement. Understanding the historical development of Moldova's environmental law, the degree of its harmonization with EU and international norms, and the institutional realities that shape enforcement is essential for identifying both the opportunities for strengthening environmental governance and the persistent obstacles that must be overcome. This analysis sets the stage for exploring how Moldova can leverage legal reforms and institutional capacity-building to foster a resilient, sustainable development pathway that meets national priorities and international expectations.

4. MOLDOVA IN INTERNATIONAL CLIMATE NEGOTIATIONS

Moldova has emerged as a proactive and increasingly ambitious player in the arena of international climate negotiations, demonstrating a firm commitment to global efforts aimed at combating climate change. Since ratifying the Paris Agreement, Moldova has aligned its national climate policies with the Agreement's core objectives: limiting the global temperature increase to well below 2°C above pre-industrial levels and pursuing efforts to cap warming at 1.5°C. Central to this commitment are Moldova's Nationally Determined Contributions (NDCs), which outline the country's targets and strategies for reducing greenhouse gas emissions and enhancing climate resilience. Notably, Moldova was among the first countries globally to submit an updated NDC (NDC2) in March 2020, raising its unconditional emissions reduction target to 70% below 1990 levels by 2030 – a significant increase from its initial pledge of 64-67%. This ambitious target reflects Moldova's alignment with the Paris Agreement's "ratchet mechanism," which encourages countries to progressively enhance their climate commitments.

The development and submission of Moldova's updated NDC were supported by the EU-funded EU4Climate project, which facilitated extensive consultations with national stakeholders, including government bodies, civil society, academia, and the private sector. This inclusive process ensured that the NDC not only sets robust mitigation goals but also integrates adaptation measures and cross-sectoral investment strategies, addressing the country's vulnerability to climate impacts such as droughts and floods. Moreover, Moldova's climate ambitions extend beyond the Paris framework through active participation in

regional initiatives like the Eastern Partnership and the Energy Community, which promote cooperation on energy efficiency, renewable energy, and climate resilience among neighboring countries. These regional platforms provide Moldova with technical assistance, policy guidance, and access to international financing mechanisms, enhancing its capacity to implement climate actions effectively.

Despite its limited economic resources, Moldova's leadership in climate diplomacy has been recognized internationally. The UNFCCC Secretariat has praised the country's commitment and progress, highlighting the forward-looking adaptation components of its NDC and its readiness to leverage international support to achieve even deeper emissions reductions – up to 88% below 1990 levels under conditional scenarios involving technology transfer and financial aid. Moldova's experience illustrates how small, vulnerable states can play a pivotal role in the global climate regime by coupling ambitious national targets with strategic engagement in international and regional climate governance. This way, Moldova's evolving role in climate negotiations, the substance and progress of its NDC commitments, and its integration into regional climate initiatives, shed light on the opportunities and challenges that define its pathway toward a sustainable, low-carbon future. Moldova has demonstrated a clear trajectory of increasing ambition in its climate commitments, as reflected in its recently submitted Nationally Determined Contribution 3.0 (NDC 3.0), which targets a 71% reduction in net greenhouse gas emissions by 2030 compared to 1990 levels – surpassing previous pledges and signaling alignment with the Paris Agreement's goals to limit global warming to 1.5°C. This commitment is part of a broader legislative framework, including the 2024 Law on Climate Actions, which envisions climate neutrality by 2050 and integrates sectoral strategies for renewable energy expansion, energy efficiency, and adaptation measures.

Moldova's NDC process has been characterized by inclusive stakeholder engagement and technical support from international partners, notably the EU's EU4Climate project, which has helped strengthen the country's institutional capacity and regulatory frameworks to meet its climate goals. The country's progress is further bolstered by its active participation in regional platforms such as the Eastern Partnership and the Energy Community, which facilitate knowledge exchange, funding access, and coordinated action on climate and energy policies. These regional initiatives are crucial in addressing transboundary environmental challenges and fostering economic integration while supporting Moldova's transition to a low-carbon economy.

However, Moldova's pathway is not without obstacles. The country faces significant financial and technical constraints, limited domestic investment capacity, and the need to balance urgent economic development priorities with long-term sustainability. Conditional targets within the NDC rely heavily on international climate finance, technology transfer, and capacity-building support

to realize deeper emissions reductions and resilience-building efforts. Furthermore, Moldova's vulnerability to climate impacts such as drought and flooding underscores the importance of integrating adaptation into its climate strategy, ensuring that development gains are not undermined by environmental risks.

In sum, Moldova's evolving role in international climate negotiations illustrates a determined effort by a small, vulnerable state to contribute meaningfully to global climate action while navigating complex domestic and regional realities. This fact highlights Moldova's ambitious NDC commitments, supported by regional cooperation and international assistance, offering a promising foundation for sustainable development. Yet, it also underscores the critical need for continued capacity-building, financing, and policy coherence to overcome persistent challenges and realize a resilient, low-carbon future (World Bank, 2023).

5. ECONOMIC DEVELOPMENT AND ENVIRONMENTAL TRADE-OFFS

Moldova's pursuit of economic development is intricately linked with its environmental regulatory framework, presenting a complex landscape of trade-offs that shape the country's sustainable growth prospects. Key economic sectors – particularly agriculture, energy, and industry – are both drivers of growth and sources of environmental pressure. Agriculture, the backbone of Moldova's economy, is highly vulnerable to climate variability and resource depletion, with droughts and soil degradation directly impacting productivity and rural livelihoods. Environmental regulations aimed at sustainable land use and water management are essential to safeguard this sector but can also impose costs on farmers who must adapt practices or invest in new technologies. Similarly, Moldova's energy sector, heavily reliant on imported fossil fuels, faces the dual challenge of securing energy supply while reducing greenhouse gas emissions. Recent policy initiatives, including the National Energy and Climate Plan 2025-2030, emphasize scaling up renewable energy and improving energy efficiency to enhance energy security and competitiveness, yet these transitions require significant investment and structural reforms.

Case studies of green economic initiatives illustrate both successes and setbacks in Moldova's green transition. For instance, the EU4Environment program has supported the development of green investment strategies and environmental impact assessments, facilitating more sustainable infrastructure projects and industrial practices. However, implementation gaps remain, particularly in enforcing pollution controls and incentivizing private sector participation. On the positive side, Moldova's ambitious Nationally Determined Contributions (NDCs) and climate legislation signal strong political will to integrate climate action with economic development, offering a roadmap for

decarbonization and resilience-building. Conversely, the country's high greenhouse gas emissions intensity – six times that of the EU per unit of GDP – and dependence on drought-prone agriculture highlight the risks of delayed or insufficient environmental action (**World Bank**, 2023).

The cost of inaction is striking. Moldova already suffers annual economic losses estimated at around \$164 million (1.3% of GDP) due to climate-related hazards such as floods and droughts, with air pollution contributing to approximately 3,000 premature deaths each year. These environmental pressures exacerbate economic volatility, deepen rural poverty, and threaten long-term growth. Conversely, a green transition offers substantial benefits: revitalizing and modernizing the economy, creating quality jobs, improving public health, and enhancing energy independence. The World Bank's Moldova Country Climate and Development Report underscores that effective climate action can serve as a catalyst for economic revival, poverty reduction, and EU market integration – provided that policies prioritize social protection, capacity-building, and private sector engagement.

Moldova's economic development path is inseparable from environmental considerations. Balancing regulatory demands with growth imperatives requires smart macro-fiscal policies, targeted investments in renewable energy and adaptation, and robust institutional frameworks. This delicate balancing act defines Moldova's challenge – and opportunity – to transform environmental trade-offs into a sustainable, inclusive growth trajectory (World Bank, 2023).

6. PATHWAYS FORWARD: RECOMMENDATIONS FOR SUSTAINABLE GROWTH

Moldova's ambitious climate and environmental commitments demand a transformative approach that transcends incremental reforms and calls for a fundamental reimagining of the country's development model. Strengthening regulatory frameworks and enforcement mechanisms is not merely a bureaucratic necessity but a strategic imperative. Moldova must accelerate the harmonization of its environmental legislation with the European Union's *acquis* and international climate obligations, while simultaneously investing in institutional capacity-building to ensure that laws are not only enacted but rigorously enforced. Without robust governance, Moldova risks undermining its credibility on the global stage and forfeiting critical international financing and technical support. This includes empowering environmental inspectorates, enhancing transparency through digital platforms such as the government's *www.project.gov.md* initiative, and fostering accountability mechanisms that engage civil society and the private sector (**UNFCCC**, 2020).

Enhancing climate adaptation and mitigation strategies must be mainstreamed across all sectors, with particular emphasis on agriculture, energy, and infrastructure, which are both the most vulnerable to climate shocks and the

largest sources of emissions. Moldova's National Adaptation Plan and updated Nationally Determined Contributions (NDC 3.0) provide a strategic blueprint, yet their success hinges on mobilizing substantial investments in climate-resilient infrastructure, drought-resistant agriculture, renewable energy, and energy efficiency. The World Bank's Country Climate and Development Report underscores the urgency of scaling up adaptation finance and integrating risk management tools such as disaster risk financing and insurance to shield the economy from recurrent shocks. Crucially, these strategies must prioritize social inclusion, ensuring that marginalized communities – often the hardest hit by environmental degradation – are supported through enhanced social protection, skills development, and access to climate-resilient services.

Fostering innovation, green investment, and inclusive growth represents the linchpin of Moldova's sustainable development pathway. The country faces a daunting financing gap estimated at over \$30 billion to achieve its climate and development goals over the next three decades, with two-thirds of this investment expected from the private sector. To mobilize this capital, Moldova must create an enabling environment through policy reforms that enhance investment attractiveness, including clear regulatory frameworks, green tax incentives, and public-private partnerships. The development of green finance instruments – such as green bonds and credit lines supported by multilateral development banks – will be critical to channelling funds into renewable energy, circular economy initiatives, and sustainable agriculture. Moreover, innovation must be coupled with inclusivity: policies should embed gender sensitivity, promote local entrepreneurship, and strengthen rural value chains to ensure that economic benefits are widely shared and contribute to poverty reduction (UNFCCC, 2024).

Ultimately, Moldova's pathway forward challenges the conventional dichotomy between economic growth and environmental protection. Instead, it demands a paradigm shift toward a model where sustainability is the engine of prosperity, resilience, and social equity. This transformation requires bold political leadership, cross-sectoral coordination, and sustained engagement with all stakeholders – from government agencies and businesses to civil society and international partners. Moldova is currently navigating significant challenges in its pursuit of sustainable economic development, particularly in the context of environmental regulation and climate change. A notable case is the country's efforts to align its environmental policies with European Union standards, particularly through the implementation of the EU Environmental Liability Directive (ELD).

Climate change poses significant threats to Moldova's ecosystems by increasing water temperatures, altering hydrological patterns, driving eutrophication, causing biodiversity loss, changing salinity levels, and degrading water quality. Human activities exacerbate these climate impacts through several key mechanisms that not only contribute to environmental degradation but also

undermine the resilience of ecosystems to climate-related stresses. Habitat fragmentation caused by urbanization, agricultural expansion, and infrastructure development disrupts ecosystem connectivity, limiting species' ability to migrate or adapt to changing conditions and increasing their risk of extinction. Over-exploitation of natural resources, including unsustainable logging, overfishing, and intensified agriculture, depletes forests and other habitats, reducing their capacity to function as carbon sinks and recover from climate shocks. Pollution from agricultural runoff laden with fertilizers and pesticides leads to eutrophication in aquatic systems, depleting oxygen and harming aquatic life, while industrial emissions further degrade air and water quality. The introduction and spread of invasive species, facilitated by human activity, outcompete native flora and fauna, altering ecosystem functions and weakening resilience to climate change (UNFCCC, 2024). Additionally, Moldova's heavy reliance on imported fossil fuels and inefficient energy use contribute to greenhouse gas emissions, intensifying climate shifts that disrupt habitats and species distributions (UNFCCC, 2024). Lastly, land use changes – particularly the conversion of natural landscapes to agriculture or urban areas – cause significant habitat loss and diminish ecosystem services vital to both biodiversity and human well-being. Together, these factors highlight how human actions amplify climate change impacts on Moldova's biodiversity. Addressing these intertwined challenges requires integrated management strategies that prioritize sustainable resource use, pollution control, habitat conservation, and climate mitigation to strengthen ecosystem resilience and safeguard Moldova's natural heritage (UNFCCC, 2024).

7. CONCLUSIONS

This paper has traced the intricate interplay between Moldova's environmental regulation, international climate commitments, and economic development, revealing a nation at the forefront of navigating complex trade-offs and opportunities in pursuit of sustainable growth. Moldova's evolving legal frameworks and active engagement in global and regional climate negotiations underscore its determination to align with rigorous EU standards while addressing acute environmental vulnerabilities. The analysis of key economic sectors highlights both the challenges posed by environmental pressures – such as climate-induced droughts, resource depletion, and pollution – and the transformative potential of green investments and innovation to drive economic modernization and resilience. Moldova's experience illustrates that sustainable development is not a distant ideal but an achievable pathway – one that requires strengthened governance, inclusive policies, and strategic international cooperation.

Importantly, Moldova emerges as a compelling model for sustainable development in Eastern Europe – a small, vulnerable country demonstrating that ambitious climate action and economic resilience can go hand in hand. Its journey

offers valuable lessons on how environmental governance can be harmonized with economic ambition, balancing regulatory rigor with social inclusion and innovation. Moldova's proactive submission of progressively ambitious Nationally Determined Contributions (NDCs), its alignment with EU environmental acquis, and its participation in regional climate initiatives exemplify a forward-looking approach that other transition economies can emulate. By embracing this integrated approach, Moldova not only safeguards its own future but also contributes meaningfully to regional and global efforts to combat climate change and promote sustainable prosperity (UNFCCC, 2024).

This synthesis invites policymakers, scholars, and practitioners to view Moldova as a living laboratory where the complexities of environmental law, climate diplomacy, and economic development converge. The country's experience highlights the critical importance of multi-level governance, capacity-building, and inclusive stakeholder engagement in transforming environmental challenges into opportunities for innovation and growth. Moldova's pathway underscores that achieving a greener, more equitable future demands not only legal and technical reforms but also a paradigm shift toward sustainability as the foundation of national development. As Moldova continues to navigate this challenging journey, its lessons resonate far beyond its borders, offering practical pathways and inspiration for other nations striving to reconcile ecological integrity with economic advancement in an era of global environmental change.

References

- 1) Ciscar, J.C., Feyen, L., Soria, A., Lavalle, C., Raes, F., Perry, M., Nemry, F., Demirel, H., Rozsai, M., Dosio, A., Donatelli, M., Srivastava, A.K., Fumagalli, D., Niemeyer, S., Shrestha, S. and Ciaian, P. (2018). *Climate Impacts in Europe: Final Report of the JRC PESETA III Project*. Luxembourg: Publications Office of the European Union. Available at: <https://publications.jrc.ec.europa.eu/repository/handle/JRC106974>
- 2) European Commission (2024). 'European Economic Forecast, Spring 2024: Moldova Country Report'. Available at: <https://economy-finance.ec.europa.eu/economic-forecast-spring-2024-moldova> (Accessed: 13 June 2025).
- 3) EU4Climate (2023). 'Supporting the development of Moldova's Nationally Determined Contributions (NDCs)'. Available at: <https://eu4climate.eu/moldova> (Accessed: 13 June 2025).
- 4) Food and Agriculture Organization of the United Nations (FAO) (2021). *Moldova: Country Programming Framework 2021–2025*. Rome: FAO. Available at: <https://www.fao.org/documents/card/en/c/cb5288en>
- 5) Government of the Republic of Moldova (2023). *National Climate Change Adaptation Strategy*. Chisinau: Ministry of Environment.
- 6) Government of the Republic of Moldova (2024). *Law on Climate Actions*. Chisinau: Official Gazette.
- 7) International Energy Agency (IEA) (2022). *Moldova 2022: Energy Policy Review*. Paris: IEA. Available at: <https://www.iea.org/reports/moldova-2022>

- 8) Ministry of Agriculture, Regional Development and Environment of Moldova (2022). *National Energy and Climate Plan 2025-2030*. Chisinau.
- 9) Ministry of Environment of Moldova (2023). *National Biodiversity Strategy and Action Plan*. Chisinau.
- 10) Organisation for Economic Co-operation and Development (OECD) (2021). *Green Growth Policy Review of Moldova*. Paris: OECD Publishing. Available at: <https://www.oecd.org/environment/country-reviews/green-growth-policy-review-moldova.htm>
- 11) UNFCCC (2020). 'Republic of Moldova's Second Nationally Determined Contribution (NDC2)'. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Moldova%20Second/Moldova_NDC2_2020.pdf (Accessed: 13 June 2025).
- 12) UNFCCC (2024). 'Republic of Moldova's Third Nationally Determined Contribution (NDC3)'. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Moldova%20Third/Moldova_NDC3_2024.pdf (Accessed: 13 June 2025).
- 13) United Nations Development Programme (UNDP) Moldova (2023). *Moldova: Climate Change and Environment Portfolio*. Chisinau: UNDP Moldova. Available at: <https://www.md.undp.org/content/moldova/en/home/projects/climate-change.html>
- 14) World Bank (2023). *Moldova Country Climate and Development Report*. Washington, DC: World Bank. Available at: <https://www.worldbank.org/en/country/moldova/publication/ccdr> (Accessed: 13 June 2025).

VALORIZATION OF OAK BARK AS A SUSTAINABLE SOLUTION FOR PRODUCING CHEMICALS AND BIOCHAR DERIVED MATERIALS

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Abstract

*Bark is typically regarded as a by-product of the wood industry and is often utilized as a horticultural substrate or incinerated for energy production due to its heterogeneous composition and high impurity content. However, its high ash content limits its efficiency as an energy source, as ash elements decrease heating value and cause fouling in combustors. Bark, however, contains a significant fraction of extractives and lignin (up to 50% on a dry basis), offering potential as a renewable source of aromatic chemicals for applications such as panels, tannins, resins, foams, and bio-oils. In this case study, the valorization of oak bark (*Quercus robur*) was evaluated through chemical extractions and the solid content processed via pyrolysis, yielding products such as biochar or bio-oils. The resulting biochar and bio-oils are evaluated in terms of yields and material characteristics such as surface area, pore volume, and surface functional groups. The integrated valorization of bark biomass into chemicals and biochar-derived materials demonstrates a sustainable approach to waste management. This process contributes to circular economy goals by optimizing resource utilization and promoting the development of bio-based materials.*

Keywords: *aromatic chemicals, biochar, environmental remediation, oak bark, waste valorization*

JEL Classification: Q55

1. INTRODUCTION

Global forestry currently harvests about 1.92 billion m³ of industrial roundwood per year, and projections from the FAO's Global Forest-Sector estimates this number will rise to 2.5–2.9 billion m³ by 2050 (FAO, 2022). Since bark typically constitutes 9–15 % of the volume of each log, this growth implies that the global bark stream currently estimated at 0.17–0.29 billion m³ annually, could reach up to 0.87 billion m³ by 2050.

In most cases, bark is treated as a low-value by-product of the wood industry. Due to its high mineral content in form of ashes, it performs poorly as a biofuel, lowering calorific value and causing slagging and fouling in the combustion systems. These limitations undermine energy recovery and run counter to the European Green Deal's Circular Economy Action Plan (CEAP), which calls for product life-cycle optimisation and minimisation of incineration across resource-intensive sectors.

Although bark is commonly downcycled into horticultural substrate, animal bedding or decorative mulch, it is in fact a chemically rich natural resource. Up to 50% of its dry mass consist of lignin and polyphenolic extractives, including condensed and hydrolysable tannins, making it a promising renewable source of aromatic compounds. These constituents can be valorised into bio-based chemicals, rich bio-oils and carbon-negative biochar, effectively transforming bark from a disposal liability into a key feedstock for circular-economy applications and climate-neutral materials strategies.

On these grounds, integrated bark valorization through extraction and pyrolysis offers both environmental and societal benefits. It reduces waste and greenhouse gas emissions by diverting biomass from incineration and capturing carbon in stable products like biochar (Şen, Esteves and Pereira, 2023). Simultaneously, it replaces fossil-derived inputs with renewable, bio-based alternatives. Recent EU monitoring shows that circular use of biomass remains below target levels, highlighting both a clear policy gap and market opportunity.

This work explores the integrated valorisation of *Quercus robur* bark through a two-step cascade process involving the extraction of bioactive compounds followed by pyrolysis of the residual biomass. The aim is to evaluate both the chemical potential of the extracts and the material properties of the resulting biochar, highlighting their applicability in sustainable material development. Valorising bark is aligned with Europe's climate and resource-efficiency goals, supporting the transition toward low-carbon, bio-based industries.

2. METHODOLOGIES

The valorisation of oak bark (*Quercus robur*) was carried out using a cascaded biorefinery approach, consisting of two main stages: (1) chemical extraction of high-value compounds, and (2) thermochemical conversion of the

residual biomass into biochar. This integrated pathway is designed to maximise resource efficiency and product diversification while aligning with circular economy principles (Figure 1).

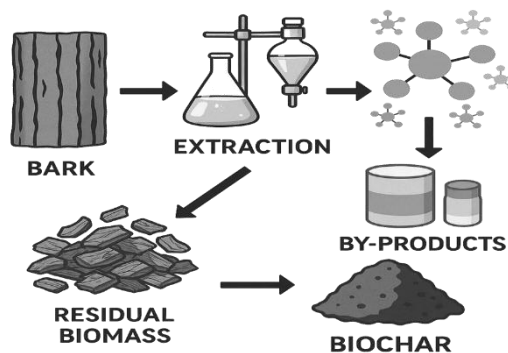


Figure 1. Stages of valorisation of residual bark.

2.1. Extraction of bioactive compounds

Bark samples need first to be dried, milled, and sieved to a uniform particle size. The powdered bark then is subjected to solvent-based extraction using environmentally friendly and inexpensive solvents (e.g., water, ethanol, or hydroalcoholic mixtures). The extraction is usually performed under controlled conditions (temperature, time, solvent-to-solid ratio) to maximise recovery of phenolic compounds, including tannins and lignin-derived aromatics. Soxhlet and Ultrasound Assisted Extractions were used to compare the extraction efficiency. After filtration, the liquid extracts are separated and concentrated. These extracts are further characterized for their chemical composition and potential applications in bio-based adhesives, additives, antioxidants, and resins.

2.2. Processing of residual biomass

The solid residue remaining after extraction referred to as residual biomass was collected, dried, and used as feedstock for pyrolysis. This thermochemical process is conducted in an inert atmosphere at moderate temperatures to produce biochar or bio-oils, as explained in the Figure 2. According to Chun et al. (2021), biochar yield and quality are influenced by feedstock characteristics and pyrolysis parameters such as temperature, heating rate, and residence time. These process parameters such as heating rate, residence time, and final temperature are optimized to enhance the yield and quality of the products. The resulting biochar is analysed for its surface area, porosity, elemental composition, and in the case of bio-oil, the physicochemical characteristics and the functional groups. After this initial profiling, it is chosen its suitability for environmental or agricultural applications.

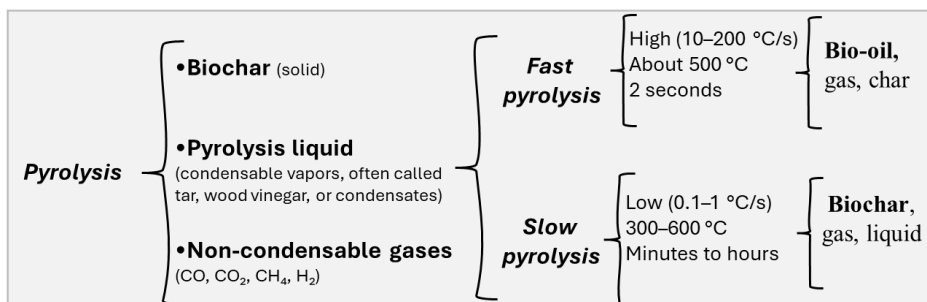


Figure 2. Thermochemical processes of residual bark.

2.3. Integration and by-product valorisation

The process applied in this study follows a cascaded approach, where oak bark is first used to extract valuable compounds, and then the remaining solid material is transformed into biochar. This means that every part of the bark is used with purpose, minimizing waste.

The liquid extracts obtained in the first step contain natural chemicals like tannins and antioxidants, which can be used in the production of bio-based materials. Meanwhile, the leftover bark solids are not discarded, instead, they are converted through pyrolysis into biochar, a carbon-rich material that can help improve soil, filter pollutants, or store carbon for long periods.

By combining both steps, this integrated process increases the value we get from bark. It also supports environmental goals by reducing waste, replacing fossil-based materials, and contributing to a more circular and sustainable use of forest resources

3. RESULTS AND DISCUSSION

3.1. Extraction of bioactive compounds

Oak bark is a rich source of bioactive molecules, particularly polyphenols, tannins, flavonoids, and lignin-derived aromatics, making it a valuable raw material for the sustainable production of functional chemicals. Various extraction methods have been explored to isolate these compounds, each with distinct advantages depending on the target compounds, environmental constraints, and final applications as is shown in Table 1.

Table 1. Characteristics of extractives from residual bark

Extraction method	Solvents	Typical Yield (%)	Yield on this study (%)	Type of compounds extracted	Potential applications	References
Hot extraction Soxhlet	Water	2-5	3	Condensed tannins, hydrolysable tannins	Animal feed additives, antimicrobials	Nisca <i>et al.</i> , 2023; Quaratesi <i>et al.</i> , 2024
Ultrasound-Assisted Extraction	Water-Ethanol	2-13	13	Phenolic acids, flavonoids, catechins	Adhesives, antioxidants, preservatives, antimicrobials	Şen, Esteves and Pereira, 2023; Nisca <i>et al.</i> , 2023; Quaratesi <i>et al.</i> , 2024
Alkaline Aqueous Extraction	Water (1% NaOH)	30-40	38	Lignin fractions, phenolics	Resins, lignin derived materials	Borrega and Kalliola 2022

Conventional hot water extraction is widely used due to its simplicity and low cost, though it typically results in modest yields and limited selectivity. The combination of ethanol and water as a co-solvent increases the solubility of phenolic compounds and significantly improves extraction efficiency. Ultrasound-assisted extraction enhances mass transfer and accelerates extraction kinetics, allowing shorter processing times and improved yields at lower temperatures, preserving sensitive molecules. Finally, alkaline aqueous extraction is particularly effective for isolating lignin fractions while maintaining the cellulose-rich solid residue, offering opportunities for further valorisation in a cascading biorefinery context.

3.2. Pyrolysis of residual bark fraction

Following extraction of bioactive compounds, the residual oak bark biomass was subjected to slow pyrolysis to obtain biochar, a carbon-rich material with multifunctional applications in agriculture, environmental remediation, and materials engineering. The physicochemical properties of biochar were found to vary significantly depending on the prior extraction method, which acts as a pre-treatment influencing carbon content, ash levels, particle size, porosity, and surface functionality, as shown in Table 2.

Biochar obtained after alkaline aqueous extraction showed the highest carbon content (72%) and the lowest oxygen content (11%), suggesting a more condensed carbon structure, favorable for long-term carbon sequestration. In contrast, biochar from solvent extractions exhibited higher surface area and larger pore volumes, making them more suitable for adsorption applications such as pollutant removal from water.

Table 2. Thermochemical processes of residual bark

Pretreatment	Solvents	Biochar properties				
		C / N / H / O content (%)	Ash content (%)	Surface area (m ² /g)	Average pore size (nm)	Mean particle size (um)
Hot water extraction	Water	68 / 1 / 1 / 17	13	55	9	50
Ultrasound-Assisted Extraction	Water-Ethanol	71 / 1 / 1 / 14	13	19	19	51
Alkaline Aqueous Extraction	Water (1% NaOH)	72 / 1 / 1 / 11	16	23	6	80

Ash content ranged from 13% to 16%, with alkaline pretreatment resulting in the highest ash level, which can affect thermal stability and nutrient retention when used as a soil amendment. All samples showed relatively low hydrogen and nitrogen content, typical of slow pyrolysis products, reinforcing their suitability for environmental uses rather than high-energy combustion. Mukherjee *et al.*, (2022) showed that variations in feedstock type substantially alter surface area of biochar, porosity, and elemental composition, findings consistent with our observations.

3.3. Integration and by-product valorisation

This valorisation step closes the loop by turning a low-value solid residue into a versatile carbon material, reinforcing circularity. Depending on its tailored properties, biochar can function as a soil conditioner, pollutant adsorbent, catalyst support, or even as a filler in biocomposites. The ability to adjust biochar characteristics through prior extraction methods exemplifies a cascade biorefinery strategy, maximizing the resource value of oak bark.

4. CONCLUSIONS

This two-step cascade valorisation strategy supports circular economy principles by maximizing resource use, minimizing waste, and generating multifunctional outputs. The combined recovery of chemical extracts and functional carbon materials demonstrates how oak bark can be transformed from a disposal challenge into a renewable resource stream, supporting climate action and sustainable material development. These findings provide a scalable model for integrating bark-derived products into bio-based value chains, contributing to the EU's goals for carbon neutrality and industrial circularity.

References

- 1) Borrega, M., Kalliola, A., Määttänen, M., Borisova, A. S., Mikkelsen, A., & Tamminen, T. (2022). Alkaline extraction of polyphenols for valorization of industrial spruce bark. *Bioresource Technology Reports*, 19, 101129.
- 2) Chun, Y., Lee, S. K., Yoo, H. Y., and Kim, S. W. (2021). Recent advancements in biochar production according to feedstock classification, pyrolysis conditions, and applications: A review. *BioResources* 16(3), 6512-6547.
- 3) Food and Agriculture Organization of the United Nations (FAO). (2022). Global Forest Sector Outlook 2050: Assessing future demand and sources of timber for a sustainable economy – Background paper for The State of the World's Forests 2022. FAO Forestry Working Paper No. 31. Rome: FAO. <https://openknowledge.fao.org/server/api/core/bitstreams/9f646b14-28d2-496e-9728-0b1c281339b5/content>
- 4) Mukherjee, A., Patra, B. R., Podder, J., & Dalai, A. K. (2022). Synthesis of biochar from lignocellulosic biomass for diverse industrial applications and energy harvesting: effects of pyrolysis conditions on the physicochemical properties of biochar. *Frontiers in Materials* 9, 870184.
- 5) Nisca, A., Ștefănescu, R., Mocan, A., Babotă, M., Nicolescu, A., Mare, A. D., & Tanase, C. (2023). A Comparative Analysis of Polyphenol Content and Biological Potential of *Quercus petraea* Matt. and *Q. pubescens* Willd. Bark Extracts. *Forests* 14(1), 116.
- 6) Quaratesi, I., Calinescu, I., Lavric, V., Ferrara, V., Badea, E., Chipurici, P., & Popa, I. (2024). Loop-Ultrasound-Assisted Extraction: An Efficient Approach for the Recovery of Bioactive Compounds from Oak Bark. *Agronomy*, 14(7), 1452.
- 7) Şen, U., Esteves, B., & Pereira, H. (2023). Pyrolysis and extraction of bark in a biorefineries context: a critical review. *Energies* 16(13), 4848.

THE CIRCULAR ECONOMY IN THE EUROPEAN UNION: LEGAL FOUNDATIONS AND REGULATORY FRAMEWORKS

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Abstract

This paper provides a comprehensive legal analysis of the time limits governing consumers' rights to claim and request product repairs. It focuses on the new EU Directive promoting product lifecycle extension through reducing, reusing, and repairing. The Directive mandates that manufacturers and sellers enable product repairs up to ten years from the date of manufacture, marking a significant advance towards sustainable consumption and enhanced consumer protection, but only for certain kinds of goods.

Scientific contribution lies in the author's critical examination of the intersection between the newly introduced obligations under the Directive and existing consumer rights under warranties and guarantees. By analysing potential overlaps and conflicts, the paper sheds light on the legal implications and challenges of harmonising these rights within current legal frameworks in selected member states.

The critical legal questions to be addressed will include alignment with existing laws and determining how the directive's mandate for repair for up to ten years aligns with existing national laws on warranties and guarantees. Additionally, stakeholders' responsibilities will be examined in relation to the analysis of the legal obligations of manufacturers and sellers under the Directive, as well as their interactions with consumers' rights to claim defects. In conclusion, the implementation challenges will be addressed to ensure the effective implementation of the Directive into national legislation.

By addressing these questions, the paper aims to provide actionable recommendations to facilitate the effective implementation of the Directive. The findings contribute to the broader discourse on consumer law reform, environmental sustainability, and the integration of circular economy principles into legal systems.

Keywords: European Union, environmental law, circular economy, consumer protection, sustainable development

JEL Classification: K32, Q58, L51

1. INTRODUCTION

The European Union has positioned itself as a global frontrunner in environmental policy, explicitly embedding sustainable development and circular economy principles within its strategic framework.

This commitment is exemplified by the establishment of a comprehensive legal architecture designed to confront environmental challenges and foster a transition towards a circular economy (Camilleri, 2020).

This paper undertakes a detailed examination of the EU's legal framework, dissecting the key directives, regulations, and policy instruments that collectively shape the EU's approach, with a particular emphasis on their legal underpinnings and practical ramifications. The EU's pursuit of a circular economy is predicated on a complex interaction of legislative measures and strategic policy initiatives (Mak & Lujinovic, 2019).

Prominent among these are the Circular Economy Action Plan, the European Green Deal, and a multitude of directives addressing specific facets of waste management, product design, and resource efficiency (Malinauskaitė & Erdem, 2021). This multifaceted approach underscores the EU's recognition of the interconnectedness of environmental challenges and the need for holistic, integrated solutions. At the heart of the EU's circular economy strategy lies a concerted effort to minimize waste generation through the promotion of reuse and recycling practices (Mikula *et al.*, 2020). Recent directives have fortified the legal framework governing these domains, establishing ambitious targets and fostering innovative approaches to waste management (Negrete-Cardoso *et al.*, 2022). The transition to a circular economy necessitates substantial modifications in both production and consumption patterns, requiring a fundamental shift away from the linear model of "take-make-dispose" (Koszevska, 2018).

Specifically, the EU's circular economy framework necessitates a comprehensive re-evaluation of product design protocols, manufacturing processes, and established patterns of consumer behavior, all with the overarching objective of minimizing waste generation and simultaneously maximizing the efficient utilization of resources (Горюхова *et al.*, 2023). The effective implementation of circular economy principles demands a collaborative effort involving governments, businesses, and individual citizens, each playing a vital role in realizing the EU's ambitious environmental goals.

2. LITERATURE REVIEW

The legal basis of these instruments will be meticulously analysed, exploring their scope, objectives, and enforcement mechanisms, thus providing a comprehensive understanding of the EU's circular economy framework.

This paper also investigates the challenges and opportunities associated with implementing these regulations across the diverse landscape of EU member states, acknowledging the varied economic, social, and environmental contexts that shape their implementation. The effectiveness of the EU's circular economy framework hinges on its ability to adapt to the specific circumstances of individual member states, while simultaneously maintaining a cohesive and harmonised approach across the Union. A crucial aspect of the EU's circular economy strategy

involves reducing waste through the promotion of reuse and recycling initiatives. Recent directives have strengthened the legal framework governing waste management, setting ambitious targets and promoting innovative approaches (Shevchenko, *et al.*, 2019). These directives have significant legal implications for businesses, consumers, and the environment, influencing waste management practices and promoting sustainability. The EU's commitment extends beyond waste management, encompassing broader aspects of sustainable development through initiatives like the European Green Deal (Mazur-Wierzbička, 2021). This initiative sets ambitious targets for climate neutrality and resource efficiency, signifying a comprehensive approach to environmental protection. Moreover, the EU's commitment to environmental stewardship extends beyond waste management, encompassing a broader range of sustainable development objectives outlined in landmark initiatives, such as the European Green Deal. (Viles *et al.*, 2020).

The transition to a circular economy represents a paradigm shift that requires not only regulatory changes but also technological innovation, investment in infrastructure, and a fundamental change in consumer behaviour (Suárez *et al.*, 2023). The EU's circular economy framework is not without its challenges, as the transition from a linear to a circular economy requires significant investments, technological advancements, and behavioural changes across all sectors of society (Petit-Boix & Leipold, 2018). The EU's circular economy strategy aims to address these challenges by establishing a supportive legal and regulatory framework, fostering innovation, and increasing public awareness of the benefits of a circular economy (Regolo *et al.*, 2024). The integration of circular economy principles into various industries, such as the fashion sector, provides a pathway towards sustainability, aligning with European legislation, including the European Green Deal and the UN Sustainable Development Goals (Shirvanimoghaddam *et al.*, 2020). Effective implementation requires collaboration among stakeholders, including businesses, policymakers, and consumers, to overcome barriers and realise the full potential of a circular economy (Milios, 2021; Taelman *et al.*, 2018).

3. DISCUSSION

The European Union has emerged as a global frontrunner in environmental policy, demonstrating a resolute commitment to sustainable development and the principles of a circular economy (Idir *et al.*, 2025). The EU's proactive stance is evident in its comprehensive legal framework designed to address environmental challenges and facilitate the transition towards a circular economy, marking a significant stride in global environmental governance (Morris *et al.*, 2021). The Circular Economy Action Plan, an integral component of the broader European Green Deal, serves as a strategic roadmap for achieving a climate-neutral, resource-efficient, and competitive economy (Husain *et al.*, 2024). This plan

encompasses a wide array of initiatives aimed at transforming the EU's economy into a circular model, where resources are utilized more efficiently and waste is minimized (Hadi *et al.*, 2021). This transition necessitates a fundamental shift in how products are designed, produced, consumed, and recycled, requiring a collaborative effort from all stakeholders. The concept of a circular economy is gaining global recognition as a viable approach to mitigating climate change and promoting sustainable development (Mukhlis, 2021). A circular economy necessitates a shift from a linear "take-make-dispose" model to a closed-loop system where resources are kept in use for as long as possible, reducing waste and minimizing environmental impact (Rahla *et al.*, 2021). Ultimately, the EU's circular economy framework seeks to create a more resilient and sustainable economy that benefits both the environment and society. Moreover, the EU's commitment to environmental protection extends beyond its borders, as it actively promotes circular economy principles on a global scale. The EU's circular economy framework is a multifaceted construct, resting upon a complex interplay of legislative acts and policy initiatives.

EU legal framework for circular economy is composed of the Circular Economy Action Plan, the European Green Deal, and numerous directives addressing specific aspects of waste management, product design, and resource efficiency (Jones & Comfort, 2021). Analyzing the legal basis of these instruments, exploring their scope, objectives, and enforcement mechanisms is highly important. The EU's approach is rooted in the principles of sustainability, resource efficiency, and waste reduction, aiming to minimize environmental impact and promote economic growth. The EU's circular economy strategy is underpinned by a comprehensive set of legal instruments, including directives, regulations, and decisions that address various aspects of the product lifecycle, from design and production to consumption and waste management. Key directives include the Waste Framework Directive, the Packaging and Packaging Waste Directive, and the End-of-Life Vehicles Directive, which set targets for waste reduction, recycling, and recovery (Milios, 2017). These directives provide a legal framework for member states to implement circular economy initiatives at the national level, while also ensuring a harmonized approach across the EU (Foggia & Beccarello, 2023). Member states are responsible for transposing EU directives into national law and ensuring their effective implementation and enforcement. The European Commission plays a crucial role in monitoring the implementation of EU environmental law and taking enforcement action against member states that fail to comply.

Waste reduction through reuse and recycling is a central tenet of the EU's circular economy strategy, as demonstrated by recent directives that have fortified the legal framework governing these domains, establishing ambitious targets and fostering innovative waste management approaches. The EU's waste management legislation is a cornerstone of its circular economy strategy, setting ambitious

targets for reducing waste generation, increasing recycling rates, and limiting the amount of waste that is landfilled. These directives have far-reaching implications for businesses, consumers, and the environment, influencing product design, manufacturing processes, and consumption patterns. Packaging and Packaging Waste Directive encompasses all packaging placed on the European market and all packaging waste, regardless of the material used (Weale *et al.*, 2002). The directives promote the reuse, recycling and other forms of recovering of packaging waste, instead of its final disposal, thus contributing to the transition towards a circular economy (Weale *et al.*, 2002). The Packaging and Packaging Waste Directive mandates EU countries to adopt measures such as national programs and incentives through extended producer responsibility schemes, to prevent packaging waste and minimize the environmental impact of packaging (Weale *et al.*, 2002). The Landfill Directive aims to prevent or reduce the negative effects of the landfilling of waste on the environment, in particular on surface water, groundwater, soil, air and human health. The Landfill Directive has been crucial in diverting biodegradable municipal waste away from landfills, thereby reducing greenhouse gas emissions and promoting the recovery of valuable materials. The Waste Electrical and Electronic Equipment Directive is focused on the collection, treatment, and recycling of electronic waste (Protopapa *et al.*, 2021). The directive sets collection targets for e-waste and requires member states to establish systems for the proper management of this waste stream. It promotes the separate collection, treatment, and recycling of e-waste, diverting it from landfills and preventing the release of hazardous substances into the environment.

4. METHODOLOGY

Beyond its focus on waste management, the EU's commitment to environmental protection extends to encompass broader dimensions of sustainable development, as exemplified by the European Green Deal, a landmark initiative that sets ambitious objectives for achieving climate neutrality and promoting resource efficiency across various

sectors. The Waste Framework Directive establishes a waste hierarchy, prioritizing prevention, preparing for reuse, recycling, other recovery (e.g., energy recovery), and, as the least preferred option, disposal (Almansour & Akrami, 2024). This directive provides a framework for waste management planning and sets targets for recycling municipal waste. It requires member states to take measures to prevent waste generation, promote the separate collection of waste, and ensure that waste is treated in accordance with the waste hierarchy. The Industrial Emissions Directive aims to prevent and reduce pollution from industrial activities. It requires industrial installations to obtain permits that set emission limits and require the use of best available techniques to prevent and control pollution. The Eco-design Directive sets ecological requirements for

energy-related products, promoting energy efficiency and reducing the environmental impact of products throughout their lifecycle.

The European Green Deal, the EU's flagship initiative, sets ambitious targets for climate neutrality and resource efficiency (Smol *et al.*, 2020). The Green Deal encompasses a wide range of policy areas, including climate action, energy, transport, industry, agriculture, and biodiversity. It aims to transform the EU into a modern, resource-efficient, and competitive economy, ensuring a high level of environmental protection and improving the health and well-being of citizens. The Circular Economy Action Plan provides a comprehensive framework for promoting circular economy principles across various sectors. It includes measures to promote sustainable product design, reduce waste generation, increase recycling rates, and create markets for secondary raw materials (Antoniadou *et al.*, 2021). The EU's approach involves open research and social enterprise, integrating connected communities into a resource-efficient and competitive economy (Rowan & Casey, 2021). The European Green Deal recognizes the crucial role of ecosystems and their services as the foundation for a fair, healthy, and prosperous society, emphasizing sustainable and just development at the center of European growth towards 2050 (Zorpas, 2020). Strategies that aim to enhance the quality of life and influence public discourse should focus on reducing the environmental impact through sustainable resource use, environmental management systems, and comprehensive impact assessments. Achieving climate neutrality by 2050 necessitates a transition to renewable energy sources, reducing greenhouse gas emissions, and promoting a circular economy (Podkolzina *et al.*, 2023). The EU's commitment involves integrating economic, technological, and social factors to decouple economic growth from environmental degradation (Doran *et al.*, 2025; Luca *et al.*, 2021; Wang & Chiu, 2013).

The transition towards a circular economy is gaining momentum in the policy plans of many countries, exemplified by the European Commission's strategic agenda to transform the EU economy into a circular one (Giannoccaro *et al.*, 2021). The EU is committed to becoming the first climate-neutral continent by 2050, with the energy sector playing a pivotal role in achieving this goal (Hao & Dragomir, 2025). The EU aims to cut emissions by at least 55% by 2030 compared to 1990 levels (Mallouppas *et al.*, 2022). This transition involves the integration of renewable energy sources, improvements in energy efficiency, and the deployment of sustainable technologies. The EU's circular economy framework aims to decouple economic growth from resource use and environmental impact by transforming how goods are produced, used, and discarded (Dăce *et al.*, 2024). This entails rethinking and redesigning products, processes, value chains, and business models to minimize waste and maximize resource efficiency (Goovaerts *et al.*, 2018). Entrepreneurial clusters play a crucial role in advancing the circular bioeconomy and fostering innovation. These clusters bring together diverse

stakeholders, including businesses, research institutions, and policymakers, to collaborate and drive the transition towards a more sustainable and circular economy (Vajda *et al.*, 2025). The EU's approach encompasses a broad range of policy areas, including sustainable product design, waste management, and the promotion of secondary raw materials markets.

The EU's emphasis on sustainability extends beyond waste management to encompass a comprehensive vision for environmental protection and resource efficiency. To support the energy transition, institutions like the European Investment Bank are investing in new technologies that promote a circular economy (Pintilie, 2021).

5. RESULTS

The regulatory landscape governing the circular economy within the European Union is characterised by a multifaceted framework comprising directives, regulations, and policy instruments, each contributing to the overarching goal of fostering sustainable development and resource efficiency. This framework necessitates a collaborative approach, involving governments, industries, and citizens, to ensure the successful implementation of circular economy principles across diverse sectors. The transition from a linear to a circular economy is formally inscribed in the EU's new Circular Economy Action Plan and reflected in several aspects of policymaking (Duquennoi & Martínéz, 2022). The EU's commitment to environmental protection and sustainable development has led to the establishment of a robust legal framework aimed at addressing environmental challenges and promoting a circular economy. The circular economy presents opportunities for businesses with a high tendency towards innovation and entrepreneurship (Luis & Celma, 2020). Common practices of the circular economy and the bioeconomy not only contribute to the reduction of the impact on natural resources but also represent an opportunity for the creation of employment and local development (Duque-Acevedo *et al.*, 2020).

The EU's circular economy framework is built upon a complex interplay of legislative acts and policy initiatives, with key instruments including the Circular Economy Action Plan, the European Green Deal, and numerous directives addressing specific aspects of waste management, product design, and resource efficiency. These directives and regulations set specific targets for waste reduction, recycling rates, and the phasing out of harmful substances in products. The global pursuit of the CE has yielded diverse frameworks, each shaped by regional priorities, resource constraints, and governance structures (Alhowaish & Alkubur, 2025). The EU's waste management hierarchy prioritizes prevention, reuse, recycling, and recovery, with disposal as the last resort. This hierarchy guides waste management policies and practices across member states. This involves promoting the design of products that are durable, repairable, and recyclable, as well as establishing systems for the collection, sorting, and

processing of waste materials. The EU promotes the adoption of extended producer responsibility schemes, which hold producers accountable for the end-of-life management of their products.

To achieve a circular economy, it is essential to promote reuse, repair and refurbishment, remanufacturing, and recycling of existing materials and products (Sah & Hong, 2024). The EU's approach involves creating incentives for businesses to adopt circular practices, such as offering tax breaks to companies that utilise recycled materials or implement waste reduction strategies.

6. CONCLUSION

The European Union's approach to sustainability is rooted in a comprehensive legal and regulatory framework designed to promote environmental protection, resource efficiency, and the transition to a circular economy.

The EU's commitment to environmental protection extends beyond waste management, encompassing broader aspects of sustainable development, as evidenced by the European Green Deal, which sets ambitious targets for climate neutrality and resource efficiency. The EU's legal framework governing waste management and recycling has been strengthened through recent directives, setting ambitious targets and promoting innovative approaches to waste management (Šarc *et al.*, 2019). These directives aim to reduce the amount of waste generated, increase recycling rates, and promote the use of recycled materials in new products. The Waste Framework Directive introduced by the European Union describes 'prevention' as the most preferable management strategy for waste management, followed by 'preparing for re-use', 'recycling', 'recovery', and finally 'disposal' (Ismail & Hanafiah, 2019). The EU's regulatory framework seeks to ensure that waste management practices are environmentally sound and economically viable. This commitment is reflected in various directives and regulations aimed at promoting sustainable product design, waste reduction, and the development of markets for secondary raw materials (Boniface *et al.*, 2024).

The European Union has emerged as a global leader in promoting the circular economy, implementing various directives and regulations to reduce waste, promote recycling, and foster sustainable development. The EU's approach involves setting ambitious targets for waste reduction and recycling, as well as promoting the development of new technologies and business models that support the circular economy. Economic incentives play a crucial role in promoting circular practices, but they are often insufficient or poorly targeted (Idir *et al.*, 2025). The EU's regulatory framework for the circular economy encompasses a wide range of policy areas, including waste management, product design, and resource efficiency.

The EU's regulatory framework is designed to promote a shift away from a linear "take-make-dispose" model towards a circular economy in which resources are used more efficiently and waste is minimized (Negrete-Cardoso *et al.*, 2022). The implementation of the circular economy requires changing the mindset of consumers and businesses, promoting collaboration across the value chain, and investing in research and innovation. This transition involves creating new markets for recycled materials, developing innovative technologies for waste treatment, and promoting sustainable consumption patterns. Ongoing training programs and awareness campaigns are needed to inform professionals about the benefits of the circular economy and modern techniques for recycling and reusing materials (Idir *et al.*, 2025). The linear economy principles, based on the raw materials transformation into final products, and their subsequent discharge as waste, cannot be longer followed (Zanoletti *et al.*, 2021). The circular economy practices have the potential to address these issues, by decoupling economic growth from resource consumption and waste generation (Grdić *et al.*, 2020).

References

- 1) Alhowaish, A. K., & Alkubur, F. S. (2025). Unlocking the Potential of the Circular Economy at Municipal Levels: A Study of Expert Perceptions in the Dammam Metropolitan Area. *Sustainability*, 17(10), 4323. <https://doi.org/10.3390/su17104323>
- 2) Almansour, M., & Akrami, M. (2024). Towards Zero Waste: An In-Depth Analysis of National Policies, Strategies, and Case Studies in Waste Minimisation. *Sustainability*, 16(22), 10105. <https://doi.org/10.3390/su162210105>
- 3) Boniface, C., Urquhart, L., & Terras, M. (2024). Towards a right to repair for the Internet of Things: A review of legal and policy aspects [Review of Towards a right to repair for the Internet of Things: A review of legal and policy aspects]. *Computer Law & Security Review*, 52, 105934. Elsevier BV. <https://doi.org/10.1016/j.clsr.2024.105934>
- 4) Camilleri, M. A. (2020). European environment policy for the circular economy: Implications for business and industry stakeholders. *Sustainable Development*, 28(6), 1804. <https://doi.org/10.1002/sd.2113>
- 5) Dăce, E., Cascavilla, A., Bianchi, M., Chioatto, E., Zecca, E., Ladu, L., & Yılan, G. (2024). Barriers to transitioning to a circular bio-based economy: Findings from an industrial perspective. *Sustainable Production and Consumption*, 48, 407. <https://doi.org/10.1016/j.spc.2024.05.029>
- 6) Doran, N. M., Bădîrcea, R. M., Jianu, E., Antoniu, M., Ciobanu, R. M. G., & Ciobanu, Ștefan C. F. (2025). Unveiling CO2 Emission Dynamics Under Innovation Drivers in the European Union. *Sustainability*, 17(8), 3463. <https://doi.org/10.3390/su17083463>
- 7) Duque-Acevedo, M., Ureña, L. J. B., Yakovleva, N., & Camacho-Ferre, F. (2020). Analysis of the Circular Economic Production Models and Their Approach in Agriculture and Agricultural Waste Biomass Management. *International Journal of Environmental Research and Public Health*, 17(24), 9549. <https://doi.org/10.3390/ijerph17249549>

- 8) Duquennoi, C., & Martínéz, J. A. (2022). European Union's policymaking on sustainable waste management and circularity in agroecosystems: The potential for innovative interactions between science and decision-making. *Frontiers in Sustainable Food Systems*, 6. <https://doi.org/10.3389/fsufs.2022.937802>
- 9) Foggia, G. D., & Beccarello, M. (2023). Sustainability pathways in European waste management for meeting circular economy goals. *Environmental Research Letters*, 18(12), 124001. <https://doi.org/10.1088/1748-9326/ad067f>
- 10) Giannoccaro, I., Ceccarelli, G., & Fraccascia, L. (2021). Features of the Higher Education for the Circular Economy: The Case of Italy. *Sustainability*, 13(20), 11338. <https://doi.org/10.3390/su132011338>
- 11) Goovaerts, L., Schempp, C., Busato, L., Smits, A., Žutelija, L., & Piechocki, R. (2018). Financing Innovation and Circular Economy. In Springer eBooks (p. 427). Springer Nature. https://doi.org/10.1007/978-3-319-66981-6_47
- 12) Grdić, Z. Š., Nižić, M. K., & Rudan, E. (2020). Circular Economy Concept in the Context of Economic Development in EU Countries. *Sustainability*, 12(7), 3060. <https://doi.org/10.3390/su12073060>
- 13) Hadi, S. P., Prabawani, B., & Qomariah, A. (2021). Circular Initiatives for Industrial Sustainability. *E3S Web of Conferences*, 317, 1078. <https://doi.org/10.1051/e3sconf/202131701078>
- 14) Hao, N., & Dragomir, V. D. (2025). Renewable Energy, Sustainable Business Models, and Decarbonization in the European Union: Comparative Analysis of Corporate Sustainability Reports. *Sustainability*, 17(8), 3646. <https://doi.org/10.3390/su17083646>
- 15) Husain, A., Karim, S., & Şensoy, A. (2024). Financial fusion: Bridging Islamic and Green investments in the European stock market. *International Review of Financial Analysis*, 94, 103341. <https://doi.org/10.1016/j.irfa.2024.103341>
- 16) Idir, R., Djerbi, A., & Tazi, N. (2025). Optimising the Circular Economy for Construction and Demolition Waste Management in Europe: Best Practices, Innovations and Regulatory Avenues. *Sustainability*, 17(8), 3586. <https://doi.org/10.3390/su17083586>
- 17) Ismail, H. and Hanafiah, M.M., 2019. An overview of LCA application in WEEE management: Current practices, progress and challenges. *Journal of Cleaner Production*, 232, pp.79–95.
- 18) Jones, P., & Comfort, D. (2021). The Circular Economy: An Exploratory Case Study from the Paper and Retail Industries. *Athens Journal of Business & Economics*, 7(4), 379. <https://doi.org/10.30958/ajbe.7-4-5>
- 19) Koszewska, M. (2018). Circular Economy – Challenges for the Textile and Clothing Industry. *Autex Research Journal*, 18(4), 337. <https://doi.org/10.1515/aut-2018-0023>
- 20) Luca, C. D., Naumann, S., Davis, M., & Tondelli, S. (2021). Nature-Based Solutions and Sustainable Urban Planning in the European Environmental Policy Framework: Analysis of the State of the Art and Recommendations for Future Development. *Sustainability*, 13(9), 5021. <https://doi.org/10.3390/su13095021>
- 21) Luis, E. C., & Celma, D. (2020). Circular Economy. A Review and Bibliometric Analysis [Review of Circular Economy. A Review and Bibliometric Analysis]. *Sustainability*, 12(16), 6381. Multidisciplinary Digital Publishing Institute. <https://doi.org/10.3390/su12166381>

- 22) Mak, V., & Lujinovic, E. (2019). Towards a Circular Economy in EU Consumer Markets Legal Possibilities and Legal Challenges and the Dutch Example. *Zeitschrift Für Europäisches Unternehmens- Und Verbraucherrecht*, 8(1), 4. <https://research.tilburguniversity.edu/en/publications/towards-a-circular-economy-in-eu-consumer-markets-legal-possibili>
- 23) Malinauskaitė, J., & Erdem, F. B. (2021). Planned Obsolescence in the Context of a Holistic Legal Sphere and the Circular Economy. *Oxford Journal of Legal Studies*, 41(3), 719. <https://doi.org/10.1093/ojls/gqaa061>
- 24) Mallouppas, G., Yfantis, E. A., Ktoris, A., & Ioannou, C. (2022). Methodology to Assess the Technoeconomic Impacts of the EU Fit for 55 Legislation Package in Relation to Shipping. *Journal of Marine Science and Engineering*, 10(8), 1006. <https://doi.org/10.3390/jmse10081006>
- 25) Mazur-Wierzbička, E. (2021). Circular economy: advancement of European Union countries. *Environmental Sciences Europe*, 33(1). <https://doi.org/10.1186/s12302-021-00549-0>
- 26) Mikula, K., Skrzypczak, D., Izydorczyk, G., Warchoń, J., Μουστάκας, K., Chojnacka, K., & Witek-Krowiak, A. (2020). 3D printing filament as a second life of waste plastics – a review [Review of 3D printing filament as a second life of waste plastics – a review]. *Environmental Science and Pollution Research*, 28(10), 12321. Springer Science+Business Media. <https://doi.org/10.1007/s11356-020-10657-8>
- 27) Milios, L. (2017). Advancing to a Circular Economy: three essential ingredients for a comprehensive policy mix [Review of Advancing to a Circular Economy: three essential ingredients for a comprehensive policy mix]. *Sustainability Science*, 13(3), 861. Springer Science+Business Media. <https://doi.org/10.1007/s11625-017-0502-9>
- 28) Milios, L. (2021). Overarching policy framework for product life extension in a circular economy – A bottom-up business perspective. *Environmental Policy and Governance*, 31(4), 330. <https://doi.org/10.1002/eet.1927>
- 29) Morris, J., Georgiou, I. Y., Guenther, E., & Caucci, S. (2021). Barriers in Implementation of Wastewater Reuse: Identifying the Way Forward in Closing the Loop. *Circular Economy and Sustainability*, 1(1), 413. <https://doi.org/10.1007/s43615-021-00018-z>
- 30) Mukhlis, I. (2021). Circular Economy Business Model in the COVID – 19 Pandemic Era in Local Communities. *International Journal of Social Science and Human Research*, 4(11). <https://doi.org/10.47191/ijsshr/v4-i11-13>
- 31) Negrete-Cardoso, M., Rosano-Ortega, G., Álvarez-Aros, É. L., Cortés, M. E. T., Lebrún, C. A. V., & Sánchez-Ruiz, F. J. (2022). Circular economy strategy and waste management: a bibliometric analysis in its contribution to sustainable development, toward a post-COVID-19 era. *Environmental Science and Pollution Research*, 29(41), 61729. <https://doi.org/10.1007/s11356-022-18703-3>
- 32) Petit-Boix, A., & Leipold, S. (2018). Circular economy in cities: Reviewing how environmental research aligns with local practices. *Journal of Cleaner Production*, 195, 1270. <https://doi.org/10.1016/j.jclepro.2018.05.281>
- 33) Pintilie, N. (2021). A review of Europe's transition from fossil fuels to renewable energy using circular economy principles [review of a review of Europe's transition from fossil fuels to renewable energy using circular economy principles]. *Business*

- excellence and management, 11(2), 95. Bucharest Academy of Economic Studies. <https://doi.org/10.24818/beman/2021.11.2-07>
- 34) Podkolzina, I. M., Tenishchev, A., Gornostaeva, Z. V., Tekeeva, H. E., & Танделова, O. M. (2023). Assessment of Threats to Environmental Security and Climate Change. *BIO Web of Conferences*, 63, 4002. <https://doi.org/10.1051/bioconf/20236304002>
- 35) Protopapa, M. L., Burrese, E., Palmisano, M., Pesce, E., Schioppa, M., Capodiceci, L., Penza, M., Sala, D. D., Vincenti, N., Accili, A., & Campadello, L. (2021). Optical methods to identify end-of-life PV panel structure. *Resources Conservation and Recycling*, 171, 105634. <https://doi.org/10.1016/j.resconrec.2021.105634>
- 36) Rahla, K. M., Mateus, R., & Bragança, L. (2021). Selection Criteria for Building Materials and Components in Line with the Circular Economy Principles in the Built Environment – A Review of Current Trends. *Infrastructures*, 6(4), 49. <https://doi.org/10.3390/infrastructures6040049>
- 37) Regolo, L., Giampieri, F., Battino, M., Diaz, Y. A., Mezzetti, B., Zabaleta, M., Pérez-Oleaga, C. M., Pifarré, K. T., & Mazzoni, L. (2024). From by-products to new application opportunities: the enhancement of the leaves deriving from the fruit plants for new potential healthy products. *Frontiers in Nutrition*, 11. <https://doi.org/10.3389/fnut.2024.1083759>
- 38) Rowan, N. J., & Casey, O. (2021). Empower Eco multiactor HUB: A triple helix ‘academia-industry-authority’ approach to creating and sharing potentially disruptive tools for addressing novel and emerging new Green Deal opportunities under a United Nations Sustainable Development Goals framework. *Current Opinion in Environmental Science & Health*, 21, 100254. <https://doi.org/10.1016/j.coesh.2021.100254>
- 39) Sah, A. K., & Hong, Y.-M. (2024). Circular Economy Implementation in an Organization: A Case Study of the Taiwan Sugar Corporation. *Sustainability*, 16(17), 7865. <https://doi.org/10.3390/su16177865>
- 40) Šarc, R., Curtis, A., Kandlbauer, L., Khodier, K., Lorber, K., & Pomberger, R. (2019). Digitalisation and intelligent robotics in value chain of circular economy oriented waste management – A review [Review of Digitalisation and intelligent robotics in value chain of circular economy oriented waste management – A review]. *Waste Management*, 95, 476. Elsevier BV. <https://doi.org/10.1016/j.wasman.2019.06.035>
- 41) Shirvanimoghaddam, K., Motamed, B., Ramakrishna, S., & Naebe, M. (2020). Death by waste: Fashion and textile circular economy case. *The Science of The Total Environment*, 718, 137317. <https://doi.org/10.1016/j.scitotenv.2020.137317>
- 42) Smol, M., Duda, J., Czaplicka-Kotas, A., & Szoldrowska, D. (2020). Transformation towards Circular Economy (CE) in Municipal Waste Management System: Model Solutions for Poland. *Sustainability*, 12(11), 4561. <https://doi.org/10.3390/su12114561>
- 43) Suárez, M. A., Gambuzzi, E., Soriano-Disla, J. M., Martínez, G. C., Poggiaroni, G., & Ling, J. (2023). ROOTS - Circular policies for changing the biowaste system. *Open Research Europe*, 3, 78. <https://doi.org/10.12688/openreseurope.15507.1>
- 44) Taelman, S. E., Tonini, D., Wandl, A., & Dewulf, J. (2018). A Holistic Sustainability Framework for Waste Management in European Cities: Concept Development. *Sustainability*, 10(7), 2184. <https://doi.org/10.3390/su10072184>

- 45) Vajda, B., Drăgan, G., Vajda, L., Gaspar, M. B., & Bagoly, M. L. (2025). The Role of Entrepreneurial Clusters in Advancing Circular Bioeconomy and Innovation: A Case Study from Romania. *Sustainability*, 17(9), 3787. <https://doi.org/10.3390/su17093787>
- 46) Viles, E., Santos, J., Fernández-Arévalo, T., Tanco, M., & Kalemkerian, F. (2020). A New Mindset for Circular Economy Strategies: Case Studies of Circularity in the Use of Water. *Sustainability*, 12(22), 9781. <https://doi.org/10.3390/su12229781>
- 47) Wang, C.-T., & Chiu, C.-S. (2013). Competitive strategies for Taiwan's semiconductor industry in a new world economy. *Technology in Society*, 36, 60. <https://doi.org/10.1016/j.techsoc.2013.12.002>
- 48) Weale, A., Pridham, G., Cini, M., Konstadakopulos, D., Porter, M., & Flynn, B. (2002). Packaging and Packaging Waste. In Oxford University Press eBooks (p. 410). Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780199257478.003.0016>
- 49) Zanoletti, A., Cornelio, A., & Bontempi, E. (2021). A post-pandemic sustainable scenario: What actions can be pursued to increase the raw materials availability? *Environmental Research*, 202, 111681. <https://doi.org/10.1016/j.envres.2021.111681>
- 50) Zorpas, A. A. (2020). Strategy development in the framework of waste management. *The Science of The Total Environment*, 716, 137088. <https://doi.org/10.1016/j.scitotenv.2020.137088>
- 51) Antoniadou, M., Varzakas, T., & Tzoutzas, I. (2021). Circular Economy in Conjunction with Treatment Methodologies in the Biomedical and Dental Waste Sectors [Review of Circular Economy in Conjunction with Treatment Methodologies in the Biomedical and Dental Waste Sectors]. *Circular Economy and Sustainability*, 1(2), 563. Springer Nature. <https://doi.org/10.1007/s43615-020-00001-0>
- 52) Gorokhova, T., Shpatakova, O., Toponar, O., Zolotarova, O., & Pavliuk, S. (2023). Circular Economy as an Alternative to the Traditional Linear Economy: Case Study of the EU. *Revista de Gestão Social e Ambiental*, 17(5). <https://doi.org/10.24857/rgsa.v17n5-002>
- 53) Shevchenko, T., Laitala, K., & Danko, Y. (2019). Understanding Consumer E-Waste Recycling Behavior: Introducing a New Economic Incentive to Increase the Collection Rates. *Sustainability*, 11(9), 2656. <https://doi.org/10.3390/su11092656>

SUSTAINABLE CONSUMPTION HABITS OF MIGRANT COMMUNITIES IN TURKEY: OPPORTUNITIES AND CHALLENGES IN THE TRANSITION TO CIRCULAR ECONOMY

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Abstract

The transformation of consumer behavior is critical in the transition to a circular economy. This study examines the sustainable consumption habits and circular economy practices of migrant communities living in four major cities of Turkey (Istanbul, Ankara, Izmir, and Gaziantep). The research analyzes survey data collected from migrant households (n=768) of different socio-economic profiles and in-depth interviews (n=16). Using a mixed-method approach, the study examines migrants' food waste prevention practices, textile reuse habits, second-hand product usage, participation in the sharing economy, and inter-household solidarity networks. The findings show that migrant communities' traditional saving practices and community-based sharing networks significantly align with circular economic objectives. They have developed sustainable practices in food sharing, household goods reuse, and textile waste utilization. The research results offer policy recommendations for local governments to support and expand the existing sustainable consumption practices of migrant communities. In this context, the study reveals the potential contribution of migrant communities to achieving Turkey's circular economy goals.

Keywords: sustainable consumption, migrant communities, circular economy, consumer behavior

JEL Classification: Q01, Q56

1. INTRODUCTION

In the process of transition to circular economy, the importance of consumer behaviour stands out as a critical element in terms of both environmental sustainability and economic efficiency. Today, resource scarcity and environmental issues have become factors that directly affect the decision-making processes of consumers. In this context, circular economy offers a solution with the goals of reducing waste generation and closing the material cycle by extending product life cycles (Ghisellini *et al.* 2016). However, consumers' adoption of

circular economy principles is not only limited to individual preferences but also plays a decisive role in changing the general attitudes and behaviours of society. However, existing research shows that consumers are not sufficiently informed about circular economy, and this lack of awareness is an obstacle to the adoption of sustainable consumption habits (Bucur, 2023; Rizos *et al.*, 2016). Therefore, the success of circular economic practices is directly related to raising awareness and increasing the participation of consumers.

The circular economy is a model that aims to use resources more sustainably and reduce waste. In this framework, consumer behaviour is at the heart of successful circular economy strategies. The shaping of consumer behaviour is directly related not only to the awareness of individuals, but also to social norms, cultural dynamics and economic conditions (Geissdoerfer *et al.*, 2017; Szilagyi *et al.*, 2022). Consumers' adoption of circular economy principles includes consuming less, increasing recycling, preferring second-hand products and supporting alternative models such as the sharing economy. In this context, a detailed analysis of the factors influencing individuals' purchasing decisions is critical for the effective integration of the circular economy.

In order to ensure the transition to a circular economy, it is necessary to increase the environmental awareness of consumers and adopt various sustainable consumption practices. As consumers become more informed about the life cycle, recycling opportunities and environmental impacts of products, they will be encouraged to make more informed purchasing decisions (Kutaula *et al.*, 2022). However, research shows that this situation is shaped not only by individual behaviour but also by the general trends and cultural norms of society. For example, in a study conducted in the European Union, it was revealed that policies that increase awareness on environmental sustainability issues positively affect consumer behaviour (Arias *et al.*, 2022).

According to research on the decisive role of consumer behaviour in the transition to a circular economy, the change in consumer trends is not only limited to knowledge and awareness; it is also closely related to the social and economic status of individuals (Camacho-Otero *et al.*, 2020). In particular, studies on migrant communities reveal that the consumption habits of these groups are shaped not only by individual preferences but also by social dynamics (Al-Husban & Adams, 2016). Therefore, it is critical for local governments and policies to develop strategies that take into account the needs of these communities in order to increase the level of participation of migrants in circular economic practices (Fry *et al.*, 2024). In addition, education and awareness-raising campaigns can have a positive impact on increasing consumers' knowledge about circular economy and enabling them to integrate this knowledge into their lives (Bucur, 2023; Mabasa *et al.*, 2021).

Turkey, as a country hosting one of the world's largest migrant populations, provides an ideal context for examining the intersection between migration and

sustainable consumption. With over 4 million registered migrants and refugees, Turkey has experienced significant demographic changes that have implications for consumption patterns and resource use (UNHCR, 2023). The country's strategic position between Europe, Asia, and the Middle East has made it a major destination and transit point for various migrant groups, creating diverse communities with distinct consumption behaviors and practices.

Due to its strategic location and historical background, Turkey is home to a large number of migrant communities with different geographical and cultural backgrounds. These migrant communities are highly heterogeneous in terms of economic and social dynamics and therefore have the potential to develop sustainable consumption practices in the context of the circular economy (Sousa *et al.*, 2021). As migrants interact with the societies they settle in, they aim to both preserve their own cultural values and adapt to local norms. This balance may affect their sustainable consumption habits and thus their contribution to the circular economy (Chao & Yu, 2023).

On the other hand, the challenges faced by migrants can have serious negative impacts on their sustainable consumption potential. Factors such as economic uncertainties, discrimination and social exclusion may prevent migrants from accessing sustainable consumption practices (Kirchherr *et al.*, 2018). However, the social networks of migrant communities can direct them towards more sustainable consumption methods by offering solidarity and cooperation opportunities. In particular, practices such as traditional exchange systems and community-based resource sharing can help these groups adopt circular economy principles (Papamichael *et al.*, 2023).

The influence of migrant communities on circular economic practices also plays an important role in the adaptation of local communities to these practices. Social integration processes and cultural exchange allow migrants to develop sustainable consumption habits and share these habits with local communities (Tortajada *et al.*, 2024). Past studies show that migrants can increase the sustainability awareness of local communities through social and cultural interactions (Rizos *et al.*, 2016).

This study analyses the sustainable consumption patterns and circular economy practices of migrant communities in four major Turkish cities, namely Istanbul, Ankara, Izmir and Gaziantep. Representing different geographical regions, economic profiles and migrant population characteristics, these cities provide a comprehensive view of migrant consumption patterns in various urban contexts. The research focuses on three key questions: current sustainable consumption practices of migrant communities and their alignment with circular economy principles, factors influencing the adoption of sustainable consumption behaviours among different migrant groups, and how existing sustainable practices can be supported and scaled up to contribute to Turkey's circular economy goals.

The main hypothesis of the study is that migrant communities have significant potential to contribute to circular economy goals through existing sustainable consumption practices. Economic constraints and strong social networks are predicted to drive migrants towards practices such as resource sharing, product reuse and waste minimization. It is also hypothesized that these practices vary among different migrant groups depending on factors such as country of origin, length of residence, socioeconomic status and level of integration.

This research contributes to the sustainable consumption literature by focussing on a population group with unique characteristics and practices, yet under-explored. The findings will inform policy development processes for both migration integration and environmental sustainability and demonstrate how inclusive approaches can achieve multiple policy objectives simultaneously. The study also offers valuable insights for local governments and civil society organisations seeking to engage diverse communities in circular economy initiatives.

2. LITERATURE REVIEW

The conceptual evolution of the circular economy (CE) represents one of the most significant paradigmatic shifts in contemporary sustainability discourse, fundamentally challenging the dominant linear economic model that has characterized industrial development since the 18th century. The theoretical foundations of the CE draw from multiple disciplinary traditions, including industrial ecology, ecological economics, and systems theory, creating a comprehensive framework for understanding resource flows and waste management in complex socio-economic systems (Ellen MacArthur Foundation, 2013; Geissdoerfer *et al.*, 2017). This interdisciplinary approach has enabled scholars to move beyond narrow technical solutions toward more holistic understandings of sustainability that encompass social, economic, and environmental dimensions.

Central to the CE paradigm is the concept of closing material loops through strategies such as reduce, reuse, recycle, and recover, often referred to as the "R-strategies" (Kirchherr *et al.*, 2017). However, recent scholarship has expanded this framework to include additional strategies such as refuse, rethink, and redesign, reflecting a more nuanced understanding of the behavioral and systemic changes required for circular transitions (Potting *et al.*, 2017). This evolution in thinking highlights the importance of consumption-side interventions, as opposed to the traditional focus on production-side efficiency improvements.

The circular economy is an innovative economic model that focuses on the efficient use of natural resources, reducing waste and closing the resource cycle (Demircioğlu & Ever, 2020). This model overcomes the limitations of the linear economy and offers alternative solutions in line with sustainable growth goals. In

the literature, it is emphasised that consumer behaviour and policies should be integrated harmoniously for the successful implementation of the circular economy (Özuyar & Gürsoy, 2021). The relationship between sustainable consumption and circular economy is explained by different theoretical frameworks. For example, environmental sustainability theories reveal that when individuals show sensitivity to environmental impacts, they are more likely to prefer more environmentally friendly products (Özdemir & Sunaoğlu, 2023). In addition, it is also stated that sustainable marketing practices are among the important factors that positively affect consumer behaviour; in this context, there is a positive relationship between environmental awareness and sustainable consumption (Küçükyörük & Kurtuldu, 2022). Therefore, educating and raising awareness of consumers plays a critical role in the dissemination of circular economy practices.

Recent research has identified several key factors that influence the adoption of sustainable consumption practices, including economic incentives, social norms, infrastructure availability, and information accessibility (Zink and Geyer, 2017). However, the literature also reveals significant challenges in translating circular economy principles into everyday consumption practices, particularly in diverse urban contexts where multiple cultural and socioeconomic groups coexist. This complexity is further compounded by the phenomenon of rebound effects, where efficiency gains are offset by increased consumption, highlighting the need for more sophisticated approaches to behavior change (Sorrell, 2007).

Within this broader theoretical landscape, the consumption behaviors of migrant communities offer a unique and largely unexplored perspective on sustainable consumption and circular economy practices. Migration studies have traditionally focused on issues of integration, labor market participation, and social cohesion, with consumption patterns receiving limited attention despite their significance for both individual well-being and broader sustainability outcomes (Castles *et al.*, 2014). This oversight is particularly notable given that migrants often develop innovative adaptive strategies in response to economic constraints, cultural displacement, and social exclusion.

Emerging research suggests that migrant communities frequently engage in practices that align with circular economy principles, albeit often out of necessity rather than environmental consciousness (Pemberton *et al.*, 2014; Sahakian *et al.*, 2020). These practices include extensive use of second-hand goods, participation in informal sharing networks, creative reuse and repair activities, and collective purchasing arrangements that reduce individual consumption needs. Such behaviors reflect what scholars have termed "practices of resilience," where resource constraints drive innovation and community-based solutions (Poulain, 2017).

The role of social capital in facilitating sustainable consumption among migrant communities has received particular attention in recent literature. Strong intra-community networks, often based on shared cultural backgrounds or

migration experiences, enable the circulation of goods, services, and information in ways that reduce resource consumption and waste generation (Putnam, 2000). These networks operate through both formal and informal mechanisms, including community organizations, religious institutions, and neighborhood-based initiatives that promote sharing and mutual support.

However, the literature also highlights significant barriers that limit the participation of migrant communities in formal circular economy initiatives. Language barriers, limited access to information about recycling and waste management systems, and exclusion from environmental education programs represent structural obstacles that prevent migrants from fully engaging with sustainability initiatives (Adger *et al.*, 2014). Additionally, precarious legal status and economic insecurity may prioritize immediate survival needs over longer-term environmental considerations, creating tensions between individual welfare and collective sustainability goals.

The intersection of migration and circular economy becomes particularly relevant in the Turkish context, where rapid urbanization, significant migrant populations, and ambitious sustainability targets create both opportunities and challenges for circular transitions. Turkey's position as a major destination and transit country for migrants from the Middle East, Africa, and Central Asia has resulted in highly diverse urban populations with distinct consumption patterns and resource needs (UNHCR, 2023). This demographic diversity presents unique opportunities for learning from different cultural approaches to resource use and waste management.

Turkey's policy response to circular economy challenges has evolved significantly in recent years, driven by both domestic environmental priorities and alignment with European Union standards and regulations (Ministry of Environment, Urbanization and Climate Change, 2021). The National Circular Economy Action Plan (2021-2023) represents the most comprehensive policy framework to date, outlining specific targets for waste reduction, resource efficiency, and the development of circular business models across key sectors including textiles, electronics, and food (Republic of Turkey, 2021). However, academic analysis of these policies reveals several implementation challenges, including fragmented governance structures, limited coordination between national and local authorities, and insufficient attention to social dimensions of circular transitions (Kilkis, 2018).

Recent studies have emphasized the importance of inclusive approaches to circular economy policy that recognize the diversity of urban populations and their varying capacities to participate in sustainability initiatives (OECD, 2022). This perspective is particularly relevant in Turkish cities, where migrant communities may possess valuable knowledge and practices related to resource conservation and waste reduction, yet remain largely excluded from formal policy processes. The failure to engage these communities represents a missed opportunity for

leveraging existing sustainable practices and scaling up community-based solutions.

Furthermore, the literature reveals a significant gap in understanding how cultural diversity and migration dynamics influence the effectiveness of circular economy interventions. Most existing research on circular economy implementation focuses on relatively homogeneous populations in developed countries, with limited attention to the complexities introduced by cultural diversity, language barriers, and varying levels of formal integration (Yıldız-Geyhan & Yıldız, 2022). This gap is particularly problematic in contexts like Turkey, where successful circular economy transitions will require the active participation of diverse communities with different cultural backgrounds, economic circumstances, and social networks.

The present study addresses these gaps by examining the sustainable consumption practices of migrant communities in Turkish cities, with particular attention to how these practices align with or diverge from formal circular economy objectives. By focusing on the intersection of migration and circular economy, this research contributes to both theoretical understanding and practical policy development in several important ways. First, it provides empirical evidence on the actual consumption behaviors of an understudied population group, moving beyond assumptions about migrant practices to document real patterns of resource use and waste management. Second, it examines how cultural backgrounds, social networks, and economic circumstances influence the adoption and maintenance of sustainable consumption practices. Third, it explores the potential for scaling up community-based sustainable practices and integrating them into broader circular economy strategies.

This research approach is particularly timely given growing recognition of the need for more inclusive and participatory approaches to sustainability governance. Recent scholarship has emphasized that successful circular economy transitions require not only technological innovation and policy reform, but also social innovation and community engagement (Schröder *et al.*, 2019). By examining the practices and perspectives of migrant communities, this study contributes to a more comprehensive understanding of how diverse urban populations can contribute to circular economy objectives while addressing their own needs and priorities.

3. METHODOLOGY

This study adopts a mixed-methods research design to comprehensively investigate the sustainable consumption habits of migrant communities in Turkey. The integration of quantitative and qualitative approaches enables a nuanced understanding of both the prevalence and underlying motivations of sustainable consumption behaviors (Creswell & Plano Clark, 2017). The following section

details the rationale for the mixed-methods approach, the sampling strategy, data collection procedures, and the analytical techniques employed.

The mixed-methods approach is increasingly recognized as a robust strategy for social science research, particularly in studies addressing complex phenomena that require both breadth and depth of analysis (Tashakkori & Teddlie, 2010). By combining quantitative survey data with qualitative in-depth interviews, this study leverages the strengths of both methodologies: the generalizability and statistical power of large-scale surveys, and the contextual richness and explanatory depth of qualitative inquiry (Bryman, 2016). The integration of these methods follows a convergent parallel design, wherein quantitative and qualitative data are collected and analyzed independently before being merged for interpretation (Creswell & Plano Clark, 2017).

Sampling was conducted in four major Turkish cities – Istanbul, Ankara, Izmir, and Gaziantep – selected for their significant migrant populations and diverse socio-economic profiles (UNHCR, 2023). The quantitative component comprises a structured survey administered to 768 migrant households, employing stratified random sampling to ensure representation across key demographic variables such as age, gender, country of origin, and length of residence. The sample size was determined using the formula for estimating proportions with a 95% confidence level and a 5% margin of error (Israel, 1992).

Sample size calculation formula:

$$n = [N \times Z^2 \times p \times (1-p)] / [e^2 \times (N-1) + Z^2 \times p \times (1-p)]$$

Where:

n = sample size

N = population size

Z = Z-score (1.96 for 95% confidence)

p = estimated proportion (0.5 used for maximum variability)

e = margin of error (0.05)

The stratified sampling approach ensures adequate representation across different migrant groups, with quotas established for major countries of origin including Syria, Afghanistan, Iraq, and Iran, as well as migrants from Sub-Saharan Africa and Central Asia. This stratification is crucial given the heterogeneity of migrant populations and the potential variation in consumption patterns across different cultural and socioeconomic backgrounds (Castles *et al.*, 2014).

For the qualitative component, 16 in-depth interviews were conducted with migrants from diverse backgrounds, selected through purposive sampling to capture a range of experiences and perspectives. The selection criteria included variation in age (18-65 years), gender, country of origin, length of residence in Turkey (ranging from 6 months to 10 years), and socioeconomic status. Interviewees were identified via community organizations, local NGOs, and

snowball sampling techniques, ensuring the inclusion of both recent arrivals and long-term residents. The interviews explored themes such as resource use patterns, waste management practices, participation in sharing economies, social networks facilitating sustainable behaviors, and perceived barriers to sustainable consumption. Data collection for the survey was carried out between March and June 2024, using a structured questionnaire developed based on existing validated instruments in the literature (Mont *et al.*, 2020; UNEP, 2015). The questionnaire development process involved extensive pilot testing with 50 respondents to ensure cultural appropriateness and linguistic clarity. The final instrument included five main sections: (1) demographic characteristics and migration history, (2) household consumption patterns and resource use, (3) participation in circular economy activities such as repair, reuse, and sharing, (4) environmental awareness and attitudes, and (5) perceived barriers and facilitators to sustainable consumption practices.

Surveys were administered in Turkish, Arabic, and English to accommodate linguistic diversity within migrant communities. Professional translators were employed to ensure accuracy and cultural sensitivity in translation. Data collection was conducted by trained enumerators who were familiar with migrant communities and sensitive to potential vulnerabilities. Face-to-face interviews were conducted in community centers, NGO offices, and other safe spaces to ensure participant comfort and confidentiality. In-depth interviews were conducted in the participants' preferred language, with professional interpreters engaged as needed. Interview duration ranged from 45 to 90 minutes, and all sessions were audio-recorded with participant consent. The interview guide was semi-structured, allowing for flexibility while ensuring coverage of key themes. Questions explored participants' consumption histories, changes in practices since migration, community networks and support systems, and aspirations for future consumption patterns.

Table 1. Summary of Key Variables and Statistical Analysis Techniques

Variable Category	Variable Name	Type	Description	Statistical Technique
Demographics	Age	Continuous	Respondent age in years (18-65)	Descriptive statistics, Regression analysis
Demographics	Gender	Categorical	Male/Female/Other	Cross-tabulation, Chi-square test
Demographics	Country of Origin	Categorical	Country of birth (8 categories)	Frequency analysis, ANOVA

Variable Category	Variable Name	Type	Description	Statistical Technique
Migration	Length of Residence	Continuous	Years residing in Turkey	Correlation, Regression analysis
Migration	Legal Status	Categorical	Refugee/Asylum seeker/Other	Cross-tabulation analysis
Consumption	Sustainable Consumption Index	Composite	Weighted index (0-100 scale)	Factor analysis, Regression
Circular Economy	Repair Frequency	Ordinal	5-point Likert scale	Mann-Whitney U test
Circular Economy	Sharing Participation	Binary	Yes/No participation	Logistic regression
Barriers	Economic Constraints	Ordinal	Perceived financial barriers	Ordinal regression
Barriers	Information Access	Ordinal	Access to sustainability info	Correlation analysis
Social	Community Networks	Continuous	Social capital index	Path analysis, SEM

Quantitative data analysis was conducted using SPSS version 28.0 and R statistical software. The analytical approach included both descriptive and inferential statistics. Descriptive analysis involved frequency distributions, measures of central tendency, and variability assessments for all variables. Cross-tabulations were performed to examine relationships between demographic characteristics and sustainable consumption behaviors. The Sustainable Consumption Index was constructed using principal component analysis (PCA) to identify underlying dimensions of sustainable behavior, following the methodology established by Jackson (2005) and refined by Mont *et al.* (2020). Inferential statistical techniques included chi-square tests for categorical variables, independent t-tests and ANOVA for continuous variables, and correlation analysis to examine relationships between variables. Multiple regression analysis was employed to identify predictors of sustainable consumption behaviors, with the Sustainable Consumption Index as the dependent variable. Logistic regression was used to model binary outcomes such as participation in circular economy activities. The following regression model was specified:

$$\text{Sustainable Consumption Index} = \beta_0 + \beta_1(\text{Age}) + \beta_2(\text{Gender}) + \beta_3(\text{Length of Residence}) + \beta_4(\text{Education}) + \beta_5(\text{Income}) + \beta_6(\text{Country of Origin}) + \beta_7(\text{Legal Status}) + \beta_8(\text{Community Networks}) + \varepsilon$$

Where β_0 represents the intercept, β_1 - β_8 are regression coefficients for predictor variables, and ϵ is the error term.

Model assumptions were tested including normality of residuals (Shapiro-Wilk test), homoscedasticity (Breusch-Pagan test), and multicollinearity (Variance Inflation Factor). Missing data analysis was conducted, and multiple imputations were employed where appropriate, following guidelines by Little and Rubin (2019). Qualitative data from interviews were transcribed verbatim and analyzed using thematic analysis, following the six-phase approach outlined by Braun and Clarke (2006). This systematic approach involved: (1) familiarization with the data through repeated reading and initial note-taking, (2) generation of initial codes through systematic coding of interesting features, (3) searching for themes by collating codes into potential themes, (4) reviewing themes through checking if themes work in relation to coded extracts and the entire dataset, (5) defining and naming themes by ongoing analysis to refine themes and generate clear definitions, and (6) producing the final report by selecting compelling extract examples and relating analysis back to research questions.

NVivo 12 software was used to facilitate coding and data management. Inter-coder reliability was established through independent coding of 25% of transcripts by two researchers, achieving a Cohen's kappa coefficient of 0.82, indicating substantial agreement (Landis & Koch, 1977). The integration of quantitative and qualitative findings was achieved through triangulation, enabling the identification of convergent and divergent patterns across data sources (Fetters *et al.*, 2013). A joint display matrix was created to systematically compare quantitative results with qualitative themes, facilitating meta-inferences about sustainable consumption patterns among migrant communities. Validity and reliability measures were implemented throughout the study. For quantitative data, internal consistency was assessed using Cronbach's alpha coefficients for multi-item scales, with all scales achieving $\alpha > 0.70$. Construct validity was evaluated through confirmatory factor analysis. For qualitative data, credibility was enhanced through member checking with selected participants, and transferability was addressed through thick description and purposive sampling across diverse migrant groups.

The mixed-methods approach adopted in this study provides a comprehensive framework for understanding the sustainable consumption practices of migrant communities in Turkey. By combining robust quantitative analysis with rich qualitative insights, the research offers both generalizable findings and in-depth contextual understanding. This methodological rigor contributes to the development of evidence-based, inclusive, and culturally sensitive circular economy policies that can effectively engage diverse migrant populations in sustainable consumption practices.

4. FINDINGS

This section presents the findings from the mixed-methods investigation of sustainable consumption practices among migrant communities in Turkey. The analysis reveals significant patterns in food waste prevention, textile reuse, second-hand product consumption, sharing economy participation, and inter-household solidarity networks. The findings are organized thematically, integrating quantitative survey results ($n=768$) with qualitative insights from in-depth interviews ($n=16$) to provide a comprehensive understanding of sustainable consumption behaviors within this population. The demographic profile of survey respondents reflects the diversity of Turkey's migrant population. Participants ranged in age from 18 to 65 years ($M=34.2$, $SD=11.8$), with 52.3% identifying as female and 47.7% as male. The sample included migrants from Syria (41.2%), Afghanistan (23.1%), Iraq (15.6%), Iran (8.9%), Somalia (4.7%), and other countries (6.5%). Length of residence in Turkey varied from 6 months to 12 years ($M=4.3$ years, $SD=2.9$), providing insights across different stages of settlement and integration.

A substantial proportion of migrant households reported active engagement in food waste prevention strategies. Quantitative survey data indicate that 68.4% of respondents regularly plan meals and shopping lists to minimize excess purchases, while 54.7% report frequent use of leftovers in subsequent meals. These findings align with global trends emphasizing the importance of household-level interventions in reducing food waste (FAO, 2019; Stenmarck *et al.*, 2016). Notably, 39.2% of households reported sharing surplus food with neighbors or community members, reflecting the role of informal solidarity networks in food redistribution (Papargyropoulou *et al.*, 2014). Qualitative interviews revealed that food waste prevention is often motivated by both economic necessity and cultural values emphasizing frugality and resourcefulness. Several participants described traditional practices such as repurposing stale bread into new dishes or organizing communal meals to utilize perishable ingredients. One interviewee from Syria stated: 'We never throw away bread; we make fattoush or feed animals. Sharing food is part of our culture.' The following table 2 summarizes the prevalence of key food waste prevention practices among survey respondents:

Table 2. Food Waste Prevention Practices

Practice	Percent of Households (%)
Meal planning and shopping lists	68.4
Use of leftovers	54.7
Sharing surplus food	39.2
Composting organic waste	12.5
Repurposing stale bread	47.8

Textile reuse practices among migrant households demonstrate significant engagement with circular economy principles, driven by both economic constraints and cultural traditions of resourcefulness. Survey results indicate that 72.1% of respondents regularly repair clothing items rather than discarding them, while 58.3% repurpose old textiles for household uses such as cleaning cloths or craft projects. These findings are consistent with research highlighting the potential for textile reuse in reducing environmental impact and extending product lifecycles (Ellen MacArthur Foundation, 2017; Niinimäki *et al.*, 2020). The practice of clothing alteration and modification is particularly prevalent, with 45.6% of households reporting regular engagement in resizing, mending, or updating garments. This behavior reflects both practical necessity and creative adaptation to changing circumstances. Qualitative interviews revealed that many participants possess traditional sewing and repair skills that facilitate textile reuse. One participant from Afghanistan noted: 'My mother taught me to sew when I was young. Here in Turkey, I fix our clothes and also help neighbors. It saves money and nothing is wasted.'

Gender differences emerged in textile reuse practices, with female respondents significantly more likely to engage in repair and repurposing activities ($\chi^2 = 23.47$, $p < 0.001$). This pattern aligns with traditional gender roles in textile work, though male participants also reported engagement in certain activities such as shoe repair and bag modification (Gwilt, 2014; Fletcher, 2014). Community networks play a crucial role in facilitating textile reuse through informal exchange systems. Approximately 34.7% of households participate in clothing swaps or donations within their communities, creating circular flows of textile goods that extend product lifecycles while meeting diverse household needs. The following table 3. presents the distribution of textile reuse practices:

Table 3. Textile Reuse Practices by Gender

Textile Reuse Practice	Percent of Households (%)	Gender Difference (M/F)
Clothing repair and mending	72.1	58.3 / 84.7
Repurposing for household use	58.3	51.2 / 64.8
Clothing alteration/modification	45.6	32.1 / 57.9
Community clothing exchange	34.7	29.4 / 39.2
Textile crafts and upcycling	28.9	18.7 / 37.8
Professional repair services	15.2	22.6 / 8.9

The utilization of second-hand products represents a significant component of sustainable consumption practices among migrant households in Turkey. Survey data reveal that 81.7% of respondents have purchased second-hand items

within the past year, with furniture (67.3%), clothing (59.8%), and household appliances (42.1%) being the most commonly acquired categories. These findings reflect both economic motivations and environmental consciousness, consistent with research on second-hand consumption patterns in diverse populations (Guiot & Roux, 2010; Cervellon *et al.*, 2012). The frequency of second-hand purchases varies significantly across product categories and demographic characteristics. Analysis reveals that length of residence in Turkey is positively correlated with second-hand consumption frequency ($r = 0.34$, $p < 0.001$), suggesting that familiarity with local markets and networks facilitates access to second-hand goods. Additionally, households with lower reported incomes demonstrate higher engagement with second-hand markets across all product categories, indicating the role of economic necessity in driving circular consumption behaviors (Bardhi & Arnould, 2005).

Qualitative interviews illuminate the complex motivations underlying second-hand consumption. Beyond economic considerations, participants frequently cited environmental awareness, quality preferences for older items, and the social aspects of second-hand shopping. One participant from Iraq explained: 'In the second-hand market, you find good quality things that last longer than new cheap items. Also, it's better for the environment, and you meet people from your community.' Trust and quality assessment emerged as critical factors influencing second-hand purchasing decisions. Participants described developing expertise in evaluating product condition and establishing relationships with trusted vendors. The role of community networks in facilitating second-hand transactions is particularly notable, with 48.6% of respondents reporting purchases through community connections rather than formal retail channels. The following analysis presented in table 4, presents second-hand consumption patterns across different product categories and demographic groups:

Table 4. Second-hand Product Purchase Patterns

Product Category	Purchase Rate (%)	Frequency (Monthly)	Primary Motivation	Trust Level (1-5)
Furniture	67.3	2.1	Economic necessity	4.2
Clothing	59.8	3.4	Economic + Quality	3.8
Household appliances	42.1	1.2	Economic necessity	3.9
Electronics	38.7	0.8	Economic necessity	3.5
Books and media	35.2	2.8	Interest + Economic	4.1
Children's items	31.9	1.9	Economic + Practical	4.0
Sports equipment	18.4	0.6	Interest + Economic	3.7

Participation in the sharing economy is a growing trend among migrant households, reflecting both adaptation to new economic realities and the leveraging of community-based resources. Survey results show that 44.9% of respondents have engaged in at least one form of sharing economy activity in the past year, including ride-sharing, tool or equipment sharing, and collaborative childcare arrangements. This rate is notably higher than the national average for the general population in Turkey, as reported by the Turkish Statistical Institute (TUIK, 2023). The most common sharing economy activities include ride-sharing (27.6%), tool/equipment sharing (21.3%), and collaborative childcare (14.8%). Engagement in digital platforms remains limited (9.2%), with most sharing activities organized through informal community networks rather than commercial apps. This finding is consistent with research indicating that trust and social capital are key enablers of sharing economy participation, especially among migrant and low-income groups (Schor, 2016; Frenken and Schor, 2017).

Qualitative interviews highlight the importance of trust, reciprocity, and cultural familiarity in facilitating sharing practices. Many participants described informal arrangements for sharing household items, transportation, and childcare with neighbors or extended family. One participant from Somalia explained: 'We share what we have with each other. If someone needs a car or a tool, we ask in our WhatsApp group. It saves money and builds trust.' Barriers to broader participation include limited access to digital platforms, language barriers, and concerns about reliability and safety. However, the strong presence of informal sharing networks suggests significant potential for expanding sharing economy models tailored to migrant communities. The following table 5. summarizes the prevalence of sharing economy activities:

Table 5. Sharing Economy Participation

Sharing Activity	Participation Rate (%)
Ride-sharing	27.6
Tool/equipment sharing	21.3
Collaborative childcare	14.8
Shared housing	11.5
Food sharing (outside family)	10.9
Digital platform use	9.2

Solidarity networks among migrant households play a crucial role in supporting sustainable consumption and resilience. Survey data indicate that 62.8% of respondents regularly participate in mutual aid activities, such as sharing food, childcare, or financial resources with other households. These networks are particularly active during periods of economic hardship or crisis, echoing findings from studies on migrant social capital and informal support systems (Putnam, 2000; Portes and Sensenbrenner, 1993). The most common forms of solidarity include food sharing (48.9%), childcare support (32.4%), and informal lending or

financial assistance (27.6%). Qualitative interviews reveal that these practices are deeply embedded in cultural traditions and are often organized through kinship, friendship, or neighborhood ties. One participant from Iran described: 'When someone in our community faces difficulty, everyone helps. We share what we have, whether it is food, money, or time.' The strength and reach of solidarity networks vary by country of origin, length of residence, and household size. Households with longer residence in Turkey and larger family networks report higher levels of participation in mutual aid. The following table 6. summarizes the prevalence of solidarity activities:

Table 6. Inter-household Solidarity Networks

Solidarity Activity	Participation Rate (%)
Food sharing	48.9
Childcare support	32.4
Financial assistance	27.6
Housing support	19.7
Job search assistance	16.3
Emotional support	54.2

The findings reveal a complex landscape of sustainable consumption practices among migrant communities in Turkey, characterized by high levels of engagement across multiple dimensions of circular economy behavior. The integration of quantitative and qualitative data demonstrates that sustainable consumption among this population is driven by a combination of economic necessity, cultural values, and adaptive strategies for navigating new social and economic environments. Several key patterns emerge from the analysis. First, economic constraints serve as a primary driver of sustainable consumption behaviors, with households demonstrating remarkable resourcefulness in extending product lifecycles and minimizing waste. However, these practices are not merely survival strategies but are deeply embedded in cultural traditions and community values that emphasize frugality, sharing, and mutual support (Appadurai, 2013; Vertovec, 2007).

Second, gender differences are evident across multiple domains, with women playing particularly prominent roles in textile reuse, food waste prevention, and household resource management. This pattern reflects both traditional gender roles and the practical realities of household management in resource-constrained environments (Mohanty, 2003; Kabeer, 2005). Third, community networks emerge as critical infrastructure for sustainable consumption, facilitating sharing, exchange, and mutual support activities that extend beyond individual household boundaries. These networks demonstrate the potential for community-based approaches to circular economy implementation that leverage existing social capital and cultural practices (Coleman, 1988; Bourdieu, 1986).

The findings have important implications for policy development and circular economy initiatives targeting migrant populations. Rather than imposing external frameworks, effective interventions should build upon existing practices and community structures, recognizing the sophisticated informal systems already in place. This approach aligns with participatory development principles and community-based resource management strategies (Chambers, 1997; Ostrom, 2009). The limitations of the study include the cross-sectional design, which limits causal inferences, and the focus on four major cities, which may not represent rural or smaller urban contexts. Future research should explore longitudinal patterns of sustainable consumption adaptation and examine the role of policy interventions in supporting or constraining these practices.

5. CONCLUSION AND RECOMMENDATIONS

This study has provided a comprehensive examination of the sustainable consumption practices among migrant communities in Turkey, with a particular focus on the alignment of traditional saving behaviors and the transformative potential of community-based sharing networks for advancing the country's circular economy goals. The findings underscore the critical role of social capital, cultural heritage, and adaptive community structures in fostering sustainable consumption and resource management, offering valuable insights for local governments and national policy frameworks. The evidence demonstrates that traditional saving practices – such as food preservation, textile repair, and the reuse of household goods – are not only strategies for economic resilience but also align closely with the principles of the circular economy (Geissdoerfer *et al.*, 2017). These practices, deeply embedded in the cultural fabric of migrant communities, contribute to waste reduction, resource efficiency, and the extension of product lifecycles, echoing the priorities outlined in the European Union's Circular Economy Action Plan (European Commission, 2020).

Community-based sharing networks emerge as a powerful mechanism for scaling sustainable behaviors beyond individual households. The study's quantitative analysis reveals that strong community ties significantly increase both sustainable consumption and participation in circular economy activities. This finding is consistent with Ostrom's (1990) theory of collective action, which highlights the effectiveness of local institutions in managing shared resources. In the Turkish context, these networks facilitate the sharing of tools, childcare, and financial resources, reducing consumption pressure and enhancing social cohesion (Schor, 2016). However, the research also identifies key barriers to the broader integration of these practices into formal circular economy initiatives. Legal status, language barriers, and digital access remain significant challenges for many migrant households, limiting their participation in formal sharing platforms and policy programs (Portes & Rumbaut, 2014; van Dijk, 2020). Addressing these

barriers is essential for realizing the full potential of community-based sustainability strategies.

For local governments, the findings suggest several actionable policy recommendations:

- Recognize and support existing community-based sharing networks as vital components of local sustainability strategies. This can be achieved through micro-grants, technical support, and the creation of community resource centers (Ostrom, 2009).

- Facilitate the integration of traditional knowledge and skills into municipal waste management, repair, and reuse programs, leveraging the expertise of migrant communities to enhance circular economy outcomes (Berkes, 2012).

- Address structural barriers by providing language support, legal assistance, and digital literacy training to ensure equitable access to formal circular economy initiatives (European Commission, 2020).

- Foster partnerships between local authorities, NGOs, and community organizations to co-design inclusive sustainability programs that reflect the needs and strengths of diverse populations (McCauley & Heffron, 2018).

At the national level, Turkey's circular economy ambitions can be significantly advanced by harnessing the adaptive capacity and social capital of migrant communities. The integration of informal, community-driven practices into national policy frameworks can accelerate progress toward the waste reduction, resource efficiency, and social inclusion targets outlined in Turkey's National Circular Economy Action Plan (Republic of Turkey Ministry of Environment, Urbanization and Climate Change, 2022). Comparative analysis with international literature reveals that Turkey's experience mirrors global trends, where community-based and culturally embedded practices often outperform top-down, technology-driven interventions in terms of participation and sustainability outcomes (Ghisellini *et al.*, 2016; Jackson, 2006). By prioritizing the empowerment of local communities and the removal of structural barriers, Turkey can position itself as a leader in inclusive and socially just circular economy transitions.

In conclusion, the study highlights the untapped potential of migrant communities as agents of sustainability and innovation. Local governments and national policymakers are encouraged to move beyond deficit-based approaches and instead recognize the value of cultural diversity, social capital, and hybrid knowledge systems in achieving circular economy goals. By fostering enabling environments for community-based action, Turkey can realize a more resilient, inclusive, and sustainable future.

References

- 1) Adger, W. N., Barnett, J., Brown, K., Marshall, N. & O'Brien, K. (2014). 'Human security', in Pelling, M., Özerdem, A. and Barakat, S. (eds.) *The Routledge Handbook of Hazards and Disaster Risk Reduction*. London: Routledge, pp. 112-122.

- 2) Al-Husban, A., & Adams, S. (2016). "Sustainable Refugee Migration: A Rethink towards a Positive Capability Approach", *Sustainability*, 8(5), 451.
- 3) Appadurai, A. (2013). *The Future as Cultural Fact: Essays on the Global Condition*. London: Verso Books. Available at: <https://www.versobooks.com/books/1426-the-future-as-cultural-fact>
- 4) Ateş, B. (2021). "Döngüsel Ekonomi Kapsamında GSYİH ile Geri Dönüşüm İlişkisi: Avrupa Birliği Ülkeleri Örneği," *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi*, doi:10.51290/dpusbe.782974.
- 5) Bardhi, F. and Arnould, E.J. (2005). Thrift Shopping: Combining Utilitarian Thrift and Hedonic Treat Benefits. *Journal of Consumer Behaviour*, 4(4), pp.223-233. DOI: <https://doi.org/10.1002/cb.12>
- 6) Berkes, F. (2012). *Sacred Ecology*. Routledge. Available at: <https://www.routledge.com/Sacred-Ecology/Berkes/p/book/9780415517324>
- 7) Botsman, R. and Rogers, R. (2010). *What's Mine Is Yours: The Rise of Collaborative Consumption*. New York: HarperBusiness.
- 8) Bourdieu, P. (1986). The Forms of Capital. In: J. Richardson, ed. *Handbook of Theory and Research for the Sociology of Education*. New York: Greenwood, pp. 241-258. Available at: <https://www.marxists.org/reference/subject/philosophy/works/fr/bourdieu-forms-capital.htm>
- 9) Braun, V. and Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, 3(2), pp.77-101. DOI: <https://doi.org/10.1191/1478088706qp063oa>
- 10) Bryman, A. (2016). *Social Research Methods*. 5th ed. Oxford: Oxford University Press. Available at: <https://www.oxfordclinicalpsych.com/view/10.1093/med/9780199588053.001.0001>
- 11) Bucur, M. (2023). "Exploring the Role of Consumers in Promoting a Circular Economy: Increasing Awareness and Engagement", *Proceedings of the International Conference on Business Excellence*.
- 12) Camacho-Otero, J. *et al.* (2020). "Consumers in the circular economy". Routledge.
- 13) Castles, S., de Haas, H. and Miller, M. J. (2014). *The Age of Migration: International Population Movements in the Modern World*. 5th ed. Basingstoke: Palgrave Macmillan.
- 14) Cervellon, M.C., Carey, L. and Harms, T. (2012). Something Old, Something Used: Determinants of Women's Purchase of Vintage Fashion vs Second-hand Fashion. *International Journal of Retail & Distribution Management*, 40(12), pp. 956-974. DOI: <https://doi.org/10.1108/09590551211274946>
- 15) Chambers, R. (1997). *Whose Reality Counts? Putting the First Last*. London: Intermediate Technology Publications. Available at: <https://www.ids.ac.uk/publications/whose-reality-counts-putting-the-first-last/>
- 16) Cohen, J. (1960). A Coefficient of Agreement for Nominal Scales. *Educational and Psychological Measurement*, 20(1), pp. 37-46. DOI: <https://doi.org/10.1177/001316446002000104>
- 17) Coleman, J.S. (1988). Social Capital in the Creation of Human Capital. *American Journal of Sociology*, 94, S95-S120. Available at: <https://www.jstor.org/stable/2780243>

- 18) Creswell, J.W. and Plano Clark, V.L. (2017). *Designing and Conducting Mixed Methods Research*. 3rd ed. Thousand Oaks: SAGE Publications. Available at: <https://us.sagepub.com/en-us/nam/designing-and-conducting-mixed-methods-research/book245927>
- 19) Demircioğlu, M., & Ever, O. (2020). "Döngüsel Ekonomiye Geçişte Endüstriyel Simbiyozun Maliyetler Üzerine Etkisi," *Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, doi:10.35379/cusosbil.778908.
- 20) Ellen MacArthur Foundation (2013). *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*. Available at: <https://ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an> (Accessed: 15 May 2024).
- 21) Ellen MacArthur Foundation (2017). *A New Textiles Economy: Redesigning Fashion's Future*. Available at: <https://ellenmacarthurfoundation.org/a-new-textiles-economy>
- 22) European Commission (2020). *Circular Economy Action Plan*. Available at: https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en
- 23) FAO (2019). *The State of Food and Agriculture 2019: Moving Forward on Food Loss and Waste Reduction*. Rome: Food and Agriculture Organization. Available at: <https://www.fao.org/3/ca6030en/ca6030en.pdf>
- 24) Feters, M.D., Curry, L.A. and Creswell, J.W. (2013). Achieving Integration in Mixed Methods Designs – Principles and Practices. *Health Services Research*, 48(6pt2), pp.2134-2156. DOI: <https://doi.org/10.1111/1475-6773.12117>
- 25) Fletcher, K. (2014). *Sustainable Fashion and Textiles: Design Journeys*. 2nd ed. London: Routledge.
- 26) Frenken, K. and Schor, J. (2017). Putting the Sharing Economy into Perspective. *Environmental Innovation and Societal Transitions*, 23, pp. 3-10. DOI: <https://doi.org/10.1016/j.eist.2017.01.003>
- 27) Fry, R., *et al.* (2024). "Policy insights on the migration–sustainability nexus for urban governance", *Global Sustainability*, xx, xx-xx.
- 28) Geissdoerfer, M., Savaget, P., Bocken, N. M. P. and Hultink, E. J. (2017). 'The Circular Economy – A new sustainability paradigm?', *Journal of Cleaner Production*, 143, pp. 757-768. Available at: <https://doi.org/10.1016/j.jclepro.2016.12.048> (Accessed: 15 May 2024).
- 29) Geissdoerfer, M., Vladimirova, K., & Bocken, N. (2018). "The Circular Economy – A new sustainability paradigm?" *Journal of Cleaner Production*, 143, 757-768.
- 30) Ghisellini, P., Cialani, C. & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, 11-32. Available at: <https://www.sciencedirect.com/science/article/pii/S0959652615012287>
- 31) Guiot, D. and Roux, D. (2010). A Second-hand Shoppers' Motivation Scale: Antecedents, Consequences, and Implications for Retailers. *Journal of Retailing*, 86(4), pp. 355-371. DOI: <https://doi.org/10.1016/j.jretai.2010.08.002>
- 32) Gwilt, A. (2014). *A Practical Guide to Sustainable Fashion*. London: Bloomsbury Academic. Available at: <https://www.bloomsbury.com/uk/a-practical-guide-to-sustainable-fashion-9781472580382/>

- 33) Israel, G.D. (1992). Determining Sample Size. University of Florida Cooperative Extension Service. Available at: <https://edis.ifas.ufl.edu/publication/PD006>
- 34) Jackson, T. (2006). The Earthscan Reader in Sustainable Consumption. Earthscan. Available at: <https://www.routledge.com/The-Earthscan-Reader-in-Sustainable-Consumption/Jackson/p/book/9781844071608>
- 35) Kabeer, N. (2005). Gender Equality and Women's Empowerment: A Critical Analysis of the Third Millennium Development Goal 1. *Gender & Development*, 13(1), pp. 13-24. DOI: <https://doi.org/10.1080/13552070512331332273>
- 36) Kilkis, Ş. (2018). 'Sustainable development of energy, water and environment systems index for Southeast European cities', *Journal of Cleaner Production*, 130, pp. 222-234. Available at: <https://doi.org/10.1016/j.jclepro.2016.07.121> (Accessed: 15 May 2024).
- 37) Kirchherr, J., Reike, D. and Hekkert, M. (2017). 'Conceptualizing the circular economy: An analysis of 114 definitions', *Resources, Conservation and Recycling*, 127, pp. 221-232. Available at: <https://doi.org/10.1016/j.resconrec.2017.09.005> (Accessed: 15 May 2024).
- 38) Küçükörük, U., & Kurtuldu, D. (2022). "Sürdürülebilir Pazarlamanın Sürdürülebilir Tüketim Üzerindeki Etkisinde Çevre Bilincinin Aracılık Rolü," *Trakya Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, doi:10.47934/tife.11.02.04.
- 39) Kuttaula, S. (2020). "Integrating fair trade with circular economy: Personality traits, consumer engagement, and ethically-minded behavior", *Journal of Business Research*, 121, 487-497.
- 40) Landis, J.R., Koch, G.G. (1977). The Measurement of Observer Agreement for Categorical Data. *Biometrics*, 33(1), pp. 159-174. DOI: <https://doi.org/10.2307/2538586>
- 41) Little, R.J.A. and Rubin, D.B. (2019). *Statistical Analysis with Missing Data*. 3rd ed. Wiley. Available at: <https://onlinelibrary.wiley.com/doi/book/10.1002/9781119013564>
- 42) MacArthur, E. (2013). "Upcycle: Beyond Sustainability – Designing for Abundance". Overlook Press.
- 43) McCauley, D. & Heffron, R. (2018). Just transition: Integrating climate, energy and environmental justice. *Energy Policy*, 119, 1-7. Available at: <https://www.sciencedirect.com/science/article/pii/S0301421518305163>
- 44) Ministry of Environment, Urbanization and Climate Change (2021). *Turkey Circular Economy Action Plan 2021-2023*. Ankara: Republic of Turkey Ministry of Environment, Urbanization and Climate Change. Available at: <https://webdosya.csb.gov.tr/db/cygm/icerikler/turkey-c-rcular-economy-act-on-plan-20210308113827.pdf> (Accessed: 15 May 2024).
- 45) Mohanty, C.T. (2003). *Feminism without Borders: Decolonizing Theory, Practicing Solidarity*. Durham: Duke University Press. Available at: <https://www.dukeupress.edu/feminism-without-borders>
- 46) Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T. & Gwilt, A. (2020). The environmental price of fast fashion. *Nature Reviews Earth & Environment*, 1, 189–200. Available at: <https://www.nature.com/articles/s43017-020-0039-9>
- 47) OECD (2022). *OECD Environmental Performance Reviews: Turkey 2022*. Paris: OECD Publishing. Available at: <https://doi.org/10.1787/9789264298095-en>

- 48) Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.
- 49) Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science*, 325(5939), 419-422. Available at: <https://www.science.org/doi/10.1126/science.1172133>
- 50) Özdemir, M., & Sunaoğlu, A. (2023). "Karanlık Üçlü Kişilik Özelliklerinin Sürdürülebilir Tüketim Davranışına Etkisi," *Pamukkale University Journal of Social Sciences Institute*, doi:10.30794/pausbed.1171780.
- 51) Özuyar, G., & Gürsoy, B. (2021). "Türkiye'deki Bilimsel Yayınlarda Döngüsel Ekonomi Teriminin Yeri," *Türk Turizm Araştırmaları Dergisi*, doi:10.26677/tr1010.2021.910.
- 52) Papargyropoulou, E., Lozano, R., Steinberger, J.K., Wright, N. and bin Ujang, Z., (2014). The Food Waste Hierarchy as a Framework for the Management of Food Surplus and Food Waste. *Journal of Cleaner Production*, 76, pp.106-115. DOI: <https://doi.org/10.1016/j.jclepro.2014.04.020>
- 53) Pemberton, S., Phillimore, J. and Robinson, D. (2014). 'Causes and experiences of poverty among economic migrants in the UK', IRIS Working Paper Series, No. 4/2014. Birmingham: University of Birmingham. Available at: <https://www.birmingham.ac.uk/Documents/college-social-sciences/social-policy/iris/2014/working-paper-series/IRiS-WP-4-2014.pdf> (Accessed: 15 May 2024).
- 54) Portes, A. & Rumbaut, R.G. (2014). *Immigrant America: A Portrait*. University of California Press. Available at: <https://www.ucpress.edu/book/9780520274026/immigrant-america>
- 55) Portes, A., Sensenbrenner, J. (1993). Embeddedness and Immigration: Notes on the Social Determinants of Economic Action. *American Journal of Sociology*, 98(6), pp.1320-1350. DOI: <https://doi.org/10.1086/230191>
- 56) Potting, J., Hekkert, M., Worrell, E. and Hanemaaijer, A. (2017). *Circular Economy: Measuring Innovation in the Product Chain*. The Hague: PBL Netherlands Environmental Assessment Agency. Available at: <https://www.pbl.nl/sites/default/files/downloads/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf> (Accessed: 15 May 2024).
- 57) Poulain, J. P. (2017). *The Sociology of Food: Eating and the Place of Food in Society*. London: Bloomsbury Academic.
- 58) Putnam, R.D. (2000). *Bowling Alone: The Collapse and Revival of American Community*. Simon & Schuster. Available at: <https://www.hks.harvard.edu/publications/bowling-alone-collapse-and-revival-american-community>
- 59) Republic of Turkey (2021). *National Circular Economy Action Plan (2021-2023)*. Ankara: Ministry of Environment, Urbanization and Climate Change. Available at: <https://webdosya.csb.gov.tr/db/cygm/icerikler/turkey-c-circular-economy-act-on-plan-20210308113827.pdf> (Accessed: 15 May 2024).
- 60) Rizos, V., *et al.* (2016). "Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers", *Sustainability*, 8(11), 1212.
- 61) Sahakian, M., Dobernig, K. and Foxon, T. J. (2020). 'The politics of sustainable consumption research and practice', in Cohen, M. J. (ed.) *Handbook of Research on Sustainable Consumption*. Cheltenham: Edward Elgar Publishing, pp. 33-47.

- 62) Schor, J. (2016). Debating the Sharing Economy. *Journal of Self-Governance and Management Economics*, 4(3), pp.7-22. Available at: <https://www.addletonacademicpublishers.com/contents-jsme/1218-volume-4-3-2016/2855-debating-the-sharing-economy>
- 63) Schor, J.B. (2016). Debating the Sharing Economy. *Journal of Self-Governance and Management Economics*, 4(3), 7-22. Available at: <https://www.cceol.com/search/article-detail?id=447112>
- 64) Schröder, P., Lemille, A. and Desmond, P. (2019). *Making the Circular Economy Work for Human Development*. New York: United Nations Development Programme. Available at: <https://www.undp.org/publications/making-circular-economy-work-human-development> (Accessed: 15 May 2024).
- 65) Sorrell, S. (2007). 'The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency', UK Energy Research Centre. Available at: <https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/03/the-rebound-effect-report.pdf> (Accessed: 15 May 2024).
- 66) Stenmarck, Å., Jensen, C., Qvested, T. and Moates, G. (2016). *Estimates of European Food Waste Levels*. Stockholm: IVL Swedish Environmental Research Institute. Available at: <https://www.eu-fusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf>
- 67) Tashakkori, A. and Teddlie, C. (2010). *Mixed Methodology: Combining Qualitative and Quantitative Approaches*. 2nd ed. Thousand Oaks: SAGE Publications. Available at: <https://us.sagepub.com/en-us/nam/mixed-methodology/book232927>
- 68) TUIK (2023). *Household Information and Communication Technology Usage Survey*. Turkish Statistical Institute. Available at: <https://www.tuik.gov.tr/>
- 69) UNHCR (2023). *Turkey Fact Sheet*. Available at: <https://www.unhcr.org/tr/en/turkey-fact-sheet> (Accessed: 15 May 2024).
- 70) UNHCR, 2023. *Turkey - Migrant Population Data*. Available at: <https://www.unhcr.org/tr/en/data>
- 71) Vertovec, S. (2007). Super-diversity and its Implications. *Ethnic and Racial Studies*, 30(6), pp.1024-1054. DOI: <https://doi.org/10.1080/01419870701599465>
- 72) Yang, X., & Xu, Y. (2024). "Direct and Spillover Effects: How Do Community-Based Organizations Impact the Social Integration of Passive Migrants?", *Sustainability*, xx, xx-xx.
- 73) Yıldız-Geyhan, E. and Yıldız, N. (2022). 'Circular economy in Turkey: A systematic review of current practices and future prospects', *Sustainability*, 14(3), 1847. Available at: <https://doi.org/10.3390/su14031847> (Accessed: 15 May 2024).
- 74) Zink, T. and Geyer, R. (2017). 'Circular Economy Rebound', *Journal of Industrial Ecology*, 21(3), pp. 593-602. Available at: <https://doi.org/10.1111/jiec.12545> (Accessed: 15 May 2024).

CHALLENGES AND POLICIES FOR A CONSUMER CIRCULAR ECONOMY IN ALBANIA'S AGRICULTURAL SECTOR

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Abstract

Agriculture remains a cornerstone of developing economies, providing livelihoods and sustaining rural communities. In Albania, the sector accounts for over 18.5% of the national GDP (INSTAT, 2023), yet it faces structural challenges including low productivity, inefficient resource utilization, environmental degradation, and vulnerability to climate change. These persistent issues underscore the urgency of transitioning from a linear to a circular economic model – one that emphasizes sustainability, resource efficiency, and closed-loop systems. This study investigates the alignment between Albania's regional development policies and the adoption of circular economy (CE) principles in the agricultural sector. Particular attention is paid to the integration of CE in national subsidy schemes and legal frameworks, reflecting Albania's commitment to sustainable development and European Union accession objectives. Findings reveal that while significant strides have been made – such as the introduction of targeted subsidy schemes in 2024 and alignment with the European Green Deal – implementation remains fragmented and constrained by institutional, financial, and technical barriers. The study advocates for a comprehensive and integrated policy framework that synergizes CE goals with regional development priorities, enhanced stakeholder engagement, and capacity-building initiatives. Accelerating Albania's

transition to a circular agriculture economy will not only foster environmental sustainability but also improve economic resilience and regional equity.

Keywords: *circular economy, agriculture subsidies, policy impact, sustainable development, Albania.*

JEL Classification: Q01, Q56

1. INTRODUCTION

Albania's agricultural sector plays a vital role in the country's socio-economic fabric, employing nearly 36% of the labor force and serving as a key income source for rural communities (INSTAT, 2023). Despite its importance, the sector is marked by fragmented landownership, outdated technologies, poor infrastructure, and limited access to finance, which collectively constrain productivity and competitiveness. Environmental pressures – such as soil degradation, water scarcity, and greenhouse gas emissions – further highlight the unsustainability of current agricultural practices and the urgent need for systemic transformation.

In response to these challenges, the integration of circular economy (CE) principles into national agricultural strategies is gaining attention. A circular economy promotes a regenerative model that seeks to design out waste, keep products and materials in use for as long as possible, and regenerate natural systems. In agriculture, this means shifting towards practices that close nutrient loops, minimize synthetic input use, valorize agricultural residues, and support biodiversity. The CE approach is particularly relevant for Albania, where agricultural systems are still predominantly linear and dependent on intensive resource extraction.

Recognizing the strategic importance of transitioning to a CE, the Albanian government has begun aligning national policies with the European Green Deal and the EU Circular Economy Action Plan. As an EU candidate country, Albania is progressively harmonizing its legal and institutional frameworks with EU *acquis*, particularly those concerning environmental sustainability, climate action, and rural development. The National Strategy for Development and Integration (NSDI) 2030, the National Plan for European Integration, and the National Plan for Integrated Waste Management 2020–2035 are among the key policy documents that integrate circularity goals into development planning.

The Ministry of Agriculture and Rural Development (MARD) has taken important steps to reform the agricultural subsidy system to support environmentally friendly practices. In 2024, the ministry allocated 3.9 billion ALL in direct subsidies aimed at enhancing sustainability in agriculture. The programs prioritize excise-free fuel for farm operations, grants for climate-resilient infrastructure such as greenhouses, and support for the modernization of agricultural machinery. These subsidies are increasingly conditioned upon the adoption of sustainable practices, including the use of organic fertilizers, reduction

of chemical inputs, water-saving irrigation technologies, and soil conservation techniques.

Efforts to operationalize CE principles are also supported by international partners, including the European Union, FAO, GIZ, and the World Bank, through technical assistance, pilot projects, and funding instruments. However, the implementation of CE in Albanian agriculture remains at an early stage. Major constraints include limited institutional capacity, weak enforcement of environmental regulations, fragmented inter-ministerial coordination, and a lack of financial incentives tailored to circular innovations. Moreover, farmers and agricultural entrepreneurs often lack awareness and technical knowledge about CE practices, making outreach, training, and knowledge transfer critical components of the transition.

As Albania advances toward EU membership, the pressure to adopt comprehensive and inclusive CE strategies in agriculture will intensify. Integrating CE principles into regional development frameworks and national rural policies not only aligns with EU accession criteria but also strengthens the country's resilience to external shocks, such as market volatility and climate change. The creation of a coherent, multi-level governance structure – encompassing national, regional, and local actors – is essential to mainstream circular practices and ensure equitable and effective implementation.

This paper aims to explore the interplay between Albania's regional development policies and CE adoption in agriculture, assessing how current subsidy schemes, legal frameworks, and stakeholder initiatives contribute to or hinder the realization of a circular and sustainable agricultural economy.

2. METHODOLOGY

This study employs a mixed-methods research approach to provide a comprehensive analysis of CE integration into Albania's agricultural subsidy system. The primary objectives are:

1. To analyze secondary data on government subsidies and their contribution to circular economy practices in agriculture.
2. To evaluate the effectiveness of these subsidies using key impact indicators.
3. To identify barriers and enabling factors affecting the implementation of CE principles in agricultural policy.

Data sources include government documents, statistical reports from MARD and INSTAT, and academic literature. A document analysis methodology is applied to assess the legal and strategic alignment of subsidies with CE principles. Quantitative data from subsidy programs are examined to determine distribution patterns and beneficiary outcomes.

3. LITERATURE REVIEW

The transition to a circular economy in agriculture is increasingly viewed as essential to achieving environmental sustainability and economic resilience in the face of climate change and resource constraints. International literature highlights CE as a model that closes resource loops through recycling, reuse, and sustainable design (Geissdoerfer *et al.*, 2017; Kirchherr *et al.*, 2018). In agriculture, this translates into practices such as nutrient recycling, organic farming, composting, and the use of renewable energy in production systems (FAO, 2020).

In the Albanian context, the integration of CE principles remains in a nascent stage, although legal and strategic frameworks are gradually evolving. The National Waste Management Plan and environmental legislation signal a policy shift toward sustainability, and the government has increasingly linked agricultural subsidies to environmental and climate goals. Initiatives under the European Green Deal and Albania's EU accession process have further reinforced the momentum toward CE, particularly through funding and policy harmonization.

However, several empirical studies note that the practical application of CE principles in Albanian agriculture is limited. Barriers include a lack of institutional coordination, insufficient training among farmers, inadequate infrastructure for waste processing and renewable energy, and limited access to green financing. Moreover, while subsidy schemes have proliferated, including support for organic farming, greenhouse construction, and modern equipment, there is little evidence that these schemes are explicitly designed with CE outcomes in mind.

This study contributes to the literature by evaluating the alignment between agricultural subsidies and CE objectives, assessing the impact of such interventions on sustainability and rural development outcomes, and identifying actionable policy recommendations.

4. STATISTICAL DATA RESULTS ANALYSIS

Albania's agricultural sector contributes significantly to the national economy, accounting for approximately 18.5% of GDP and employing over one-third of the total workforce, according to the latest data from INSTAT (2023). The sector remains predominantly rural, with over 45% of the population living in rural areas, many of whom depend directly or indirectly on agriculture for their livelihoods. However, agriculture in Albania is characterized by small, fragmented farms – with the average farm size less than 1.2 hectares – which limits economies of scale and modernization efforts (INSTAT, Agricultural Census 2018; Eurostat, 2022).

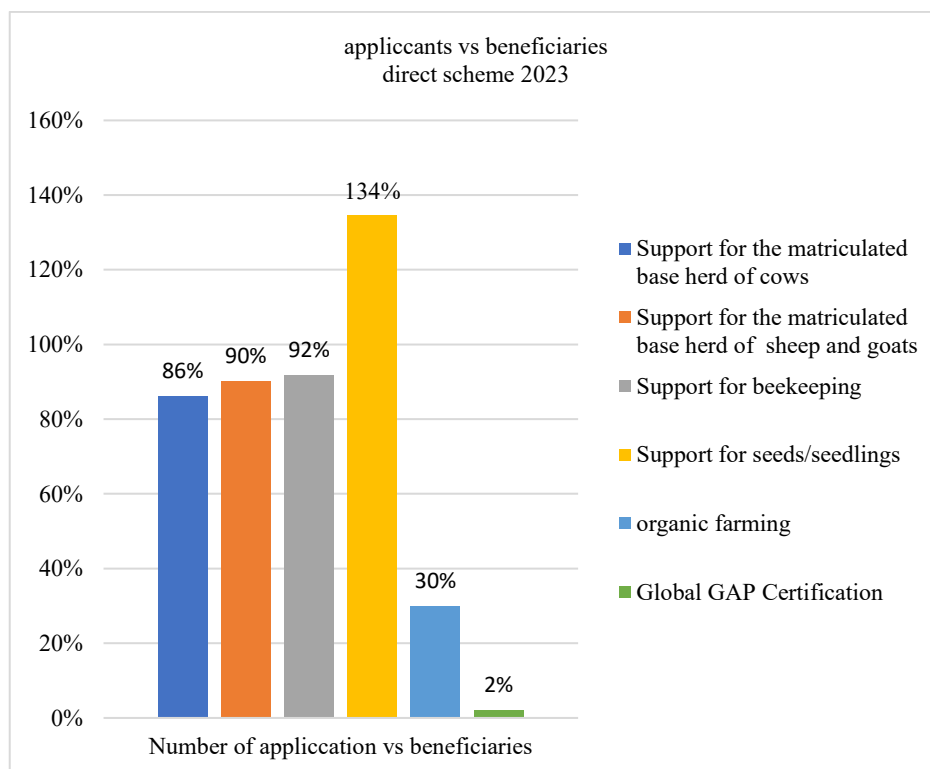
The sector also lacks in terms of productivity and innovation. According to FAOSTAT (2023) and World Bank Development Indicators, Albania's agricultural value added per worker is significantly lower than the EU average,

reflecting underinvestment in technology, infrastructure, and sustainable practices. Water use in irrigation remains inefficient, while fertilizer and pesticide usage is often unregulated, contributing to land degradation and water pollution. INSTAT reports that more than 60% of Albania's arable land is subject to moderate to severe erosion risk, further underscoring the need for sustainable land and resource management (more details are in table 1)

Table 1. Key Indicators on Agriculture and Circular Economy in Albania

Indicator	Value / Description	Source
Agriculture share of GDP	18.5%	INSTAT, 2023
Agricultural employment	~36% of total workforce	INSTAT, 2023
Rural population share	45%	INSTAT, 2022
Average farm size	1.2 hectares	INSTAT, Agricultural Census 2018
Land affected by erosion	>60% of arable land	Ministry of Environment, 2021
Agricultural value added per worker	~\$3,000 (USD, est.)	World Bank, 2023
Subsidies allocated to agriculture (2024)	3.9 billion ALL	Ministry of Agriculture, 2024
CE-specific initiatives in agriculture	Waste reduction, eco-technologies, greenhouse support	MARD, 2024; EU Delegation
National CE policy alignment	Aligned with EU Green Deal & CE Action Plan	NSDI 2030; National CE Roadmap

In addition to INSTAT, national policy documents such as the National Strategy for Agriculture and Rural Development (NSARD) 2021–2027 and the National Environmental Strategy provide a framework for agricultural modernization and environmental protection, incorporating sustainability and circular economy objectives. The 2024 Budget Report from the Ministry of Finance and Economy details the financial allocations for agriculture, including the 3.9 billion ALL allocated for sustainability-oriented subsidies (MARD, 2024). These schemes include support for excise-free fuel, greenhouse technologies, organic production, and improved waste management – all integral to advancing circular economy practices.



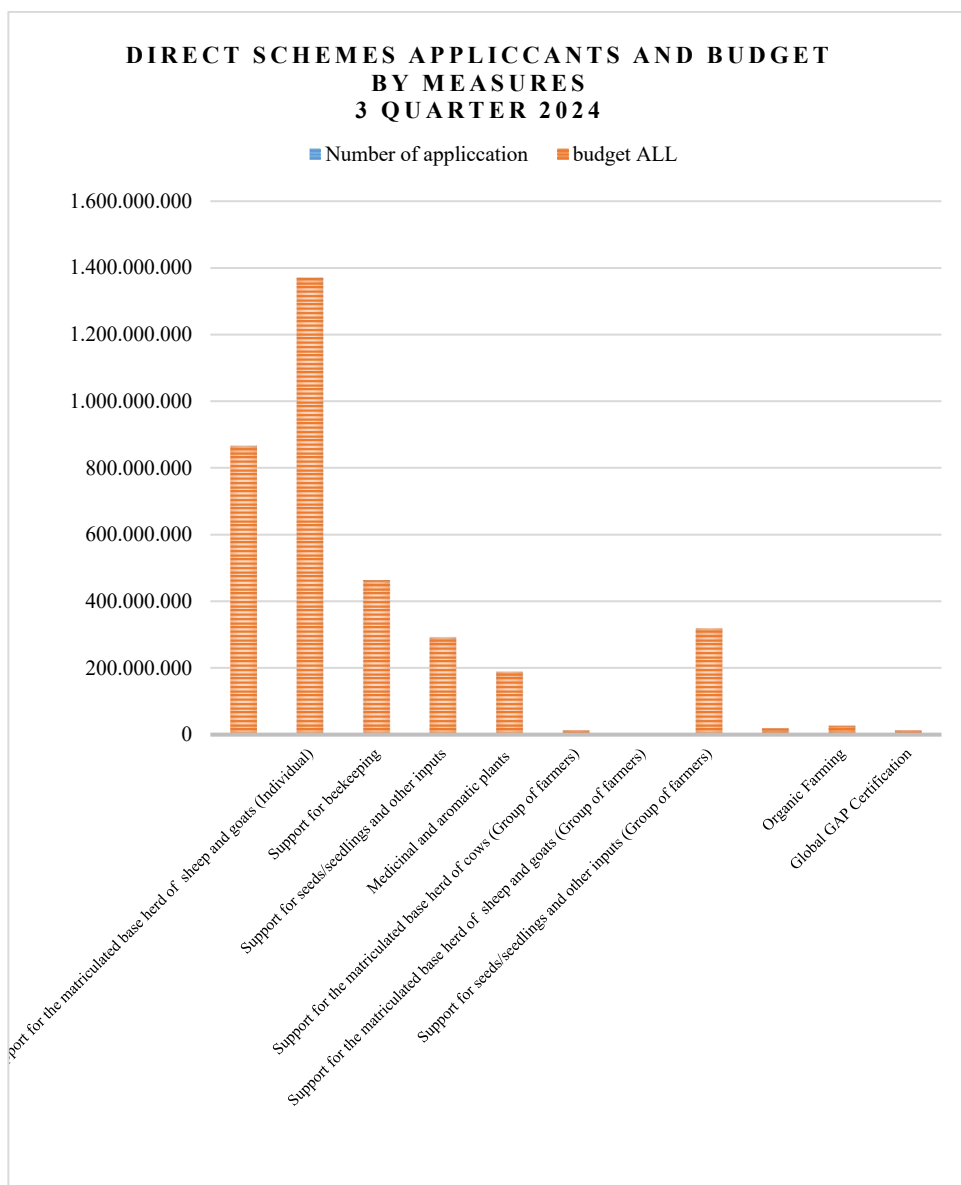
Source: Ministry of Agriculture and Rural Development, annual report 2023

Chart 1. Applicants vs beneficiaries by measures direct schemes financed through national budget, 2023

Based on the data analyses it results that national program for agriculture number of beneficiaries is the highest for the matriculated base herd of sheep and goats, and for seed and seedlings meanwhile there is the lowest number of beneficiaries for organic farming only 30 % of applicants benefited the support.

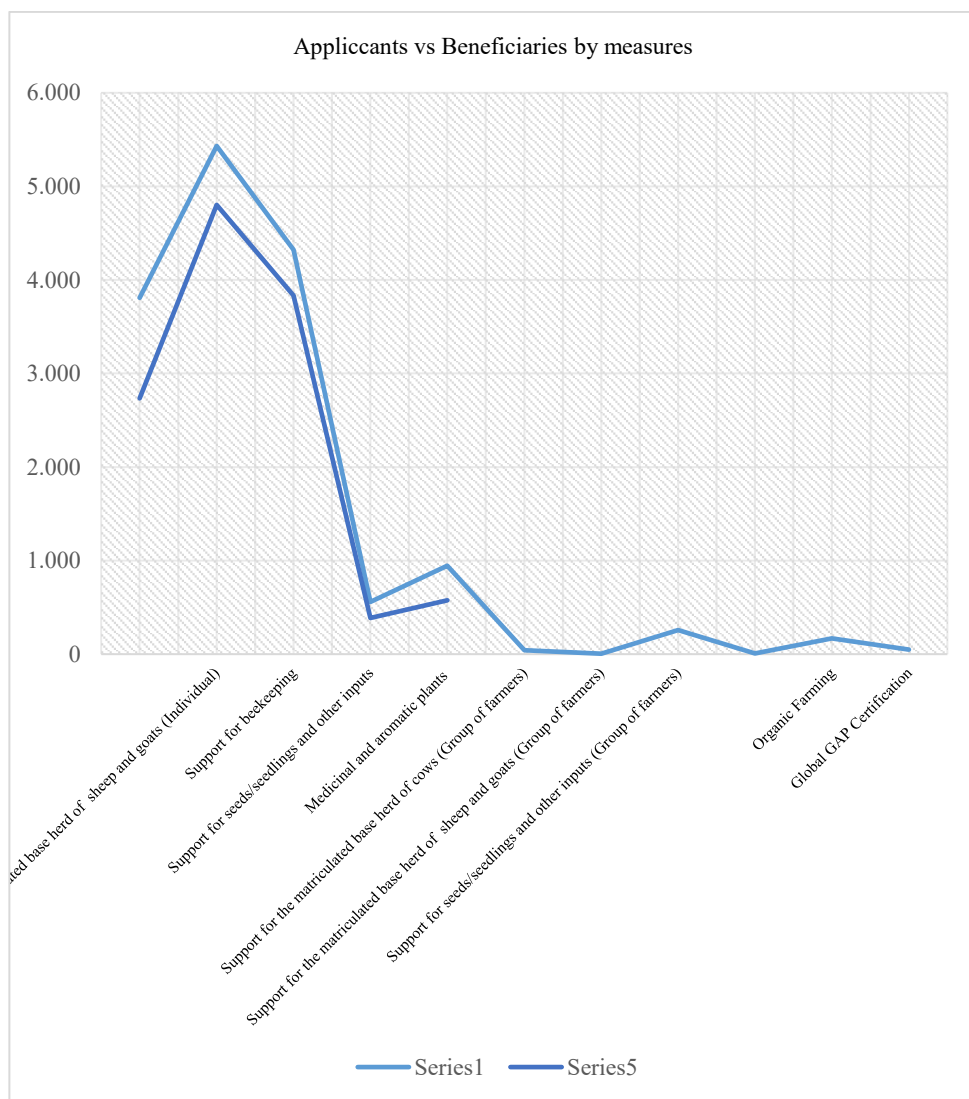
During the analysis of data, it results that there is a higher number of applicants compared to the beneficiaries, that shows lack of budget to subsidize all farmers.

Analysis of data from MARD's 2023 and 2024 reports reveals key trends in the implementation of agricultural subsidy schemes. Direct support programs funded through the national budget show a high concentration of beneficiaries in livestock-related measures, especially for sheep and goat herds, and for seed and seedling support.



Source: Ministry of Agriculture and Rural Development, 2024

Chart 2. Applicants and budgeted by measures. direct schemes financed through national budget



Source: Ministry of Agriculture and Rural Development, 2024

Chart 3. Applicants vs beneficiaries by measures. direct schemes financed through national budget

Conversely, support for organic farming remains limited, with only 30% of applicants receiving subsidies. This indicates potential misalignment between policy goals and implementation. Budget constraints also surface, as a significantly higher number of applicants than beneficiaries is recorded across most schemes.

Visual data presented in charts further illustrate this gap between application and funding, suggesting that while demand for support is high, fiscal and administrative limitations restrict comprehensive implementation.

The results of the analysis indicate a mixed pattern in the effectiveness of current agricultural subsidy schemes in promoting circular economy (CE) principles in Albania. Based on 2023 and 2024 data from the Ministry of Agriculture and Rural Development (MARD), several key findings emerge:

High Participation in Conventional Subsidies: Livestock farming received the largest portion of national subsidies, particularly for sheep and goat herds. These measures, while important for economic stability, largely follow linear production models with minimal incorporation of CE practices such as nutrient recycling or waste reduction.

Limited Support for Organic Farming: Despite national commitments to sustainable development, only 30% of applicants for organic farming received subsidies. This reflects both budgetary limitations and a lack of structured incentives for CE-aligned practices such as composting, reduced pesticide use, and integrated soil fertility management.

Mismatch Between Demand and Funding Capacity: Visual data analysis shows a consistently higher number of applications than actual beneficiaries across all subsidy programs. In 2023, only 52% of all applicants received some form of support, illustrating a demand-supply imbalance that restricts broader CE implementation.

Underutilization of EU IPARD II Funds: While Albania received over €94 million under IPARD II, absorption rates remain below EU averages. Project data suggests that complex administrative procedures and limited advisory services deter participation, especially for CE-targeted investments such as biogas systems, eco-efficient irrigation, and circular packaging.

Lack of Monitoring Indicators: None of the subsidy schemes currently include specific CE performance indicators. As a result, it is difficult to assess whether financial support leads to tangible improvements in resource efficiency, waste reduction, or ecosystem services.

5. CONCLUSIONS AND RECOMMENDATIONS

During the design of policy making in agriculture sector Subsidies in Albania should improve Policy Integration Develop targeted policies that encourage Circular Economy in agriculture, supported by clear incentives and regulatory frameworks.

Improve capacity, Train farmers and agribusinesses on CE practices and their economic and environmental benefits.

Investment in infrastructure by establishing composting facilities, biogas plants, and water recycling systems in agricultural regions.

Market development, create demand for recycled and bio-based agricultural products through subsidies, awareness campaigns, and public procurement. Research and innovation, Support R&D for CE technologies and practices tailored to Albania's agricultural context.

References

- 1) FAO (2020). *The Circular Economy and the Bioeconomy – Partners in Sustainability*. Rome: Food and Agriculture Organization of the United Nations.
- 2) Geissdoerfer, M., Savaget, P., Bocken, N.M.P. and Hultink, E.J. (2017). 'The Circular Economy – A New Sustainability Paradigm?', *Journal of Cleaner Production*, 143, pp. 757–778.
- 3) INSTAT (2023). *Statistical Yearbook: Agriculture*. Available at: <https://www.instat.gov.al/al> (Accessed: 1 May 2025).
- 4) INSTAT. (2018). *Agricultural Census 2018*. Albanian Institute of Statistics.
- 5) Kirchherr, J., Reike, D. and Hekkert, M. (2018). 'Barriers to the Circular Economy: Evidence from the European Union', *Ecological Economics*, 150, pp. 264–272.
- 6) Ministry of Environment. (2021). *National Strategy for Integrated Waste Management 2020–2035*.
- 7) Ministry of Agriculture and Rural Development (MARD) (2023). *Annual Report 2023*. Available at: <https://bujqesia.gov.al> (Accessed: 1 May 2025).
- 8) Ministry of Agriculture and Rural Development (MARD) (2024). *Annual Report 2024*. Available at: <https://bujqesia.gov.al> (Accessed: 1 May 2025).
- 9) World Bank. (2023). *World Development Indicators*. <https://data.worldbank.org>

CROSS-BORDER ENVIRONMENTAL EXPERTISE – AN INSTRUMENT FOR ENVIRONMENTAL IMPACT ASSESSMENT

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Abstract

At the beginning of the new millennium, balancing the need for economic and social development, on the one hand, and environmental protection, on the other, is a crucial priority in the international climate. This involves the promotion of sustainable development, which must embrace economic growth, improvement of the quality of life, health, education, social development and environmental protection.

Environmental problems are particularly complex, as the causes are interrelated, requiring action at all levels: local, national and regional authorities, as well as the European Union, each with its own role in increasing responsibility for environmental protection.

In order to help Member State authorities and developers to better manage the environmental consequences of construction projects, the Commission has brought together all existing EU legislation governing environmental impact assessment (hereafter EIA).

In this study we intend to approach transboundary environmental expertise as an essential mechanism in the context of infrastructure projects, exploitation of natural resources, construction of hydropower plants, transportation of hazardous substances and other activities that may have a wide-ranging environmental impact across borders.

Keywords: *environment, environmental expertise, cross-border, natural resources, liability.*

JEL Classification: K32

1. INTRODUCTION

In the current context of global development, many economic and infrastructure projects have environmental effects that extend beyond national borders, endangering ecosystems and communities in multiple countries. Cross-border environmental expertise thus becomes an essential tool for assessing and minimizing environmental impact in the context of such projects. This article explores the role of this type of expertise, the relevant legislative framework, and

the challenges faced by national and international authorities in conducting effective cross-border assessments.

1.1. Defining Cross-Border Environmental Expertise

Cross-border environmental expertise refers to the process by which the environmental impact of a project is formally assessed when this impact exceeds the borders of a single country. Unlike domestic environmental assessments, which are limited to the jurisdiction of a single state, cross-border expertise involves collaboration between authorities from several states to analyze potential negative effects on the environment, population, and ecosystems in neighboring regions. Its purpose is to protect the environment and ensure that cross-border projects comply with environmental standards and contribute to sustainable development.

This expertise is essential, especially for large-scale projects such as the construction of dams, international highways, nuclear power plants, oil pipelines, and gas pipelines, which can affect multiple ecosystems and populations in neighboring regions. The cross-border impact assessment involves a thorough analysis of risks, identification of impact mitigation solutions, and ensuring the sustainable management of natural resources.

1.2. The Necessity of Cross-Border Expertise in the Context of Globalization

Globalization and the intensification of economic cooperation between states have led to an increase in the number of projects with cross-border impact. Extended economic activities, from natural resource exploitation to transport infrastructure development, have long-term ecological effects and can affect public health, biodiversity, and natural resources in several countries.

Cross-border environmental expertise is necessary to ensure that all involved countries have a clear understanding of the risks and that appropriate measures are adopted for environmental protection. In the absence of such expertise, cross-border projects risk causing environmental degradation and conflicts between states, especially when economic interests are prioritized over ecological protection.

1.3. Basic Principles of Cross-Border Environmental Expertise

The cross-border environmental expertise process is based on several fundamental principles, including:

- The precautionary principle: In cases where there is uncertainty about a project's potential environmental impact, the involved states are encouraged to adopt preventive measures. This principle allows authorities to make conservative decisions, avoiding major environmental risks even when scientific evidence is not fully conclusive.

- The prevention principle: States must take measures to prevent and minimize the negative impact of cross-border projects on the environment. This involves implementing advanced technological solutions and best ecological practices to limit harmful effects on natural resources.
- The principle of transparency and public consultation: Cross-border environmental expertise includes the obligation to consult the public and stakeholders in all countries affected by the project. Transparency in the assessment process ensures that citizens and environmental organizations can contribute to the project analysis and express their opinions.
- The principle of international cooperation: States involved in cross-border projects must collaborate to identify optimal solutions and reduce environmental impact. This involves the exchange of information and expertise between authorities, as well as supporting countries that lack the technical or financial capacities to carry out a complete assessment.

1.4. Cross-Border Environmental Expertise and Sustainable Development

Through the detailed evaluation of environmental effects, cross-border environmental expertise supports sustainable development, ensuring a balance between economic growth and ecological protection.

This means that projects are evaluated not only in terms of economic profit but also based on their long-term impact on natural resources, public health, and biodiversity. Thus, cross-border expertise helps prevent environmental conflicts between states and promotes rational use of resources, minimizing ecological risks and supporting sustainable economic development.

1.5. Examples of Projects Requiring Cross-Border Environmental Expertise

Energy and transportation infrastructure projects are among the most common examples requiring cross-border environmental expertise. A relevant example is the construction of gas pipelines that cross multiple European countries, such as the Nord Stream pipeline, which connects Russia to Germany through the Baltic Sea. This project had a significant impact on the marine environment, and the regional states were consulted to assess the impact and identify mitigation measures.

Another example is the construction of hydropower plants on transboundary rivers, such as the Danube River, which flows through multiple European countries. These projects can have a major impact on biodiversity and downstream communities, which is why international collaboration and a detailed ecological impact assessment are necessary before implementation.

2. THE INTERNATIONAL LEGISLATIVE FRAMEWORK OF CROSS-BORDER ENVIRONMENTAL EXPERTISE

2.1. The Espoo Convention (Espoo Convention (1991)) and Its Importance for Cross-Border Environmental Expertise

The Convention on Environmental Impact Assessment in a Transboundary Context, known as the Espoo Convention (Espoo Convention 1991), is an international agreement adopted in 1991 under the auspices of the United Nations Economic Commission for Europe (UNECE).

The Espoo Convention (Espoo Convention 1991) represents a major step in international environmental protection, establishing the obligations of states to assess the potential impact of projects that may affect the environment beyond their national borders.

To date, the Espoo Convention (Espoo Convention 1991) has been signed by numerous countries, including those outside of Europe, emphasizing the global importance of protecting the environment in a cross-border context.

According to the provisions of the Espoo Convention (Espoo Convention 1991), signatory states are obliged to inform and consult neighboring states when planning projects with significant ecological impact.

These cross-border consultations ensure that all affected parties have the opportunity to evaluate the environmental impact and contribute to identifying suitable solutions to reduce negative effects.

The Espoo Convention (Espoo Convention 1991) also includes the obligation to conduct detailed impact studies and present proposed measures for pollution prevention and control.

2.2. The Evaluation Procedure under the Espoo Convention (Espoo Convention 1991)

The Espoo Convention (Espoo Convention 1991) provides a standard procedure for evaluating transboundary environmental impact, structured into several essential steps:

- **Notification:** The country of origin of the project is required to notify neighboring states about the proposed project and its potential environmental impact. The notification includes details about the nature and location of the project, as well as a preliminary description of the possible ecological effects.
- **Public consultation:** The Convention mandates that both the public in the country of origin and the public in the affected countries be involved in the assessment process, giving them the opportunity to participate and express concerns about the project (Jay *et al.*, 2007).
- **Environmental Impact Assessment (EIA):** A detailed environmental impact assessment report is prepared by the country of origin and presented to the affected states. This report includes an analysis of the impact on

ecosystems, biodiversity, water and air resources, and proposes measures to reduce negative impact.

- **Negotiation and agreement:** In cases where affected states disagree with the implementation of the project or consider that the mitigation measures are insufficient, the Convention allows negotiations and mediation to reach an acceptable solution for all involved parties.
- **Project monitoring:** After project approval, the Espoo Convention (Espoo Convention 1991) provides for the monitoring of environmental impact to ensure that all proposed protective measures are effectively implemented.

2.3. European Union Directives and Cross-Border Environmental Expertise

The European Union is a global leader in environmental protection and has adopted a series of directives supporting environmental impact assessment, including for cross-border projects:

- Environmental Impact Assessment Directive (EIA Directive): Initially adopted in 1985 and periodically updated, this directive regulates environmental impact assessment for large infrastructure projects and other economic activities that may have a significant environmental impact. The EIA Directive requires EU member states to conduct impact studies and consult both the public and neighboring states when projects may affect the cross-border environment.
- Habitats Directive (European Commission 1992) and Birds Directive (European Commission 1979): These directives are essential tools for biodiversity protection in the EU and are part of the Natura 2000 network, a protected area network including valuable ecosystems across Europe. Cross-border projects that may affect protected habitats or species of community interest must be carefully assessed, and protective measures are essential to safeguard these areas.
- Floods Directive (European Commission 2007): This directive requires member states to develop flood risk maps and management plans, being particularly important in the case of transboundary rivers and shared river basins. For rivers crossing several countries, such as the Danube, states are required to collaborate to protect aquatic ecosystems and reduce flood-related risks.

2.4. Other Relevant International Agreements

Besides the Espoo Convention (Espoo Convention 1991) and EU directives, other international conventions contribute to cross-border environmental expertise, especially in water and biodiversity protection:

- Helsinki Convention (Helsinki Convention 1992) on the Protection and Use of Transboundary Watercourses and International Lakes (1992): This convention promotes cooperation among states for the protection and

sustainable use of transboundary watercourses. It requires signatory states to implement preventive measures to avoid water quality degradation and to conserve aquatic ecosystems.

- Convention on Biological Diversity (CBD, 1992): Although broader in scope, the CBD also includes aspects relevant to the cross-border context, particularly when proposed projects affect critical habitats and ecosystems essential for biological diversity.

2.5. The Importance of the International Legislative Framework for Environmental Protection

International legislative instruments, such as the Espoo Convention (Espoo Convention 1991) and EU directives, play a crucial role in protecting the environment from cross-border project impacts. These agreements provide a framework for collaboration and harmonization of environmental standards among states, facilitating rigorous assessment and appropriate environmental protection.

This legislative framework is essential for preventing ecological conflicts and promoting balanced, sustainable economic development that respects natural resources and protects public health.

Additionally, the international legislative framework helps establish common environmental standards, enabling states to adopt best practices in environmental protection. This is a vital component of cross-border environmental expertise, ensuring that projects comply not only with national regulations but also with international environmental requirements, thereby safeguarding shared resources and ecosystems.

3. METHODOLOGY OF CROSS-BORDER ENVIRONMENTAL EXPERTISE

Cross-border environmental expertise is based on a series of methods and techniques that enable the identification, evaluation, and mitigation of potential environmental impacts in projects conducted across multiple countries. The methodological process involves complex and multidisciplinary stages aimed at ensuring rigorous assessment and protecting affected ecosystems and communities (Kidd and Fischer, 2020).

3.1 Assessment of Environmental Risks

One of the initial steps in conducting cross-border environmental expertise is the assessment of the ecological risks that a project may generate. This stage involves identifying the potentially affected environmental components, such as water, air, soil, biodiversity, and public health. Ecological risk assessment is carried out through field data collection, including species monitoring, water and

air quality measurements, soil analysis, and direct observations of natural habitats (Glasson *et al.*, 2013).

This stage requires a thorough analysis of how the project might impact each environmental element. For example, in the case of constructing a dam on a transboundary river, experts must analyze the impact on aquatic ecosystems, the river's self-purification capacity, and the flood risks for downstream riparian areas.

3.2. Data Collection Techniques and Tools

Cross-border environmental expertise employs a wide range of techniques and tools for collecting and analyzing environmental data:

- **Field studies:** A fundamental component of the assessment involves field studies, which include direct observations and the collection of soil, water, and air samples from areas affected by the project. These studies allow the identification of local flora and fauna species, water resources, and the geological and topographical characteristics of the land.
- **Laboratory analyses:** The samples collected from the field are analyzed in laboratories to evaluate environmental parameters such as chemical pollution levels, the presence of heavy metals, and other toxic substances. Laboratory analyses provide detailed information about the quality and contamination level of water and soil resources.
- **Use of GIS and remote sensing technologies:** Geographic Information Systems (GIS) and remote sensing techniques enable extensive monitoring of cross-border areas impacted by projects. Satellite remote sensing, for example, can be used to observe landscape changes, monitor water levels in rivers and lakes, or track vegetation shifts over time (European Environment Agency, 2018). These data are extremely useful for assessing long-term environmental impact and for monitoring the effects of a project on the environment.

3.3. Ecological Impact Modeling

Ecological impact modeling is an essential technique in cross-border environmental expertise, as it allows the simulation of a project's potential effects before its implementation. Ecological models are based on collected data and use algorithms to project possible environmental consequences of the project. For instance, a model can simulate the dispersion of pollutants in a transboundary river or estimate changes in natural habitats.

Modeling makes it possible to anticipate negative effects and supports the development of strategies to reduce ecological impact. This is especially important for projects involving gas emissions or pollutants that may affect air quality, such as the construction of a power plant, where pollutant dispersion models can be used to evaluate the potential contamination of neighboring areas.

3.4 Mitigation and Adaptation Measures

After ecological risks have been assessed and environmental impacts have been modeled, cross-border environmental expertise proposes mitigation measures to reduce the project's negative effects on the environment. These measures include strategies and technologies aimed at minimizing the project's impact on natural resources and affected communities. Some of the most common mitigation measures include:

- **Emission filtration and reduction technologies:** In the case of power plants or industrial projects that emit gases and pollutants, air and water filtration technologies can be employed to reduce contamination levels and limit the effects on public health.
- **Creation of ecological corridors and buffer zones:** For infrastructure projects that cross natural habitats, experts may propose ecological corridors that allow the movement of wildlife and prevent habitat fragmentation. Buffer zones can also be established to protect water resources from construction-related pollution.
- **Water management:** For projects involving the use of water resources, adaptation measures may include techniques for regulating water flow, such as reducing water intake during critical periods to prevent resource depletion and ensure the continuity of aquatic ecosystems (Petts, 1999).

3.5. Public Consultation and Stakeholder Involvement

A central aspect of cross-border environmental expertise is the consultation of the public and the involvement of stakeholders from all affected states. This stage is essential to ensure transparency in the evaluation process and to allow citizens, environmental organizations, and local authorities to contribute to the assessment. Public consultation can offer important insights into the project's impact on local communities and can lead to the identification of more effective ecological solutions.

Public consultation is conducted through open meetings, information sessions, and online consultations, ensuring that all opinions are considered in the evaluation process. By actively involving citizens and organizations, cross-border environmental expertise becomes a participatory process, contributing to informed and equitable decision-making.

3.6. Post-Project Monitoring

The completion of a project does not mark the end of cross-border environmental expertise. Post-project monitoring is an essential stage to ensure that all protection and mitigation measures are properly implemented and that negative environmental effects are effectively controlled. This monitoring may

include ongoing measurements of water and air quality, monitoring of flora and fauna species, and regular inspections of the infrastructure.

Through post-project monitoring, authorities and stakeholders can identify and address any issues that may arise after project implementation. Additionally, monitoring contributes to improving future environmental assessments by providing relevant data for similar projects (Morgan, 2012).

4. CHALLENGES IN CONDUCTING CROSS-BORDER ENVIRONMENTAL EXPERTISE

The process of cross-border environmental expertise involves numerous challenges that can affect both the quality of the assessment and the implementation of environmental protection measures. These challenges are diverse in nature, encompassing legal, technical, coordination, and financial aspects, and require collaborative and innovative solutions to ensure the success of the evaluation process.

4.1. Legal Challenges

Differences in environmental legislation and standards among countries involved in a cross-border project represent a major obstacle to effective environmental expertise. Each state has its own regulations and requirements regarding environmental protection, which can create difficulties in harmonizing the assessment process. For instance, one country may have stricter standards for pollutant emissions or biodiversity protection than a neighboring country participating in the same project.

This issue can lead to conflicts between states regarding ecological requirements and the necessary mitigation measures. In some cases, states must negotiate to reach a common understanding and adopt uniform standards, but this process can be cumbersome and time-consuming. The solution often involves referring to the international legal framework and applying agreements such as the Espoo Convention to facilitate compliance with shared minimum standards (Espoo Convention 1991).

4.2. Coordination and Communication Issues

Coordination among environmental authorities from different countries represents a critical challenge in cross-border environmental expertise. Each country has its own institutions and environmental agencies, and the lack of effective coordination can lead to confusion and delays in the evaluation process. Additionally, language barriers, differences in organizational culture, and administrative procedures can hinder communication and collaboration among authorities.

To address these issues, states may establish joint commissions or working groups that facilitate information exchange and collaboration between experts and

institutions. The use of online data-sharing platforms and the adoption of clear communication protocols can also help improve coordination and prevent conflicts among authorities.

4.3. Limited Technical and Financial Resources

Conducting cross-border environmental expertise requires financial resources and advanced technical expertise; however, not all participating states have the necessary capacities to carry out such a rigorous evaluation. Transboundary assessments involve the collection of complex data, ecological impact modeling, and public consultation – activities that are costly and require qualified personnel.

Less developed countries or those with limited resources often face difficulties in financing such expertise, which may affect the quality of the environmental assessment. To address this issue, international organizations such as the European Union and the United Nations Environment Programme (UNEP) provide technical assistance and financial support to states in need. International partnerships and the use of external funding sources are essential for ensuring an efficient and fair assessment process.

4.4. Ecosystem Impact Complexity

Assessing the impact on transboundary ecosystems is often complex due to the interdependence of natural ecosystems and the difficulty of estimating long-term effects. For instance, a forest exploitation project in one country may affect biodiversity and the hydrological cycle in a neighboring region, but the consequences of such changes may only become visible over time.

This complexity requires an interdisciplinary approach and advanced ecological modeling tools to evaluate long-term impacts. Environmental experts face challenges in predicting all potential effects of projects on transboundary ecosystems, particularly in the case of large-scale initiatives such as dams, mining operations, or transportation infrastructure. The use of ecological modeling methods and continuous monitoring of environmental parameters are necessary to provide as accurate an assessment as possible.

4.5. Public Participation Challenges

Public consultation and stakeholder involvement in transboundary impact assessment represent an essential stage, though not without challenges. States have different systems for public consultation and transparency, and involving citizens from multiple countries can be difficult due to linguistic and cultural differences.

Moreover, populations in affected regions may hold different perceptions and interests regarding the project, which can lead to disagreements and tensions. For infrastructure or natural resource exploitation projects – such as gas pipelines –

citizens in the countries of origin may be less exposed to risks, while communities in neighboring countries may experience more significant impacts. To facilitate public consultation, authorities can organize open information sessions and ensure that relevant documents are translated for the public in all affected countries.

4.6. Methodological Limitations and Uncertainty

Cross-border environmental expertise also faces methodological challenges, as environmental impact predictions are often based on models and data that may have inherent limitations. Uncertainty regarding the outcomes of ecological models and the difficulty of anticipating all consequences of a project can influence decisions about its implementation (Canter, 1996).

This uncertainty is particularly significant in the case of projects with long-term impacts, such as nuclear power plants or maritime transport developments, where the potential environmental effects are difficult to predict with precision. To mitigate these uncertainties, the involved states may apply the precautionary principle and periodically review impact studies in light of new data and updated technologies.

4.7. Case Study: Danube River Projects

A relevant example of the challenges in cross-border environmental expertise is the case of projects carried out on the Danube River, which flows through ten European countries. Hydroelectric and navigation infrastructure projects on the Danube often pose risks to aquatic biodiversity, water quality, and the health of riparian ecosystems, and these risks directly affect all riparian states (ICPDR, 2020).

Assessing the transboundary impact of such projects requires intensive cooperation among the involved countries and the implementation of complex environmental protection measures. For instance, the construction of hydroelectric dams necessitates evaluation of the effects on water flow, sediment transport, and migratory fish species. In these cases, the involved states must collaborate to identify conservation solutions, such as creating ecological corridors or implementing pollution reduction technologies.

5. CONCLUSIONS

Cross-border environmental expertise plays a crucial role in environmental protection and in ensuring a balance between economic development and the conservation of natural resources. In a world where many infrastructure and development projects affect territories across multiple countries, cross-border expertise is an indispensable tool for assessing environmental impact, minimizing risks, and preventing ecological conflicts between states.

This form of expertise supports not only environmental protection but also international cooperation and sustainable development, ensuring that economic

interests do not compromise the health of ecosystems and the well-being of communities.

The challenges associated with cross-border environmental expertise are significant and include regulatory differences between countries, difficulties in coordination among authorities, lack of financial and technical resources, as well as the complexity of assessing impacts on ecosystems. These difficulties underline the need for a well-structured international legislative framework, such as the Espoo Convention, and for financial and technical support measures provided by international organizations.

Recommendations for Improving Cross-Border Environmental Expertise:

- Harmonization of Environmental Standards: It is essential for states to harmonize their environmental standards in order to facilitate the cross-border evaluation process and to avoid conflicts. Adopting common norms and guidelines based on best ecological practices can contribute to more effective assessments and better environmental protection.
- Strengthening International Cooperation and Regional Partnerships: Cross-border projects require close collaboration among states. Joint commissions and working groups, supported by international organizations, can facilitate coordination among authorities and improve the quality of environmental assessments.
- Increasing Transparency and Public Participation: Public consultation and the involvement of stakeholders from all affected states are essential to the success of cross-border expertise. Informing citizens and providing participation opportunities ensure a comprehensive assessment and contribute to public acceptance of the projects.
- Supporting States with Limited Resources: Countries with limited financial and technical capacities need support to conduct rigorous assessments. International funding and technical assistance provided by bodies such as the European Union and the United Nations Environment Programme are crucial for strengthening these states' ability to engage in cross-border environmental evaluations.
- Use of Advanced Monitoring and Ecological Modeling Methods: Ecological simulation models, GIS, and remote sensing technologies can contribute to a better understanding of the impact of projects on the cross-border environment and allow for the anticipation and monitoring of long-term effects. Implementing advanced technologies can reduce uncertainty and increase the precision of assessments.

In conclusion, cross-border environmental expertise is an essential tool for ensuring a healthy environment and promoting sustainable development in a global context. Through international cooperation, technical and financial support, and the active involvement of all stakeholders, states can contribute to the

protection of ecosystems and to a sustainable future, where economic development does not compromise ecological integrity.

References

- 1) Canter, L.W. (1996). Environmental Impact Assessment. 2nd ed. McGraw-Hill.
- 2) Convention on Biological Diversity (CBD) (1992). Text of the Convention, [online] Available at: <https://www.cbd.int/convention/> [Accessed 12 June 2025].
- 3) European Commission (2011). Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (EIA Directive). Official Journal of the European Union, L26/1.
- 4) European Commission (2000). Directive 2000/60/EC establishing a framework for Community action in the field of water policy (Water Framework Directive). Official Journal of the European Union, L327/1.
- 5) European Commission (2007). Directive 2007/60/EC on the assessment and management of flood risks (Floods Directive). Official Journal of the European Union, L288/27.
- 6) European Commission (1992). Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive). Official Journal of the European Union, L206/7.
- 7) European Commission (1979). Directive 79/409/EEC on the conservation of wild birds (Birds Directive). Official Journal of the European Union, L103/1.
- 8) European Environment Agency (2018). GIS and Remote Sensing for Environmental Assessment. [online] Available at: <https://www.eea.europa.eu> [Accessed 13 June 2025].
- 9) Espoo Convention (1991). Convention on Environmental Impact Assessment in a Transboundary Context. United Nations Economic Commission for Europe (UNECE), Espoo, Finland. [online] Available at: <https://unece.org/environment-policy/environmental-assessment> [Accessed 13 June 2025].
- 10) Glasson, J., Therivel, R. and Chadwick, A. (2013). Introduction to Environmental Impact Assessment. 4th ed. Routledge.
- 11) Helsinki Convention (1992). Convention on the Protection and Use of Transboundary Watercourses and International Lakes. United Nations Economic Commission for Europe (UNECE). [online] Available at: <https://unece.org/water> [Accessed 13 June 2025].
- 12) ICPDR (2020). International Commission for the Protection of the Danube River. [online] Available at: <https://www.icpdr.org> [Accessed 13 June 2025].
- 13) Jay, S., Jones, C., Slinn, P. and Wood, C. (2007). Environmental Impact Assessment: Retrospect and Prospect. Environmental Impact Assessment Review, 27(4), pp.287-300.
- 14) Kidd, S. and Fischer, T.B. (2020). Strategic Environmental Assessment and Land Use Planning: An International Evaluation. Earthscan.
- 15) Morgan, R.K. (2012). Environmental impact assessment: the state of the art. Impact Assessment and Project Appraisal, 30(1), pp.5-14.
- 16) Petts, J. (1999). Handbook of Environmental Impact Assessment. Vol. 1. Blackwell Science.
- 17) UNEP (2021). Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach. United Nations Environment Programme. [online] Available at: <https://www.unep.org/resources/toolkits-manuals-and-guides/environmental-impact-assessment-and-strategic-environmental> [Accessed 13 June 2025].

ANALYSING CIRCULAR ECONOMY VALUE CHAINS WITH A FOCUS ON STAKEHOLDER ENGAGEMENT AND COLLABORATION DYNAMICS

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Abstract:

The article proposes a critical reconfiguration of traditional value chains, from a linear logic – oriented towards extraction, consumption and disposal – to a circular architecture, in which resources are rethought, reused and reintroduced into sustainable production cycles. This transition is analysed through the lens of interactions between diverse actors, emphasising the complexity of stakeholder engagement and the dynamics of cross-sectoral collaboration. Theoretically grounded in the circular economy paradigm as a strategy for sustainable development, the study examines how circular design and collaborative governance become key tools in increasing resource efficiency and reducing waste. The investigative approach pays particular attention to the concerted participation of relevant actors – governments, businesses, civil society and local communities – in the co-creation of circular solutions, focusing in particular on the socio-economic context of Romania and the Republic of Moldova. The central argument is that the viability of the circular economy cannot be separated from the existence of solid collaboration mechanisms, distributed leadership within the network, transparent communication, and coherent public policies and appropriate economic incentives. In conclusion, the article emphasises that a truly resilient and inclusive circular economy can only be achieved through collective, adaptive efforts that are deeply rooted in local and regional realities. Thus, the circular economy is not just a technical model for optimising resources, but an emerging form of ecological social contract based on solidarity, shared responsibility and collective learning.

Keywords: circular economy, value chains, inter-organisational collaboration, stakeholder engagement, sustainability

JEL Classification: Q01, Q56

1. INTRODUCTION

The circular economy is now emerging as a fundamentally alternative model of sustainable development to the traditional linear paradigm – that of ‘take, make, consume, dispose’ – by proposing a closed-loop approach, in which resources are kept in circulation for as long as possible, waste is minimised and the value of materials is continuously regenerated (Kirchherr *et al.*, 2018; Stahel, 2016). This concept, which has gained global traction amid growing concerns about the depletion of natural resources and multiple environmental impacts, highlights the urgent need to rethink resource management with a view to ecological and economic efficiency (United Nations General Assembly, 2015; Dobre-Baron *et al.*, 2022). Far from being a simple technical adjustment, the circular economy is a critical and systemic response to the structural inefficiencies of the linear economy, which is based on an extractive and dissipative logic, where resources gradually lose their value over a one-way journey. Breaking with this wasteful logic, the circular model aims not only to slow down the flow of materials, but also to restore and maintain their value through strategies such as consumption reduction, reuse, repair and recycling. This paradigm shift, brought to the forefront by pioneering initiatives such as the Ellen MacArthur Foundation (2013) and consolidated by academic research (Plotnic & Praporšćic, 2024; Kirchherr *et al.*, 2017), is therefore not limited to technical and industrial innovation: it involves a profound reconfiguration of the relationship that societies have with the materiality of the economy, natural resources and ecosystem balances. In this sense, the circular economy is less a solution than a framework for thinking, a call to revisit the very foundations of production and consumption from an ethical, responsible and sustainable perspective.

2. MATERIALS AND METHODS

The conceptual and political rise of the circular economy in recent decades has been catalysed by a number of significant institutional initiatives. The Ellen MacArthur Foundation has played a central role in articulating a coherent economic narrative in favour of the circular transition, bringing to the attention of policymakers and market actors not only the environmental benefits but also the economic opportunities of this model (Ellen MacArthur Foundation, 2013). In parallel, the European Union has integrated the circular economy into the heart of its sustainable development strategies through policy documents such as the Circular Economy Action Plan (European Commission, 2015, 2020), which propose closing value loops and transforming circularity into a vector for competitiveness. In a broader context, the United Nations has anchored the principles of the circular economy in its global sustainable development goals, in particular SDG 12 – Responsible consumption and production (United Nations

General Assembly, 2015), thereby strengthening the universal and cross-sectoral status of this model.

Walter R. Stahel, one of the pioneers of the concept, argues that a circular economy generates "*a new relationship with our goods and materials*", with the potential to save resources, reduce pollution and create jobs locally (Stahel, 2016). The opening of the current framework for reflection on the circular economy highlights the imperative of rethinking value chains in a circular manner, going beyond the mere technological dimension or business model innovation. There is an increasing focus on the need for multisectoral cooperation to anchor the transformations in a broad collaborative framework in which the actors involved – from public institutions and the private sector to civil society and academia – act synergistically.

An essential step in this direction is to identify and address the specificities of value chains in the circular economy, understood not only as economic structures but as dynamic networks of interaction between stakeholders. Their active and conscious participation is not just a contextual element but a determining factor for success in the transition to circularity. In this regard, recent analysis – from both a theoretical and applied perspective – highlights the nuanced ways in which interdependencies between actors shape the trajectory of implementation.

Contributions from Romania and Moldova provide a valuable framework for contextualised understanding of these processes, highlighting not only the systemic challenges of the region, but also its adaptive capacity and local innovation potential. These regional perspectives are not mere appendices to the global discourse on circularity, but constitute important landmarks for understanding how the circular economy can be anchored in diverse socio-economic realities and, through this, become sustainable and resilient in the long term.

3. CORE CONTENT

Circular economy value chains are the network of activities and partnerships through which products maintain their value throughout their extended life cycle. Instead of the value of materials being lost at the end of use, as happens in a linear value chain, in a circular value chain materials and components are reintegrated into production, repaired or recycled so as to create new value cycles (Kirchherr *et al.*, 2017; Zucchella & Previtali, 2018). With circular design, products are designed from the outset to facilitate the disassembly and reuse of components, and waste from one industry can become a resource for another – a concept known as *waste-as-food* in the literature (Zucchella & Previtali, 2018). This ecosystemic model typically involves business model innovation and close co-operation along the entire value chain, from suppliers and producers to distributors, consumers and recyclers (Ellen MacArthur Foundation, 2013; Farooque *et al.*, 2019).

A key feature of circular value chains is their systemic and integrated nature, requiring inter-organisational coordination. For example, closing the materials loop in an industry such as electronics or textiles requires collaboration between producers (facilitating repairability and recycling), consumers (returning or handing in used products), collection and recycling centres, and policy makers who can incentivise these practices through regulation (OECD, 2020; Kirchherr *et al.*, 2018). The World Economic Forum emphasises that an effective circular value chain relies on deep collaboration between diverse actors (World Economic Forum, 2019), including private companies, non-governmental organisations, local communities and authorities, so that all links – from the design stage to waste management - are aligned towards common goals. There is also an emphasis on the *inclusiveness* of circular value chains, where marginalised communities or local groups can play an active role and benefit from the transition, thus avoiding the repetition of inequalities in previous development models (Milošević *et al.*, 2025).

Studies emphasise that transforming traditional value chains into circular value chains brings multiple benefits as well as challenges. The advantages of transitioning to a circular economy are numerous: more efficient use of resources, substantial long-term savings, and the emergence of new opportunities for innovation and business models (Stahel, 2016; Ellen MacArthur Foundation, 2013). However, this systemic transformation is not without challenges. One of the main obstacles is the need for a high degree of coordination and cooperation between the various actors in the value chain – a requirement that goes far beyond that imposed by the traditional linear model. This need for inter-organisational collaboration, which is often complex, becomes even more difficult when certain actors, whether producers or consumers, show little interest or do not clearly perceive the benefits – or even the necessity – of such a transition (Kirchherr *et al.*, 2018).

Extensive research conducted at the European Union level confirms that *consumer disinterest* and *cultural reluctance within companies* are among the main barriers to the widespread adoption of circular practices, even ahead of technological barriers (Kirchherr *et al.*, 2017). It therefore appears that the obstacles are not only technical or economic, but also deeply cultural and institutional.

Indeed, the lack of an organisational culture conducive to change, combined with consumer disengagement, weakens the systemic dynamics necessary for the circular reconstruction of value chains. Thus, for the circular economy to truly take root, it is imperative to move beyond purely economic rationality and think about transformation from a holistic perspective that includes the social, cultural and behavioural dimensions of collective action.

This situation highlights the crucial importance of the active and concerted involvement of all relevant actors. The successful reconfiguration of value chains

into a circular paradigm cannot take place without alignment to a common vision, supported by appropriate incentives and an institutional framework that fosters deliberative participation. From this perspective, stakeholder involvement and collaborative dynamics are not only enabling conditions but essential elements for the operationalisation of a genuine circular economy – aspects that will be detailed in the following sections. From a resolutely systemic perspective, the circular economy mobilises a diverse range of stakeholders whose coherent interaction is essential to the effective implementation of its underlying principles. These stakeholders – or *acteurs concernés* in French terminology – cover a broad spectrum: public authorities (at local and national level), private companies throughout the value chain, non-governmental organisations, academic and research institutions, local communities and citizens as consumers or end users.

Due to its holistic nature, the circular economy requires a profound structural transformation in which all actors – whether from the public sector, the private sector, the scientific community or civil society – have a role to play. As the OECD points out, this transition ‘requires systemic change, involving all stakeholders, from citizens to knowledge institutions’ (OECD, 2020). As a result, the effective involvement of stakeholders is not simply a procedural addition, but a prerequisite for designing and implementing robust and sustainable circular economy strategies.

Many international organisations emphasise the need to engage these stakeholders in an inclusive, transparent and structured manner in decision-making processes relating to the circular economy (OECD, 2020; Ellen MacArthur Foundation, 2021). The OECD specifies that consultation should include ‘different levels of governance (multi-level), the private sector, regulators, service providers, development agencies, investors, and civil society in its various forms (citizens, NGOs, consumer movements, etc.), "illustrating the inherent plurality and complexity of circular governance (OECD, 2020). etc.)", thus illustrating the plurality and complexity inherent in circular governance (OECD, 2020).

This participatory approach, based on inclusiveness, provides a better understanding of the specific needs of each category of actors, while strengthening the democratic legitimacy of the policies adopted. At the same time, it increases the chances of success of circular initiatives by promoting their collective ownership and adaptation to local realities.

Early and active stakeholder involvement has multiple benefits: it increases stakeholder buy-in and trust in circular projects, facilitates social acceptance of new models (e.g. second-hand products, packaging return systems) and allows early identification of possible obstacles or divergent views (OECD, 2020; Kirchherr *et al*, 2018). For example, governments developing national circular economy strategies have set up consultation platforms with business and civil society: the case of the European Circular Economy Stakeholder Platform

launched in 2017 is illustrative, bringing together networks and best practices from across Europe in a joint effort to accelerate the transition (Ellen MacArthur Foundation, 2021). At the national level, countries that actively involve citizens and consumer organisations in circularity policies – such as the Netherlands, which is revising its circular roadmap by putting the citizen at the centre – are achieving better results in changing consumption behaviour (OECD, 2020).

Companies from different sectors are also collaborating with NGOs and research institutions to develop innovative circular solutions, from biodegradable packaging to sharing platforms. In these multi-stakeholder collaborative networks, it is sometimes necessary to have an "*orchestrator*" – a central entity that facilitates interactions, aligns the parties' goals and manages joint projects (Zucchella & Previtali, 2018). Involving dedicated *innovation champions* or project leaders can increase the chances of success, as they can balance the individual stakeholder interests with the network's common goal (Batista *et al.*, 2018; Zucchella & Previtali, 2018). The literature shows that when the needs and roles of different stakeholders are explicitly identified and addressed, commitment and joint decisions are facilitated (Frishammar & Parida, 2019; OECD, 2020). Public-private partnerships in waste management or extended producer responsibility schemes are not simply technocratic formulas; they are, in fact, complex arenas of negotiation between authorities, producers and recyclers operating in an often fragmented socio-economic landscape. Without a clear framework for communication and delineation of responsibilities, the effectiveness of these mechanisms risks being compromised and their transformative potential wasted (OECD, 2020).

In Romania and the Republic of Moldova, the involvement of relevant actors in circular economy initiatives is still at an early but promising stage, as the concept begins to be internalised at the local level. Romania, supported by European structures, has outlined a national strategy for the circular economy, a process in which experts, representatives of the business community and civil society were consulted – an essential step in formulating coherent and prioritised implementation measures (European Commission, 2020). The literature indicates that, although the conditions for a genuine transition to a circular economy exist – especially in the context of external pressures and alignment with EU policies – achieving these objectives remains dependent on collaborative perseverance between the government, the private sector and citizens (Dobre-Baron *et al.*, 2022; Milošević, Arsić, & Stojanović, 2023).

In the Republic of Moldova, the challenges are different but no less significant. Recent research highlights the need to adapt the principles of the circular economy to the structural realities of the national economy, suggesting that there can be no successful model without a strategic algorithm for action. This algorithm should include reducing pressure on the environment and optimising the use of resources – a task that is impossible to achieve without cohesion

between the government, local businesses and civil society (Ganea *et al.*, 2022). In fact, without joint commitment and active participation from these parties, strategies remain exercises in good intentions with limited practical relevance – a lesson that is universally valid in any transition to circularity.

Thus, what appears to be a technical process of implementing environmental policies becomes, in essence, a challenge of participatory governance, where success depends on building trust, institutional coherence and the ability of each society to transform global principles into locally adapted solutions.

In conclusion, stakeholder involvement in the circular economy is not only desirable, but mandatory: only through *co-creation* and *continuous dialogue* between actors can widely accepted solutions be generated and obstacles such as lack of trust or resistance to change be avoided (Kirchherr *et al.*, 2018; OECD, 2020). This level of engagement sets the stage for the dynamics of collaboration, which will be discussed below.

Collaboration between stakeholders in circular value chains is a dynamic, often complex process, involving coordination, communication and alignment of objectives between actors with different perspectives and interests. The dynamics of collaboration evolve over time as partners learn to work together, share information and adjust their practices to achieve the common goal of circularity. The literature highlights some key aspects of successful collaboration in the context of the circular economy:

a. Establishing a common vision and shared goals: A critical factor is that all actors involved – be they producers, authorities or NGOs – agree on the overall goals (e.g. reducing waste by X% or increasing recycling rates to a certain level) and the values that guide the collaboration (Ellen MacArthur Foundation, 2021; OECD, 2020). A clear vision, communicated at the outset, helps to motivate the parties towards *common goals*, even if their individual interests may differ. Ishii and van Houten (co-chairs of the Platform for Accelerating the Circular Economy) emphasise the need for "*deep collaboration between business, government and civil society*" to achieve a resilient circular economy, pointing out that only by combining the knowledge, power and influence of these actors can systemic results be achieved (Ellen MacArthur Foundation, 2021). In other words, effective collaboration is based on empathy and an understanding of each partner's motivations, allowing points of convergence to be identified.

b. The role of orchestrators and network leaders: In many large-scale circular initiatives there are entities or leaders that act as "orchestrators" of the network of stakeholders, facilitating co-operation. Focusing around a central actor – which can be an innovative company, a visionary local authority or a collaborative platform – helps to coordinate tasks and maintain common momentum (Zucchella & Previtali, 2018; Kujala *et al.*, 2023). For example, a *focal firm* in an agricultural circular chain can coordinate farmer cooperatives, processors, retailers, and phytosanitary authorities, ensuring that everyone fulfils

their role and that information flows from one end of the chain to the other (Zucchella & Previtali, 2018). Such orchestrators create spaces for sustainable interaction, such as public-private partnerships or circular industry clusters, and can act as mediators when tensions or conflicts of interest arise between parties (Batista *et al.*, 2018). The result is often increased trust between partners and greater joint decision-making capacity, which are essential for complex projects involving joint investment and benefit sharing (Kujala *et al.*, 2023).

c. Communication mechanisms and knowledge sharing: Effective collaboration requires transparency and continuous communication. Regular meetings, digital data-sharing platforms, and common performance indicators can support alignment and monitoring of progress (Frishammar & Parida, 2019). In the circular economy, where innovation is often incremental and experimentation-based, *mutual learning* between partners plays a key role (Oberholzer *et al.*, 2023). For example, a manufacturer can learn from a recycler about how to optimally design a package for recycling, while the recycler can learn from the manufacturer about new materials being introduced to the market. Such knowledge exchanges, sometimes facilitated by coordinated stakeholder networks or joint pilot projects, can lead to process or product innovations beneficial to all parties (Farooque *et al.*, 2019; Ascione *et al.*, 2021). Of course, for these exchanges to take place, a climate of trust and an attitude of *open innovation* is needed, where parties are willing to share sensitive information knowing that the long-term benefit is mutual.

d. Creating the right incentives and frameworks for collaboration: cross-sectoral collaboration often needs an external impetus, either in the form of economic incentives (grants, co-financing, tax benefits for circular projects) or regulations mandating cooperation (such as reporting obligations or recovery targets imposed on companies) (OECD, 2020; European Commission, 2020). One example is *deposit-payment* schemes for packaging, which induce retailers, manufacturers and local authorities to co-operate on collection and return systems for reusable packaging. The dynamics of collaboration in such cases are influenced by how costs and benefits are shared: it is important that no actor perceives that it bears the costs of the transition alone, while others reap the benefits (Kirchherr *et al.*, 2018). Here, participatory governance and honest dialogue become key to adjust the collaborative framework - for example, by negotiating purchase prices for recycled materials or sharing savings from efficiencies (OECD, 2020).

e. Overcoming obstacles to collaboration: Even with common goals, collaboration can be hampered by obstacles such as differences in organisational culture, lack of mutual trust or communication problems. Research indicates that many of these obstacles can be mitigated through trust-building initiatives - for example, through successful small projects carried out together that create a positive track record of partnership (Kirchherr *et al.*, 2018). It is also useful to

involve neutral third parties (such as mediators, consultants or support organisations) to facilitate dialogue and provide independent technical expertise when the parties fail to reach technical or economic consensus (OECD, 2020). Another aspect is the adaptability of collaboration: circular value chains are constantly evolving due to technological advances (e.g. the emergence of digital collaborative economy platforms or monitoring technologies through the Internet of Things), so partnerships need to be *flexible* and willing to recalibrate their mode of cooperation along the way (Awan *et al.*, 2021; Geissdoerfer *et al.*, 2017). The ability to jointly innovate - to develop circular business models together - is the next level of collaboration, where parties create new value that they could not have achieved individually (Frishammar & Parida, 2019; Geissdoerfer *et al.*, 2018).

4. RESULTS AND DISCUSSIONS

Overall, the dynamics of collaboration in the circular economy are characterised by an *ecosystem approach*: each actor realises that it is part of a wider system and that its own performance depends to a large extent on the performance of others. Creating the conditions for collaboration – either through public policy or voluntary industry initiatives – thus becomes a priority. The Ellen MacArthur Foundation (2021) emphasises that achieving system-wide solutions requires well-coordinated collective efforts: the traditional compartmentalised way of working (in *silos*) is no longer effective in the face of systemic challenges such as environmental challenges. Instead, joint teams, cross-sectoral partnerships and innovation networks are being promoted, with each contributing its own expertise. Through these collaborative mechanisms, circular value chains are realised and the benefits – economic, social and environmental – are amplified for all involved.

The transition to the circular economy is at an early stage in Eastern Europe, but interest and initiatives in Romania and the Republic of Moldova have visibly increased in recent years. In Romania, alignment with European policies has led to concrete steps: the elaboration of the National Strategy for the Transition to the Circular Economy (2022-2030) involved consultation with domestic stakeholders, and the related Action Plan foresees measures in areas such as waste management, eco-design in industry, sustainable consumption and circular innovation (European Commission, 2020). Academic research shows that Romania starts from a relatively low level of circularity indicators (e.g. municipal waste recycling rates below the EU average and a low rate of reuse of materials) – fluctuations detailed by Oana Dobre-Baron *et al.* (2022) point to precisely these challenges, especially in the area of packaging and household waste. However, in the long term, econometric models suggest favourable premises for improving these indicators if policies are implemented consistently and private actors increase their investments in the necessary technologies (Dobre-Baron *et al.*, 2022). A key element highlighted in work on the transition to a circular economy is the

importance of raising awareness and increasing participation, both among the public and among businesses. Without significant changes in consumer behaviour and without the active involvement of businesses in waste reduction, the strategic objectives set will be difficult to achieve. In this regard, coalitions and platforms bringing together stakeholders interested in circular dynamics are emerging in Romania. The Circular Economy Coalition (CERC), for example, is working to promote the objectives of the European Union's Circular Economy Action Plan at the national level by supporting the development of new circular markets and sustainable economic models (Circular Economy Coalition, n.d.). These participatory networks help to build a collaborative dynamic by creating spaces for dialogue between public institutions, businesses and civil society.

In the Republic of Moldova, the circular economy is beginning to be integrated mainly through waste management and resource efficiency issues, within the broader framework of national efforts to promote sustainable development. Although Moldova is not a member of the European Union, European trends are nevertheless increasingly influencing the national environmental agenda. In 2022, a group of Moldovan and Romanian authors (Ganea *et al.*, 2022) analysed the circular economy as a relevant prospective model for Moldova, highlighting the need to adapt its principles to the specific realities of the local context. Their analysis calls for a reduction in environmental pressure through policies focused on reuse and optimal resource recovery, while also calling for the development of an institutional framework capable of providing concrete support for the functioning of the circular economy in the Moldovan socio-economic space (Ganea *et al.*, 2022).

This perspective once again highlights that the transition to a circular economy cannot succeed without deep societal roots, shared governance and a collective capacity to translate global principles into concrete actions adapted to local contexts.

Among the reported challenges are underdeveloped recycling infrastructure, lack of economic incentives for companies to adopt circular models, and a low level of public awareness of the benefits of circularity. However, there are positive steps: the involvement of non-governmental organisations such as *e-Circular* (an association founded in 2010 to promote circular economy in Moldova) running education and pilot projects at local level, or cross-border collaborations bringing expertise from Romania to develop pilot circular economy strategies at municipal level. A notable example is the national conference "Circular Economy in the Republic of Moldova" (2023), where topics such as waste management, extended producer responsibility and financing of circular projects were discussed by authorities, academia and the private sector, a sign that multi-stakeholder dialogue is starting to take shape here as well.

In both Romania and Moldova, a determining factor for the success of circular initiatives will be the strengthening of partnerships. European funds and

international technical assistance can provide important catalysers, but implementation depends on the capacity of local actors to collaborate effectively. In Romania, the application of circular economy principles in sectors such as construction, textiles, agriculture or waste management requires co-operation between private firms and authorities, as well as the active participation of local communities to embrace and support change (European Commission, 2020). In Moldova, where financial resources and infrastructure are more limited, collaboration becomes all the more necessary to share costs and benefit from synergies; for example, industrial parks could be rethought along the lines of *industrial symbiosis* - businesses sharing resources and waste streams – but this requires policy coordination and strong public-private partnerships (Ganea *et al*, 2022).

In conclusion, the regional perspective confirms on a smaller scale the general conclusions: engagement and collaboration remain the cornerstones of the circular economy. Without a real engagement of stakeholders across sectors and a collaborative dynamic that generates trust and joint action, circular value chains cannot be built and sustained in the long term. Both Romania and Moldova are on the necessary trajectory, but the pace and scale of the transition will depend on the extent to which key actors work together to overcome existing barriers and capitalise on the opportunities of a circular economy.

5. CONCLUSIONS

The transition to circular economy value chains is a complex endeavour, requiring both technological and organisational transformations, underpinned by a new collaborative paradigm. This analysis has highlighted that stakeholder involvement and the dynamics of collaboration between stakeholders are not secondary elements, but central success factors in the implementation of the circular economy. The theoretical underpinning and practical examples clearly show that a circular economy cannot be built in isolation: it "*requires a system change*" in which governments, business, academia and citizens act in concert. Circular value chains require ecosystem partnerships, in which value is co-created, distributed and recaptured through joint endeavour (Zucchella & Previtali, 2018; Ellen MacArthur Foundation, 2013).

As the literature progresses and more empirical studies become available, the evidence on the role of collaboration is also strengthening: cities and regions that have adopted participatory approaches and facilitated collaboration between parties demonstrate higher success rates in circular projects (OECD, 2020). Mutual trust, shared vision and open communication have proven to be indispensable ingredients of successful initiatives, be it industrial symbiotic networks, collaborative economy platforms or national recycling schemes (Frishammar & Parida, 2019; Kirchherr *et al*, 2018). At the same time, it appears that barriers to the adoption of the circular economy – such as a reluctant organisational culture or a lack of awareness – can only be overcome by directly

involving the relevant stakeholder groups. This requires consumer education, the introduction of incentives for businesses through public policy, and the active involvement of civil society in deliberative processes (Kirchherr *et al.*, 2018; European Commission, 2020).

In the case of Romania and the Republic of Moldova, these findings are particularly relevant. Although their economic and social contexts are different, these two countries share a common potential: that of benefiting from the integration of circular principles into their value chains, provided that they develop effective collaboration mechanisms, both internally and externally. Recent academic work in the region (Dobre-Baron *et al.*, 2022; Ganea *et al.*, 2022) also emphasises the need for a contextualised and cooperative approach, involving local actors in defining solutions tailored to their realities.

Furthermore, the involvement of these countries in regional and international initiatives related to the circular economy – whether European platforms or partnerships with organisations such as the OECD or the UN – opens up significant opportunities for the exchange of best practices and access to strategic resources that could accelerate progress at the national level.

What the research reveals is that circular economy value chains are not built in isolation: they are built through cooperation. Stakeholder participation is not simply a procedural requirement, but the very driving force behind innovation and resilience in these new economic models. Positive collaborative dynamics – whether in the form of strategic alliances, orchestrated networks or participatory mechanisms – transform the challenges of transition into opportunities for sustainable development.

Thus, the circular economy can no longer be considered a mere theory or normative framework; it is increasingly emerging as a partnership-based practice that reconciles economic objectives with social and environmental imperatives (Stahel, 2019; Ellen MacArthur Foundation, 2021). Fully realising this vision will require perseverance and continuous adaptation, but the expected benefits – ecosystem protection, job creation, emergence of new markets – fully justify collective investment in energy and cooperation (Tjiptadjaja & François-Ferrière, 2024).

In closing, we can say that circular value chains are, at their core, chains of collaboration: they bring governments, businesses and communities together in a common endeavour to rethink how we create and sustain value. The future of the circular economy depends on strengthening these links and on our collective ability to learn from each other, to innovate together and to act in solidarity towards a common goal – a sustainable future.

References

- 1) Ascione, G.S., Cuomo, F., Mariotti, N. *et al.* (2021). *Urban Living Labs, Circular Economy and Nature-Based Solutions: Ideation and Testing of a New Soil in the City of Turin Using a Multi-stakeholder Perspective*. *Circ. Econ. Sust.* 1, 545–562. <https://doi.org/10.1007/s43615-021-00011-6>
- 2) Awan, U., Sroufe, R., & Shahbaz, M. (2021). *Industry 4.0 and the circular economy: A literature review and recommendations for future research*. *Business Strategy and the Environment*, 30(4), 2038–2060. DOI: 10.1002/bse.2731
- 3) Batista, L., Bourlakis, M., Liu, Y., Smart, P., & Sohal, A. (2018). Supply chain operations for a circular economy. *Production Planning & Control*, 29(6), 419–424. <https://doi.org/10.1080/09537287.2018.1449267>
- 4) Circular Economy Coalition (CERC). (n.d.). *Coaliția pentru Economie Circulară – Obiective și inițiative în România*. Recuperat din Circular Economy EU Platform: <https://circulareconomy.europa.eu/platform/en/dialogue/existing-eu-platforms/cerc-coalitia-pentru-economie-circulara-circular-economy-coalition>
- 5) Dobre-Baron, O., Nițescu, A., Niță, D., & Mitran, C. (2022). *Romania's perspectives on the transition to the circular economy in an EU context*. *Sustainability*, 14(9), 5324. <https://doi.org/10.3390/su14095324>
- 6) Ellen MacArthur Foundation. (2013). *Towards the circular economy: Economic and business rationale for an accelerated transition* (Vol. 1). Ellen MacArthur Foundation. <https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an>
- 7) Ellen MacArthur Foundation. (2021, August 16). *Fostering collaboration to obtain system-level solutions*. Ellen MacArthur Foundation (Policy & Business section). <https://www.ellenmacarthurfoundation.org/covid-19-fostering-collaboration-to-obtain-system-level-solutions>
- 8) European Commission. (2015). *Closing the loop – An EU action plan for the Circular Economy* (COM/2015/614 final). Bruxelles: Comisia Europeană. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614>
- 9) European Commission. (2020). *Circular economy action plan: For a cleaner and more competitive Europe*. European Commission. <https://www.eu2020.de/resource/blob/2429166/156d2d98b66b2ff28b6990161eed91e9/12-17-kreislaufwirtschaftsaktionsplan-bericht-de-data.pdf>
- 10) Farooque, M., Zhang, A., Thurer, M., Qu, T., & Huisingsh, D. (2019). *Circular supply chain management: A definition and structured literature review*. *Journal of Cleaner Production*, 228, 882–900. <https://doi.org/10.1016/j.jclepro.2019.04.303>
- 11) Frishammar, J., & Parida, V. (2019). *Circular business model transformation: A roadmap for incumbent firms*. *California Management Review*, 61(2), 5–29. <https://doi.org/10.1177/0008125618811926>
- 12) Ganea, V., Trushkina, N., Țirlea, M. R., & Bîrcă, I. (2022). *Economia circulară – un model de perspectivă pentru Republica Moldova* [Circular economy – a perspective model for the Republic of Moldova]. *Univers Strategic*, 4(52), 52–68.
- 13) Geissdoerfer, M., Morioka, S. N., de Carvalho, M. M., & Evans, S. (2018). "Business models and supply chains for the circular economy." *Journal of Cleaner Production*, 190, 712–721. doi: 10.1016/j.jclepro.2018.04.159

- 14) Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). *The Circular Economy – A new sustainability paradigm?* Journal of Cleaner Production, 143, 757-768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- 15) Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Müller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). *Barriers to the circular economy: Evidence from the European Union (EU)*. Ecological Economics, 150, 264-272. <https://doi.org/10.1016/j.ecolecon.2018.04.028>
- 16) Kirchherr, J., Reike, D., & Hekkert, M. (2017). *Conceptualizing the circular economy: An analysis of 114 definitions*. Resources, Conservation & Recycling, 127, 221-232. <https://doi.org/10.1016/j.resconrec.2017.09.005>
- 17) Kujala, J., Heikkinen, A., & Blomberg, A. (Eds.). (2023). *Stakeholder engagement in a sustainable circular economy: Theoretical and practical perspectives*. Springer Nature. <https://doi.org/10.1007/978-3-031-31937-2>
- 18) Milošević, I., Arsić, S., Stojanović, A. (2023). Corporate Social Responsibility, Circular Economy and Sustainable Development: Business Changes and Implications in Project-Oriented Companies. In: Obradović, V. (eds) Sustainable Business Change. Springer, Cham. https://doi.org/10.1007/978-3-031-23543-6_5
- 19) Milošević, I., Plotnic, O., Stanković, Z., Tick, A., & Buzdugan, A. (2025, February 14–16). *Circular economy as a strategic imperative for fostering sustainability and consumer engagement (K02140)*. In R. Mitoula (Ed.), Book of Abstracts – 2nd Open-Air Cities International Conference: Local and Regional Sustainable Development and Urban Reconstruction. Harokopio University of Athens. ISBN 978-618-87070-3-0.
- 20) Oberholzer, S., & Sachs, S. (2023). *Engaging Stakeholders in the Circular Economy: A Systematic Literature Review*. In: J. Kujala, A. Heikkinen & A. Blomberg (Eds.), *Stakeholder Engagement in a Sustainable Circular Economy* (pp. 57–97). Palgrave Macmillan Cham. https://doi.org/10.1007/978-3-031-31937-2_3
- 21) OECD. (2020). *The Circular Economy in Cities and Regions: Synthesis Report*. Paris: OECD Publishing. <https://doi.org/10.1787/10ac6ae4-en>
- 22) Plotnic, O., & Praporšćic, V. (2024, May 17–18). *Legal adaptation strategies for unforeseen events in the circular economy through the integration of resilience and material reuse*. In European Financial Resilience and Regulation (pp. 256–270). Iași: Universitatea „Alexandru Ioan Cuza” din Iași. ISBN 978-606-714-891-6; ISSN 3044-8689.
- 23) Stahel, W. R. (2016). *The circular economy*. Nature, 531(7595), 435-438. <https://doi.org/10.1038/531435a>
- 24) Stahel, W. R. (2019). *The Circular Economy: A User's Guide*. Londra: Routledge. 118 p.
- 25) Tjiptadjaja, T., & François-Ferrière, M. (2024, May 29). *5 critical actions to establish inclusive, collaborative and sustainable circular value chains*. World Economic Forum. Retrieved from <https://www.weforum.org/stories/2024/05/5-critical-actions-to-establish-inclusive-circular-value-chains/>
- 26) United Nations General Assembly. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development (A/RES/70/1)*. New York: United Nations. <https://sdgs.un.org/2030agenda>
- 27) World Economic Forum. (2019). *Platform for accelerating the circular economy (PACE): A global public-private collaboration platform and project accelerator*.

- Prepared in collaboration with Accenture Strategy. https://www3.weforum.org/docs/WEF_PACE_Platform_for_Accelerating_the_Circular_Economy.pdf
- 28) Zucchella, A., & Previtali, P. (2018). *Circular business models for sustainable development: A “waste is food” restorative ecosystem*. *Business Strategy and the Environment*, 28(2), 274-285. <https://doi.org/10.1002/bse.2216>

FOSTERING THE CIRCULAR ECONOMY THROUGH FISCAL POLICY: INSIGHTS FROM ALBANIA AND THE WESTERN BALKANS

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Abstract

The circular economy (CE) provides a revolutionary economic model for sustainable development by reducing waste, reusing resources, and encouraging eco-friendly practices. Fiscal policy plays a crucial role in shaping consumer behavior within the circular economy by using taxes, subsidies, and incentives to stimulate sustainable consumption. This study examines the relationship between fiscal tools and circular economy principles, focusing on their implementation in the Western Balkans, with a main focus on Albania. Fiscal policy tools, such as environmental taxes, subsidies for green innovations, and incentives for reducing waste, can potentially shape consumer behavior by promoting sustainable consumption and production practices. However, the Western Balkans region faces distinct socio-economic and institutional obstacles that hinder the adoption of circular practices. In Albania, recent initiatives, such as waste management reforms and tax incentives for eco-friendly businesses, demonstrate initial efforts toward CE integration. Despite these efforts, limited public awareness, fragile institutional structures, and lack of enforcement mechanisms remain significant barriers to progress. In this context, this paper points out major challenges in Albania in promoting circular practices. By addressing these challenges, Albania and its neighboring countries can accelerate their transition to a circular economy, paving the way for sustainable economic development and increased environmental resilience. In conclusion, the main recommendations of this paper involve implementing a more integrated fiscal policy framework aimed at both producers and consumers, enhancing public awareness initiatives to advance circular economy principles, and fostering stronger collaboration between government, businesses, and civil society. Additionally, it is recommended that coordinated regional strategies be developed in the Western Balkans to ensure alignment with European Union objectives and global sustainability goals.

Keywords: circular economy, fiscal policy, Western Balkans, Albania, sustainability.

JEL Classification: Q58, H23, Q01, H50.

1. INTRODUCTION

The rapid increase in environmental pollution, depletion of natural resources, and climate change have positioned the circular economy (CE) at the forefront of global debates on sustainable development. Unlike the traditional linear economic model of “take, make, dispose,” the circular economy aims to decouple economic growth from resource consumption by promoting systems of reuse, recycling, and waste reduction. In doing so, materials retain their value for as long as possible, minimizing environmental harm and enhancing socio-economic resilience in the long term. This study examines how fiscal policy can serve as a transformative tool to support the transition to a circular economy in Albania and the Western Balkans. It analyzes the role of environmental taxes, green subsidies, and CE-oriented fiscal incentives in promoting sustainable practices, reducing waste, and aligning national systems with the European Green Deal and the EU Circular Economy Action Plan. The research also highlights regional disparities, institutional challenges, and the growing momentum driven by EU integration efforts and cross-sectoral cooperation. In Europe, the transition to a circular economy is not only an environmental necessity but also a strategic pillar of the Green Deal and Circular Economy Action Plan (European Commission, 2020). These frameworks emphasize the importance of policy instruments – particularly fiscal tools – to stimulate circular investments, foster sustainable consumption, and internalize the costs of pollution and waste into market prices. Albania and the Western Balkans are at a critical juncture in this transition. While EU integration remains a key driver of environmental and economic reforms, the practical implementation of CE principles remains limited. Countries like Albania face challenges such as weak institutional capacity, low public awareness, fragmented inter-institutional cooperation, and underdeveloped fiscal mechanisms. Nevertheless, recent years have seen important progress, including the adoption of national waste management strategies, guidelines for green public procurement, and targeted fiscal incentives. Fiscal policy emerges as a central lever in this transformation. As a macroeconomic tool, it can influence market behavior through taxes, subsidies, and tailored incentives aligned with CE objectives. Environmental taxes, green subsidies, and fiscal relief can reshape consumer preferences, promote green entrepreneurship, and support investments in recycling, eco-design, and resource efficiency. However, the effectiveness of these tools depends on clear policy design, robust implementation, and regional cooperation. This article explores the role of fiscal policy in advancing the circular economy in Albania and the Western Balkans. It assesses the scope, impact, and limitations of current fiscal instruments and identifies opportunities for policy innovation and alignment with EU standards. The study aims to contribute to the growing literature on CE implementation in developing economies by analyzing national strategies, regional trends, and comparative policy frameworks.

The core research questions include:

- a) Which fiscal tools are currently employed to promote circular economy practices in Albania and the Western Balkans?
- b) How effective are these instruments in facilitating the transition to CE?
- c) What policy gaps, institutional barriers, and regional disparities hinder progress?
- d) How can fiscal policy be restructured to better align with CE principles and EU integration goals?

1.1. Methodology

This study adopts an integrated methodological approach of a qualitative and comparative nature, aimed at analyzing the role of fiscal policies in facilitating and accelerating the transition toward a circular economy (CE) in Albania and the Western Balkan countries. Grounded in the methodological guidelines of the OECD (Svatikova, Brown & Börkey, 2025), the research examines existing policies, national and international strategic documents, and international best practices related to the use of fiscal instruments for environmental objectives. Central to the analysis are fiscal tools such as environmental taxes, green subsidies, tax incentives, and extended producer responsibility (EPR) schemes, which are considered key mechanisms for influencing the behavior of consumers and businesses and for guiding markets toward sustainable models of production and consumption. The analysis relies on institutional sources that provide a clear political and regulatory context, including the National Strategy for Integrated Waste Management 2020–2035 (Ministry of Tourism and Environment), the European Commission’s annual progress reports for the region, regional assessments conducted by UNEP and the EEA, and the World Bank’s 2022 Green Transition Assessment. These documents contribute to identifying institutional and operational challenges, as well as opportunities for integrating fiscal instruments in alignment with CE objectives. The methodological approach focuses on three main dimensions:

- 1) the identification of existing fiscal instruments aimed at promoting the circular economy;
- 2) the assessment of the effectiveness of these instruments in altering individual and institutional behavior; and
- 3) a cross-country comparison among Western Balkan countries to highlight implementation gaps and extract best practices that can serve as transferable models.

2. LITERATURE REVIEW

The transition to a circular economy (CE) is increasingly recognized as a strategic priority for sustainable development, aiming to decouple economic growth from negative environmental impacts (Kirchherr *et al.*, 2018; Ghisellini *et*

al., 2016). CE principles focus on maintaining resource value, minimizing waste, and restoring natural balance. Kirchherr *et al.* (2018) emphasize CE as rooted in resource efficiency, recycling, and regenerative design, while Ghisellini *et al.* (2016) describe it as a rethinking of production and consumption aligned with the balance between economic development and environmental preservation. Circular economy policies are multidimensional, with environmental, economic, and social implications. Economically, CE promotes innovation, generates new employment opportunities, and enhances resource efficiency. Socially, it contributes to improved public health and heightened environmental awareness, while environmentally, it reduces landfill dependency and enhances soil and water quality. A key driver of CE is fiscal policy. According to OECD (2017), instruments such as environmental taxes, green subsidies, and targeted incentives are critical to financing circular solutions and integrating environmental costs into market mechanisms. Fiscal policy is not merely a revenue tool but a strategic framework to restructure production and consumption. This includes environmental taxes on pollution and resource use (Svatikova, Brown & Börkey, 2025), green subsidies for eco-innovation (Kalmykova *et al.*, 2018), and CE-specific incentives such as VAT reductions on recycled products (World Bank, 2025). However, as Kirchherr *et al.* (2018) argue, such measures are insufficient without strong institutional cooperation and public education (UNEP, 2020; UNDP Albania, 2021). In the Western Balkans, countries face structural challenges and emerging opportunities in advancing CE. This transition requires reforming production-consumption models, integrating technological innovation, and strengthening institutional capacity. EU integration serves as a key driver of this process, demanding alignment with the European Green Deal and the CE Action Plan, which aim for a climate-neutral, resource-efficient, and competitive economy by 2050 (European Commission, 2020). In line with these goals, Albania has initiated the integration of CE principles into national policy frameworks. The National Waste Management Strategy 2021–2035 outlines objectives for waste reduction, increased recycling, and implementation of the “polluter pays” principle (Ministry of Tourism and Environment, 2020). Additionally, the Albanian government has introduced fiscal incentives for green businesses, including VAT exemptions for clean technology and incentives for the use of recycled materials (Ministry of Infrastructure and Energy, 2021; KPMG Albania, 2023; OECD, 2024). Nonetheless, implementation remains fragmented due to limited public sector capacity, weak inter-institutional coordination, and low public awareness of CE (The Balkan Forum, 2020). Accelerating this transition requires not only financial and technical support but also strong political and institutional commitment across all levels of governance. Across the Western Balkans, countries face specific challenges and opportunities related to CE. According to the World Bank (2022) and UNEP (2020), EU integration acts as a major catalyst, requiring alignment with the Green Deal and CE Action Plan

(European Commission, 2020). Albania has taken steps such as adopting the National Waste Strategy and green fiscal incentives, but still struggles with weak institutional enforcement, inter-agency fragmentation, and limited public education (EEA, 2020; UNDP Albania, 2021). Cross-country comparisons reveal notable differences in CE instrument implementation, particularly in green public procurement. Serbia and North Macedonia have made substantial progress in institutionalizing green procurement practices, including legal provisions, technical guidelines for public authorities, and donor-funded pilot projects. These countries have benefited from technical assistance and capacity building to integrate sustainability criteria in procurement procedures (European Commission, 2024a). In contrast, Montenegro and Bosnia and Herzegovina face significant hurdles due to limited administrative capacity, fragmented institutional mandates, and lack of clear policy frameworks. In these countries, weak inter-institutional coordination hampers the development of coherent national and local sustainability strategies. Common regional challenges include lack of reliable data, political fragmentation, and behavioral obstacles such as low public awareness, resistance to change, and the dominance of the informal economy, which limits the inclusion of informal actors in circular systems (European Commission, 2024b; Ignjatović *et al.*, 2023). In this context, Kalmykova *et al.* (2018) stress the importance of integrating CE principles into public governance and national economic strategies. This includes aligning legislation, building inter-sectoral institutional structures, and introducing fiscal and regulatory incentives that foster innovation and ecologically responsible behavior (Kalmykova *et al.*, 2018; Ignjatović *et al.*, 2023).

3. FISCAL TOOLS AND THE IMPLEMENTATION OF THE CIRCULAR ECONOMY IN ALBANIA

Albania has made significant progress in its transition toward a circular economy (CE), in alignment with its commitments to European Union (EU) integration and the implementation of the European Green Deal objectives. These efforts have materialized through the formulation of national policies, the adoption of incentivizing fiscal instruments, and increased public awareness on sustainable resource management. A key strategic document in this context is the National Waste Management Strategy 2021–2035, which aims to reduce waste generation, increase recycling rates, and implement the “polluter pays” principle (Ministry of Tourism and Environment, 2020). In addition, the National Environmental Protection Program 2020–2030 integrates CE principles into its long-term environmental objectives (European Commission, 2023). On the fiscal front, concrete measures have been introduced, including value-added tax (VAT) exemptions for renewable energy equipment and clean technologies, intended to stimulate investment in environmentally friendly sectors (Ministry of Infrastructure and Energy, 2021). The Law on Technological and Scientific Parks

has also provided tax relief for enterprises contributing to sustainable and circular production solutions. Albania is actively involved in regional and international programs supported by the EU, OECD, GIZ, and the World Bank, which aim to strengthen institutional capacities and embed CE principles into national economic policies. Nevertheless, empirical data reveal persistent challenges: the recycling rate in urban areas remains at only 18.81%, while the coverage of waste separation reaches just 40% (INSTAT, 2023; Municipal Reports, 2023). These figures highlight the need for further reinforcement of existing measures and more effective implementation of circular economy-related policies, as presented in table 1:

Table 1. Circular Economy Indicators in Albania (2023–2024)

Indicator	Value
Recycling Rate (urban areas, 2023)	18.81%
Renewable Energy Share in Final Energy	38.5%
Environmental Tax Revenue (% of GDP)	2.5%
Households Benefiting from Green Subsidies	24,000 (2022–2024 est.)
Circular Startups Supported by the State	~65
Waste Separation Coverage (urban)	40%

Source: Compiled by the author based on data from INSTAT, EEA, Eurostat, OECD, Ministry of Infrastructure, AKSHI / Ministry of Finance, and Municipal Reports (2022–2024)

Currently, 38.5% of final energy consumption in Albania is derived from renewable sources, reflecting the positive impact of tax exemptions and state support for clean technologies (Eurostat). Environmental tax revenues account for 2.5% of the country's GDP, indicating an initial level of fiscal integration into circular economy (CE) policies (OECD). Between 2022 and 2024, approximately 24,000 households have benefited from green subsidies, and around 65 startups operating in the circular economy sector have received public support (Ministry of Infrastructure; NAIS / Ministry of Finance). However, as illustrated in Figure 1, the implementation of environmental taxes remains uneven across sectors, with the energy sector achieving relatively higher effectiveness (3/5), while the industrial sector lags significantly behind (1/5). This disparity highlights the need for stronger institutional coordination and a more balanced fiscal policy approach to support CE objectives.

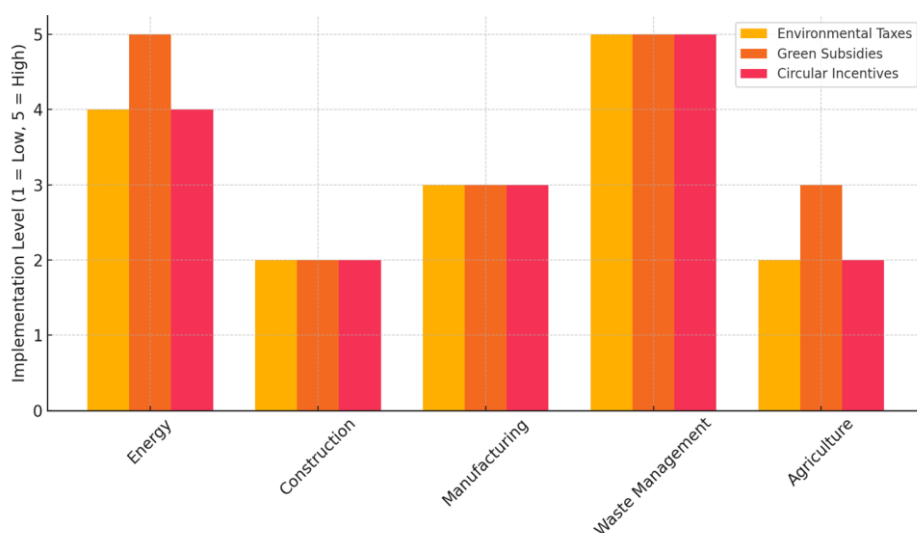


Figure 1. Fiscal Tools by Sector in Albania
(Implementation Level: 1 = Low, 5 = High)

Source: Compiled by the author based on qualitative assessments from national policy documents and international institutional reports (2022–2024)

Beyond the implementation of environmental taxes, Albania has begun to develop additional fiscal instruments and green subsidies to support the transition toward a circular economy (CE). These include grants for renewable energy, support for recycling and sustainable packaging, as well as funding for research and development in CE-related technologies (Kalmykova *et al.*, 2018; UNDP Albania, 2021). However, access to these programs by businesses is often constrained by complex administrative procedures and limited institutional capacities (EEA, 2020). In parallel, more targeted fiscal incentives have been introduced, including Extended Producer Responsibility (EPR) schemes, tax deductions, and VAT exemptions for “eco” enterprises operating in Technological and Economic Development Zones. Nevertheless, these measures remain at a pilot stage and are less advanced compared to those in North Macedonia and Serbia (World Bank, 2022). Moreover, policy implementation remains inconsistent, fragmented, and poorly coordinated across institutions, while the absence of standardized data and monitoring mechanisms weakens impact evaluation (UNEP, 2020; EEA, 2020). As highlighted by the OECD (2022), enhancing the effectiveness of fiscal instruments and improving inter-institutional coordination are critical elements for consolidating the circular economy agenda in Albania.

4. COMPARATIVE EXPERIENCE FROM THE WESTERN BALKANS

The Western Balkans is currently at a critical juncture in its transition toward a circular economy (CE), driven by the objectives of sustainable development and the ongoing European integration process. While all countries in the region face similar structural and institutional challenges, their approaches and outcomes in implementing CE vary significantly. Albania has made notable progress through national policy initiatives and donor-supported programs; however, its overall performance remains moderate when compared to neighboring countries. North Macedonia stands out as one of the regional frontrunners in adopting advanced fiscal practices for CE, including reduced VAT rates for recycled products, green public procurement, and fiscal incentives for circular investments. Serbia has also made considerable advancements, implementing Extended Producer Responsibility (EPR) schemes in the packaging and electronics sectors, establishing circular economy clusters, and providing fiscal stimuli for recycled goods and eco-innovation services. These initiatives are financed through dedicated environmental taxes, and Serbia's institutional coordination is widely regarded as more effective, offering a potential model for countries like Albania. The table 2 presents a comparison of environmental tax revenues as a percentage of GDP across Western Balkan countries. Albania leads with a rate of 2.5%, followed by Serbia (2.4%) and Montenegro (2.3%). North Macedonia and Bosnia and Herzegovina report 2.1% and 2.0%, respectively, while Kosovo records the lowest level in the region at 1.8%. These figures indicate that Albania has achieved a relatively high level of environmental tax integration into its fiscal framework, whereas Kosovo still has considerable room for improvement in aligning its tax policies with environmental objectives.

Table 2. Environmental Tax Revenue as a Share of GDP in Western Balkans (2022-2023)

Country	Environmental Tax Revenue (% of GDP)
Albania	2.5%
Bosnia and Herzegovina	2.0%
Montenegro	2.3%
North Macedonia	2.1%
Serbia	2.4%
Kosovo	1.8%

Source: Compiled by the author based on international statistical databases and institutional reports (2023)

On the other hand, Montenegro, Kosovo, and Bosnia and Herzegovina remain in the early stages of developing a circular economy (CE). Montenegro has initiated green tax reforms aligned with the European Green Deal, yet significant administrative challenges and limited implementation capacity persist. Kosovo is experimenting with local-level pilot projects focused on waste recycling and reuse, including municipal tax credits and exemptions for circular construction initiatives. Bosnia and Herzegovina has undertaken a number of fragmented initiatives in green public procurement and support for small enterprises, often backed by international donor assistance. Meanwhile, Table 3 provides a comparative overview of green financing and energy efficiency measures in Albania, North Macedonia, and Bosnia and Herzegovina. Albania has implemented a broad range of initiatives, including subsidies for solar panels (targeting households and public institutions), energy efficiency renovations in schools and residences, as well as pilot subsidies for waste-to-energy projects. These efforts are supported by the EU's €1 billion energy support package, EU IPA funds, and UNDP programs. North Macedonia focuses on improving household energy efficiency by offering grants for thermal insulation, energy-efficient appliances, and support for energy audits and renovation interventions. Funding is provided through EU IPA funds and technical assistance from KfW and UNDP. Bosnia and Herzegovina offers cantonal-level grants for solar panels and heat pumps, energy efficiency upgrades targeted at SMEs, and has launched a pilot Green Innovation Fund. These programs are supported by GEF/UNEP, SIDA, and the Regional Cooperation Council (RCC). As a result, Albania stands out for the breadth of its interventions, North Macedonia for its emphasis on household energy efficiency, and Bosnia and Herzegovina for its decentralized, innovation-oriented approach targeting both households and businesses.

Table 3. Green Subsidy Programs in the Western Balkans

Country	Green Subsidy Programs	EU/International Support
Albania	- Subsidies for solar panels (households, public buildings) - Energy efficiency renovations in housing & schools - Waste-to-energy pilot subsidies	CiB EU Energy Support Package EU IPA funds UNDP
Serbia	- Biomass incentives for households & farms - Grants for public building insulation and LED retrofitting	EBRD Green Economy Financing Facility EU Delegation
North Macedonia	- Grants for home insulation and efficient appliances - Energy audits and retrofitting incentives	EU IPA funds KfW & UNDP
Montenegro	- Energy-efficient appliance rebates - Municipal grants for building retrofits - Low-interest loans for renewable installations	GIZ support WBIF (Western Balkans Investment Framework)
Bosnia & Herzegovina	- Cantonal-level grants for solar panels and heat pumps - SME-targeted energy upgrades - Green Innovation Fund pilot	GEF/UNEP SIDA RCC
Kosovo	- Pilot VAT exemptions for solar and eco-construction - Municipal co-financing for building insulation - Energy poverty relief subsidies	EU Energy Transition Grant Scheme Helvetas & UNDP

Source: Compiled by the author based on various institutional documents and donor-supported reports (2022–2024)

In terms of incentives for circular practices, the Western Balkan countries have begun to implement targeted measures to support the circular economy (CE), although these remain fragmented and largely in early stages. In Albania and Serbia, Extended Producer Responsibility (EPR) schemes have been introduced, requiring producers to assume responsibility for the collection and recycling of their products after use. North Macedonia has taken more advanced steps by reducing VAT rates for recycled products and repair services, as well as offering tax deductions for businesses investing in circular economy practices. Furthermore, in the region's Technological and Economic Development Areas (TEDAs), VAT exemptions and tax holidays are applied to enterprises adopting green production methods or holding ecological certifications. These fiscal incentives are complemented by pilot projects and grants for startups focused on recycling, sustainable design, and emerging CE technologies, as well as funding for research and development in this domain. Specifically, Montenegro has introduced reforms in green taxation and earmarked revenues for sustainable investment, while Kosovo is experimenting with municipal tax credits and exemptions for circular construction, fostering innovation in local governance. Overall, these initiatives reflect the region's growing commitment to transitioning toward a circular economy. However, achieving long-term impact will require enhanced institutional coordination, legal harmonization, and more substantial financial support to ensure the scalability and effectiveness of these measures.

Table 4. Fiscal strategies and regional strengths for each Western Balkan country, followed by key themes emerging across the region.

Country	Fiscal Strategy Highlights	Regional Strengths
North Macedonia	CE Roadmap, VAT incentives, green procurement	Policy alignment with EU CE objectives
Serbia	EPR schemes, tax-based incentives for producers	Private sector engagement in CE design
Montenegro	Green taxation reform, earmarked revenue	Fiscal transparency and reinvestment
Albania	TEDA-linked tax holidays, SME eco-certification	Early integration of CE into industrial zones
Kosovo	Municipal tax credits, circular construction exemptions	Innovation in local governance and pilot programs
Bosnia & Herzegovina	Cantonal grants for SME recycling adaptation	Subnational flexibility to foster local circularity

Source: Developed by the author using national policy frameworks, EU circular economy evaluations, and reviews of donor-funded programs (2022–2024)

Despite these differences, several common themes are evident across the region: an increasing effort to align with the EU Green Deal and the Circular Economy (CE) Action Plan, as well as the growing role of IPA funds and international donor assistance in shaping the CE agenda. Fiscal reform is

progressing at varying speeds across the Western Balkans, with countries such as Serbia and North Macedonia demonstrating greater dynamism, while Albania and others remain in experimental or pilot phases. Major challenges persist, including the lack of standardized performance data, limited access of SMEs to green finance, and difficulties in local policy implementation. Recent reports (OECD, 2022; World Bank, 2022) emphasize the need to improve cross-border cooperation, enhance data sharing, and establish regional networks for innovation and CE-related startup development. The Western Balkans is at a critical juncture in its transition toward a circular economy, as part of broader sustainable development efforts and the EU integration process. Countries in the region have made moderate yet uneven progress in advancing CE principles, with an average performance score of 45.8% based on the 2024 Green Agenda Assessment. In this context, Albania, Montenegro, and Serbia lead the region, benefiting from stronger policy frameworks, early adoption of CE roadmaps, and participation in EU-supported initiatives. Albania has made notable progress in reducing material consumption, while Montenegro and Serbia have gradually expanded measures for recycling and resource efficiency. North Macedonia stands close to the regional average, with national strategies under development and several pilot programs. Meanwhile, Kosovo and Bosnia & Herzegovina lag behind due to weak institutional capacities, underdeveloped infrastructure, and high dependency on donor-driven projects. This disparity is also reflected in the CE performance index, where, according to Figure 1, Montenegro (48.0%), Serbia (47.0%), and Albania (46.0%) exceed the regional average, while North Macedonia (44.0%) is near the mean. Kosovo (41.5%) and Bosnia & Herzegovina (38.5%) report the lowest scores, highlighting more pronounced gaps in reform implementation, infrastructure development, and institutional readiness.

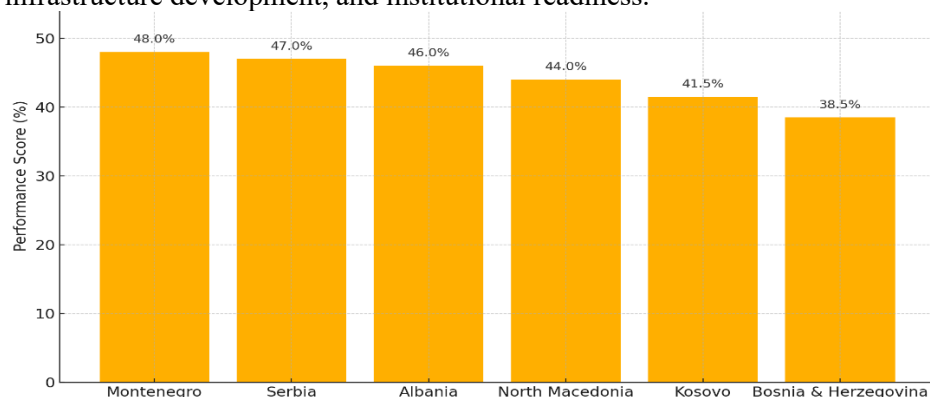


Figure 2. Circular Economy Progress in the Western Balkans (2024)

Source: Regional Cooperation Council (RCC). (2023)

Despite these differences, the region has strengthened cooperation through the adoption of national roadmaps for the circular economy (CE) and the participation of over 700 stakeholders in more than 460 interrelated initiatives since 2022. EU financial instruments – such as IPA II, the Western Balkans Investment Framework (WBIF), and the EU4Green Recovery Programme – continue to support infrastructure development and innovation linked to CE. Reports emphasize that in order to fully achieve the objectives of the circular economy, a deeper national commitment is required, along with improved governance and sustained coordination between public and private sector actors.

4.1. Challenges Facing Albania and the Region

Despite the positive steps taken, Albania and the other Western Balkan countries face substantial challenges in effectively integrating the circular economy (CE) into their fiscal policy frameworks (UNDP Albania, 2021; OECD, 2022). One of the most significant obstacles is the weak implementation of environmental taxes and incentive mechanisms – such as green subsidies – stemming from administrative constraints and limited inter-institutional cooperation between fiscal and environmental authorities. Insufficient monitoring capacity and inadequate, often non-standardized data systems further hinder an objective assessment of policy impacts (EEA, 2020). A second major challenge is the low level of awareness among businesses and consumers regarding the benefits of CE. Small and medium-sized enterprises frequently lack information on fiscal incentives and Extended Producer Responsibility (EPR) schemes, while consumers remain wedded to traditional linear consumption patterns, curbing demand for sustainable products (World Bank, 2022). Policy fragmentation and uneven implementation across municipalities exacerbate these issues, producing inconsistent and unsustainable outcomes at the national level. Many measures remain at the pilot stage, lacking a unified strategy and clear impact assessments (OECD, 2022; UNEP, 2020). Structural barriers – including high levels of informality, limited budgetary resources, and reliance on external funding – further complicate implementation. Consequently, a resilient transition to CE will require not only fiscal reform but also institutional consolidation, strengthened local capacities, and broader stakeholder engagement.

5. OPPORTUNITIES

Despite the structural and institutional challenges facing Albania and the Western Balkan region, there is significant potential to leverage fiscal policy as a tool to accelerate the transition toward a circular economy (CE) (OECD, 2022; UNEP, 2020). The European Green Deal and the Circular Economy Action Plan offer a comprehensive framework of support, including European Union funding and technical assistance for pilot projects and institutional capacity-building (European Commission, 2020). In this context, aligning national fiscal policies

with EU directives is essential for effectively capitalizing on these opportunities. Fiscal instruments such as the expansion of environmental taxation, green subsidies, and tax exemptions serve as powerful tools to steer markets toward sustainable practices and stimulate the development of innovative CE technologies (Kalmykova *et al.*, 2018). Strengthening and scaling up Extended Producer Responsibility (EPR) schemes across additional sectors can significantly enhance the impact of fiscal measures in promoting a circular economic model (World Bank, 2022). A major challenge, however, remains the lack of inter-institutional coordination and policy fragmentation between central and local levels. Establishing national platforms for cooperation and integrating fiscal objectives with CE strategies would enhance implementation effectiveness (UNDP Albania, 2021). Moreover, fiscal education and public awareness are essential for fostering the active participation of citizens and local communities (UNEP, 2020). Another serious barrier is the absence of standardized data and measurable evaluations. Developing a monitoring and reporting system would enable evidence-based policymaking (EEA, 2020). Finally, regional cooperation and support from EU funding instruments and international donors are crucial for building a competitive and sustainable circular economy in Albania and across the region. Strengthening regional collaboration will also help harmonize fiscal approaches and foster innovative CE networks, supported by donor assistance and EU resources (OECD, 2022). These steps are vital to advancing Albania and the Western Balkans toward a more resilient and competitive economic future.

6. CONCLUSIONS

This study underscores the critical role of fiscal policy in advancing the circular economy (CE) in Albania and the Western Balkans. While Albania has made commendable strides – particularly through environmental taxation, green subsidies, and incentives for clean technology – implementation remains uneven, fragmented, and constrained by institutional and administrative limitations. The recycling rate and waste separation coverage remain low, and access to fiscal instruments is often hindered by bureaucratic inefficiencies and insufficient public awareness. Nevertheless, Albania leads the region in environmental tax revenue as a share of GDP and has actively aligned its national strategies with the EU Green Deal and CE Action Plan.

A comparative analysis across the Western Balkans reveals significant disparities in policy development and implementation. North Macedonia and Serbia have demonstrated greater progress through targeted incentives, EPR schemes, and institutionalized green procurement, whereas countries such as Kosovo and Bosnia and Herzegovina lag behind due to structural and capacity-related barriers. Shared challenges – such as limited data availability, low SME access to green finance, and weak cross-level coordination – persist throughout the region. To maximize the transformative potential of fiscal instruments, deeper

policy integration and harmonization with EU standards are imperative. Strengthening inter-institutional coordination, expanding fiscal incentives, and improving data collection mechanisms are necessary steps. Equally important is the empowerment of local actors and broader stakeholder engagement through education and awareness initiatives. Regional cooperation and sustained support from the EU and international donors will be crucial in bridging performance gaps and fostering scalable, innovative CE models. Ultimately, fiscal policy must evolve from isolated interventions into a strategic framework for long-term sustainable development.

References

- 1) Djatkov, D. (2024). Policy report on the green transition in the Western Balkans (Edition 2024). Western Balkans Infohub. Retrieved from https://www.westernbalkans-infohub.eu/wp-content/uploads/2024/08/Report_Green-Transition_final.pdf
- 2) European Commission. (2020). Circular Economy Action Plan. <https://ec.europa.eu/environment/circular-economy/>
- 3) European Commission. (2020.). Guidelines for the implementation of the Green Agenda for the Western Balkans. Retrieved June 11, 2025, from https://enlargement.ec.europa.eu/guidelines-implementation-green-agenda-western-balkans_en#description
- 4) European Commission. (2022). EU Energy Support Package for the Western Balkans. Brussels: European Commission. Retrieved from <https://neighbourhood-enlargement.ec.europa.eu>
- 5) European Commission. (2023). 2023 Enlargement Package: Albania Report. Brussels. https://enlargement.ec.europa.eu/albania-report-2023_en
- 6) European Commission. (2024a). North Macedonia 2024 Report. Retrieved from <https://enlargement.ec.europa.eu>
- 7) European Commission. (2024b). Bosnia and Herzegovina 2024 Report. Retrieved from <https://enlargement.ec.europa.eu>
- 8) European Environment Agency. (2020). Municipal waste management in Western Balkans. <https://www.eea.europa.eu/publications/municipal-waste-management-in-western>
- 9) European Environment Agency. (2020). Municipal waste management in Western Balkans. Retrieved from <https://www.eea.europa.eu/publications/municipal-waste-management-in-western>
- 10) Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, 11–32. <https://doi.org/10.1016/j.jclepro.2015.09.007>
- 11) GIZ. (2024). Green Agenda: Supporting the Western Balkans in Adapting to Climate Change. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrived: <https://www.giz.de/en/worldwide/153413.html>
- 12) Ignjatović, J., Filipović, S., & Radovanović, M. (2023). Challenges of the Green Transition for the Recovery of the Western Balkans. *Energy, Sustainability and Society*, 13(1), 1–14. <https://doi.org/10.1186/s13705-023-00421-4>

- 13) Institute of Statistics (INSTAT). (2023). Environmental taxes in Albania 2022. Tirana, Albania. <https://www.instat.gov.al/media/13224/environmental-taxes-in-albania-2022.pdf>
- 14) Kalmykova, Y., Sadagopan, M., & Rosado, L. (2018). Circular economy – From review of theories and practices to development of implementation tools. *Resources, Conservation and Recycling*, 135, 190–201. <https://doi.org/10.1016/j.resconrec.2017.10.034>
- 15) KfW Development Bank. (2022). Energy Efficiency Programmes in North Macedonia.
- 16) Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, 221–232. <https://doi.org/10.1016/j.resconrec.2017.09.005>
- 17) KPMG Albania. (2023). Guidance on law providing tax incentives for technological and scientific parks. Retrieved from <https://kpmg.com/us/en/home/insights/2023/08/tmf-albania-guidance-law-direct-indirect-tax-incentives-technological-scientific-parks.html>
- 18) Ministry of Infrastructure and Energy. (2021). Decision on VAT exemption for equipment used in renewable energy production. Retrieved from <https://balkangreenenergynews.com/albania-to-cancel-vat-for-solar-wind-power-equipment/>
- 19) Ministry of Infrastructure and Energy. (2021). Policies and Incentives for Renewable Energy and Clean Technologies in Albania. Tirana, Albania.
- 20) Ministry of Tourism and Environment. (2020). Decision no. 418, dated 27.05.2020: On the approval of the Strategic Policy Document and the National Integrated Waste Management Plan. Government of Albania. Retrieved from https://turizmi.gov.al/wp-content/uploads/2021/10/Vendim-2020-05-27-418_Per-miratimin-e-Dokumentit-te-Politikave-strategjike-dhe-te-Planit-Kombetar-per-menaxhimin-e-Integruar-te-Mbetjeve-1.pdf
- 21) Municipal Reports. (2023). Local Government Performance on Waste Separation and Urban Sanitation – Annual Summary Report. Association of Albanian Municipalities.
- 22) OECD (2024a). A roadmap towards circular economy of Albania. Retrieved from https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/03/a-roadmap-towards-circular-economy-of-albania_0fd9c3a4/8c970fdc-en.pdf
- 23) OECD. (2024b). Circular Economy in the Western Balkans: Progress and Policy Priorities. Paris: OECD Publishing.
- 24) RCC (2023). Report on the implementation of the Green Agenda for the Western Balkans Action Plan (GAWB).
- 25) SIDA. (2023). Swedish Support to Green Transition in the Balkans. Swedish International Development Cooperation Agency.
- 26) Svatikova, K., Brown, A., & Börkey, P. (2025). Economic instruments for a resource-efficient circular economy (OECD Environment Working Papers, No. 257). OECD Publishing. https://www.oecd.org/en/publications/economic-instruments-for-a-resource-efficient-circular-economy_35a7051a-en.html

- 27) The Balkan Forum (2021a). 'Circular Economy in the Western Balkan', https://thebalkanforum.org/file/repository/Circular_Economy_in_the_Western_Balkans_region.pdf.
- 28) The Balkan Forum. (2021b). Circular economy in the Western Balkans. https://thebalkanforum.org/file/repository/Circular_Economy_in_the_Western_Balkans_region.pdf
- 29) UNDP. (2023). Regional cooperation for better energy efficiency in buildings in the Western Balkans. United Nations Development Programme.
- 30) United Nations Environment Programme (2022). Summary Report - Western Balkans forum: Environmental / Climate Achievements and Future Challenges - Regional Exchange organized by the United Nations Environment Programme, 17 & 18 November 2022. <https://wedocs.unep.org/20.500.11822/41449>.
- 31) World Bank. (2021). Western Balkans regular economic report No. 20: Greening the recovery (Fall 2021). World Bank Group. Retrieved from <https://documents1.worldbank.org/curated/en/900381634670558017/pdf/Greening-the-Recovery.pdf>
- 32) World Bank. (2025). Western Balkans Regular Economic Report No. 27, Spring 2025: Adapting for the Future. Washington, D.C.: World Bank Group. Retrieved from: <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099042325021511545>

THE UNEQUAL GREEN TRANSITION: RENEWABLE ENERGY AND INCOME (IN)EQUALITY IN SOUTHEAST EUROPE

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Abstract

To investigate the relationship between the utilization of renewable energy sources and the income inequality in Albania, Serbia, Croatia, Bulgaria, and Romania, this study makes use of time series data collected from the year 2000 until the year 2022. These economies, which are located in Southeastern Europe, have experienced certain events that make them especially important for analyzing times of economic growth and stagnation. The ARDL bounds testing methodology is an appropriate approach for examining the energy-inequality link in countries experiencing both random shocks (outliers) and persistent shocks (structural breaks), which we employ in our analysis. Inequality has been linked to health and well-being, economic development, and environmental issues, among other variables. Empirical validation of the relationship between inequality and renewable energy is essential to inform policy decisions since the social benefits and positive externalities of reducing income disparity may speed up the adoption of renewable energy. The GINI coefficient functions as the dependent variable in our estimated model. The selected independent variables include renewable energy consumption per capita, gross domestic product per capita, real gross fixed capital formation, exports, imports, and the political instability index, among others. According to the preliminary empirical findings, the energy-led growth theories of the chosen nations are supported. According to our analysis, in some countries, political instability obstructs economic growth and development. This finding supports earlier hypotheses.

Keywords: Renewable energy, income inequality, southeastern European countries.

JEL Classification: Q42, D63, P48

1. INTRODUCTION

When it comes to the subjects of economics and sustainability studies, one of the most significant topics that should be discussed is the relationship that exists

between energy and economic expansion. There is a strong correlation between the process of industrialization and the expansion of the economy, which in turn leads to higher agricultural productivity and efficiency, as well as increased water consumption. Renewable energy is a significant contributor to economic growth (Acaravci & Ozturk, 2010; Stern, 2011; Merko *et al.*, 2020; Triantafyllidou *et al.*, 2023).

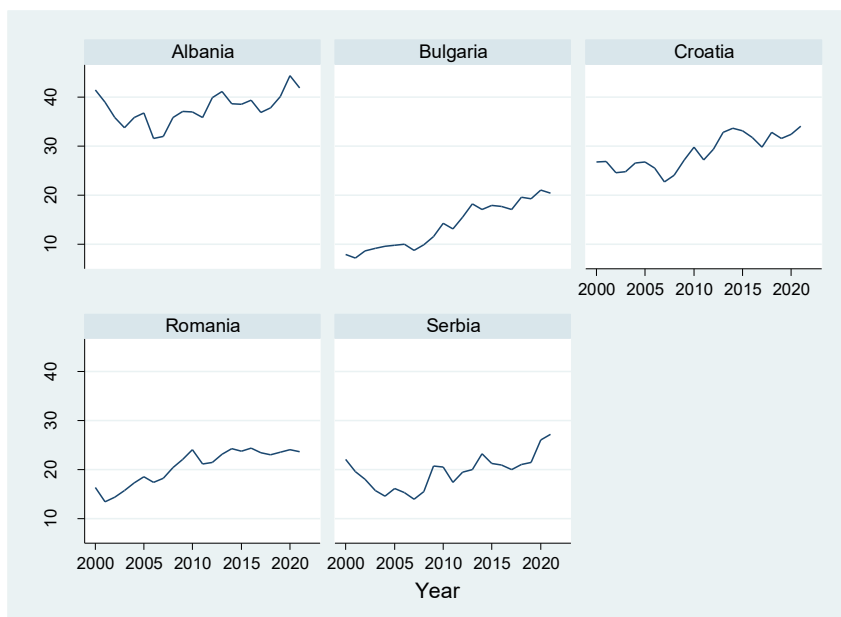
The renewable energy is commonly defined as energy generated from solar, wind, geothermal, tide and wave, wood, waste, and biomass. Compared to conventional energy, renewable energy is clean, safe and endless. The empirical findings show that renewable energy is crucial for economic growth and economic growth stimulates the use of more renewable energy sources (Heerink *et al.*, 2001; Apergis & Danuletiu, 2014). However, it has been noted that that an increase in income inequality can affect all parts of society to have a shortsighted overview. The long-term effects of economic activities such as consumption cannot be enough taken into consideration (Berthe & Elie, 2015).

It is important to note that energy encompasses not only the movement of people and goods, but also the transportation and mobility of commercial commodities. Since climate change is a component that is contributing to the shift to methods of energy generation that are more ecologically friendly and renewable, there is a relationship between energy in general and the environment. Furthermore, there is a connection between energy and the environment (Apergis & Tang, 2013; Alper, 2016; Acheampong *et al.*, 2018; Merko & Kalaj, 2025).

The association between income inequality and the consumption of renewable energy has been the focus of an extensive amount of research that has recently been carried out. Numerous studies have centered their attention on the factors that influence the use of renewable energy sources because of the ever-present significance of renewable energy. The emphasis put on income inequality is significant since it has been linked to a few outcomes that have the potential to impose an impact on renewable energy (Bozoklu & Yilanci, 2013; Kalaj & Merko, 2020; Chen *et al.*, 2020).

2. BACKGROUND AND MOTIVATION

To give an answer to the research question we employ annual time series data from 2000 to 2022 for the following countries: Albania, Serbia, Croatia, Bulgaria, and Romania. The countries that were chosen are at various stages in the development of the energy market, and as a result, they are dealing with a multitude of challenges and opportunities. Table 1 shows the level of the renewable energy consumption measured as a percentage of the final energy consumption.

Table 1. Renewable energy consumption as % of final energy consumption

Source: Authors' calculation

The energy markets in selected countries have unique characteristics shaped by their histories, resources, and policy environments. Albania's energy market is heavily reliant on hydropower, which accounts for almost all its electricity generation. During periods of drought, it faces energy shortages and relies on imports. Albania has undertaken significant reforms to liberalize its energy market, improve regulatory frameworks, and attract foreign investment.

Serbia's energy mix is dominated by coal, particularly lignite, which fuels most of its electricity generation. Hydropower is the second-largest source of electricity. It is also exploring the potential of renewable energy sources like wind and solar. Serbia is gradually liberalizing its energy market, aiming to align with EU regulations. Croatia has a relatively diverse energy mix, including natural gas, hydropower, and renewables. It also imports electricity to meet demand. As an EU member, Croatia's energy market is integrated with the EU's energy policies and regulations (Ritchie, *et al.*, 2024).

Bulgaria has a significant nuclear power capacity, providing a substantial portion of its electricity. Coal remains an important energy source, but the country is also increasing its investment in renewable energy, especially wind and solar. Bulgaria exports electricity to neighboring countries. Romania has a diverse energy mix, including natural gas, coal, nuclear, hydropower, and renewables. The country has substantial oil and natural gas reserves, making it relatively energy

independent compared to its neighbours. As an EU member, Romania aligns its energy policies with EU directives (Ritchie, *et al.*, 2024).

3. DATA AND METHODOLOGY

In this study, a panel of the countries mentioned above for years from 2000 to 2022 are included. The data that we use comes from three different sources: World Development Indicators, the International Labour Organization, and Transparency International. Table 2 provides a brief description of the variables, in addition to the sources from which they were obtained.

Table 2. Description of variables

Dependent Variable	Source	Description
GINI Index	WB	The Gini index measures the extent to which the distribution of income or consumption among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality.
Explanatory variables		Description
GDP per capita	WB	Annual percentage growth rate of GDP per capita based on constant local currency. GDP per capita is gross domestic product divided by midyear population.
Political stability	IMF	Political Stability and Absence of Violence/Terrorism: Estimate
Unemployment rate	ILO	Unemployment refers to the share of the labor force that is without work but available for and seeking employment.
Openness	WB	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
Renewable energy	WDI	Renewable energy consumption is the share of renewable energy in total final energy consumption.

We utilize the Arellano and Bond (1991) generalized method of moments (GMM) technique to estimate the correlation between GINI and Renewable energy. We employ a two-step technique due to the tendency of the one-way fixed effect model of Dynamic panel data to produce correlation between regressors and error. In practice, we define the functional form of the equations for GINI and Renewable energy in the following way:

$$GINI_{i,t} = \beta_0 + \beta_1 GINI_{i,t-1} + \beta_2 REN_{i,t} + \gamma X_{i,t} + \mu_{i,t} \quad (1)$$

where:

$GINI_{i,t}$ is gini index used to measure income inequality,

$Ren_{i,t}$ is renewable energy consumption as a share of total energy,

$X_{i,t}$ is vector of variables including GDP per capita growth, consumer price index, unemployment rate, openness to trade etc.

To address our research inquiry regarding the correlation between inequality of income and corruption, we adopted the Dynamic Panel Data (DPD) model. These models incorporate one or more lagged dependent variables, enabling the representation of a partial adjustment mechanism (Blundell, *et al.*, 2001; Bun & Windmeijer, 2010).

4. REGRESSION RESULTS

We conducted unit root tests to address the study question. These tests assist in determining if a time series variable is non-stationary and contains a unit root. The null hypothesis is typically characterized by the existence of a unit root, while the alternative hypothesis may indicate stationarity, trend stationarity, or an explosive root, contingent upon the specific test performed. Table 3 represents a summary of the unit root tests. Our variables are not negatively affected by stationarity, as evidenced by the results.

Table 3. Unit root tests

Variables	Im, Peasaran and Shin W-stat	ADF – Fisher Chi-square	PP – Fisher Chi-square
GINI index	-4.193***	192.276***	186.219***
GDP per capita	-7.778***	131.652**	165.601***
Political stability	-2.498***	141.415***	130.09***
Unemployment rate	-2.447***	163.374***	126.643**
Openness	-8.266***	173.354***	169.463***
Renewable energy	-2.443***	150.717***	162.134***

Source: Authors' calculation

Furthermore, we conducted a Granger causality test to gain deeper insights into the relationship between income inequality and the utilization of renewable energy (Granger, 2001). As demonstrated in tables 4 and 5, we conducted both the standard homogeneous test and the heterogeneous test (Dumitrescu & Hurlin, 2012).

Table 4. Granger causality test assuming homogeneity of coefficients

Null Hypothesis:	t-statistics	Prob.
a. Renew does not Granger Cause GINI	-.0168	0.224
b. GINI does not Granger Cause Renew	-.1427	0.007

Source: Authors' calculation

Table 5. Granger causality test assuming heterogeneity of coefficients

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
a. Renew does not homogeneously cause GINI	2.121	2.296	0.0217
b. GINI does not homogeneously cause Renew	2.514	3.411	0.0006

Source: Authors' calculation

The null hypothesis is rejected when the p-value is less than 0.05 (Granger, 2001). Referring to the coefficients of tables 4 and 5, we have insights on the relationship between income inequality and the use of renewable energy. When testing while assuming homogeneity, only inequality causes the use of renewables and not vice versa. Nevertheless, if we assume heterogeneity, we obtain a two-way causality, illustrated in table 5.

Table 6. System dynamic panel-data estimation, by country

Income Inequality	(1) Albania	(2) Serbia	(3) Croatia	(4) Bulgaria	(5) Romania
L. Gini index	-.2 (.314)	.021** (.01)	.186 (.343)	.561** (.281)	.802*** (.244)
GDP per capita	-.005 (.149)	.003* (.002)	-.16** (.066)	-.005 (.065)	-.025 (.046)
Political stability	-.159 (.108)	-.002*** (.001)	-.128** (.061)	.028 (.032)	.011 (.056)
Unemployment rate	.556** (.255)	-.004** (.002)	-.021 (.092)	.057 (.106)	-.175 (.295)
Openness	.087 (.081)	-.003*** (.001)	.107** (.052)	-.015 (.023)	-.019 (.062)
Renewable energy	-.577** (.285)	.01* (.005)	.033 (.136)	.006 (.071)	-.411* (.224)
_cons	21.238 (17.256)	34.603*** (.492)	40.106* (21.937)	12.003 (7.958)	28.907* (15.339)
Observations	22	22	22	22	22
Pseudo R ²	.32	.26	.31	.28	.41
Wald chi2	33.76	83.16	19.36	34.31	67.79

*** $p < .01$, ** $p < .05$, * $p < .1$

Based on the country-specific regression results, interesting findings can be noticed. The findings regarding the yearly growth of per capita GDP remain appropriate to both Croatia and Romania. In the cases of Serbia and Croatia, an increase in the levels of political stability is indicative of an improvement in income inequality, as indicated by theory and earlier empirical findings (Policardo & Carrera, 2018; Badur *et al.*, 2023). This is not statistically significant in the remaining countries included in our investigation.

According to the model coefficients presented in Table 6, empirical findings indicate that increased use of energy from renewable sources increases to equality in both Albania and Romania. On the other hand, it does not appear that this is the case for all the countries that have been included in the sample. However, in the study there are some limitations due to the lack of data on variables that we could have used to investigate on the relationship between inequality and use of renewable energy.

5. CONCLUSIONS

This study investigates the theory that the use of renewable energy sources is a factor that contributes to economic equality. The findings of this research provide evidence to support the hypothesis in certain countries. The period from the year 2000 to the year 2022 is included by the panel data that we used for Southeast European countries. The results of the research we conducted indicate that the rise in the perception of renewable energy sources within a sample of countries is the cause of an increase in economic equality.

The results show that the overall sample's trade openness, unemployment, and GDP per capita growth all contribute to rising income disparity. This conclusion pertains to the current state of unemployment, which impacts the less fortunate segments of the population. Additionally, trade openness is implemented in a way that does not equally contribute to population growth everywhere.

The cases of Albania and Romania suggest that the utilization of renewable resources contributes to the observed income equality. The findings do not provide a definitive answer for the remaining countries in our study. The results offer important recommendations for policymakers.

Equitable income distribution and environmental quality, which are both essential elements of sustainable development objectives, can be accomplished together.

References

- 1) Acaravci, A. & Ozturk, I. (2010). Electricity consumption-growth nexus: evidence from panel data for transition countries. *Energy Economics*, 32(3), pp. 604-608.
- 2) Acheampong, A. O. (2018). Economic growth, CO2 emissions and energy consumption: what causes what and where? *Energy Economics*, Issue 74, pp. 677-692.
- 3) Alper, A. & O. O. (2016). The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renewable and Sustainable Energy Reviews*, Volume 60, pp. 953-959.
- 4) Apergis, N. & Danuletiu, D. C. (2014). Renewable energy and economic growth: Evidence from the sign of panel long-run causality. *International Journal of Energy Economics and Policy*, 4(4), pp. 578-587.
- 5) Apergis, N. & Tang, C. F. (2013). Is the energy-led growth hypothesis valid? New evidence from a sample of 85 countries. *Energy Economics*, Issue 38, pp. 24-31.

- 6) Badur, M. M., Yılmaz, E. & Sensoy, F. (2023). Do corruption and inequality shape sustainable development? Evidence from the post-soviet countries. *International Journal of Social Economics*, 51(1), pp. 115-132.
- 7) Berthe, A. & Elie, L. (2015). Mechanisms explaining the impact of economic inequality on environmental deterioration. *Ecological Economics*, Volume 116, pp. 191-200.
- 8) Blundell, R., Bond, S. & Windmeijer, F. (2001). Estimation in dynamic panel data models: improving on the performance of the standard GMM estimator. *Nonstationary panels, panel cointegration, and dynamic panels*, pp. 53-91.
- 9) Bozoklu, S. & Yilanci, V. (2013). Energy consumption and economic growth for selected OECD countries: Further evidence from the Granger causality test in the frequency domain. *Energy Policy*, Volume 63, pp. 877-881.
- 10) Bun, M. J. & Windmeijer, F. (2010). The weak instrument problem of the system GMM estimator in dynamic panel data models. *The Econometrics Journal*, 13(1), pp. 95-126.
- 11) Chen, C., Pinar, M. & Stengos, T. (2020). Renewable energy consumption and economic growth nexus: Evidence from a threshold model. *Energy Policy*, Issue 139, pp. 95-112.
- 12) Dumitrescu, E. I. & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic modelling*, 29(4), pp. 1450-1460.
- 13) Granger, C. W. (2001). *Essays in econometrics: collected papers of Clive WJ Granger*. 32 ed. s.l.: Cambridge University Press.
- 14) Heerink, N., Mulatu, A. & Bulte, E. (2001). Income inequality and the environment: aggregation bias in environmental Kuznets curves. *Ecological Economics*, 38(3), pp. 359-367.
- 15) International Labour Organization (2024). *Statistics on unemployment and labour underutilization*. [Online] Available at: <https://ilostat.ilo.org/topics/unemployment-and-labour-underutilization/>
- 16) Kalaj, E. H. & Merko, F. (2020). Analyses of financial obstacles facing SME-S: Evidence from Albania. *KNOWLEDGE-International Journal*, 43(1), pp. 117-121.
- 17) Merko, F. & Kalaj, E. H. (2025). Energy, Economic Growth, and Climate Change in Southeast European Countries. *Agriculture and Water Management Under Climate Change*, pp. 137-151.
- 18) Merko, F., Kalaj, E. & Merko, F. (2020). How does Economic Growth Affect Deforestation-Evidence from Albania. *Journal of International Environmental Application and Science*, 15(3), pp. 152-157.
- 19) Policardo, L. & Carrera, E. J. S. (2018). Corruption causes inequality, or is it the other way around? An empirical investigation for a panel of countries. *Economic Analysis and Policy*, Volume 59, pp. 92-102.
- 20) Ritchie, H., Roser, M. & Pablo, R. (2024). *Energy*. [Online] Available at: <https://ourworldindata.org/energy>
- 21) Stern, D. I. (2011). The role of energy in economic growth. *Annals of the New York Academy of Sciences*, 1219(1), pp. 26-51.
- 22) Transparency International, 2024. <https://www.transparency.org>. [Online] Available at: <https://www.transparency.org/en/our-national-chapters>

- 23) Triantafyllidou, A., Polychronidou, P. & Mantzaris, I. (2023). Primary energy consumption and economic growth: the case of Greece. *Eastern Journal of European Studies*, 14(2).
- 24) World Bank (2024). *Poverty and Inequality Platform*. [Online] Available at: <https://datacatalog.worldbank.org>

TRANSFORMING CONSUMER BEHAVIOR TOWARDS SUSTAINABLE TEXTILES

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Abstract

The global textile industry approaches a critical transformation threshold where environmental necessity converges with technological breakthroughs and unprecedented market opportunity. As a cornerstone of the European economy, the textile sector employs approximately 1.5 million people and generates €162 billion in annual turnover across the EU, making its sustainable transformation not only an environmental imperative but also a critical economic priority. Sustainable textiles are projected to reach \$75 billion by 2032, growing at 23% annually, while conventional textiles expand at only 3.5%. However, this transformation faces a fundamental barrier: the persistent gap between consumer sustainability intentions and purchasing behavior. While 73% of Gen Z consumers express willingness to pay sustainability premiums, 61% still prioritize price over sustainability in actual decisions, creating a critical implementation challenge that educational interventions must address.

Given the sector's substantial economic footprint and employment impact, transforming consumer behavior becomes essential for environmental sustainability, maintaining competitive advantage, and securing the livelihoods of millions of workers transitioning toward sustainable production methods. This comprehensive analysis examines how targeted educational frameworks can transform consumer behavior to support the sustainable textile revolution, drawing on evidence from the EUSusTex project implementation and global market trends. The research demonstrates that experiential learning through industry collaboration achieves 85% success rates in developing critical consumption patterns, while integrated decision-making frameworks enable 70% of participants to increase sustainable alternative considerations. These findings provide actionable strategies for bridging the \$133 million ton supply gap between sustainable material demand and projected supply by 2030.

Keywords: Sustainable textiles, consumer behavior, educational intervention, circular economy

JEL Classification: Q56, D12, I23, Q57, L67, F18

1. THE SUSTAINABLE TEXTILE REVOLUTION: MARKET DYNAMICS AND CONSUMER CHALLENGES

1.1. Market Transformation Accelerates

The textile industry's environmental footprint demands immediate transformation, particularly given its substantial economic significance as a cornerstone of European industry employing 1.5 million people and generating €162 billion in annual turnover across the EU (European Commission, 2023). With 93 billion cubic meters of annual water consumption (European Parliament, 2020) and 8-10% of global CO₂ emissions (Frontiers, 2022), the sector's environmental impact positions textiles as a critical sustainability priority where transformation affects both ecological systems and millions of livelihoods. Cotton production alone requires 7,000-29,000 liters per kilogram (Decathlon, 2024), while a single t-shirt consumes 2,700 liters and jeans require over 8,000 liters (FSU, 2024). This resource intensity, combined with 1.2-1.7 billion tonnes of annual CO₂ emissions (Frontiers, 2022), creates an urgency that market forces are beginning to address through unprecedented growth in sustainable alternatives.

Sustainable textile market dynamics reveal exponential growth potential driven by converging technological, regulatory, and consumer forces (GM Insights, 2024). The market, valued at \$8 billion in 2024, projects to reach \$40-75 billion by 2032 at 22.6% annual growth – three times faster than conventional textiles at 3.5% growth (Cognitive Market Research, 2024). This expansion creates \$20-30 billion annual investment opportunities in fashion technology, supported by initiatives like the \$250 million Fashion Climate Fund targeting \$2 billion in blended capital for supply chain decarbonization (Apparel Impact Institute, 2024).

Revolutionary technologies enable this transformation through breakthrough innovations achieving commercial viability (C&EN, 2022). Supercritical CO₂ dyeing eliminates water usage entirely while achieving 100% dye exhaustion rates (de Oliveria *et al.*, 2024). Chemical recycling technologies deliver 80-90% CO₂ emission reductions compared to virgin production (Fashion Dive, 2024), with companies like Eastman Chemical achieving 110,000 metric tons annual capacity and planning additional facilities through 2030. Bio-based materials, led by mycelium leather partnerships with Adidas, Stella McCartney, and Lululemon (Future Market Insights, 2024), demonstrate 50% lower CO₂ emissions than virgin polyester with growth times of just two weeks versus years for livestock (GM Insights, 2024).

1.2. The Consumer Behavior Challenge

Despite technological advances and market growth, consumer behavior remains the critical bottleneck for sustainable textile adoption (Harris *et al.*, 2016).

Research reveals complex contradictions in consumer decision-making that educational interventions must address systematically (Lundblad and Davies, 2016).

Demographic analysis shows Gen Z consumers represent 40% of global consumers with \$143 billion spending power and demonstrate highest sustainability engagement, with 73% willing to pay premiums. However, behavioral contradictions persist as 72% of college students purchased fast fashion despite sustainability concerns, highlighting the intention-behavior gap requiring strategic intervention (Fibre2Fashion, 2021).

Economic barriers create significant implementation challenges (BCG, 2023). While consumers express willingness to pay 9.7% sustainability premiums on average (PwC, 2024), 61% prioritize price over sustainability in actual purchasing decisions (Nosto, 2022). 56% consider sustainable fashion too expensive (Statista, 2022), creating market tension that requires sophisticated resolution strategies. Only 35% of US consumers willingly spend significantly more on sustainable fashion, while 49% of UK consumers accept "a little more" premium (Statista, 2021).

Trust and transparency issues compound decision-making challenges. 54% do not trust brand sustainability claims and 55% find sustainable product identification confusing, indicating critical needs for verified information and clear communication. The EU Commission's finding that 39% of environmental claims for textile products are false or misleading (European Commission, 2022) emphasizes the importance of education in developing consumer evaluation skills.

1.3. The Supply-Demand Gap Crisis

A critical 133 million ton supply gap between sustainable material demand and supply is projected by 2030, creating both challenge and opportunity for consumer education initiatives. Current European capacity targets 1.25-1.3 million tons annually by 2025, comprising 1 million tons mechanical and 250,000 tons chemical recycling. However, this falls dramatically short of projected demand, highlighting the importance of consumer behavior change in managing demand-side pressures.

Recycling infrastructure limitations compound supply challenges. Current textile recycling rates remain critically low, with less than 0.5% of post-consumer textile waste recycled into new textiles and 73% ending up in landfills or incineration. Chemical recycling companies like Syre, H&M's joint venture, committed \$60 million for 10,000 metric tons capacity by 2025, targeting 3 million metric tons by 2034, but scaling remains dependent on consumer acceptance and behavior change.

2. EDUCATIONAL FRAMEWORK FOR CONSUMER TRANSFORMATION

2.1. The EUSusTex Model: Evidence-Based Consumer Education

The EUSusTex project at Bartın University provides compelling evidence for effective consumer education strategies targeting the sustainable textile transformation. Implemented as an Erasmus+ Jean Monnet Module, the project reaches over 300 students across multiple faculties, reflecting the interdisciplinary nature of sustainability challenges requiring collaboration across technical and non-technical disciplines.

Educational structure integration addresses consumer decision-making complexity through systematic approaches. The framework incorporates parallel courses totaling 4 hours weekly: Environment and Energy (2h/week) providing foundational climate and policy knowledge, and Sustainability in Textiles (2h/week) focusing on sector-specific applications including environmental impact assessment, resource consumption analysis, and consumer decision-making frameworks.

Measurable transformation results demonstrate educational effectiveness across multiple dimensions. Environmental impact awareness increased from 20% to 80% following intervention, while 90% of students reported using decision framework elements for actual purchasing decisions.

2.2. Industry Collaboration: Experiential Learning Impact

Industry-academia partnerships prove most effective for transforming consumer understanding through authentic learning contexts. Factory visits and expert interactions create tangible connections between theoretical knowledge and real-world implementation, with students reporting these as the most influential components of their educational experience.

Authentic implementation contexts enable students to witness sustainable production processes including supercritical CO₂ dyeing, chemical recycling operations, and bio-based material production. These experiences provide practical understanding of the \$1-2.5 million investments required for achieving 50% reductions in materials, energy, or water usage, helping students appreciate both challenges and opportunities in sustainable production.

Professional network development through industry partnerships exposes students to sustainability professionals and potential career pathways in sustainable textile industries. This connection helps bridge the skills gap in implementing complex requirements including eco-design criteria, EPR system management, digital product passport development, and green claims verification.

2.3. Consumer Decision Framework Development

Systematic decision-making tools translate complex sustainability concepts into practical daily actions, addressing the fundamental challenge of connecting policy objectives with individual behaviors. The framework organizes consumer decisions into three lifecycle stages corresponding to EU Strategy objectives:

Pre-Purchase Stage implements objectives related to reducing excessive production through systematic need assessment, evaluation of second-hand alternatives, and consideration of ethical production practices. Students learn to evaluate fundamental durability elements including color retention, tear resistance, seam strength, and zipper quality, directly supporting the EU objective of creating longer-lasting products.

Usage Stage supports durability and repairability objectives through sustainable care practices. Students learn about the critical first 5-10 wash cycles when microplastic emission is most intensive from synthetic fabrics, with approximately 40,000 tons of synthetic fibers entering the environment annually from laundry activities alone. Proper care education addresses both product longevity and environmental impact reduction.

The end-of-life stage addresses waste prevention and circularity enhancement through responsible disposal options, which include donation, reselling, repurposing, and recycling. This stage directly supports the 5.8 million tons of annual EU textile waste reduction goals and EPR implementation requiring separate textile waste collection by January 1, 2025.

3. TECHNOLOGY INTEGRATION AND SCALABILITY SOLUTIONS

3.1. AI-Enhanced Personalized Learning

Advanced educational technologies provide scalability solutions for reaching broader consumer populations beyond traditional academic settings. The proposed Adaptive Dynamic Intelligent Teaching System addresses individual learning needs while maintaining educational quality standards.

Personalized learning paths customize content delivery based on individual progress, knowledge levels, and learning preferences. This addresses the challenge of diverse backgrounds in interdisciplinary sustainability courses while ensuring comprehensive coverage of complex topics including chemical recycling achieving 80-90% emission reductions, bio-based materials reaching cost parity, and circular business model implementation.

Real-time analytics and feedback enable immediate assessment of learning progress with adaptive content adjustment based on performance patterns. This technological integration supports the \$30 billion annual investment opportunities in sustainable textiles by developing informed consumers capable of driving market demand for sustainable alternatives.

3.2. Cross-Sectoral Integration and Systems Thinking

Interdisciplinary approaches foster comprehensive sustainability understanding by connecting textile challenges with broader environmental systems. The educational framework examines sustainability across multiple industrial sectors including construction, steel, and plastics, helping students understand interconnections between different industries.

Systems-level understanding proves essential for implementing circular economy principles effectively. Students develop appreciation for how textile waste collection mandates, digital product passport requirements, and destruction bans for unsold products influence supply chain management and business model innovation throughout the value chain.

Global perspective integration through international partnerships provides diverse cultural and economic contexts for understanding sustainability challenges. Collaboration with universities in the UK, Indonesia, and Egypt demonstrates varying approaches to Extended Producer Responsibility implementation, green claims verification, and policy framework effectiveness across different national contexts.

4. MARKET-DRIVEN CONSUMER EDUCATION STRATEGIES

4.1. Economic Literacy and Value Proposition Understanding

Cost-benefit education addresses the fundamental economic barriers preventing sustainable adoption despite positive environmental attitudes (Nosto, 2022). Students learn total cost of ownership analysis including durability benefits, end-of-life value retention, and health cost avoidance that offset initial price premiums (Statista, 2022).

Investment return demonstration shows how brands using sustainable raw materials achieve average 6% net profit increases within five years (BCG, 2023), while most fashion brands can reduce greenhouse gas emissions by 60% for less than 1-2% of revenues (McKinsey, 2024). This economic literacy helps consumers understand how their purchasing decisions support business models that deliver both environmental and financial returns.

Market dynamics education reveals how the second-hand market grows 15 times faster than overall fashion, valued at \$177 billion in 2022 and projected to reach \$351 billion by 2027 (Value the Markets, 2024). Understanding these trends helps consumers recognize sustainable alternatives as mainstream market opportunities rather than niche premium options (D'Adamo *et al.*, 2022).

4.2. Technology Adoption and Digital Literacy

Digital product passport utilization prepares consumers for transparency initiatives providing comprehensive tracking of material composition, sustainability performance, carbon and water footprint, and recycling potential

(Environment EC, 2022). Students learn to access and interpret this information through QR codes and digital platforms supporting informed decision-making (Carbonfact, 2024).

Green claims verification skills address the 39% of false or misleading environmental claims in textile marketing by teaching recognition of certified labels and independent verification sources (European Commission, 2022). This education protects consumers from misleading marketing while supporting legitimate sustainable businesses (Patwary *et al.*, 2023).

Supply chain transparency education enables consumers to understand complex global production networks and identify companies implementing fair labor practices, chemical safety protocols, and environmental protection measures throughout their operations (World Bank, 2019).

5. POLICY INTEGRATION AND REGULATORY ALIGNMENT

5.1. EU Strategy Implementation Through Consumer Action

Regulatory framework understanding connects individual purchasing decisions with policy objectives including mandatory eco-design criteria, EPR system implementation, and fast fashion elimination. Students learn how their choices support or undermine regulatory effectiveness in achieving 50% reduction in overall textile carbon footprint by 2030.

Extended Producer Responsibility support through strategic purchasing considers company EPR practices and end-of-life services. This connects individual purchasing power with policy implementation as separate textile waste collection becomes mandatory across all 27 EU member states by January 1, 2025.

Circular economy participation through end-of-life decisions prioritizing reuse, repair, and recycling directly addresses EU concerns about 5.8 million tons of annual textile waste generation. Consumer education enables active participation in destruction bans for unsold products and microplastic pollution control initiatives (European Commission 2022).

5.2. Global Policy Coordination and Implementation

International regulatory alignment addresses the global nature of textile supply chains through education about varying EPR implementation approaches, chemical safety standards, and labor protection requirements across different national contexts. This understanding helps consumers make informed decisions about products from different regions.

Innovation support mechanisms teach consumers to identify and support bio-based and low-carbon textile fiber development through initiatives like New European Bauhaus and Circular Bio-based Europe. Purchasing decisions supporting innovative materials help drive the \$20-30 billion annual investment required for sustainable technology deployment (Fashion for Good, 2024).

5.3. Corporate Sustainability Commitments and Industry Self-Regulation

Corporate sustainability commitments demonstrate industry transformation with quantitative targets. The UK Textiles Pact signed up 130 businesses representing 62% of the UK market, targeting a 50% carbon footprint reduction, 40% water footprint reduction, and 25% waste reduction by 2030. However, year-two results show mixed progress, with a 2% carbon decrease but an 8% water footprint increase, highlighting implementation challenges (WRAP, 2023).

This mixed progress underscores the importance of consumer education in supporting corporate sustainability goals. Educational initiatives can help bridge the gap between corporate commitments and actual performance by creating informed consumer demand that incentivizes genuine transformation over superficial commitments.

6. MEASURING IMPACT AND SCALING SUCCESS

6.1. Behavioral Change Assessment and Validation

Quantitative measurement frameworks track actual behavioral changes over time through comprehensive assessment methods including pre-post knowledge evaluation, behavioral intention measurement, practical skill assessment, and long-term follow-up tracking.

Sustained impact validation requires extended follow-up studies tracking consumer behavior over multiple years to confirm lasting transformation. The EUSusTex project's 85% success rate in developing critical consumption patterns provides baseline evidence, but scaling requires systematic measurement across diverse populations and contexts.

Cross-cultural validation examines educational framework effectiveness across different cultural and institutional contexts to assess generalizability and adaptation requirements. This research supports development of scalable approaches reaching the global consumer base necessary for achieving the 133 million ton sustainable material supply gap reduction.

6.2. Institutional Integration and Policy Support

Educational policy integration recognizes consumer education as essential for policy implementation success, requiring dedicated resources and strategic planning to maximize contribution to circular economy objectives. The 73% of Gen Z willing to pay premiums demonstrates market readiness requiring systematic educational support.

Multi-stakeholder platform development supports industry-academia-government collaborations providing authentic contexts for understanding regulatory requirements. These partnerships demonstrate eco-design compliance, EPR implementation, and green claims verification processes while developing workforce capabilities for regulatory compliance management.

Scaling mechanisms include development of shared educational resources, collaborative learning experiences across institutions, and standardized assessment frameworks ensuring quality while enabling widespread adoption. Success requires coordination across educational institutions, policy makers, and industry stakeholders to create comprehensive transformation capacity.

7. FUTURE RESEARCH DIRECTIONS AND IMPLEMENTATION PRIORITIES

7.1. Advanced Technology Integration

Artificial intelligence applications enhance educational effectiveness through adaptive learning systems incorporating real-time market data, supply chain transparency information, and regulatory updates. AI-driven personalization addresses individual learning needs while maintaining comprehensive coverage of complex sustainability topics.

Virtual reality experiences provide immersive learning opportunities including virtual factory tours, environmental impact visualization, and decision-making simulations. These technologies scale authentic learning experiences beyond geographic limitations while reducing costs associated with industry partnerships.

Blockchain verification systems enable students to access verified sustainability data supporting informed decision-making while learning about emerging technologies transforming textile supply chain transparency and accountability.

7.2. Global Implementation Coordination

International framework development creates standardized approaches adaptable to different cultural, economic, and regulatory contexts while maintaining core effectiveness elements. This coordination supports the global nature of textile supply chains and consumer markets requiring coordinated transformation approaches.

Policy integration mechanisms establish systematic approaches connecting educational initiatives with regulatory implementation timelines, ensuring consumer readiness for January 1, 2025 textile waste collection mandates, digital product passport deployment, and EPR system activation across different jurisdictions.

Innovation ecosystem development connects educational institutions with \$20-30 billion annual investment opportunities in sustainable textile technologies, creating pathways for students to contribute to innovation while developing market demand for breakthrough solutions.

8. CONCLUSIONS AND STRATEGIC RECOMMENDATIONS

8.1. Consumer Education as Market Transformation Catalyst

The convergence of \$75 billion market opportunity, breakthrough technologies achieving 80-90% emission reductions, and regulatory mandates requiring transformation by 2025 creates unprecedented conditions for sustainable textile adoption. However, realizing this potential requires systematic consumer education addressing the persistent gap between sustainability intentions and purchasing behavior.

Evidence-based educational frameworks demonstrate significant effectiveness in transforming consumer understanding and behavior. The EUSusTex project's 85% success rate in developing critical consumption patterns and 70% increase in sustainable alternative consideration provides replicable models for scaling consumer engagement across different contexts and populations.

Industry collaboration proves essential for creating authentic learning experiences that transform abstract sustainability concepts into practical decision-making capabilities. Experiential learning through real-world exposure achieves superior results compared to traditional classroom instruction alone, suggesting that hands-on experiences should be central to consumer education programs.

8.2. Strategic Implementation Priorities

Immediate priorities include scaling proven educational frameworks to reach broader consumer populations, integrating advanced technologies for personalized learning delivery, and establishing systematic measurement frameworks tracking behavioral change over time. The 133 million ton supply gap by 2030 requires urgent action to modify consumer demand patterns while supply capacity develops.

Medium-term objectives focus on policy integration ensuring consumer readiness for EPR implementation, digital product passport deployment, and circular economy participation required by evolving regulatory frameworks. Educational initiatives must align with policy timelines to maximize transformation effectiveness.

Long-term transformation requires comprehensive ecosystem development connecting educational institutions, industry stakeholders, and policy makers in coordinated approaches supporting the transition from fast fashion worth \$124 billion annually to sustainable alternatives projected at \$75 billion by 2032. Success depends on systematic behavior change across global consumer populations supported by robust educational infrastructure.

8.3. Call for Coordinated Action

The sustainable textile revolution requires unprecedented coordination between technological innovation, regulatory implementation, and consumer behavior change. Educational interventions are critical for connecting these elements through informed consumer decision-making, supporting market transformation and policy effectiveness.

Stakeholder collaboration across academia, industry, and government creates the authentic learning contexts necessary for effective consumer education while ensuring alignment with regulatory requirements and market realities. The \$30 billion annual investment opportunities in sustainable textiles depend on consumer readiness to adopt innovations and support sustainable business models.

Global coordination ensures educational approaches address the international nature of textile supply chains while respecting local cultural and economic contexts. The transformation from 93 billion cubic meters of annual water consumption and 8-10% of global CO₂ emissions to sustainable alternatives requires coordinated consumer action supported by comprehensive education enabling informed participation in circular economy principles.

Through strategic educational interventions targeting the critical consumer behavior gap, the textile industry can achieve its sustainable transformation potential while delivering both environmental protection and economic opportunity at unprecedented scale (D'Adamo *et al.*, 2022). The evidence demonstrates that consumer education is not merely supportive of sustainable textile adoption – it is essential for realizing the \$75 billion market opportunity and achieving the environmental impact reductions necessary for planetary sustainability (Ellen MacArthur Foundation, 2017).

References

- 1) Apparel Impact Institute (2024). The Fashion Climate Fund. Available at: <https://apparelimpact.org/fashion-climate-fund/> (Accessed: 6 June 2025).
- 2) BCG (2023). Sustainable Raw Materials Will Drive Profitability for Fashion and Apparel Brands. Boston Consulting Group. Available at: <https://www.bcg.com/publications/2023/driving-profitability-with-raw-materials-in-fashion> (Accessed: 6 June 2025).
- 3) C&EN (2022). Transforming textiles. Chemical & Engineering News. Available at: <https://cen.acs.org/environment/green-chemistry/Transforming-textiles/100/i11> (Accessed: 6 June 2025).
- 4) Carbonfact (2024). Full overview of the EU textile strategy and regulations. Available at: <https://www.carbonfact.com/blog/policy/eu-regulations-for-textile-brands> (Accessed: 6 June 2025).
- 5) CNBC (2025). Meet the sustainable fashion startup backed by H&M and Amazon. Available at: <https://www.cnbc.com/2025/05/19/meet-the-sustainable-fashion-startup-backed-by-hm-and-amazon.html> (Accessed: 6 June 2025).

- 6) Cognitive Market Research (2024). The Global Sustainable Fashion market size was USD 7915.2 Million in 2024! Available at: <https://www.cognitive-marketresearch.com/sustainable-fashion-market-report> (Accessed: 6 June 2025).
- 7) Compliance & Risks (2024). Development and Potential of Extended Producer Responsibility in the Textiles Sector. Available at: <https://www.complianceandrisk.com/blog/development-and-potential-of-extended-producer-responsibility-for-textiles/> (Accessed: 6 June 2025).
- 8) Credence Research (2024). Sustainable Fashion Market Size, Growth and Forecast 2032. Available at: <https://www.credenceresearch.com/report/sustainable-fashion-market> (Accessed: 6 June 2025).
- 9) D'Adamo, I., Lupi, G., Morone, P. and Settembre-Blundo, D. (2022). Towards the circular economy in the fashion industry: The second-hand market as a best practice of sustainable responsibility for businesses and consumers. *Environmental Science and Pollution Research*, 29, pp. 46620-46633.
- 10) Decathlon (2024). Why does it take so much water to make a cloth? Available at: <https://sustainability.decathlon.com/why-does-it-take-so-much-water-to-make-a-cloth> (Accessed: 6 June 2025).
- 11) Earth.org (2022). EU Strategy for Sustainable Textiles: 5 Takeaways. Available at: <https://earth.org/5-takeaways-from-the-new-eu-circular-fashion-strategy/> (Accessed: 6 June 2025).
- 12) Ecosistant (2024). EU Textile EPR Directive for Fashion Brands. Available at: <https://www.ecosistant.eu/en/eu-textile-epr-directive-for-fashion-brands/> (Accessed: 6 June 2025).
- 13) Ellen MacArthur Foundation (2017). *A New Textiles Economy: Redesigning Fashion's Future*. UK: EMF Publications.
- 14) Environment EC (2022). Textiles strategy - European Commission - EU Environment. Available at: https://environment.ec.europa.eu/strategy/textiles-strategy_en (Accessed: 6 June 2025).
- 15) European Commission (2022). *EU Strategy for Sustainable and Circular Textiles*. European Commission, Brussels.
- 16) European Commission (2023). *EU Strategy for Sustainable and Circular Textiles*. European Commission Report, Brussels.
- 17) European Parliament (2020). The impact of textile production and waste on the environment (infographics). Available at: <https://www.europarl.europa.eu/topics/en/article/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographics> (Accessed: 6 June 2025).
- 18) Fashion Dive (2024). Textile recycling company Infinited Fiber closes \$43.8M funding round. Available at: <https://www.fashiondive.com/news/infinited-fiber-new-funding-recycled-textile/710276/> (Accessed: 6 June 2025).
- 19) Fashion for Good (2024). Fashion for Good & BCG launch New Report – Financing the Transformation in Fashion. Available at: https://www.fashionforgood.com/our_news/fashion-for-good-bcg-launch-new-report-financing-the-transformation-in-fashion/ (Accessed: 6 June 2025).
- 20) Fibre2Fashion (2021). The future of sustainable fashion – Gen Z and Millennials. Available at: <https://www.fibre2fashion.com/industry-article/9028/the-future-of-sustainable-fashion-gen-z-and-millennials> (Accessed: 6 June 2025).

- 21) Frontiers (2022). An overview of the contribution of the textiles sector to climate change. *Frontiers in Environmental Science*. Available at: <https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2022.973102/full> (Accessed: 6 June 2025).
- 22) FSU (2024). *Clothed in Conservation: Fashion & Water*. Florida State University Sustainable Campus. Available at: <https://sustainablecampus.fsu.edu/blog/clothed-conservation-fashion-water> (Accessed: 6 June 2025).
- 23) Future Market Insights (2024). *Mycelium Leather Market Size & Outlook 2024-2034*. Available at: <https://www.futuremarketinsights.com/reports/mycelium-leather-market> (Accessed: 6 June 2025).
- 24) GM Insights (2024). *Mycelium Market Size, Share, Trends, Growth, Forecasts 2034*. Global Market Insights. Available at: <https://www.gminsights.com/industry-analysis/mycelium-market> (Accessed: 6 June 2025).
- 25) Harris, F., Roby, H. and Dibb, S. (2016). Sustainable Clothing: Challenges, Barriers and Interventions for Encouraging More Sustainable Consumer Behaviour. *International Journal of Consumer Studies*, 40(3), pp. 309-318.
- 26) Lundblad, L. and Davies, I.A. (2016). The Values and Motivations Behind Sustainable Fashion Consumption. *Journal of Consumer Behaviour*, 15(2), pp. 149-162.
- 27) Market Research Future (2024). *Sustainable Fabrics Market Size, Share, Growth | Report, 2032*. Available at: <https://www.marketresearchfuture.com/reports/sustainable-fabrics-market-7435> (Accessed: 6 June 2025).
- 28) MDPI (2023). *Systematic Insights into a Textile Industry: Reviewing Life Cycle Assessment and Eco-Design*. Available at: <https://www.mdpi.com/2071-1050/15/21/15267> (Accessed: 6 June 2025).
- 29) McKinsey (2024). *Sustainable style: How fashion can afford and accelerate decarbonization*. McKinsey & Company. Available at: <https://www.mckinsey.com/industries/retail/our-insights/sustainable-style-how-fashion-can-afford-and-accelerate-decarbonization> (Accessed: 6 June 2025).
- 30) Nosto (2022). *New Research: 61% of Fashion Shoppers Put Price Above Sustainability as Living Costs Rise*. Available at: <https://www.nosto.com/blog/sustainable-fashion-consumer-research-2022/> (Accessed: 6 June 2025).
- 31) Patwary, S., Haque, M.A., Kharraz, J.A., Khanzada, N.K., Farid, M.U. and Kumar, N.M. (2023). Apparel Consumer Behavior and Circular Economy: Towards a Decision-Tree Framework for Mindful Clothing Consumption. *Sustainability*, 15(1), pp. 656.
- 32) PwC (2024). *Consumers willing to pay 9.7% sustainability premium, even as cost-of-living and inflationary concerns weigh: PwC 2024 Voice of the Consumer Survey*. Available at: <https://www.pwc.com/gx/en/news-room/press-releases/2024/pwc-2024-voice-of-consumer-survey.html> (Accessed: 6 June 2025).
- 33) Rev-log (2024). *Textile EPR Explained: Essential FAQs*. Reverse Logistics Group. Available at: <https://rev-log.com/textile-epr-explained-essential-faqs/> (Accessed: 6 June 2025).
- 34) de Oliveira, C. R. S., de Oliveira, P. V., Pellenz, L., de Aguiar, C. R. L., & da Silva Júnior, A. H. (2024). Supercritical fluid technology as a sustainable alternative method for textile dyeing: An approach on waste, energy, and CO2 emission

- reduction. *Journal of Environmental Sciences*, 140, 123-145. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S1001074223002590> (Accessed: 6 June 2025).
- 35) Statista (2021). Willingness to pay for sustainable fashion in the United States 2021. Available at: <https://www.statista.com/forecasts/1235883/willingness-to-pay-for-sustainable-fashion-in-the-us> (Accessed: 6 June 2025).
 - 36) Statista (2022). Agreement sustainable fashion is too expensive U.S. 2022. Available at: <https://www.statista.com/statistics/1382928/agreement-that-sustainable-fashion-is-too-expensive-us/> (Accessed: 6 June 2025).
 - 37) Textile Exchange (2024). Materials Market Report 2024. Available at: <https://textileexchange.org/knowledge-center/reports/materials-market-report-2024/> (Accessed: 6 June 2025).
 - 38) Value The Markets (2024). Investing in Sustainable Fashion: Companies, Trends & ESG. Available at: <https://www.valuethemarkets.com/analysis/investing-in-sustainable-fashion-companies-trends-and-esg> (Accessed: 6 June 2025).
 - 39) World Bank (2019). How Much Do Our Wardrobes Cost to the Environment? Available at: <https://www.worldbank.org/en/news/feature/2019/09/23/costo-moda-medio-ambiente> (Accessed: 6 June 2025).
 - 40) WRAP (2023). Textiles 2030 Annual Progress Update 2022-23. The Waste and Resources Action Programme. Available at: <https://www.wrap.ngo/resources/report/textiles-2030-annual-progress-update-2022-23> (Accessed: 6 June 2025)

EXTERNALITIES FOR BUSINESS DECISION MAKING OF CIRCULAR ECONOMY IMPLEMENTATION IN SMART CITIES

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Abstract

Externality is either an indirect cost or indirect benefit that is caused by one party but financially incurred or received by another. Externalities can be negative or positive. A negative externality is the indirect imposition of a cost by one party onto another. A positive externality, on the other hand, is when one party receives indirect benefit as a result of actions taken by another. For a successful business model of any publicly funded

project, direct and indirect benefits and costs must be fully established to derive a positive business case (e.g. based on benefit over cost ratio). This paper contributes to Eco4All by deriving new insights into the stakeholders' challenges, consumers' value chain, business processes and obstacles in the implementation of circular economy concepts within smart city environments. The main aim of the study is to determine externalities and enable the policies to implement a common circularity framework for inclusive application and assessment in smart cities to support decision-making for all value chain stakeholders and consumers enhancing the implementation level of the European Circular Economy Action Plan (ECEAP). Based on extensive industry expert interview, our new findings reveal the lack of value transfer across stakeholders and consumers, and there is an urgent need for more actionable and pragmatic solutions for circularity (including technology enabler, social value enabler, circular business model, human capability & behavior, and standard & legislation).

Keywords: externality, business model, circular economy, smart cities

JEL Classification: D62, Q51, Q56, R11, O18, L26

1. INTRODUCTION

Built environment sector and its supply chains contribute over 60% of total carbon emissions worldwide towards global warming. The built environment involves all aspects of our lives, encompassing the buildings we use and reside, the systems that distribute internet, telecommunication, water and electricity, and the roads, bridges, railways, airports, and other mobility systems we use to travel from place to another place. Generally, it is described as the man-made or constructed structures that enable living, working, travelling, and recreational spaces. Constructing, operating and maintaining all these spaces and systems requires enormous resources (i.e. materials, energy, fuel, labour, time, and money). In particular, the buildings are responsible for around 40% of energy and process-related carbon emissions. They consume 50% of all extracted (fossil) materials and 33% of water and then cause 35% of generated waste (European Commission, 2025a; 2025b). These combined actions can implicitly induce indirect environmental impacts including resource depletion, air, water and land pollution, environmental toxicity, habitat disruption and biodiversity loss. In fact, these will be exacerbated by the fact that the global population will increase nearly 30% to almost 10 billion on earth by 2025 with the exponential need for housing and urban development (Kaewunruen *et al.*, 2016). Today, over 55% of the world's population lives in urban areas, and United Nation (2025) has also predicted that the urban population density is expected to increase to 68% by 2050. This implies that the problems will be tremendous if there is no solution to help the transition. In various countries, smart cities have been recently developed to digitally facilitate the urbanised built environment and improve the quality of life. However, neither are smart cities sustainable nor circular. On this ground, there is an urgent call for faster green transition of urban areas including smart cities to net zero and regenerative resources.

In recent years, European Green Deal has been introduced to offer a concerted strategy for a climate-neutral, resource-efficient and competitive economy (European Commission, 2025b). In order to achieve the net zero, circular economy (CE) principles have been a key instrument to drive the green transition. However, many challenges and barriers exist (across technical and scientific, economic, market, social and cultural, and regulatory aspects) against the implementation of circular economy for consumers and related stakeholders. A recent study revealed that consumers such as asset owners and managers are among the most influencers in decision making processes for circularity actions. However, the key concern of consumers is the financial burden and resource constraint due to the lack of sustained and viable business models for circular economy (Kaewunruen *et al.*, 2024). A successful viable business model requires the thorough understanding and quantification of both cost(s) and benefit(s) over the whole lifecycle of the assets. At present, the cost and benefit are crudely estimated, resulting in miscalculation or misinterpretation of benefit over cost ratio (BBC, 2023). The issues are the lack of tools, methodologies and understanding into externality to derive benefit(s) and cost(s) for better and more informed decision-making mechanism. Externality is either an indirect cost or indirect benefit that is caused by one party but financially incurred or received by another. Externalities can be negative or positive. A negative externality is the indirect creation of a cost by one stakeholder onto another. In contrast, a positive externality is when a stakeholder earns an indirect benefit because of actions taken by another. Improving externalities can generate regional growth.

Accordingly, Eco4All Project has been established to promote green circular economy as a behaviour, by driving the actions and decisions of governments, companies, workers, citizens and consumers to realise their economic, environmental and social impacts in a responsible manner. This paper thus contributes to Eco4All by deriving new insights into the stakeholders' challenges, consumers' value chain, business processes and obstacles in the implementation of circular economy concepts within smart city environments. The main aim of the study is to determine externalities and recommend policies to implement a common circularity framework for inclusive application and assessment in smart cities to support decision-making for all value chain stakeholders and consumers enhancing the implementation level of the European Circular Economy Action Plan (ECEAP). The outcome of this study will address the business model challenges for smart built environments

2. CONCEPTS AND METHODOLOGY

We bring together a network of stakeholders with a significant impact on different life cycle stages of smart buildings and smart cities. Actors from multidisciplinary fields from two EU Cost Actions (Eco4All and CircularB) have been consulted to communicate to enhance circularity implementation in buildings constantly. Some stakeholders related to smart cities include:

- a) Academia from different European universities with distinct expertise (Architecture, Construction Materials, Economics, Engineering, Management, Urban Planning, Smart Cities)
- b) Research institutes currently working on smart cities, smart buildings, and circularity topics, such as assessment methods, efficient management, smart technologies of CDW, recycling and reuse, and design strategies
- c) Practitioners, including smart building designers, contractors, consultants, material producers and supplier companies, waste management companies, and international environmental consultancy
- d) National and local authorities and policymakers, including European municipalities; and,
- e) National associations, including smart building and construction institutes, material producer representatives, professional associations, civil society, NGOs, etc.
- f) By expert discussions within Eco4All & CircularB projects, the relationship among stakeholders and value chain consumers can be illustrated in Figure 1.

To conduct a critical literature review, keywords were derived from the research goal to facilitate the search for literature. The derived keywords were: ‘Externalities’, ‘Circular Economy’ and ‘Smart Cities’. Additionally, when considering a CE implementation, it is often considered as a ‘Business Model’. To the best of our knowledge, the study into externalities of circularity at the intersection of smart cities is relatively scarce, and our study is unprecedented.

Our research has then adopted a

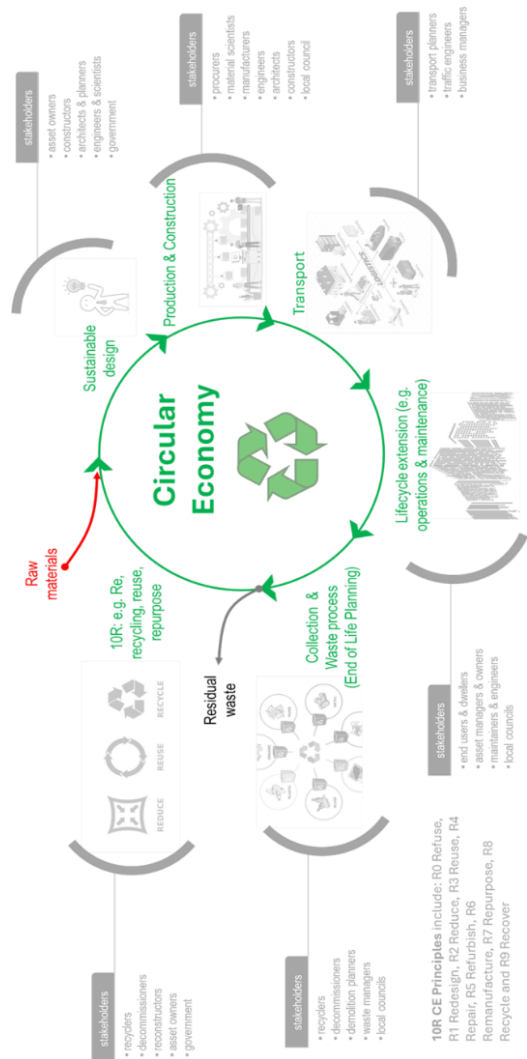


Figure 1. Stakeholders across different lifecycle stages of smart cities

qualitative approach via semi-structured interviews and dialogue with different stakeholders and consumers within a smart city environment (see Figure 2). The non-personal data was collected anonymously without withholding person information. All respondents had given consent for data collection. The data requested in this study was collected and processed by the researchers in accordance with the provisions of Regulation (EU) 2016/679 (the General Data Protection Regulation, GDPR) and all other applicable EU and UK privacy and data protection legislation. Open- end questions were asked to yield insights into the externalities of circular practices within smart cities.

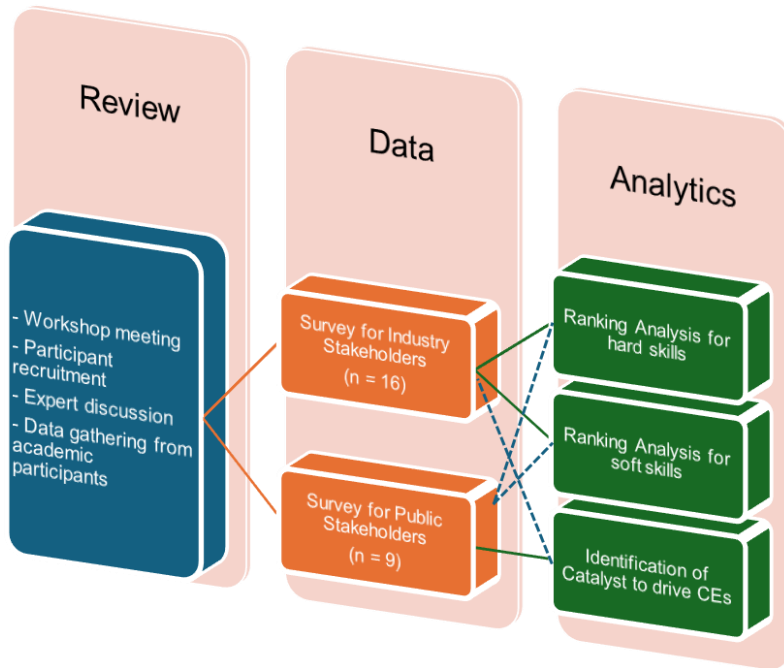


Figure 2. Research methodology

3. RESULTS AND DISCUSSION

Based on the expert interview, we have observed that the experts provided agreeable results. It is also noted that after 15-20 interviews, the experts' responses highly converge with very little variance. In Figure 3, the externalities observed by consumers and stakeholders for implementing circular practices in smart cities have been presented at different stages of life cycle. Green color implies indirect benefits and red implies indirect costs.

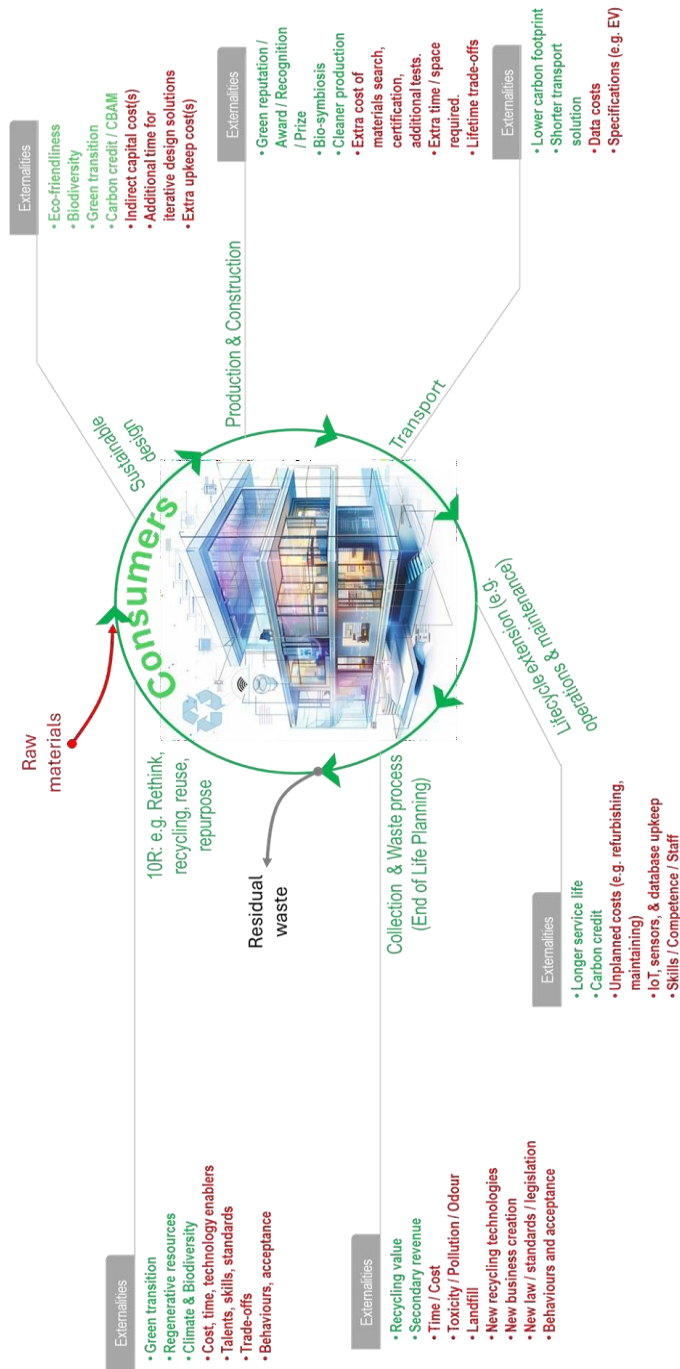


Figure 3. Circular externalities in the smart built environment

It is apparent that the common externalities for consumers are skills and capabilities, carbon credits or values, biodiversity conservation, and additional indirect costs for upkeep. The outcome also confirms previous findings by Neale *et al.* (2025) that future workforce must be highly collaborative and know how to engage industry, community and stakeholders. This resonates with a report by WEF – World Economic Forum (2025) that the most critical hard skill needed in 2030 are (i) artificial intelligence, (ii) digital engineering, and (iii) green transition / circular economy. Soft skills needed are (i) life-long learning and (ii) stakeholder engagement. This externality could be perceived as an indirect cost for consumers, but it can create new value and economy opportunities for other stakeholders (e.g. academic institutions, professional association, training centres, etc.).

According to a UK government report (2025), the carbon markets are not well established and do not currently reach their full potential. This is due to a lack of clarity among businesses and organisations on how carbon credits can be realised, and some poor practice affecting the effectiveness in delivering meaningful climate action and economic growth. There have been significant demands from businesses and organisations for greater clarity in how to use these carbon credit markets as part of their plans to reach net zero. This creates externalities (e.g. added value, new business opportunities, employment growth, etc.) for various stakeholders. The carbon credits derived from circular practices (e.g. the use of recycled materials, reused components, etc.) can generate indirect value and reputation to them. For example, these can help asset owners or investors achieve green building status and/or carbon neutrality, enhancing the assets' market value proposition, market penetration, brand and reputation. Note that the value of the global green economy has significantly increased from

\$7.2tn in 2024 to nearly \$8tn in 2025 (CRN, 2025). This indeed demonstrates the real use-case and industry demand for externality or indirect added value of circular economy practices.

The externality to biodiversity is invaluable. The circular practices generally help to escalate sustainable development of the built environment. However, there are two folds. Certain circular practices may reduce durability and service life of the assets while targeting at only environmental benefits. This action may not strike the balance for sustainability where all three pillars (including economic, social, and environmental pillars) should be considered. On this ground, European Commission (2025c) has launched “**Level(s)**” as an assessment and reporting tool for improving the sustainability performance of buildings. Level(s) has six macro-objectives, as shown in Table 1, to appropriately enrich circularity. In smart cities, these indicators are being monitored by sensors & IoT systems. The additional costs for digital technology enablers and relevant skills & capabilities have become an economic challenge for consumers but are new opportunities for research and new business.

Table 1. Level(s) for sustainable buildings (adapted from European Commission, 2025c and Bragança *et al.*, 2025)

Level(s) macro objective	Indicators	Circular Practice
1. Greenhouse gas emissions along a buildings life cycle	• Use stage energy performance (kWh/m²/yr) • Life cycle Global Warming Potential (CO₂ eq./m²/yr)	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover
2. Resource efficient and circular material life cycles	• Bill of quantities, materials and lifespans • Construction & Demolition waste and materials • Design for adaptability and renovation • Design for deconstruction, reuse and recycling	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover
3. Efficient use of water resources	• Use stage water consumption (m³/occupant/yr)	R0 Refuse, R1 Redesign, R2 Reduce, and R9 Recover
4. Healthy and comfortable spaces	• Indoor air quality • Time outside of thermal comfort range • Lighting and visual comfort • Acoustics and protection against noise	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover
5. Adaption and resilience to climate change	• Protection of occupier health and thermal comfort • Increased risk of extreme weather • Sustainable drainage	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover
6. Optimised life cycle cost and value	• Life cycle costs (€/m²/yr) • Value creation and risk factors	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover

4. CONCLUSIONS

Circular business process and enablers driving consumers engagement for successful circular implementation in smart cities need to robustly realise both direct and indirect benefits(s) together with cost(s). Our study is the world's first to discover the externalities of circular practices at different stages of life cycle

throughout the asset's life. With the unified goal to promote greener transition, our study synergises and complements two EU Cost Actions: Eco4All (EU Circular Economy Network for All: Consumer Protection through reducing, reusing, repairing) and CircularB (Implementation of Circular Economy in the Built Environment) funded by European Cooperation for Science and Technology (COST).

Our study delves into the externalities by conducting rigorous open-end interviews with professionals and experts who have delivered smart cities. It is clear that consumers (or value chain stakeholders) face common externalities including skills and capabilities, realisation of carbon credits or values, biodiversity conservation, and additional indirect costs. The findings infer the common challenges and barriers for consumers to implement circular economy in practice. To overcome these challenges, the government and authorities must provide greater clarity for communicating and realising the externalities where businesses and consumers can both benefit from. It is critical to have the thorough understanding into the externalities and relevant stakeholders or consumers. This will help to facilitate essential relationship which underpins successful circular business model within the smart city environments, as illustrated in Figure 4. With these critical ingredients, the consumers will be protected and empowered to participate in the full circularity of the process.

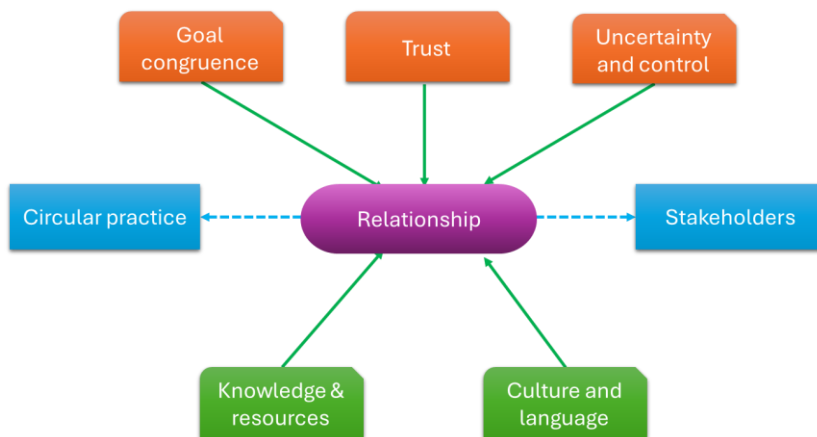


Figure 4. Critical ingredients to successful circular business model

References

- 1) European Commission. (2025a). A new Circular Economy Action Plan for a cleaner and more competitive Europe, Access Online Available at: https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en [Accessed on 10.05.2025]
- 2) European Commission (2025b). Energy Performance Building Directives, Access

- Online: Available at: https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en [Accessed on 10.05.2025]
- 3) Kaewunruen, S., Sussman, J. M. & Matsumoto, A. (2016). Grand challenges in transportation and transit systems. *Front. Built Environ.* 2, 4. <https://doi.org/10.3389/fbuil.2016.00004>
 - 4) United Nations (2025). 68% of the world population projected to live in urban areas by 2050, Available at: <https://www.un.org/uk/desa/68-world-population-projected-live-urban-areas-2050-says-un> [Accessed on 10.05.2025]
 - 5) Kaewunruen, S., Teuffel, P., Donmez Cavdar, A. *et al.* (2024). Comparisons of stakeholders' influences, inter-relationships, and obstacles for circular economy implementation on existing building sectors. *Sci Rep* 14, 11046. <https://doi.org/10.1038/s41598-024-61863-0>
 - 6) BBC (2023). HS2 Ltd miscalculating impact on nature - Wildlife Trusts, Available at: <https://www.bbc.co.uk/news/science-environment-64558664> [Accessed on 10.05.2025]
 - 7) Neale, B.; Kaewunruen, S.; Li, D.; Donmez Cavdar, A.; Askar, R.; Tambovceva, T.; Bajare, D. (2025). Challenges of Engineering Skillsets Essential for Driving Circularity of Smart Cities. *Appl. Sci.*, 15, 809. <https://doi.org/10.3390/app15020809>
 - 8) WEF - World Economic Forum (2025). The reskilling revolution, Available at: <https://initiatives.weforum.org/reskilling-revolution/home> [Accessed on 10.05.2025]
 - 9) UK Government (2025). Press release: UK backs businesses to trade carbon credits and unlock finance, Available at: <https://www.gov.uk/government/news/uk-backs-businesses-to-trade-carbon-credits-and-unlock-finance> [Accessed on 10.05.2025]
 - 10) CRN, (2025). Global green economy now worth \$7.9tn according to report, Available at: <https://www.channelweb.co.uk/news/2025/global-green-economy-now-worth-7-9tn-according-to-report> [Accessed on 10.05.2025]
 - 11) European Commission (2025c). A quick introduction to Level(s), Access Online: Available at: https://green-forum.ec.europa.eu/levels/quick-introduction-levels_en [Accessed on 10.05.2025]
 - 12) L. Bragança *et al.* (eds.). (2025). Circular Economy Design and Management in the Built Environment - A Critical Review of the State of the Art, Springer Tracts in Civil Engineering, https://doi.org/10.1007/978-3-031-73490-8_1

FOOD WASTE AND CIRCULAR PRACTICES IN THE HOSPITALITY SECTOR

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Abstract

The global consumption of commodities is anticipated to quadruple in the next forty years, while annual waste production is anticipated to rise by 70% by 2050 (Cesaro and Klontza, 2023). The demand for food by 2050 requires the agricultural global production to increase by 70% (5.1 billion tons) and at the same time, it is strongly affected by severe climate events (droughts, floods, tropical storms, heat waves, and wildfires). Moreover, each year, a third of global food production (around 1.3 10⁹ tons) exits the food supply chain as waste (FAO, 2019). To this extent, the linear economic models based on production-consumption-disposal schemes tend to be replaced by circular and resource-efficient economic models, which focus on the whole material cycle to promote reuse as well as to reduce waste and utilize resources as efficiently as possible. Hotel sector contributes significantly to the global environmental footprint, since they utilize significant single use materials and produce large quantities of food waste (Klontza et al., 2016). Reduction of food loss and waste contributes to food security for all, to the reduction of greenhouse gas emissions as well as water and energy saving along with increased production and economic development at global level (Coudard et al. 2021; Skawińska E., Zalewski, 2022).

The main objective of this study is to map food loss and waste during hotel operation. Data were collected and analyzed from three 5-star hotels. On-site measurements were combined with interviews, and questionnaires. Key performance indicators were calculated; water and energy consumption per guest night and food waste per night and reduction scenarios were evaluated. Food waste was characterized as avoidable and non-avoidable and the unconsumed food was characterized as edible and non-edible. Breakfast buffet seems to be the major source of food waste and the biggest percentage (76%) is unconsumed and non-edible.

Keywords: food waste, hospitality sector, tourism, circular solutions.

JEL Classification: Q53, Q56

1. INTRODUCTION

Food waste is a significant environmental concern, particularly within the hospitality sector, where high volumes of food are produced and consumed daily. Research indicates that approximately 1.3 billion tons of food are wasted globally each year, contributing to greenhouse gas emissions and straining natural resources (Khoshnevisan & Pahlavani, 2024). In hotels and restaurants, food waste accounts for a substantial portion of operational waste, with estimates suggesting that between 30% to 50% of prepared food is discarded (Melacini & Perego, 2022). This not only poses environmental challenges but also has economic implications, as hotels incur costs related to purchasing, preparing, and disposing of food that ultimately goes uneaten. The implementation of circular economy principles offers a promising framework for addressing food waste in the hospitality sector. Khoshnevisan and Pahlavani (2024) emphasize that adopting these principles can lead to more sustainable food management practices, focusing on reducing waste, reusing resources, and recycling organic materials. This paradigm shift encourages hotels to rethink their food production and consumption practices, ultimately leading to enhanced resource efficiency and reduced environmental impact. Consumer behavior plays a pivotal role in the generation of food waste within hospitality settings. A systematic review by Kuehnel and Brenner (2024) highlights that guest preferences, dining formats, and portion sizes significantly influence waste generation. Understanding these behavioral patterns is crucial for developing targeted strategies to mitigate waste. For instance, buffet-style dining often results in higher waste levels, as guests tend to over-serve themselves, leading to uneaten food being discarded (Pahlavani *et al.*, 2019). Best practices and strategies for food waste management have been extensively documented in the literature. Voukkali, *et al.* (2023) outline various approaches that hotels can adopt, such as implementing waste tracking systems, optimizing menu design, and enhancing staff training. These strategies not only reduce the volume of food waste but also foster a culture of sustainability within the hospitality industry. Moreover, various case studies demonstrate the effective application of these practices across different regions. Hotels that have embraced

waste reduction initiatives have reported significant reductions in food waste, improved operational efficiency, and enhanced guest satisfaction (Melacini & Perego, 2022). By leveraging innovative technologies and fostering collaboration among stakeholders, the hospitality sector can make substantial strides toward minimizing food waste and promoting sustainable practices.

This study aims to explore the current state of food waste management in hotels, investigate the effectiveness of various strategies and technologies, and highlight successful case studies that exemplify best practices in reducing food waste. By addressing the multifaceted challenges of food waste in the hospitality sector, this research seeks to contribute to the ongoing dialogue on sustainability and resource efficiency within the industry.

2. THE BIG PICTURE

The Food and Agriculture Organization (FAO) reports that approximately one-third of food produced globally is wasted, highlighting the need for targeted interventions in the hospitality industry. Recent reports by the World Tourism Organization (UNWTO) and the European Union (EU) have underscored the urgency of addressing food waste within the tourism sector. The UNWTO's report on sustainable tourism emphasizes that food waste is a significant contributor to the overall environmental impact of tourism, accounting for a substantial portion of greenhouse gas emissions. The organization highlights the need for the industry to adopt sustainable practices and implement effective waste management strategies. They recommend that tourism stakeholders, including hotels and restaurants, engage in initiatives aimed at reducing food waste, thereby promoting sustainability and improving their environmental footprint. Similarly, the European Union has recognized food waste as a critical issue in its Circular Economy Action Plan. The EU has set ambitious targets to reduce food waste by 50% by 2030, in line with the United Nations Sustainable Development Goals (SDGs). The EU's reports stress the importance of collaboration among various stakeholders, including the hospitality sector, to achieve these goals. Initiatives such as the EU Food Waste Prevention Program encourage hotels and restaurants to implement practices that minimize waste generation, such as better inventory management, portion control, and the donation of surplus food. Moreover, the EU's Green Deal emphasizes a holistic approach to sustainability, urging businesses to transition toward more circular practices. This includes not only reducing food waste but also improving resource efficiency and promoting sustainable sourcing of ingredients.

The hospitality sector, as a significant player in the tourism industry, is expected to lead by example in adopting such practices. In response to these growing concerns, this study aims to map food loss and waste during hotel operations, utilizing data collected from three 5-star hotels through on-site measurements, interviews, and questionnaires. Key performance indicators

(KPIs) will be established to assess water and energy consumption per guest night and quantify food waste generated per night.

Key Performance Indicators (KPIs)

To assess water and energy consumption per guest night alongside food waste generation, key performance indicators (KPIs) were calculated. This included metrics such as:

- **Water Consumption per Guest Night:** Measured by tracking total water usage in relation to guest occupancy.
- **Energy Consumption per Guest Night:** Analyzed by monitoring energy usage associated with food preparation and storage.
- **Food Waste per Night:** Quantified by weighing collected food waste daily.

Food waste should be categorized into avoidable and non-avoidable, with further classification of unconsumed food into edible and non-edible categories. The data collection process aims to provide a comprehensive overview of food waste generation and identify major sources of waste within hotel operations.

Food waste production varies significantly across different types of accommodations in the hospitality sector. A study by the World Wildlife Fund (WWF) found that 5-star hotels generate between 2.5 to 5 kg of food waste per guest per day, primarily due to extensive buffet offerings and high food variety (WWF, 2019). In contrast, 3-star hotels typically produce around 1.5 to 3 kg per guest per day, as they often have fewer dining options and smaller-scale buffets. All-inclusive resorts tend to produce even more food waste, averaging 3 to 6 kg per guest per day. This is largely due to the nature of all-inclusive dining, where guests may overindulge in food options available at all hours (Harrison *et al.*, 2020). A report from The Green Hotelier noted that these resorts could waste up to 40% of the food they prepare, emphasizing the need for better inventory management and portion control. Bed and breakfast establishments generally produce less food waste, averaging around 0.5 to 1 kg per guest per day, due to their smaller scale and more personalized dining options (Smith *et al.*, 2021). However, even these smaller operations can accumulate substantial waste when considering the total number of guests served over time. A comprehensive study by The Ellen MacArthur Foundation highlighted that across the European hospitality sector, hotels and restaurants contribute to about 8-10 million tons of food waste annually, with buffets being the largest source of waste (Ellen MacArthur Foundation, 2021). The report stressed the importance of implementing circular economy principles, such as better meal planning and food donation programs, to mitigate waste across all types of accommodations.

Consumer behavior plays a pivotal role in the generation of food waste within hospitality settings. A systematic review by Kuehnelt and Brenner (2024) highlights that guest preferences, dining formats, and portion sizes significantly

influence waste generation. Understanding these behavioral patterns is crucial for developing targeted strategies to mitigate waste. For instance, buffet-style dining often results in higher waste levels, as guests tend to over-serve themselves, leading to uneaten food being discarded (Pahlavani *et al.*, 2019; Economou *et al.*, 2023).

Best practices and strategies for food waste management have been extensively documented in the literature. There are various approaches that hotels can adopt, such as implementing waste tracking systems, optimizing menu design, and enhancing staff training. These strategies not only reduce the volume of food waste but also foster a culture of sustainability within the hospitality industry.

Moreover, various case studies demonstrate the effective application of these practices across different regions. Hotels that have embraced waste reduction initiatives have reported significant reductions in food waste, improved operational efficiency, and enhanced guest satisfaction (Melacini & Perego, 2022). By leveraging innovative technologies and fostering collaboration among stakeholders, the hospitality sector can make substantial strides toward minimizing food waste and promoting sustainable practices.

2.1. Applications in European Islands

Several real-world applications of food waste management technologies and projects have been reported in hotels and hospitality settings across European islands, showcasing effective strategies to reduce food waste.

Lanzarote, Canary Islands - The Food Waste Project in Lanzarote, a pilot project aimed at reducing food waste in hotels was launched, involving a collaboration among local authorities, hotels, and the University of Las Palmas de Gran Canaria. The project utilized smart waste management technologies, including automated weighing systems to monitor food waste in real-time. Results indicated a 30% reduction in food waste within participating hotels over a six-month period. The project emphasized the importance of staff training and guest awareness programs to maximize waste reduction (Universidad de Las Palmas de Gran Canaria, 2021).

Santorini, Greece – Smart Waste Solutions on the island of Santorini, a project implemented by Stop Waste focused on integrating smart waste management systems in several hotels. The project utilized a combination of waste monitoring sensors and staff training to facilitate better food inventory management. Findings revealed a 25% decrease in food waste over one year, with participating hotels reporting significant cost savings from reduced disposal fees. The project also highlighted the need for ongoing monitoring and support to sustain waste reduction efforts (STOP WASTE, n.d.).

Malta - Food Waste Reduction Initiative in Hotels; a food waste reduction initiative was launched in Malta, supported by the Malta Chamber of Commerce and local environmental organizations. The initiative involved several hotels adopting the Winnow Solutions smart meter system to track food waste. A study

conducted over 12 months revealed that participating hotels achieved a 40% reduction in food waste. The hotels implemented changes based on insights gained from the data, such as optimizing menu offerings and portion sizes to better align with guest consumption patterns (Winnow Solutions, n.d.).

Crete, Greece – KITRO Implementation in Crete, the KITRO system was adopted by numerous hotels to automate food waste tracking and analysis. The system provided real-time data on waste generation, allowing hotels to identify trends and implement targeted strategies for waste reduction. Findings from a recent evaluation showed an average reduction of 35% in food waste within the first year of implementation. Additionally, participating hotels reported enhanced operational efficiency and reduced food purchasing costs (KITRO, n.d.).

These applications illustrate how innovative technologies and collaborative efforts can lead to significant reductions in food waste within the hospitality sector on European islands. The projects not only resulted in environmental benefits but also provided economic advantages for participating hotels, demonstrating the feasibility of sustainable practices in the industry.

3. CONCLUSIONS

Food waste presents a significant challenge for the hospitality sector, with profound implications for environmental sustainability and economic viability. As global consumption continues to rise, projecting a quadrupling of commodity use in the next forty years, the urgency to address food waste becomes increasingly critical. The anticipated increase in food demand by 2050 necessitates a 70% increase in agricultural production, all while climate change exacerbates food insecurity through severe weather events, including droughts and floods (Cesaro & Klontza, 2023). The hospitality industry, characterized by high volumes of food production and consumption, is a major contributor to this waste, with estimates indicating that up to one-third of food produced globally is wasted each year (FAO, 2019). Adopting circular economy principles offers a transformative pathway for the hospitality sector. By shifting from linear production-consumption-disposal models to circular resource-efficient practices, hotels can significantly reduce food waste while enhancing sustainability. This involves not only minimizing waste at the source but also promoting practices such as recycling, composting, and food recovery programs. The findings from this study underscore the potential for circular solutions to contribute to broader environmental goals, including greenhouse gas emissions reduction and resource conservation (Coudard *et al.*, 2021; Skawińska & Zalewski, 2022). Effective strategies for managing food waste in hospitality settings include portion control, dynamic pricing, and comprehensive education programs for both staff and guests. By implementing innovative technologies, such as waste tracking systems, hotels can gain insights into food waste patterns, enabling them to optimize their operations and align food offerings more closely with guest consumption

behaviors (Kuehnel & Brenner, 2024; Voukkali *et al* 2023). Furthermore, initiatives that foster collaboration among stakeholders – ranging from suppliers to local communities – can amplify the impact of these strategies, driving a more sustainable dining experience. The study's analysis of food waste generation in three 5-star hotels highlighted that breakfast buffets accounted for the largest share of waste, with 76% of food waste classified as unconsumed and non-edible. This finding points to the need for targeted interventions in buffet settings, such as enhancing menu planning and offering smaller portion sizes to reduce overproduction and excess waste. Continued research is essential to explore innovative solutions tailored to the unique challenges of food waste in the tourism industry. This includes investigating the behavioral aspects of guests and how their choices contribute to waste generation. Future studies should also consider the economic implications of food waste reduction initiatives, examining the return on investment for hotels implementing these practices. In conclusion, addressing food waste in the hospitality sector is not merely an operational issue; it is a vital component of a sustainable future. By embracing circular economy principles and implementing effective waste management strategies, the hospitality industry can lead the way in promoting environmental stewardship and enhancing food security, ultimately benefiting both the industry and society as a whole.

References

- 1) Bennett, R., *et al.* (2020). "The potential for food waste reduction in restaurants: Results from a multi-country survey." *Journal of Cleaner Production*, 243, 118628.
- 2) Bohdanowicz, P., *et al.* (2011). "European hoteliers' environmental attitudes: The impact of environmental sustainability on hotel performance." *International Journal of Hospitality Management*, 30(2), 364-372.
- 3) Cesaro, A., & Klontza, E. (2023). Foreword: Advances in Environmental Chemistry in the context of circular economy. *Sustainable Chemistry and Pharmacy* <https://doi.org/10.1016/j.scp.2023.101003>
- 4) Coudard, A., *et al.* (2021). [Research on food security and environmental impact].
- 5) EU Fusions. (2016). "Estimates of European food waste levels." European Commission.
- 6) Economou F., Papamichael I., Voukkali I., Loizia P., Klontza E., Lekkas D.F., Naddeo V, Demetriou G., Navarro-Pedreño J., Zorpas A, (2023). Life cycle assessment of potato production in insular communities under subtropical climatic conditions, *Case Studies in Chemical and Environmental Engineering*, <https://doi.org/10.1016/j.scp.2023.101003>
- 7) Ellen MacArthur Foundation. (2021). *Completing the Picture: How the Circular Economy Tackles Food Waste*.
- 8) European Commission. (2020). "The EU and food waste: A European strategy."
- 9) FAO. (2013). "Food waste and climate change." Food and Agriculture Organization of the United Nations.
- 10) FAO. (2019). "The State of Food and Agriculture 2019." Food and Agriculture Organization of the United Nations.

- 11) Garrone, P., *et al.* (2014). "Food waste in the hospitality sector: A review of the literature." *Journal of Foodservice Business Research*, 17(4), 365-385.
- 12) Harrison, G., Newholm, T., & Shaw, D. (2020). Food Waste in All-Inclusive Resorts: A Case Study of Sustainable Practices. *Journal of Sustainable Tourism*.
- 13) Jansen, L., *et al.* (2018). "The role of the hospitality sector in food waste reduction: A systematic review." *International Journal of Hospitality Management*, 75, 167-177.
- 14) Kantor, L. S., *et al.* (1997). "Estimating and addressing America's food losses." *Food Review*, 20(1), 2-12.
- 15) KITRO (2019). Simplified food waste management. Available online at <https://www.kitro.ch/>
- 16) Klontza, E Kampragkou, K Ververidis, MP Papadopoulou, DF Lekkas (2016) Evaluation of water saving measures for mid-sized tourist lodging units: the case of Samos Island, Greece *European Journal of Environmental Sciences* 6 (1) <https://doi.org/10.14712/23361964.2016.7>
- 17) Kumar, S., & Singh, R. (2018). "Food waste in tourism: A systematic review of the literature." *Tourism Management Perspectives*, 26, 160-167.
- 18) Mena, C., *et al.* (2011). "The role of the hospitality sector in food waste: A case study of the foodservice sector." *Waste Management*, 31(8), 1662-1670.
- 19) Smith, J., Williams, R., & Johnson, T. (2021). Assessing Food Waste in Bed and Breakfasts: A Small-Scale Study. *International Journal of Hospitality Management*.
- 20) Stangherlin, I. D., *et al.* (2018). "Food waste in hotels: A case study." *Tourism Management*, 64, 115-128.
- 21) STOP WASTE. (n.d.). Food Waste Reduction in Santorini Hotels. Retrieved from [STOP WASTE website link].
- 22) UNEP. (2021). "Food Waste: A Global Review." United Nations Environment Programme.
- 23) Universidad de Las Palmas de Gran Canaria. (2021). Food Waste Reduction Project in Lanzarote. Retrieved from [University website link].
- 24) Voukkali I, Papamichael I, Economou F, Loizia P, Klontza E, Lekkas DF , Naddeo V, Zorpas A (2023). Factors affecting social attitude and behavior for the transition towards a circular economy *Sustainable Chemistry and Pharmacy* <https://doi.org/10.1016/j.scp.2023.101276>
- 25) Wansink, B., & van Ittersum, K. (2012). "Portion size and food waste: The role of the restaurant experience." *Journal of Service Management*, 23(1), 146-162.
- 26) World Wildlife Fund (WWF). (2019). The Food Waste Challenge: A Guide for Becker, M., *et al.* (2017). "Food waste in the hospitality sector: A systematic literature review." *Waste Management*, 64, 144-154.
- 27) Winnow Solutions. (n.d.). Food Waste Management in Malta Hotels. Retrieved from [Winnow Solutions website link].
- 28) Leverenz D., Hafner, G., Moussawel S., Kranert M., Goossens Y., Schmidt T., (2021). Reducing food waste in hotel kitchens based on self-reported data, *Industrial Marketing Management*, doi.org/10.1016/j.indmarman.2020.08.008.

CONSUMER AWARENESS AND BEHAVIOURAL DYNAMICS IN THE CIRCULAR ECONOMY: GREEN PUBLIC PROCUREMENTS IN MUNICIPALITIES

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Abstract

Sustainable consumption is the use of products and services to reduce environmental impact. It is the cornerstone of well-being and a key driver of the circular economy. Sustainable consumption can be implemented in a way that meets the needs of both people today and future generations. Education plays a crucial and invaluable role in fostering a sustainable society by raising awareness of circular practices across the many types of consumers.

In 2024, the first scientifically based survey of Latvian municipalities was conducted to assess the level of circular economy, or readiness for the transition from a linear to a circular economy. In conducting a self-assessment, all 43 municipalities in Latvia provided their views on the main aspects of the new economic paradigm. This research examines the relationship between perceived and actual circular behaviour at the municipal level, focusing specifically on Green Public Procurement (GPP) practices as a measurable indicator for sustainable action.

By comparing self-assessed GPP usage with objective procurement data from the Procurement Monitoring Bureau, the research reveals a weak but positive correlation, suggesting that awareness does not consistently translate into behaviour. Despite this, municipalities demonstrated a higher GPP share than national institutions, suggesting that local governance may play a crucial role in accelerating circular economy transitions.

Keywords: *circular economy, municipalities, green public procurement, Latvia*

JEL Classification: I38, R11, A23

1. INTRODUCTION

The circular economy (CE) represents a systemic shift from the traditional linear “take-make-dispose” model to one that aims to maintain the value of products, materials, and resources for as long as possible (Geissdoerfer *et al.*, 2017; Alhola *et al.*, 2019). Consumer awareness and behaviour play a crucial role in the success of this transition (Toth-Peter *et al.*, 2025), particularly in the context of green public procurement (GPP) at the municipal level. GPP is increasingly recognized as a strategic approach for state and municipal governments to achieve environmental sustainability goals (Liu *et al.*, 2019; Ortega Carrasco *et al.*, 2025). This process involves public authorities seeking goods, services, and works that minimize environmental impact, thereby playing a vital role in fulfilling broader sustainable development objectives (Karnavos *et al.*, 2022; EPA, no date). With public procurement constituting about 15–20 % of the global GDP and local governments handling nearly 50% of these decisions, there is a significant opportunity to leverage purchasing power for environmental benefit (Ellen MacArthur Foundation, 2023).

Consumer awareness and behaviour are fundamental to fostering a culture of sustainable consumption and the successful implementation of the CE (Sustainability Directory, 2025). Informed individuals are more likely to consider the environmental, social, and ethical implications of their purchasing decisions (Osburg *et al.*, 2019; Nie *et al.*, 2021). This awareness not only empowers consumers to support businesses that prioritize sustainability but also encourages the adoption of responsible consumption practices (Camacho-Otero, Boks & Pettersen, 2018). As a result, understanding and addressing these behavioral dynamics is essential for overcoming challenges to implementing effective GPP strategies. The notable significance of GPP lies in its potential to align public procurement practices with broader environmental policy objectives, thereby promoting sustainable development goals (Ortega Carrasco *et al.*, 2025).

This research explores the link between awareness and action in the context of the circular economy, focusing on how public sector entities, particularly municipalities, understand and implement sustainable procurement practices. By comparing self-assessed use of GPP with actual procurement data across Latvian municipalities and state institutions, the study reveals both strengths and gaps in environmental awareness and behavioural alignment.

The central research question is: To what extent does institutional awareness reflect actual environmentally responsible behaviour in public procurement within the framework of the circular economy?

2. LITERATURE REVIEW

The transition to CE is a strategic imperative for achieving environmental sustainability, long-term economic stability, and social equity (Vlialko, 2024).

Defined as an economic system that replaces the "end-of-life" concept by reducing, reusing, recycling, and recovering materials throughout production, distribution, and consumption processes, CE fundamentally rethinks current production and consumption practices (Geissdoerfer *et al.*, 2017; Kristensen, Mosgaard & Remmen, 2021; Avrami *et al.*, 2024; Toth-Peter *et al.*, 2025). This shift is crucial for sustainable development, as it aims to decouple value creation from waste generation and resource use through radical transformations in existing systems (Camacho-Otero, Boks and Pettersen, 2018). Achieving circularity requires systemic changes across product systems, as purchasing and utilization patterns fundamentally determine material demand (Avrami *et al.*, 2024).

GPP is a critical policy instrument for implementing the CE as it is closely intertwined with the CE concept. GPP is formally defined as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" (European Commission, no date). Over time, GPP has evolved to include social and economic considerations, broadening its scope to what is known as Sustainable Public Procurement (SPP), which aims to achieve sustainable development objectives through purchasing and supply processes (Uttam and Le Lann Roos, 2015; Cheng *et al.*, 2018).

Governments, as major consumers, wield significant purchasing power, spending approximately 12.5 % of the European Union's GDP annually on goods and services (European Commission, 2021). This purchasing power acts as a powerful market trigger, incentivizing companies to develop and provide greener products and services, thereby driving demand for sustainable solutions and fostering innovation across supply chains (Wang *et al.*, 2021; Behravesh, Darnall & Bretschneider, 2022). By establishing high environmental performance standards, GPP aims to reduce waste, enhance resource efficiency, and promote the reuse and recycling of materials (Vlialko, 2024). Many governmental and local initiatives that promote GPP are, in effect, also promoting Circular Public Procurement (CPP), which is explicitly defined as public procurement conducted in line with CE principles, aiming to contribute to closed energy and material loops across the entire lifecycle (Kristensen, Mosgaard and Remmen, 2021; Ntsondé & Aggeri, 2021). This approach necessitates new ways of thinking about needs, processes, and organizational structures, moving beyond mere environmental criteria integration (Sönnichsen and Clement, 2020).

A crucial aspect of promoting CE and GPP/SPP is understanding consumer and institutional awareness and how it translates into action (Nie *et al.*, 2021). Research indicates a significant positive correlation between environmental concern and purchasing behavior. However, this positive correlation often shows a weaker impact on actual purchase behavior compared to purchase intention,

illustrating a persistent “attitude-behavior gap” or “words-deeds gap” (Borges-Tiago *et al.*, 2024; Kossmann and Gomez-Suarez, no date). This gap is a significant impediment to the wider adoption of CE, with a lack of consumer interest and awareness identified as a main barrier in the European Union (Camacho-Otero, Boks & Pettersen, 2018; D’Amato, 2021). Consumer behavior in a circular economy is influenced by perceived costs and benefits (both environmental and economic), trust in product quality, and cultural perceptions (Henriques, Figueiredo & Nunes, 2023; Vidal-Ayuso, Akhmedova & Jaca, 2023; Lopez & Legardeur, 2024). Studies suggest that proactive efforts, such as strategic messaging emphasizing collective impact, can significantly increase perceived eco-alignment and willingness-to-pay for circular offerings (Avrami *et al.*, 2024). However, consumers often prioritize personal financial benefits over purely ecological reasons and are generally unwilling to pay a premium for circular economy products (Toth-Peter *et al.*, 2025).

For public sector entities, particularly municipalities, their role as effective information communicators can be pivotal in disseminating green consumption knowledge (Wang *et al.*, 2021). Awareness and knowledge among procurers are identified as key drivers for developing effective CPP procedures, often being considered even more important than financial resources (Sönnichsen and Clement, 2020). Individual procurers' beliefs, along with adequate training and guidance, are essential for effective CPP implementation (Grimbert and Zabala-Iturriagoitia, 2024). Therefore, organizational structures must actively support knowledge dissemination and provide continuous training for staff involved in CPP-related tasks (D’Amato, 2021).

3. RESEARCH METHODOLOGY AND RESULTS

In the research, a two-tier data set was used to analyse the GPP practices in Latvian municipalities:

- 1) Primary data from the survey, conducted across all 43 municipalities, covered several aspects of the CE, including a question on how frequently the GPP is used;
- 2) Secondary data from the national Procurement Monitoring Bureau (PMB) on the public procurement procedures announced in 2023.

Using the advanced search on the PMB website, all published notices for tenders from January 1, 2023, to December 31, 2023, were exported. After exporting, manual data processing was performed to exclude irrelevant entries and retain only those published by state and municipal institutions and enterprises. Based on the name of the contracting authority, the records were classified into four categories:

1. Central government institutions, agencies, services, etc.;
2. State-owned enterprises;
3. Municipality or city council (central administration);

4. Municipal enterprises and institutions.

Categories (1) and (2) were analysed as state administration, while categories (3) and (4) were analysed as municipalities. For categories (3) and (4), the distinction between city and rural municipality was also indicated. This data analysis aimed to determine the share of GPP in the total number of announced procurement procedures and conduct a detailed breakdown by contracting authority categories.

In total, 12,336 procurement procedures were announced in 2023. Of these, 11,131 did not include environmental protection requirements, while 1,205 tenders did, i.e., were classified as GPP. Analysing the data at state and municipal levels, it was concluded that municipalities (central administration and enterprises) were more active procurers (7,098 procedures) than the state administration (5,238 procedures) (see Figure 1).

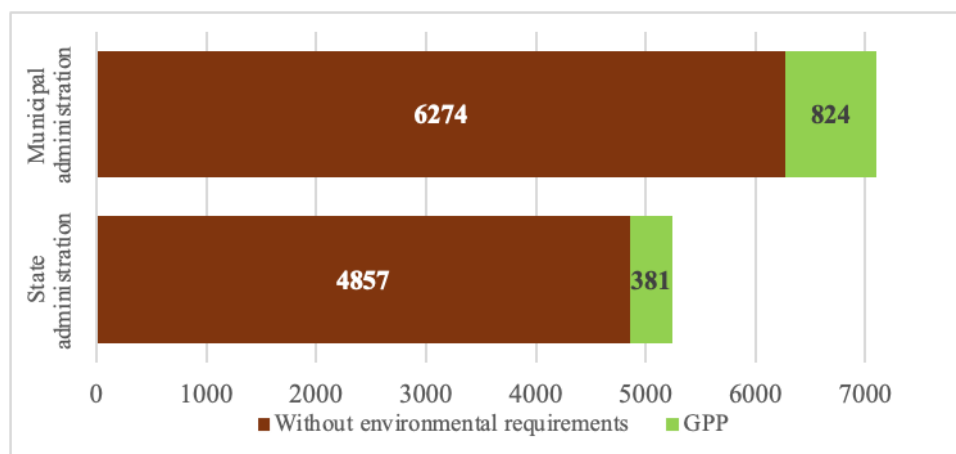


Figure 1. Announced Procurement Procedures:
State and Municipal Administrations, 2023

Source: created by the authors, based on the PMB data

In 2023, municipalities (11.61 %) were generally more active in implementing GPP than the state sector (7.27 %), resulting in the overall GPP share of 9.77 %. Among the subcategories (see Figure 2), municipal or city councils (central administration) had the highest share (13.77 %), which is a positive result from an environmental and circularity standpoint, suggesting a relatively high level of awareness and responsibility at this level of governance.

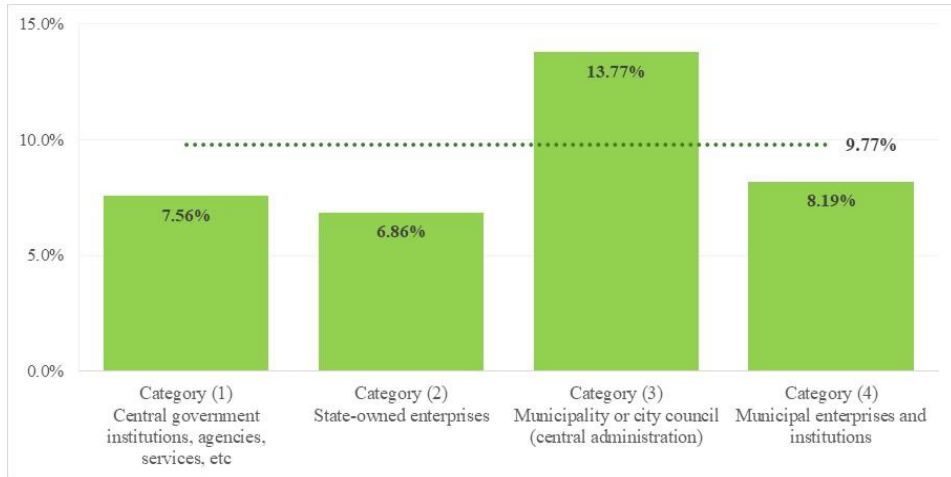


Figure 2. GPP Share, %: State and Municipal Administrations, 2023, 2023

Source: created by the authors, based on the PMB data

Six municipalities even scored above 20 %, while eleven municipalities, including the capital city, were below the national average of 9.77 %.

To compare the result of publicly available data analysis with the municipality survey results, a correlation analysis using Spearman's rank correlation coefficient was conducted.

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)}$$

Where:

$\sum d_i^2$ – sum of squared rank differences, and

n – number of municipalities included in the dataset (43).

The question “To what extent has your municipality used Green Public Procurement during the past six months?” was answered using the Likert scale (from “Never” to “Very often”). Each answer was assigned a numerical score from 1 to 5, and the survey results were compared with the GPP share based on PMB data.

The calculated correlation coefficient was $\rho = 0.165849$. Although a weak positive trend exists, the correlation is not strong enough to indicate a statistically significant monotonic relationship between the GPP share and self-assessment results. It may be coincidental. Higher GPP shares might correlate with higher self-assessment scores, but the evidence is insufficient to confirm this confidently. Additionally, the evaluation periods differed: while public data was for a full year, survey responses referred to perceived GPP usage frequency in the last six months.

4. CONCLUSIONS

Data quality and availability are crucial for evidence-based measurements. Significant manual work was needed to process the initial data export and add the necessary analysis attributes. Due to the lack of data on the final contract value, it was not possible to analyse GPP in monetary terms, which may be more informative than the procedure counts. Since no centralized institution in Latvia compiles information on actual money spent on GPP compared to other procurements, the actual GPP share in the public expenditure can only be estimated, not calculated precisely.

Correlation analysis between the actual GPP share and the self-assessed GPP usage suggests that there is some alignment between how municipalities perceive their use of Green Public Procurement and their actual performance, but the relationship is very weak and not statistically significant. The low correlation implies that municipalities' awareness or understanding of their own GPP practices may be incomplete or inaccurate, as they overestimate or underestimate how much they are actually using GPP. The discrepancy between perceived and actual GPP use may indicate that survey respondents lack detailed knowledge of procurement practices. This might be the key area for local policymakers to be aware of and improve to facilitate the transition to the CE.

The fact that municipalities demonstrate a higher GPP share than state institutions suggests a stronger engagement at the local level in adopting sustainable procurement practices. This indicates that municipalities may be more responsive to environmental priorities and closer to community-level behavioural shifts, playing a pivotal role in driving the transition towards the CE. Their proactive stance reflects growing institutional awareness and accountability in implementing green initiatives.

References

- 1) Alhola, K. *et al.* (2019). 'Exploiting the Potential of Public Procurement: Opportunities for Circular Economy', *Journal of Industrial Ecology*, 23(1), pp. 96–109. Available at: <https://doi.org/10.1111/jiec.12770>.
- 2) Avrami, E. *et al.* (2024). 'A New Concept of Consumer Behavior in the Circular Economy', *Emerging Science Journal*, 8(4), pp. 1536–1553. Available at: <https://doi.org/10.28991/ESJ-2024-08-04-018>.
- 3) Behraves, S.-A., Darnall, N. and Bretschneider, S. (2022). 'A framework for understanding sustainable public purchasing', *Journal of Cleaner Production*, 376, p. 134122. Available at: <https://doi.org/10.1016/j.jclepro.2022.134122>.
- 4) Borges-Tiago, M.T. *et al.* (2024). 'Bridging the innovative Attitude–Behavior Gap: A dual-level analysis', *Journal of Innovation & Knowledge*, 9(4), p. 100561. Available at: <https://doi.org/10.1016/j.jik.2024.100561>.
- 5) Camacho-Otero, J., Boks, C. and Pettersen, I.N. (2018). 'Consumption in the Circular Economy: A Literature Review', *Sustainability*, 10(8), p. 2758. Available at: <https://doi.org/10.3390/su10082758>.

- 6) Cheng, W. *et al.* (2018). ‘Green Public Procurement, missing concepts and future trends – A critical review’, *Journal of Cleaner Production*, 176, pp. 770–784. Available at: <https://doi.org/10.1016/j.jclepro.2017.12.027>.
- 7) D’Amato, D. (2021). ‘Sustainability Narratives as Transformative Solution Pathways: Zooming in on the Circular Economy’, *Circular Economy and Sustainability*, 1(1), pp. 231–242. Available at: <https://doi.org/10.1007/s43615-021-00008-1>.
- 8) Ellen MacArthur Foundation (2023). *Circular public procurement: lessons learnt*. Available at: <https://www.ellenmacarthurfoundation.org/circular-public-procurement/lessons-learnt-by-cities> (Accessed: 15 June 2025).
- 9) EPA (no date) *Green Public Procurement*. Available at: <https://www.epa.ie/our-services/monitoring--assessment/circular-economy/green-public-procurement/> (Accessed: 15 June 2025).
- 10) European Commission (2021). *DocsRoom - European Commission*. Available at: <https://ec.europa.eu/docsroom/documents/48156> (Accessed: 15 June 2025).
- 11) European Commission (no date) *Green Public Procurement - European Commission*. Available at: https://green-forum.ec.europa.eu/green-public-procurement_en (Accessed: 15 June 2025).
- 12) Geissdoerfer, M. *et al.* (2017). ‘The Circular Economy – A new sustainability paradigm?’, *Journal of Cleaner Production*, 143, pp. 757–768. Available at: <https://doi.org/10.1016/j.jclepro.2016.12.048>.
- 13) Grimbert, S.F. and Zabala-Iturriagagoitia, J.M. (2024). ‘Closing the loop without reinventing the wheel: public procurement for innovation promoting a circular economy’, *Science and Public Policy*, 51(3), pp. 491–508. Available at: <https://doi.org/10.1093/scipol/scad084>.
- 14) Henriques, R., Figueiredo, F. and Nunes, J. (2023). ‘Consumers’ Perspectives on Circular Economy: Main Tendencies for Market Valorization’, *Sustainability*, 15(19), p. 14292. Available at: <https://doi.org/10.3390/su151914292>.
- 15) Karnavos, D. *et al.* (2022). ‘Green Public Procurement as a Tool for the Transition from the Linear Model of Economy to the Circular Economy’, *Advances in Social Sciences Research Journal*, 9(7), pp. 566–579. Available at: <https://doi.org/10.14738/assrj.97.12698>.
- 16) Kossmann, E. and Gomez-Suarez, M. (no date) ‘Frontiers | Words-Deeds Gap for the Purchase of Fairtrade Products: A Systematic Literature Review’. Available at: <https://doi.org/10.3389/fpsyg.2019.02705>.
- 17) Kristensen, H.S., Mosgaard, M.A. and Remmen, A. (2021). ‘Circular public procurement practices in Danish municipalities’, *Journal of Cleaner Production*, 281, p. 124962. Available at: <https://doi.org/10.1016/j.jclepro.2020.124962>.
- 18) Liu, J. *et al.* (2019). ‘Enhancing green public procurement practices in local governments: Chinese evidence based on a new research framework’, *Journal of Cleaner Production*, 211, pp. 842–854. Available at: <https://doi.org/10.1016/j.jclepro.2018.11.151>.
- 19) Lopez, N.S.R. and Legardeur, J. (2024). ‘Consumer behaviour in the context of circular economy: a systematic literature review | Proceedings of the Design Society’, *Cambridge Core*, 4(DESIGN 2024), pp. 1417–1426. Available at: <https://doi.org/10.1017/pds.2024.144>.

- 20) Nie, W. *et al.* (2021). 'Do Health, Environmental and Ethical Concerns Affect Purchasing Behavior? A Meta-Analysis and Narrative Review', *Social Sciences*, 10(11), p. 413. Available at: <https://doi.org/10.3390/socsci10110413>.
- 21) Ntsondé, J. and Aggeri, F. (2021). 'Stimulating innovation and creating new markets – The potential of circular public procurement', *Journal of Cleaner Production*, 308, p. 127303. Available at: <https://doi.org/10.1016/j.jclepro.2021.127303>.
- 22) Ortega Carrasco, P. *et al.* (2025). 'Green public procurement as an effective way for sustainable development: A systematic literature review and bibliometric analysis', *Sustainable Development*, 33(2), pp. 2364–2391. Available at: <https://doi.org/10.1002/sd.3234>.
- 23) Osburg, V.-S. *et al.* (2019). 'The influence of contrasting values on consumer receptiveness to ethical information and ethical choices', *Journal of Business Research*, 104, pp. 366–379. Available at: <https://doi.org/10.1016/j.jbusres.2019.07.022>.
- 24) Sönnichsen, S.D. and Clement, J. (2020). 'Review of green and sustainable public procurement: Towards circular public procurement', *Journal of Cleaner Production*, 245, p. 118901. Available at: <https://doi.org/10.1016/j.jclepro.2019.118901>.
- 25) Sustainability Directory (2025). 'How Does Consumer Behavior Impact Circular Economy Implementation? → Question', *Sustainability Directory*, 18 April. Available at: <https://sustainability-directory.com/question/how-does-consumer-behavior-impact-circular-economy-implementation/> (Accessed: 15 June 2025).
- 26) Toth-Peter, A. *et al.* (2025). 'Are Retail Consumers Willing to Pay for All Circular Products? A Study on Consumer Perception of the Circular Economy in Retail', *Business Strategy and the Environment*, p. bse.4269. Available at: <https://doi.org/10.1002/bse.4269>.
- 27) Uttam, K. and Le Lann Roos, C. (2015). 'Competitive dialogue procedure for sustainable public procurement', *Journal of Cleaner Production*, 86, pp. 403–416. Available at: <https://doi.org/10.1016/j.jclepro.2014.08.031>.
- 28) Vidal-Ayuso, F., Akhmedova, A. and Jaca, C. (2023). 'The circular economy and consumer behaviour: Literature review and research directions', *Journal of Cleaner Production*, 418, p. 137824. Available at: <https://doi.org/10.1016/j.jclepro.2023.137824>.
- 29) Vlialko, I. (2024). 'THE EU GREEN PUBLIC PROCUREMENT AS A POLICY TOOL TO IMPLEMENT THE CIRCULAR ECONOMY', *Actual Problems of International Relations*, 1(159), pp. 86–93. Available at: <https://doi.org/10.17721/apmv.2024.159.1.86-93>.
- 30) Wang, Q. *et al.* (2021). 'Green public procurement as a promoter for green consumption: From the perspective of individual's knowledge', *Cleaner and Responsible Consumption*, 3, p. 100035. Available at: <https://doi.org/10.1016/j.clrc.2021.100035>.

ADVANCING DUAL VET FOR THE GREEN ECONOMY: STRENGTHENING SUSTAINABILITY AND INDUSTRY ALIGNMENT IN THE VET SYSTEM OF KOSOVO

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Abstract

The shift to a green economy necessitates a qualified workforce capable of adopting sustainable practices. The Vocational Education and Training (VET) system in Kosovo, has difficulties in aligning curricula with industry specific sustainability requirements. This article investigates the integration of sustainability and circular economy ideas into the Dual VET system, focusing on three main sectors: renewable energy/energy efficiency (RE/EE), ICT and wood processing.

The research suggests that while some VET institutions have adopted green initiatives, such as the installation of solar panels, recycling programs and eco-clubs, the progress remains unsatisfactory due to limited financial and technical resources, outdated curricula and a lack of alignment with environmental standards (ISO 14001:2015, etc.). Many businesses struggle to engage with the Dual VET system due to unclear legal frameworks and administrative burdens, further hindering the development of sustainability skills.

To overcome these gaps, this study suggests greater coordination among VET institutions, the business sector and policymakers, as well as increased investment in contemporary training facilities, curriculum revisions, and sustainability certifications. Establishing sectoral skills committees, incorporating green skills into all VET content and increasing awareness through media campaigns and business collaborations can help to guarantee that Kosovo's workforce is ready for the demands of the green and circular economy. Strengthening these efforts will help Kosovo's climate obligations, Smart Specialization Strategy and long-term economic sustainability.

Keywords: *Dual VET, sustainability, green economy, vocational education, renewable energy.*

JEL Classification: C0

1. INTRODUCTION

The education system in Kosovo is mainly public and is organised as follows:

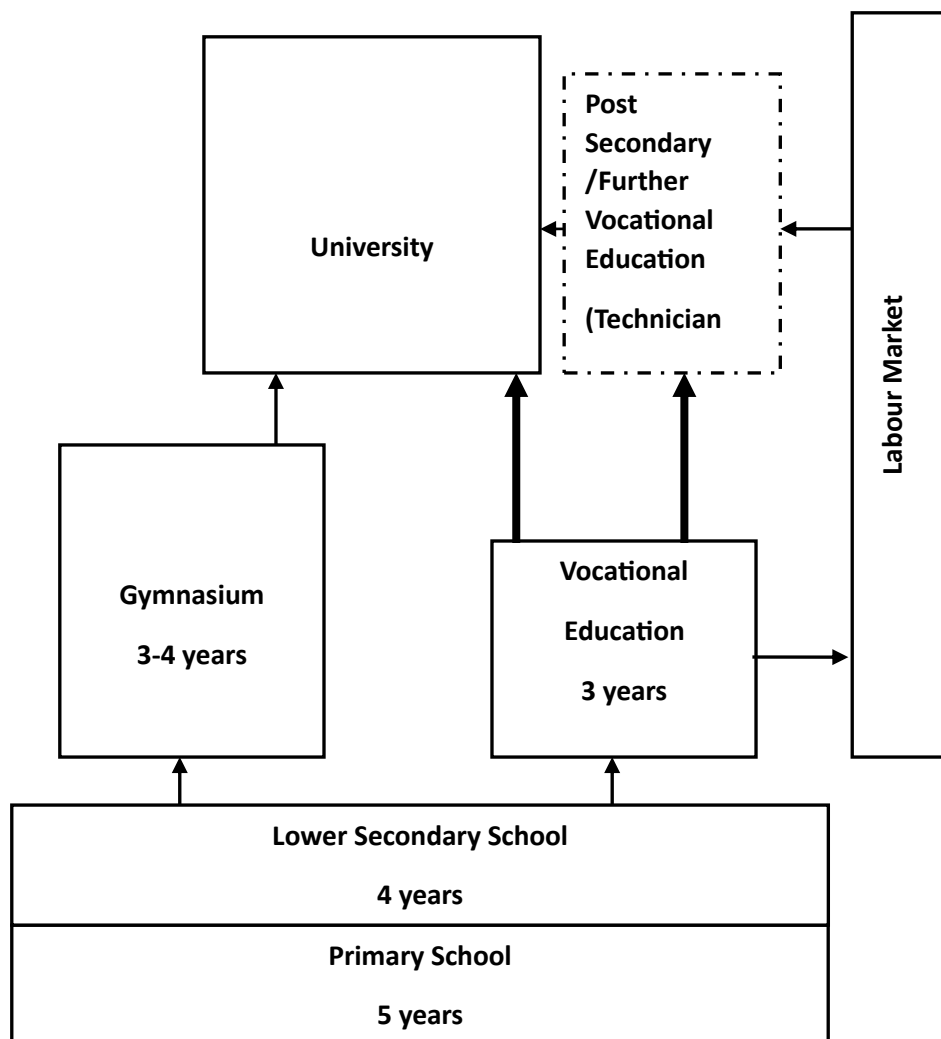


Figure 1. Structure of the education system in Kosovo

The Vocational education and training (VET) system in Kosovo is part of Pre-University Education. The formal qualifications in VET include Levels 3 to 5 as regulated by the National Qualifications Authority (NQA) (NQF, 2020). Level 3 is achieved after completion of grades 10 and 11, while Level 4 is achieved after completion of grade 12. Level 5 is achieved after completion of academic and professional qualifications (formal and informal) between upper-secondary level and higher education.

Kosovo has 68 public VET schools, including six Centers of Competence managed by AVETAE, a MESTI agency (Law no 04/L-138, 2013). Due to capacity constraints, AVETAE has directly managed the Centers of Competence, whereas other VET schools are under the umbrella of MESTI. Municipal Education Directorates (MEDs) oversee VET administration in Kosovo, managing facility construction, maintenance, health, safety. Under the Law on Pre-University Education, they also hire and pay teachers. However, varying interpretations create regional differences in VET administration (Themel, 2024).

In Kosovo, 23 VET schools have fewer than 200 students, while 16 have fewer than 100, indicating a lack of adequate equipment for quality VET instruction. In the 2023/2024 school year, 57.5% of upper secondary students are enrolled in VET programs, 42.5% of them are girls (EMIS, 2024), although only 14.6% of girls enroll in technical profiles. In-company training involves 27.8% Work Based Learning (WBL) and 50% Dual Learning (Bajrami, 2024).

Traditional VET programs include school based (SB) training and WBL, as well as standardized professional practice in school workshops or enterprises. WBL duration is set in the curriculum (MESTI AI 137, 2020).

- Grade 10: 35 weeks with 1 day of WBL and 4 days of SB VET.
- Grade 11: 35 weeks, 1.5 days of WBL and 3.5 days of SB VET.
- Grade 12: 32 weeks with 2 days of WBL and 3 days of SB VET.

Schedules are determined by schools and workplaces, with WBL available as a full-semester block in Grade 12 (Likaj, 2023, p.21).

Dual education programs are based on traditional VET and use standardized curricula approved by the Ministry of Education. Professional practice is entirely company-based, with a systematic approach that aligns traditional curriculum content with job-specific training and credit needs.

Dual education in Kosovo started implementation in the school year 2022/2023, involving five classes of 10th-grade students specializing in hairdressing, culinary arts, hotel hospitality assistance, and masonry. VET students will have the chance to dedicate over half of their educational time to practical experiences in authentic work environments throughout the three-year program.

MESTI has announced that in the school year 2023/2024, dual education will be expanded with an additional 8 new profiles. There will be a total of 12 dual education profiles in 21 vocational schools across 14 different municipalities.

The profiles in which dual VET will be piloted are Cook, Hotel Hospitality Assistant (Waiter/Waitress), Hairdresser and Mason, Tailoring, Automotive Mechanic, Metal Processing, Wood Processing, Heating and Air Conditioning Installer, Electrician, Wholesale and Retail Trade and Aesthetician (Likaj, 2023).

Table 1 presents a comparison of professional practice between traditional and dual curricula in public VET schools in Kosovo.

Table 1. Comparison of professional practice: traditional vs dual curricula

	Work-based learning in companies	
	traditional	dual
Number of days in companies	on average 1,5 days	on average 2,5 days
Teaching units per week	9	16,66
Total amount of TH	909 out of 3264	at least 1632 out of 3264
Share of overall TH	27,8%	50%

Source: WBL in Kosovo; An assessment per EU quality standards
(K. Bajrami, 2004, p. 24)

2. LITERATURE REVIEW

Moving towards green skills and a green future refers to the shift toward an environmentally sustainable, circular, and carbon-neutral economy while ensuring fairness and inclusivity. This transition has broad social impacts, affecting employment, income, healthcare, household costs, and gender roles, varying across sectors and demographics.

Dual Vocational Education and Training (VET) is inherently collaborative and plays a crucial role in facilitating the transition. It helps by:

Educating students with green skills helps in equipping workers with green skills and reskilling them for evolving industries. Adapting curricula to green skills encourages new professionals to adopt new green innovations in terms of green processes and green products in a way that in future economies they will produce with a focus not only on economic performance but also on environmental performance.

Strengthening cooperation among key stakeholders, including government, businesses, and educational institutions, with the help of countries, including Kosovo, to a better future for all the citizens.

Dual VET must integrate economic, social, and ecological factors. A holistic perspective ensures that vocational training aligns with sustainability goals while addressing the needs of all stakeholders in the VET ecosystem.

Within this context, VET is seen as a crucial component of skill-formation systems that support green jobs and skills in these policy environments (Avis, 2020). Based on surveys and interviews with VET instructors and student teachers, research has also helped develop a pedagogical framework for green skills (Nurdiansyah *et al.*, 2019; Ramli *et al.*, 2019; Setiawan *et al.*, 2017).

Also, based on the Oslobrück Declaration (2020) for the years 2021 to 2025, considering the revised European Skills Agenda and the idea for a Council recommendation on VET for sustainable competitiveness, social justice, and resilience, the four key topics are:

1. Resilience and excellence through quality, inclusive and flexible VET
2. Establishing a new lifelong learning culture – relevance of C-VET and digitalization.

3. Sustainability – a green link in VET
4. European Education and Training Area and international VET

The second objective of (Oslobrück Declaration, 2020) is that people want assistance to upskill and upgrade their abilities when employment and qualification profiles shift and new professions arise in the digital and green transitions. National and European qualification systems have grown to be essential components of methods for qualifications that promote openness and excellence in credentials. Promoting VET is essential, specifically on the pathways of the green transitions between education and shaping the new professions. Based on objective 3 (Oslobrück Declaration, 2020), businesses and cultures are impacted by responsible environmental behavior. Concerns like labor demand, education, skills, occupations, and the geographic distribution of employment and people are all impacted by sustainability. Businesses, groups in the private sector, and community projects are important forces behind economic and social sustainability. It should be the goal of Dual Vet to incorporate sustainable skills into their policies and procedures.

3. METHODOLOGY

This study assessed the VET system in Kosovo using a mixed-methods approach that included desk research, primary data gathering and stakeholder consultations. It concentrated on capacities, problems and opportunities in ICT, Green Energy and Wood Processing. The methodology aimed to assess the business sector's and public VET school readiness for Dual VET implementation through extensive data collection, analysis and evaluation.

3.1. Research design

The research used qualitative and quantitative methods to assess VET schools and companies' readiness for Dual VET, green agenda, sustainability and alignment of VET study programs with labour market needs. The study combined primary and secondary research, incorporating stakeholder feedback through consultations to ensure accurate and relevant findings.

3.2. Data collection

The study used several research approaches. Desk research analyzing secondary data, such as government strategies and sectoral reports, to determine skill requirements in green energy, ICT and wood processing. The survey evaluated the readiness of all public VET schools, training centers and around 40 businesses for Dual VET expansion. Semi-structured interviews with most important relevant stakeholders (government, education and labour agencies, business associations, VET providers, etc.), businesses covering three sectors for sector-specific insights (ICT, RE, EE and wood processing). Focus groups with

key 27 stakeholders discussed VET preparedness, work-based learning best practices, gender inclusion, the integration of sustainability and circular ideas into for Dual system.

3.3. Data analysis and limitations

The analysis employed both quantitative and qualitative approaches. Surveys and secondary data were analyzed statistically to investigate VET trends and skill gaps. Data gaps, particularly in enrollment and green energy skills, were addressed through consultations and secondary sources.

4. KEY FINDINGS

The research is focused on key sectors with economic potential, skill demands and vocational training alignment. The ICT sector has expanded significantly, doubling the number of active companies and boosting exports. Software development and outsourcing are key drivers, but skill gaps in software engineering, data analysis and cybersecurity persist. Emerging technologies like AI and blockchain further highlight workforce misalignment with industry needs (Likaj *et al.*, 2025).

Renewable energy and energy efficiency are expanding areas, pushed by Kosovo's environmental objectives. Investments in solar, wind and hydropower provide green jobs, but labor preparedness remains an issue. Training system design, installation and maintenance are insufficient, necessitating curriculum revisions and capacity building (Euler, 2024).

The wood processing business has gradually expanded, with a 50% rise in companies and jobs. The demand for trained personnel in CNC programming and complex machinery is increasing, but VET programs are not aligned with labour market needs and do not follow the technological trends, with low enrollment and negligible female participation. Expanding practical training and work-based learning is critical to maintaining industry growth.

Figure 2 shows the sectors of DUAL VET in which companies operate. The most popular sector is ICT, followed by renewable energy and energy efficiency. Traditional sector, such as wood processing has a smaller share but are nevertheless essential.

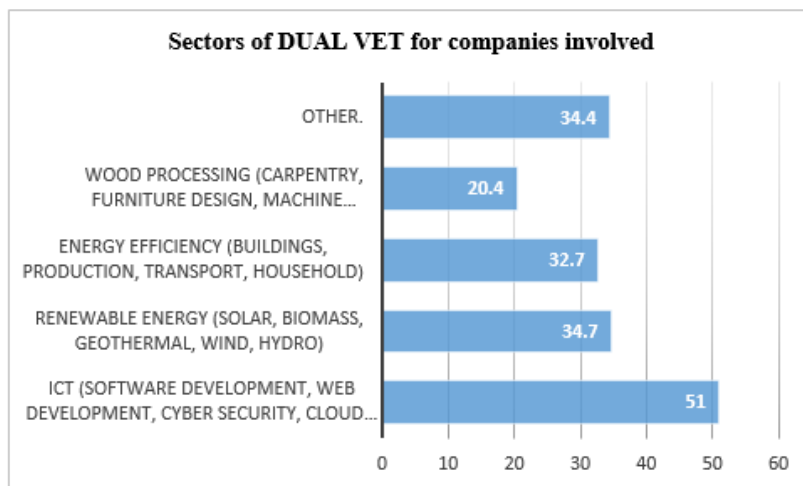


Figure 2. Sectors of Dual VET for companies

4.1. Dual VET sustainability and green agenda, Companies vs VETI

The VET system in Kosovo faces challenges in integrating environmental considerations. On the environmental front, sustainability is mentioned in the Kosovo Development Strategy but is not adequately reflected in VET curricula and the Strategy for Environmental Protection and Sustainable Development 2022 – 2031 (GOK NDS, 2030). The renewable energy sector, essential for Kosovo’s green transition, lacks specialized training despite its growth. Learning from countries with advanced green skills integration, Kosovo could embed sustainability modules across VET profiles. Green initiatives are gradually being incorporated through eco-clubs, recycling, and renewable energy workshops. About two-thirds of businesses recognize the importance of environmental issues. Expanding sustainability in VET and aligning with standards like ISO 14001 will enhance practical learning but it needs greater scale to address climate change effectively (Likaj, *et al.*, 2025).

Green activities are a major focus, with VET schools teaching students about sustainability, energy efficiency (EE), and environmental protection. Some VET Schools are recognised for their initiatives, such as installing solar panels and mitigating climate change. VET programs should further include EE and environmental protection to better equip students for green careers. Awareness campaigns, seminars, and student eco groups encourage environmental preservation through hands-on training and recycling. However, insufficient financial and technical resources, particularly in smaller or less-equipped VET schools and companies, may impede the full implementation of sustainability initiatives (Likaj, *et al.*, 2025). Furthermore, there are gaps in integrating educational goals with industry specific sustainability requirements, notably in the

green sector. A lack of awareness and ability to apply environmental standards, such as ISO 14001:2015, impedes progress as shown in Figure 3.

To promote environmental sustainability, systemic initiatives are necessary, such as implementing mandatory green skills training across all VET profiles to make sustainability a core competency and by enhancing partnerships with donors and international organizations to test inclusive and ecologically friendly VET programs. By addressing these issues, Kosovo may develop a VET system that not only meets labor market demands, but also promotes and supports the country's green transformation.

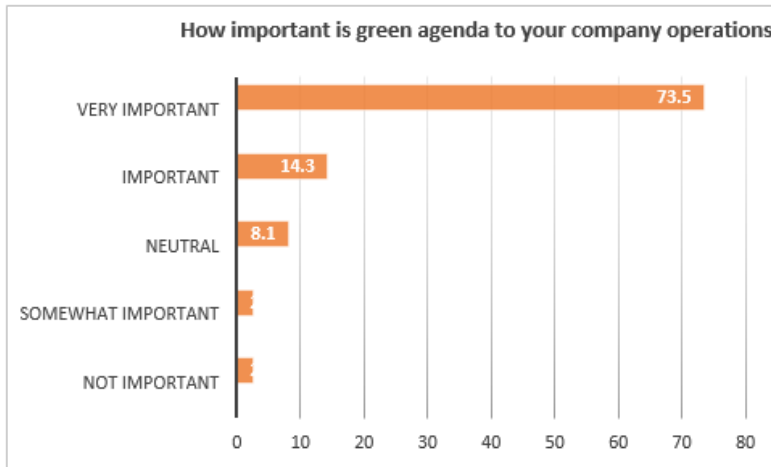


Figure 3. Importance of the green agenda for company operations

The majority of respondents 87.8% combined for very important and important believe that the Green Agenda is extremely essential, indicating that sustainability is becoming more and more acknowledged as a critical component of their operations. A smaller percentage, on the other hand, is neutral or less convinced, suggesting a possible area for additional discussion and education on the subject.

The answers from Figure 4, show the widespread adoption of sustainable practices, which place a high priority on recycling, waste reduction, and energy efficiency. An extensive business commitment to the education of staff about sustainability is indicated by the comparatively high adoption rate of environmental awareness training.

The decreased use of sustainable sourcing and other unique approaches, however, suggests that additional actions or investments might be required.

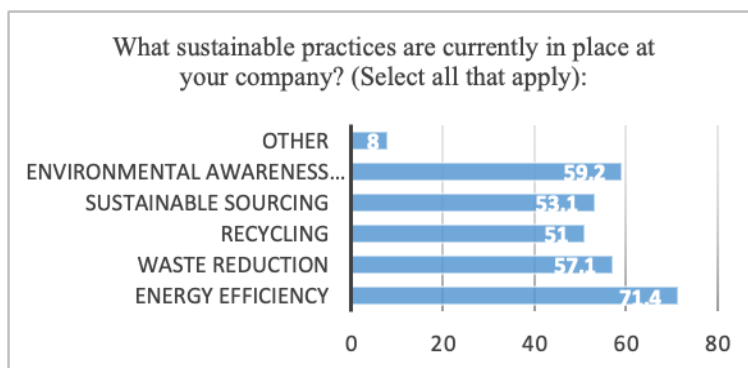


Figure 4. Sustainable practices implemented in companies

A majority of respondents 87.8% in this section emphasize the Green Agenda's significance in their business strategies by stating that they consider it to be crucial to their operations. EE 71.4%, waste reduction 57.1%, and environmental awareness training 59.2% are the sustainable strategies that are most frequently used. But recycling 51% and sustainable sourcing 53.1% are also important, but a little less common. Although more involvement may be required for organizations that place less focus on sustainability, the low percentage of organizations 2.5% that believe the Green Agenda is not vital indicates that sustainability is becoming more and more significant.

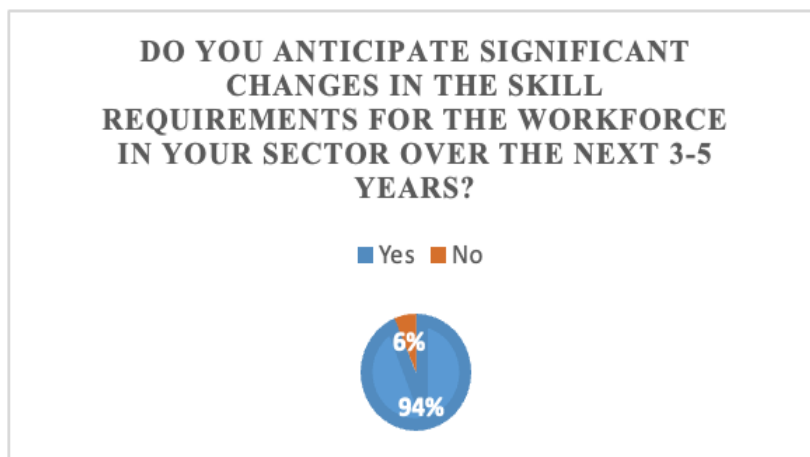


Figure 5. Skill requirements for the next 3 -5 years

Results shown in Figure 5 indicate that over the next 3-5 years, 93.9% of respondents anticipate major changes in the skills needed. Figure 6, illustrates the rising need for expertise in sustainability and innovative technology, especially in

the areas of advanced technical skills 68.1%, digital and IT skills 70.2%, and green skills 59.6%. Additionally, respondents predict that automation, AI and green technology will significantly boost the demand for skilled people, pointing out the significance of future VET programs to satisfy these changing demands as shown in Figure 7.

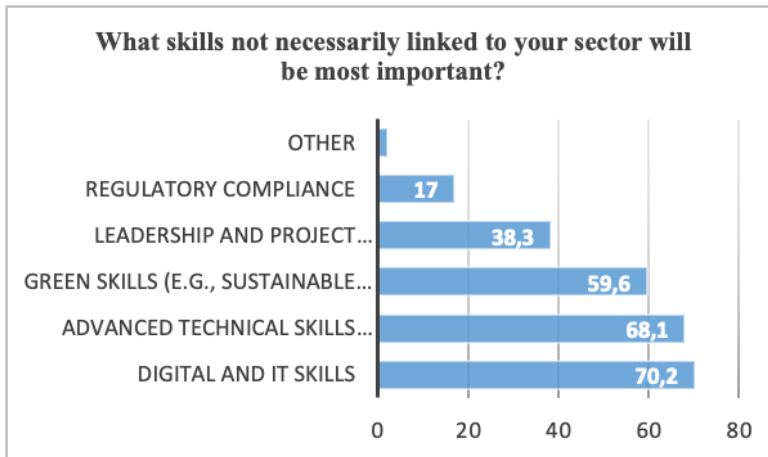


Figure 6. Skills that are not necessarily linked with the respective sector but are most important for company operation

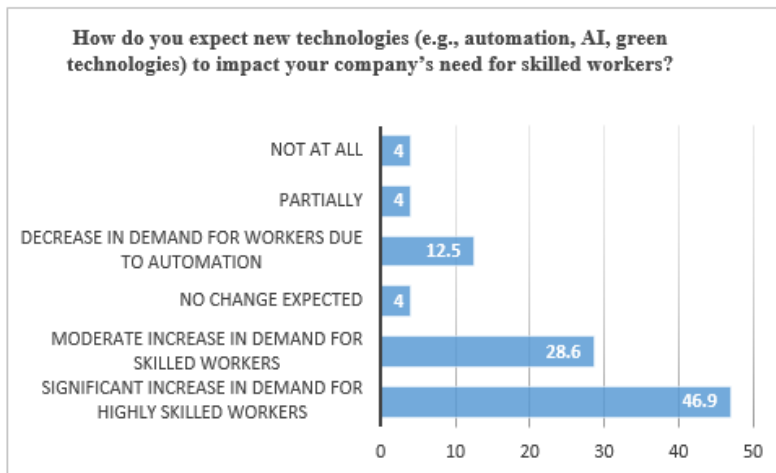


Figure 7. The company needs skilled workers (e.g. automation, AI, green)

To reach a wider environmental impact, it is advised that businesses keep waste reduction and energy efficiency as top priorities while stepping up their efforts in recycling and sustainable procurement. Green practices can be further

improved by putting more emphasis on integrating sustainability into supplier chains and other business areas.

Furthermore, integrating sustainability into company culture may be achieved by promoting greater environmental awareness through more specialized training.

Increased commitment to sustainability may result from interacting with businesses that place less emphasis on or are neutral toward the Green Agenda. Furthermore, integrating sustainability into company culture may be achieved by promoting greater environmental awareness through more specialized training and guidance.

In conclusion, even though VET graduates are widely appreciated, there is a noticeable need for better alignment with industry needs and advancements in technical, digital, and soft skills. To prepare students for the demands of the profession in the future, employers are looking for more hands-on, practical training and want VET programs to keep up with technological developments.

It is advised that VET programs concentrate on improving technical, digital, and project management skills to better meet industry needs and address the problems mentioned. To guarantee that training is customized to particular job profiles, there should be more collaboration between VETI and businesses.

Training periods should be flexible to allow for more hands-on experience, and curricula should be made more adaptable to changing industry demands. Clearer career advancement pathways and greater harmonisation with students' interests are two crucial ways to improve student engagement and retention.

Additional hands-on experience and industry specific expertise should be included in VET teacher qualifications. Lastly, to prepare the workforce for the future, VET programs need to incorporate green skills and emerging technologies (Likaj *et al.*, 2025).

Results of the survey shown in Figure 8, show that a considerable number of VETI 90.9% understand the importance of the Green Agenda in their operations, with 31.8% rating it as extremely essential and 59.1% as important. This demonstrates a good correlation with sustainable practices, indicating that VETI are progressively incorporating environmental considerations into their actions.

The high percentage of environmental awareness training demonstrates that VETI prioritizes knowledge dissemination to promote sustainability among employees and students.

Sustainable practices undertaken include EE and waste reduction 27.3% each, recycling and sustainable resources 22.7% each and environmental awareness training 63.6%. Only 4.5% of VETI have green groups or teams as shown in Figure 9.

This implies a high level of awareness and execution of sustainable practices, but it also points out the need for further community engagement and deeper integration of green initiatives.

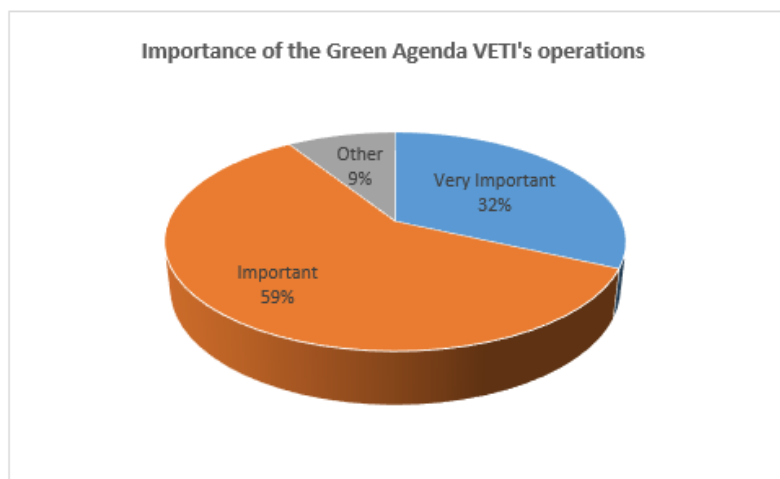


Figure 8. Importance of the green agenda for VETI operations

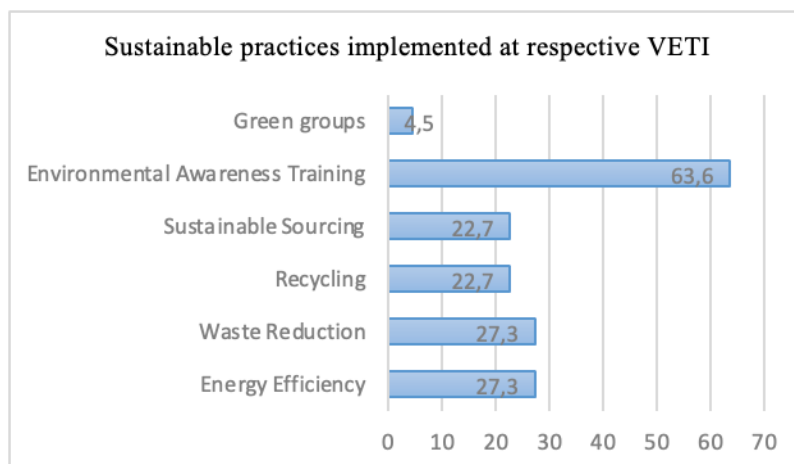


Figure 9. Sustainable practices implemented in VETI

To encourage involvement of students, teaching staff and other stakeholders VETI can increase environmental awareness training and promote green clubs. Integrating sustainable resources and circular economy principles into education processes. Furthermore, sustainability should be included in the curriculum framework and procurement policies to increase environmental actions and train students for green sectors.

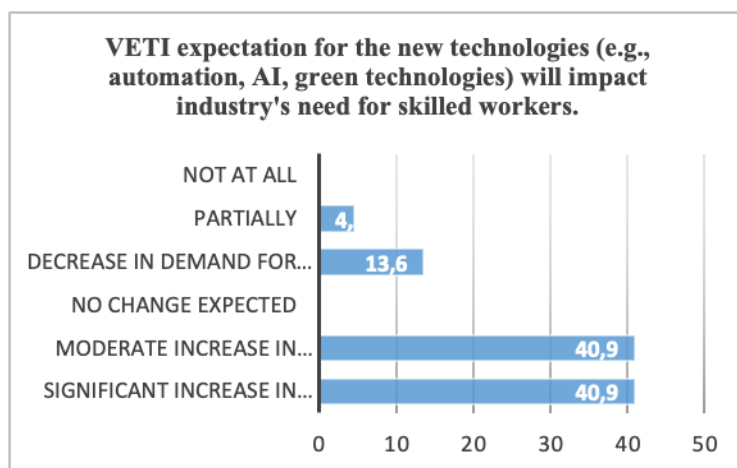


Figure 10. VETI expectations for the new technologies impact on skill needs (e.g. automation, AI, green)

The results of the survey shown in Figure 10, indicate that the impact of new technologies such as automation, AI and green technology is predicted to significantly increase demand for skilled labor with 40.9% of respondents expecting a major increase. VET institutions must react to these developments by providing training in emerging technologies to suit future industry demands.

4.2. Renewable Energy and Energy Efficiency Sector

Solar energy technicians and energy management specialists top the list of job profiles in the RE and EE sectors, according to the study results (Likaj, *et al.*, 2025). Wind turbine technicians and energy efficiency inspectors are also in high demand, as shown in Figure 11. Nevertheless, there was no response to the question about essential abilities or competences and skills, which may indicate a lack of knowledge or understanding regarding the precise competences and skills needed for these positions. Given the growing demand for solar energy technicians, energy management specialists, and EE auditors, it is advised to concentrate on improving training programs for these professions and coordinating educational initiatives with business demands (Likaj *et al.*, 2025).

This role has the highest demand of the listed profiles, indicating a strong interest in solar energy technologies and EE which are critical in the transition to renewable energy.

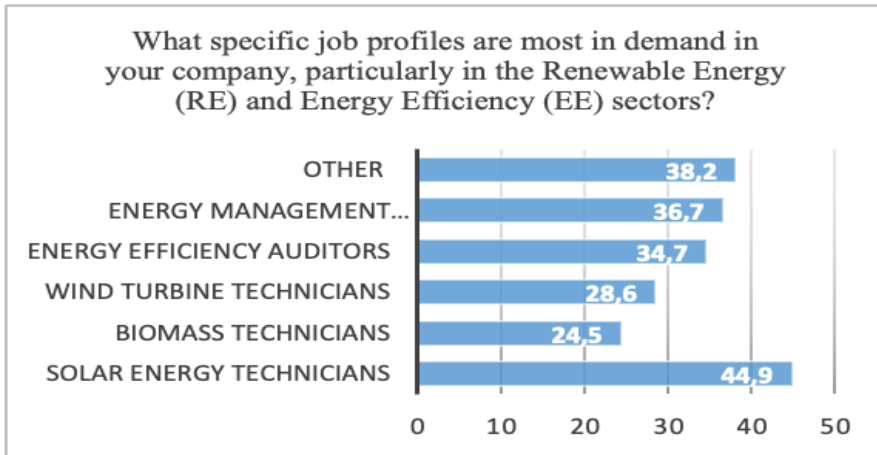


Figure 11. Job profiles in demand for the companies (RE, EE)

The study results in Figure 12, show a significant need for Solar Energy Technicians 18.2%, EE jobs 27.3%, indicating the growing importance of these industries. However, 57.5% of respondents reported no demand for any of the specified job descriptions, indicating a gap in industry awareness or preparation, thus raising awareness of career options in these sectors is critical.

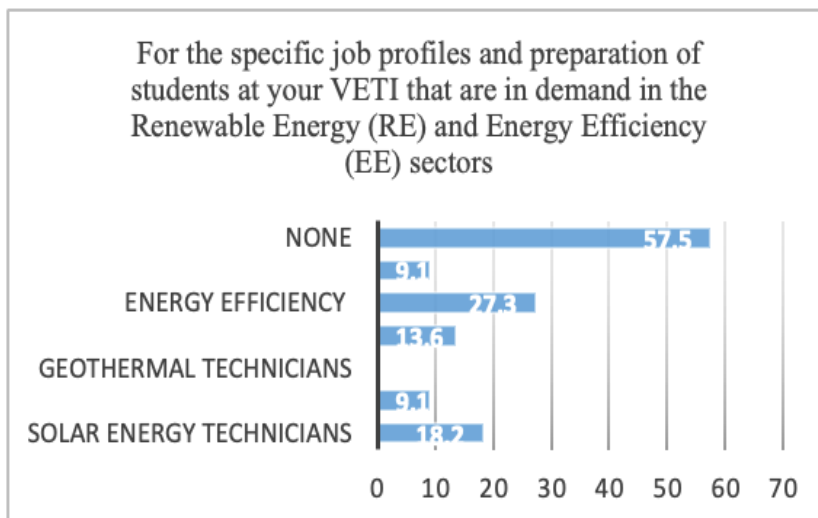


Figure 12. Job profiles in demand for provision at VETI (RE, EE)

5. CONCLUSIONS

Despite mentioning sustainability in the Climate Change Strategy, the Kosovo VET system faces obstacles in incorporating environmental factors. There is a shortage of specialist training in the renewable energy sector, although green initiatives such as eco-clubs and workshops are gradually being implemented. Two-thirds of firms acknowledge environmental concerns, but financial and technical obstacles prevent full adoption of sustainability initiatives. Many firms understand the value of green talents and anticipate a need for technological, digital, and green skills in the coming years. VET programs must better correspond with business needs, including developing technology and green skills (Likaj, *et al.*, 2025).

Solar energy and energy efficiency positions are in high demand, yet there is a lack of understanding about the exact skills required. More study is needed to identify these skills and guarantee that VET programs meet the changing needs of the labor market. Improved relationships with businesses and the extension of sustainability training can assist in closing these gaps.

To increase the integration of sustainability in Kosovo's VET system, sustainability must be made a fundamental skill across all training programs, with environmental issues incorporated into curricula. The renewable energy sector, notably solar energy, energy management, and energy efficiency, should get more targeted training to fulfill the growing demand for competent professionals in these disciplines. Strengthening collaborations with corporations, funders, and international organizations will assist in giving practical, hands-on training in developing technologies while also ensuring that VET programs remain relevant to industry demands.

Despite the rapid growth of the ICT sector in Kosovo, talent deficiencies threaten the long term viability of the digital and circular economy. Employers are having difficulty finding skilled youngsters in software engineering, data analysis and cybersecurity, all of which are critical for green and circular solution development. Emerging technologies like artificial intelligence, cloud computing, and blockchain highlight the need for more industry specific training. While institutions in Kosovo produce ICT graduates, improved academic industry links are critical for building a resilient, sustainable and digitally oriented economy, (Likaj *et al.*, 2025).

Furthermore, VET courses must be revised to reflect industry-specific sustainability standards, emphasizing the importance of green technology, automation, AI and digital skills. Promoting environmental awareness in VET institutions through eco-clubs and sustainability workshops will involve students and faculty in active environmental conservation. Finally, addressing knowledge gaps about the unique competences necessary in green sectors will guarantee that training programs keep up with changing labor market demands.

References

- 1) Administrative Instruction on Workplace Learning in IVET - AI 137/2020. Ministry of Education, Science, Technology, and Innovation. [online] Available at: <https://masht.rks-gov.net/wp-content/uploads/2022/05/udhzimi-administrative-me-nr-137-2020-te-mesurit-ne-vendin-e-punese-ne-iaap.pdf> [Accessed 21.02.2025].
- 2) Bajrami, K. (2024). Work-based Learning in Kosovo: An assessment against EU quality standards. *Report prepared for ETF*, pp 1-47.
- 3) Euler, D. (2024). Dual Learning in the VET System of the Republic of Kosovo, Strategic Process for Harmonization of Donor Support, Report prepared for GIZ, pp. 1-30.
- 4) MESTI (2024). Statistikat e arsimit në Kosovë [2023-2024. Report. [online] Available at: <https://masht.rks-gov.net/statistikat-e-arsimit-ne-kosove-2023-2024>. [Accessed 21.02.2025].
- 5) Kosovo Education Strategy 2022-2026. [online] Available at: <https://masht.rks-gov.net/en/education-strategy2022-2026>[Accessed 21.02.2025].
- 6) Law no 04/L-138 for Vocational Education and Training. [online] Available at: <https://gzk.rks-gov.net/ActDocumentDetail.aspx?ActID=8676> [Accessed 21.02.2025].
- 7) Likaj, R. (2023). Analysis of development resources needed at VET provider level and options for their integration in the organizational structures of VET providers – with a specific focus on initial VET, Report prepared for OEAD, pp 1-71.
- 8) Likaj, R., Danuza, T., Vitija, N., Lubishtani, E., Mirashi, M., Prapashtica, N., Kacaniku, A., "Evaluation of the capacity of VET schools and private sector needs Prepared for "Skills for sustainable jobs in Kosovo" project, 2025, <https://civitta.com/wp-content/uploads/2025/02/Evaluation-of-the-capacity-of-VET-schools-and-private-sector-needs.pdf>.
- 9) National Development Strategy 2030. Government of Kosovo. (2023). [online] Available at: <https://kryeministri.rks-gov.net/wp-content/uploads/2023/03/06032023-Strategjia-dhe-Plani-Kombetare-per-Zhvillim-2030.pdf> [Accessed 21.02.2025].
- 10) National Qualification Framework Kosovo, [online] Available at: Dokumentet - AKK[Accessed 21.02.2025].
- 11) Themel, M. (2024). Key Policy Developments in Education, Training, and Employment, Kosovo, European Training Foundation, pp 1-35.
- 12) Work-based Learning Operational Guide. Ministry of Education, Science, Technology and Innovation, December, 2020.

STIMULATING GREEN ENERGY FOR CONSUMERS: A STUDY ON BIOFUEL POLICY AND CIRCULAR ECONOMY PATHWAYS IN MOLDOVA

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Abstract

This study analyzes the economic and policy dimensions of biofuel development in the Republic of Moldova in the context of its transition toward a circular and consumer-oriented economy. With transport energy demand fully dependent on fossil fuel imports and limited domestic refining capacity, Moldova faces structural barriers in achieving its Renewable Energy Sources in Transport (RES-T) targets set by RED II and national legislation (Law No. 10/2016). The paper examines production cost scenarios and incentive strategies for first- and second-generation biofuels – bioethanol and biodiesel – based on local feedstocks such as corn, sunflower oil, sugar beet, and DDGS. Supply chain modeling reveals that domestic production of cereal-based bioethanol is the most feasible in the short term, while advanced biofuels from waste residues are constrained by technology costs and infrastructure gaps. The analysis further explores the role of Free Economic Zones (FEZs), logistics via the Giurgiulesti Port, and regional blending options as cost-reduction levers. Key stakeholders including national producers and fuel distributors are identified as ready to operationalize blending strategies under EU sustainability standards. The study concludes with short- and long-term recommendations for policy and investment strategies to strengthen Moldova's biofuel sector as part of a broader circular economy model, enhancing both energy security and consumer access to sustainable transport fuels.

Keywords: *biofuels, Moldova, renewable energy policy, circular economy, consumer transition*

JEL Classification: Q42, Q48, O13, R41

INTRODUCTION

Aligned with the 2030 targets of the Renewable Energy Directive (RED II), Moldova aims to achieve 9% of transport energy from biofuels. EU market trends show increasing demand for bioethanol and biodiesel, including advanced biofuels like UCO biodiesel and straw-based ethanol.

This paper provides an analysis of biofuel development, incentive policies, and supply chain options through Free Economic Zones. It draws from both EU

and national market conditions. Moldova, part of the EU's Eastern Partnership and the Energy Community since 2010, is committed to aligning with EU renewable energy laws, particularly RED II (Plotnic Olesea, 2022). National priorities include decarbonizing transport through biofuel integration, reflected in strategic documents like Moldova 2030, the National Energy Strategy, and the forthcoming NECP.

Law 10/2016 (transposing RED I) sets Moldova's renewable energy targets: 17% in overall energy (met in 2020) and 10% in transport by 2030. Despite success in heating/cooling, renewable energy in transport is minimal – just 0.18%, largely due to electric public transport.

Barriers include the lack of a national biofuel framework, blending mandates, and infrastructure. Amendments to Law 10/2016 now aim to scale up biofuel use and set thresholds:

- ☐ 2% cap on food-based biofuels,
- ☐ 1.7% from UCO and animal fats,
- ☐ 3.5% from advanced biofuels by 2030.

Transport represents 26% of energy use, dominated by imported fossil fuels. To meet the 9% target, Moldova must consume ~71 million liters of biofuels annually (46,640 tons biodiesel, 14,220 tons bioethanol). Achieving this requires mobilizing local feedstock, enabling infrastructure, and incentivizing investment.

1. PRELIMINARY ANALYSIS: ECONOMIC FACTORS AND INCENTIVE POLICY

This section outlines key economic factors affecting biofuel production costs in Moldova, particularly biodiesel and bioethanol, in line with Law No. 10/2018 and RED II targets for 2030.

It reviews market dynamics, production costs, and how biofuels compare with fossil fuels after blending. The analysis also highlights how fiscal policies – especially those linked to Free Economic Zones (FEZs) – influence national biofuel demand.

Additionally, it considers stakeholder interests and available production data to assess the economic viability of expanding Moldova's biofuels industry.

1.1. Preliminary Assessment of Biofuels in Moldova

Biofuel cost analysis in Moldova must consider production costs, market conditions, and legal frameworks such as RED II and the national RES Law No. 10/2016, which prioritizes local feedstocks.

Key feedstocks include corn, sunflower oil, straw, and by-products like SSDG. Advanced biofuels made from residues are eligible for double counting under RED II. The viability of biofuel production depends on:

- Feedstock type and price
- Harvesting and processing efficiency

Transport and distribution costs

Market competition with food/feed sectors

Volatility in fossil fuel and crop prices

EU experiences show that targeted subsidies, tax incentives, and credits (e.g., RECs) play a major role in offsetting production costs. In Moldova, Free Economic Zones (FEZs) offer opportunities to lower financial barriers and enhance industry competitiveness.

In short, Moldova's biofuel production costs are shaped by domestic agricultural practices, policy support, and global energy trends (Iarmenco Mihaela, 2020). Prioritizing local biomass and adopting RED II-aligned incentives can create a viable biofuel market.

1.2. Trends in Biofuel Costs and Technology Readiness (Shortened)

Biofuel prices are largely driven by feedstock costs and the maturity of conversion technologies.

First-generation biofuels (from corn, sugar beet, sunflower, rapeseed) are commercially viable and widely used.

Advanced biofuels, made from residues (straw, algae, lignin), offer greater sustainability but are more expensive due to immature technology (TRL 3–8) and limited scale.

Emerging technologies such as gasification, pyrolysis, and hydrothermal liquefaction remain costly but are essential for long-term decarbonization. EU policy supports these pathways through incentives and double-counting mechanisms.

Biofuel innovation also includes the use of renewable hydrogen and captured CO₂ to produce synthetic fuels (e-fuels), though still in early development.

Moldova can benefit by adopting cost-effective first-generation biofuels in the short term while gradually investing in advanced pathways aligned with EU sustainability goals.

1.2.1. Effect of Feedstock and Technology on Biofuel Costs (Shortened)

Producing transport biofuels remains more expensive than fossil fuels, requiring policy support to be economically viable. However, using lower-cost feedstocks – such as waste or residues – can reduce costs. Technologies that improve conversion efficiency or generate valuable co-products also help.

Hydrotreated vegetable oil (HVO) production is expanding in countries like Sweden due to cost-saving measures and policy incentives. In contrast, advanced biofuels from lignocellulosic materials (e.g., straw, wood) remain costly due to high investment needs and logistics.

According to the IEA (2020), production costs for advanced biofuels range between 17–44 EUR/GJ using biomass, and 13–29 EUR/GJ with waste feedstocks

– compared to fossil fuels at 8–14 EUR/GJ (as of 2019). These figures highlight feedstock and capital costs as major cost drivers.

Opportunities for cost reduction include:

- a) Integration of advanced biofuels with existing plants;
- b) Scaling up technology to reduce capital costs;
- c) Access to cheaper finance through risk mitigation;
- d) Implementation of carbon pricing to close the cost gap.

Although fossil fuel prices have fluctuated significantly (from <18 €/barrel in 2020 to >110 €/barrel in 2022), most technology and cost-related barriers remain relevant (IEA, 2024).

IEA also identifies research needs to lower costs and expand market potential, particularly for lignocellulosic ethanol and hydrocarbon biofuels. These include:

- a) More efficient pre-treatment and conversion processes;
- b) Novel biological strains for fuel production;
- c) Advanced separation technologies;
- d) Lignin valorization for fuels and bio-based products.

Despite higher costs, advanced biofuels offer long-term opportunities for decarbonizing transport and building a resilient renewable fuel market.

1.2.2. Current Biofuel Production and Use in the EU (Shortened)

The most widely used biofuels in EU transport are first-generation **bioethanol**, **biodiesel (FAME)**, and **HVO**.

- a) **FAME** is now typically blended with diesel at 7–8% due to compatibility issues with modern engines.
- b) **Bioethanol** is blended with gasoline at 5–7%, or used at 85% in flex-fuel vehicles.
- c) **HVO** and paraffinic fuels (e.g. Fischer-Tropsch) are drop-in fuels and can fully replace fossil diesel. While often blended at 30%, pure HVO use is growing, especially in freight transport.

2. EU BIOETHANOL PRODUCTION TRENDS

Bioethanol, produced by fermenting crop-based carbohydrates, saw EU production grow from 4.8 billion liters in 2014 to 5.57 billion liters in 2023 (Fig. 1). Consumption increased steadily, driven by rising blending mandates and competitive pricing versus gasoline.

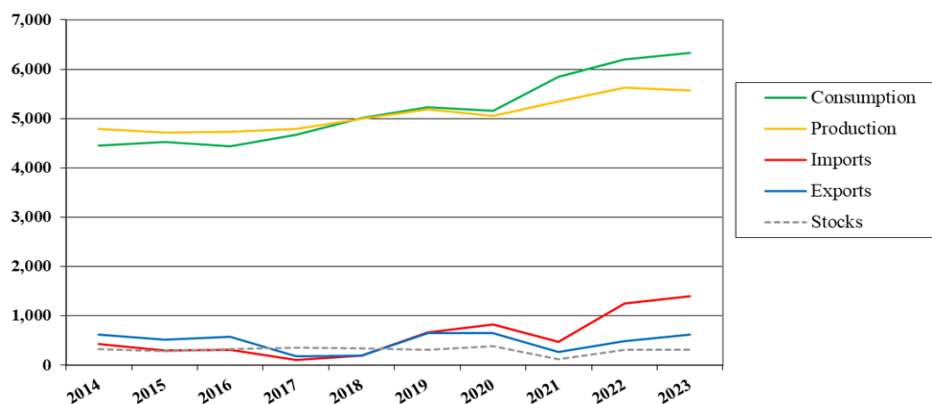


Figure 1. Millions of Liters of Bioethanol-fuel market and trend in EU (USDA, 2023)

Since 2019, the EU has become a net importer of bioethanol. In 2023, despite stronger demand, production declined due to reduced sugar beet cultivation in France.

Outlook:

- Expansion of crop-based (first-gen) bioethanol is expected to plateau due to RED II limits.
- Cellulosic (advanced) ethanol remains underdeveloped due to high costs, regulatory uncertainty, and weak supply chains.
- EU production capacity for cellulosic ethanol reached only 125 million liters in 2022.
- Advanced ethanol from non-cellulosic waste (Annex IX Part A) rose from 240 million liters in 2019 to 575 million liters in 2021 (ePURE, 2022).

In sum, while traditional bioethanol continues to grow moderately, large-scale adoption of advanced ethanol depends on clearer policies and greater investment support.

2.1. Feedstock Use and Co-product Trends in EU Bioethanol Production

EU bioethanol production continues to rely heavily on cereals – primarily corn, wheat, barley – and sugar beet. By 2023, production approached 6 billion liters, requiring an estimated 18 million tons of biomass, with ~10.2 million tons of cereals expected in 2024.

Sugar beet remains the largest feedstock, although its use is declining. Corn and wheat are increasingly used, while cellulosic biomass accounts for only 1%.

Corn imports for bioethanol mainly come from the U.S. and Ukraine. Despite the ongoing conflict, Ukraine remains a key supplier due to its non-GMO corn. Moldova plays a notable role in supplying barley to the EU, supporting feedstock diversification amid geopolitical disruptions.

Feedstock prices rose sharply in early 2022 due to the war and fuel volatility. Though prices stabilized later, the cost of bioethanol remains tied to feedstock price fluctuations, as presented in table 1.

Table 1. Cost of bioethanol in 2024

Feedstock	2024 Cost (€/liter)
Wheat	0.97
Corn	0.90
Barley	0.88
Sugar Beet	0.70

Choosing cost-effective, locally sourced feedstocks aligned with existing infrastructure will be critical for Moldova's bioethanol strategy.

2.2. Biodiesel Production Costs and Trends in the EU

Global biodiesel production reached 52 million tonnes in 2022–2023, with the EU producing ~14 million tonnes (25%). After peaking in 2019, EU production slightly declined due to COVID-19 but remains strong due to RED II mandates, especially for advanced biodiesel, as presented in table 2.

Table 2. Biodiesel production costs per country in 2023

Top EU Producers (2023)	Production (mil. tons)
Germany	3.43
France	2.16
Spain	1.61
Italy	1.26
Netherlands	2.10

Biodiesel is mainly produced from oil crops (FAME), and hydrogenated vegetable oils (HVO). Advanced feedstocks like used cooking oil (UCO) and animal fats, listed in RED II Annex IX, are gaining market share.

Challenges: EU FAME production faces competition from cheap imports (e.g., Argentina's SME, Indonesia's PME) and some plants have shut down or operate below capacity.

HVO production is increasing due to new dedicated plants and policy incentives. While traditional FAME output may decline, advanced biodiesel is expected to grow as EU countries seek to meet climate goals and reduce fossil fuel reliance.

2.3. Feedstock Market Impacts on Biodiesel Production

Globally, biodiesel production relies mainly on vegetable oils: palm oil (36%), soybean oil (23%), and rapeseed oil (14%). Waste oils (UCO) and animal fats contribute 14% and 5%, respectively.

In the EU, agricultural crops account for 76% of biodiesel feedstock. Rapeseed oil leads with 42% of inputs, despite reduced imports from Russia. This has been partially offset by rising palm oil imports from Asia and growing use of advanced feedstocks (UCO, animal fats) listed in RED II Annex IX.

Sunflower oil usage has declined, as the EU prioritized its use for food due to supply disruptions caused by the war in Ukraine. This highlights the close link between biodiesel and food markets.

Table 3. EU Biodiesel Feedstock Composition in 2023

Feedstock	2023 Tons (1,000 Mt)	% Share
Rapeseed oil	6,375	42%
Used Cooking Oil	4,350	29%
Palm Oil	1,400	9%
Animal Fats	1,000	7%
Soybean oil	740	5%
Sunflower Oil	265	2%
Others	950	6%

Moldova remains a minor but strategic supplier, exporting around 9% of sunflower oil used for EU biodiesel.

Feedstock prices have fluctuated due to high energy costs and supply chain disruptions. Despite this, UCO-based biodiesel prices remain stable (~1,020 €/mt, March 2024) due to support from RED II's double-counting mechanism, which boosts demand and policy value.

In contrast, FAME biodiesel faces weak demand and greater volatility due to market saturation and reduced diesel use.

The growing share of advanced feedstocks (now ~24%) reflects a structural shift driven by RED II and sustainability concerns. As palm oil is gradually phased out under ILUC rules, the EU is expanding partnerships with non-EU countries – including Moldova, Ukraine, Indonesia, and Argentina – for more resilient feedstock sourcing.

3. BIOFUEL COSTS AND RES-T INCENTIVES IN MOLDOVA

This market analysis identifies key factors for advancing biofuels in Moldova:

- 2030 Decarbonization Targets: Achieve 9% renewable energy in transport, as mandated by RED II and Moldova's RES Law (2018).
- Current Market Status: The biofuels market remains undeveloped, with no official biofuel imports/exports despite strong feedstock availability.
- Infrastructure: Moldova lacks refineries and blending infrastructure, hindering domestic biofuel integration.

- d) Stakeholder Interests: There is emerging interest, but capacity gaps exist in production, certification, and logistics.
- e) Free Economic Zones (FEZ): FEZs present strong potential to support investment in biofuel infrastructure and supply chains.

The analysis supports defining realistic pathways toward Moldova's 2030 targets, while also identifying existing barriers and policy gaps.

3.1. Current Status and Future Demand for Biofuels in Moldova

Moldova has the potential to become a producer of biofuel feedstocks (e.g., cereals, sunflower oil), yet domestic biofuel production is minimal due to the absence of blending mandates and fiscal incentives.

To meet the 9% transport energy target by 2030, according to the table 4, Moldova must integrate ~52 million liters of biofuels annually, including:

- a) 36.6 million liters of biodiesel
- b) 15.5 million liters of bioethanol

Table 4. Status for biofuels in Moldova

Fuel Type	2022–23 Use (liters)	Required Biofuel Blending (liters)
Diesel	757 million	36.6 million (biodiesel)
Gasoline	225 million	15.5 million (bioethanol)

Key barriers include:

- a) Lack of refineries and blending infrastructure;
- b) Absence of biofuel production facilities (traditional and advanced);
- c) Low awareness across the value chain – from suppliers to end users.

Opportunity: With policy reform, stakeholder engagement, and infrastructure support (especially via FEZs), Moldova can build a viable domestic biofuel market and meet its 2030 climate obligations.

3.2. Biofuel Cost Analysis and Incentive Strategy to 2030

Moldova imports all fuel for transport due to the lack of domestic refineries. However, there is local bioethanol production capacity (e.g., Zernoff Company), with potential for blending at Giurgiulești and Constanța ports or in Free Economic Zones (FEZs).

Project consultations identified key stakeholder synergies:

- a) Zernoff: Can produce 1st-gen bioethanol and possibly biodiesel from DDGS.
- b) Rompetrol: Open to blending domestic and imported biofuels with conventional fuels in line with EU standards (RED II, FQD, DAFI).

Three strategic supply chain options were defined:

1. Domestic Production & Blending (Best Option): Biofuel production, storage, and blending inside Moldova, using FEZs like Giurgiulești.

2. Blending Abroad & Re-import: Production in Moldova, blending abroad (e.g., Constanța), then re-imported. Higher cost but feasible.
3. Full Import of Pre-Blended Fuels: Highest cost (+30%) but required in absence of local biodiesel infrastructure.

Currently, as per table 5, Moldova produces ~25.4 million liters/year of bioethanol – covering 74% of national demand (~34.3 million liters). Biodiesel supply is negligible, requiring imports to meet demand (~36.6 million liters/year).

Table 5. Biofuel cost analysis

Biofuel Type	Domestic Supply	National Demand (liters)
Bioethanol (Zernoff)	25.4 million liters	34.3 million liters
Biodiesel (DDGS)	<1% of demand	36.6 million liters

Future potential includes:

- a) Advanced bioethanol from straw (double-counting eligible)
- b) 1st-gen ethanol from sugar beet (not eligible)
- c) Biodiesel from sunflower oil (1st-gen, not eligible) and UCO (double-counting eligible)

Cost considerations include:

- a) Biomass feedstock price & availability
- b) Technology readiness (TRL)
- c) Blending, logistics, VAT, and import duties

Oil companies estimate fuel price increases of:

- a) ~€0.20/liter for E5 gasoline (5% ethanol) and B7 diesel (7% biodiesel)

Stakeholders are ready to collaborate, with implementation timelines of 4–6 months once regulations are finalized. National law No. 10/2016 supports prioritizing local feedstock, especially for options 1 and 2.

3.3. Cost Analysis of Biofuel Supply Chains in Moldova

This section outlines cost estimates for various biofuel production pathways under national and EU-aligned scenarios. All figures reflect updated assumptions for 2024–2030.

3.3.1. Cereal-Based Bioethanol (1st Generation)

Produced locally by companies like **Zernoff**, corn-based ethanol is Moldova's most advanced domestic biofuel pathway. It covers up to 74% of national demand.

Component	€/L
Feedstock + Conversion	0.82
Taxes, blending, logistics	0.49
Total cost at pump (5% blend)	1.31
Gasoline pump price (2023–24)	1.30

→ Slightly more expensive than pure gasoline; however, feasible with targeted incentives.

3.3.2. Cellulosic-Based Bioethanol (Advanced Biofuel)

No production exists in Moldova; imports from the EU are the only option. Supported by RED II for double counting, cellulosic ethanol is sustainable but expensive.

Total cost at pump (5% blend)	1.84 €/L
Gasoline pump price	1.30 €/L

→ Advanced bioethanol is 40–50% more costly due to high feedstock and conversion costs.

3.3.3. Sugar Beet-Based Bioethanol

While production in Moldova is absent, sugar beet remains a cost-effective feedstock if reintroduced.

Total cost at pump (8% blend)	1.30–1.33 €/L

→ Comparable to conventional gasoline; viable if processing capacity is developed.

3.3.4 Biodiesel from DDGS (Advanced Biofuel)

Derived from residues of bioethanol production (Zernoff), DDGS-based biodiesel is a potential double-counting biofuel, though supply is limited (~1% of demand).

Component	€/L
Feedstock + Conversion	0.92
Taxes, blending, logistics	0.55
Total cost at pump (7% blend)	1.12–1.47 €/L
Diesel pump price (2023–24)	~1.06 €/L

→ National production is minimal; imports remain essential to meet biodiesel targets.

Key Takeaways

- Local cereal-based bioethanol is currently the most cost-effective and scalable option.
- Advanced biofuels (e.g., straw ethanol, DDGS biodiesel) are sustainable but costly.
- Strategic use of Free Economic Zones, targeted subsidies, and regional partnerships can reduce costs and strengthen supply chains.

3.3.5. Cost Analysis: Sunflower Oil-Based Biodiesel

Sunflower oil is abundant in Moldova but mainly used for food. According to EU STAR data, up to 20% could be diverted to biodiesel production without affecting food markets. Biodiesel could also be imported from neighboring countries.

Component	€/L
Feedstock + Conversion	0.67
Duties, blending, distribution	0.44
Total cost at pump (7% blend)	1.10–1.27
Diesel pump price (2023–2024)	~1.06

→ Feasible option if national capacity is expanded or supplemented by regional imports.

3.4. Strategies to Reduce Biofuel Costs

Improving logistics and using Free Economic Zones (FEZ) – especially Giurgiulești Port – can lower costs by up to €0.20/L. The port's multimodal infrastructure, oil terminal, and storage capacity make it a prime location for biofuel handling and blending.

Key features of Giurgiulești Port:

- Trimodal transport (road, rail, river);
- Oil and grain terminals, 50,000-ton storage;
- Customs-free operations under FEZ status.

Other active FEZs (e.g., Bălți) can host agro-energy and biofuel production investments, benefitting from:

- VAT/excise exemptions;
- 25-year guaranteed FEZ status;
- Favorable export/import conditions.

4. CONCLUSION AND FINAL RECOMMENDATIONS

Moldova relies heavily on fuel imports, yet holds strong potential to develop biofuel production using local biomass (e.g., cereals, sunflower oil, DDGS). While the absence of refineries remains a constraint, interim blending can occur via Giurgiulești or Constanța ports.

Scaling national biofuel capacity could:

- Reduce energy dependency;
- Boost rural income and jobs;
- Align with RED II and Moldova's Renewable Energy Law (10/2016).

Blending mandates and targeted investments will be key to unlocking this sector by 2030.

Short-Term Strategy (by 2030):

- a) Blend national and imported biofuels at ports or in EU-based refineries.
- b) Enforce compliance with RED II, FQD, ILUC.
- c) Certify sustainability and blending quality via accredited labs and operators.

Long-Term Strategy (Post-2030):

- a) Develop decentralized biofuel plants for cost-effective rural production.
- b) Focus investments on:
 - Local biomass availability
 - Stakeholder capacity-building (farmers, companies, regulators)
 - Policy incentives for advanced biofuels
- c) Monitor evolving trends: EV expansion, biofuel tech, commodity prices.

References

- 1) Agency for Energy Efficiency (2023). *Annual Report on Renewable Energy Progress in Moldova*. Chişinău: AEE.
- 2) Civitta and IWA (2023). *Analysis of Renewable Energy Potential in Moldova*. Chişinău: UNDP Moldova.
- 3) Energy Community Secretariat (2023). *Renewable Energy Statistics and Targets*. [online] Available at: <https://www.energy-community.org> [Accessed 2 Jun. 2025].
- 4) European Commission (2023). *Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (RED II)*. Official Journal of the European Union.
- 5) International Renewable Energy Agency (IRENA) (2022). *Renewable Energy Market Analysis: Southeast Europe*. Abu Dhabi: IRENA.
- 6) Iarmenco Mihaela, Donos Evlampie, Plotnic Olesea, (2020), Promotion of renewable energy in the European Union, International Conference on “European Finance, Business and Regulation-(EUFIRE 2020), pp. 709-716
- 7) Ministry of Energy of the Republic of Moldova (2024). *Draft National Energy and Climate Plan 2030*. Chişinău: Government of Moldova.
- 8) Ministry of Environment of the Republic of Moldova (2023). *GHG Inventory Report and Climate Policy Progress Review*. Chişinău: Government of Moldova.
- 9) Platonic Olesea, Popescu Lucia (2022). Climate change and sustainable development: issues for international trade system, European Finance, Business and Regulation. Challenges of Post-Pandemic Recovery. Proceedings of the International Conference EUFIRE 2022, 313.
- 10) UNDP Moldova (2024). *Baseline Assessment on Sustainable Biofuels and Energy Poverty Reduction*. Chişinău: UNDP.
- 11) World Bank (2021). *Moldova Energy Vulnerability and Transition Assessment*. Washington, DC: The World Bank Group.
- 12) Zernoff S.A. (2022). *Company Profile and Ethanol Production Data*. Chişinău: Internal Company Reports.

ENHANCING WATER RECOVERY IN ROSE OIL PRODUCTION: CERAMIC MEMBRANE APPLICATIONS FOR SUSTAINABILITY AND CIRCULAR ECONOMY

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Abstract

The distillation process in the rose oil production sector produces organically rich, high temperature wastewater. This type of effluent constitutes a serious environmental disposal issue but at the same time contains valuable compounds. The present work investigates a sustainable approach to address this issue by applying ceramic membrane filtration to treat rose processing wastewater and recovery of valuable polyphenols. Characterization of the wastewater showed a complex chemical composition of high organic content and diverse phenolic compounds. Two-stage membrane filtration through a ceramic microfiltration membrane and then a ceramic nanofiltration membrane was employed. The microfiltration process generated higher flux and higher flux recovery ratio compared to nanofiltration. Though the lower flux is typical for denser membranes such as nanofiltration, these ceramic systems are robust and good for efficient pollutant removal and recovering polyphenols. The paper also discusses the application of these ceramic membrane systems to existing rose processing plants, citing their potential to create new sources of income through polyphenol recovery and enable the reuse of water. Inspired by successful applications of membrane systems in similar agro-industrial waste treatment, the economic and energy considerations implies that membrane technology has a lower energy profile and a favourable return on investment. Therefore, this study suggests that ceramic membrane filtration is an economically viable and environmentally sustainable solution for rose processing wastewater.

Keywords: water recovery, circular economy, sustainability, rose oil distillation wastewater.

JEL Classification: Q25

1. INTRODUCTION

Roses, includes over a hundred species, grow across Europe, Asia, and North America. While many roses have been cultivated for ages, wild varieties can still be found growing naturally. For thousands of years, rose leaves, flowers, and even their fruits have been used for medicinal purposes (Koczka *et al.*, 2018).

Even though there are over a hundred rose varieties globally, the *Rosa damascena* stands out as the most productive for essential oil extraction. This perennial plant, native to Europe and the Middle East, is the type widely grown in Türkiye (Rusanov *et al.*, 2014). Türkiye produces about 60% of the world's annual *Rosa damascena*.

After harvesting roses, rose oil and rose water are produced through steam distillation and rose absolute through n-hexane and ethyl alcohol extraction (KGM, 2020). It takes around 3,000 kg of rose blossoms to produce just 1 kg of rose oil, and for every 1 kg of fresh roses, 2 kg of waste is produced. A single two-hour distillation cycle uses 1,000 kg of rose petals and 4,000 liters of water. After the distillation, a hot waste mixture of flower residue and distillation water is left in the tank which includes valuable non-volatile phenolic compounds (Rusanov *et al.*, 2014).

Since rose flowers are harvested in May and June, rose oil production follows the same timeline. Polyphenols are present in hot wastewater (around 40 °C) produced during distillation (Avsar *et al.*, 2007). Rose oil and water production industry faces a challenge about managing the comparatively high-temperature wastewater generated during distillation.

Polyphenols are becoming increasingly valuable in various industries, so finding a way to recover them from the waste stream of rose processing wastewater is important. Hence, the aim of this work is to investigate the treatability of rose wastewater and the recovery of polyphenols using membrane systems, specifically focusing on ceramic membranes. The key areas covered in this paper are experimental filtration results, integration potential and operational costs of ceramic membranes.

2. POLYPHENOLS

Phenolic compounds are bioactive phytochemicals that occur naturally in plants. These reactive compounds have one or more hydroxyl groups directly attached to an aromatic benzene ring. Many types, such as flavonoids, anthocyanins, and carotenoids, are found in a variety of foods, including medicinal herbs, vegetables, and legumes. They act as antioxidants, by both scavenging free radicals and by chelating metals (Cendrowski *et al.*, 2017, Choi *et al.*, 2015).

Polyphenols offer a broad range of biochemical and pharmacological benefits because of their antioxidant, anticancer, anti-inflammatory, and lipid-lowering properties, and their protective effects on the cardiovascular system. Specifically, rose petals are known to contain variety of polyphenols such as flavonoids, gallic and protocatechuic acids, and tannins (Rusanov *et al.*, 2014).

The global polyphenols market is expected to grow significantly by 7.4% between 2023-2030. This growth is largely driven by the expansion of the global functional food and beverage industry and advancements in polyphenol extraction technologies. As people become more aware of the benefits of herbal products

over synthetic drugs, the demand for polyphenols is set to increase. In addition, polyphenols are generally recognized as safe, expanding their use beyond just disease prevention and treatment, to a broader food and beverage industry (GVR, 2025).

After functional beverages, functional foods are the second largest area where polyphenols are used (Fig. 1). Functional foods play an important role in preventive healthcare by strengthening the immune system and helping to prevent diseases. Dietary supplements have become increasingly popular among consumers looking for natural solutions to various health problems (GVR, 2025). In addition to food industry, polyphenols are also used in polishes, medicines, pesticides, and in the production of cosmetics and synthetics (Mudimu *et al.*, 2012).

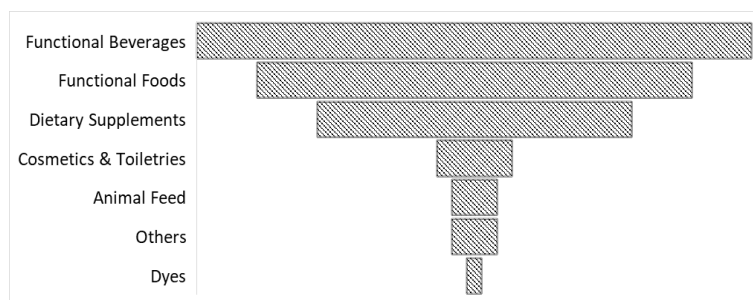


Figure 1. Global Polyphenol Market Share by Application, 2022 (GVR, 2025)

The increasing use of polyphenols in functional food, beverage, and nutritional supplement production, along with their application in cosmetics, dyes, and animal feed, is transforming the market. Their widespread use in different industries, leading to high sales values, makes the recovery of polyphenols from wastewater highly desirable. Therefore, it is very important to recover valuable products such as polyphenols from waste streams such as rose oil production wastewater. Polyphenols have shown promising results in preventing a number of health issues, including cardiovascular diseases, cancer, diabetes, neurodegenerative conditions, aging and skin problems. They also have an important prebiotic effect. Therefore, the use of polyphenols is expected to increase in the functional food market (GVR, 2025).

3. ROSE PROCESSING WASTEWATER TREATMENT

Studies by Tosun *et al.* (2002) revealed that classic coagulation wasn't effective for treating rose processing wastewater, while Fenton's reagent achieved a 76% chemical oxygen demand (COD) removal, and electrocoagulation provided an 81% COD removal (Avsar *et al.*, 2007).

In their review paper Slavov *et al.* (2017) summarized studies on the valorisation of rose oil production waste. They grouped these studies into categories like obtaining new aromatic products/increasing essential oil yield, isolating biologically active substances, composting, biosorption of pollutants, using it as feed or feed additives, gasification and biogas production, and other recovery methods. Rusanov *et al.* (2014) recovered polyphenols from rose processing wastewater using activated resins.

Pulido (2016) suggested on their review that feeding raw wastewater into membrane systems without pretreatment leads to serious fouling problems. Effective antifouling solutions are crucial to make membrane systems more technically and economically viable. However, it's important to note that olive mill wastewaters are different from rose processing wastewaters because it does not emerge at high temperatures. This limits the applicability of polymeric membranes, which have proven effective with olive mill wastewater, to rose processing wastewater at high temperatures.

4. MEMBRANE TECHNOLOGY

Membranes are divided into two main groups: inorganic and organic. Among organic membranes, polymeric membranes dominate the market. Inorganic membrane materials typically consist of oxide mixtures and sintered metals. Oxides like alumina, silica, and titania, or mixtures of these compounds, are commonly used in commercial ceramic membranes (Goh and Ismail, 2018).

Inorganic membranes are gaining a lot of attention due to their chemical, thermal, and mechanical stability. This makes ceramic membranes an ideal choice for treating challenging wastes, such as industrial wastewater treatment and oil/water separation processes that involve harsh conditions. Because inorganic membranes can withstand aggressive chemical and thermal cleaning methods and backwashing, it's easier to recover flux after cleaning (Chen *et al.*, 2017).

While organic membranes currently hold the largest share of the membrane market, their limited thermal and chemical stability can sometimes lead to lower performance compared to inorganic membranes for certain types of wastewaters. Hence, research on inorganic membranes is growing every day. In 1985, 474 articles were published on inorganic membranes and in 2016, 3682 were published. This clearly shows the rapid development of academic work in this area (Chen *et al.*, 2017).

Using inorganic membranes offers an attractive alternative for challenging water treatment processes where polymeric membranes might fail or be ineffective due to fouling or material instability. This includes desalination, wastewater treatment, handling radioactive substances, concentrated organic waste, and wastewaters containing oil and grease (Goh and Ismail, 2018). In recent years, inorganic membranes have been successfully applied in a wide range of industries because of their thermal and chemical stability. Key applications

include producing drinking water, desalination, textile wastewater treatment, oily wastewater treatment, electronic industry wastewater treatment, fruit juice concentration, and wastewater treatment.

Inorganic membranes can compete with polymeric membranes, which are often unstable in long-term applications, because of the advantages listed above. As a result, inorganic membranes are considered cost-effective and efficient water treatment alternative compared to polymeric membranes in long-term (Chen *et al.*, 2017). Nowadays, inorganic membranes, with their exceptional chemical and physical properties, are attracting increasing attention due to their adaptability to different conditions and their reusability (Goh and Ismail, 2018). Inorganic membranes can withstand harsh conditions in wastewater treatment and aggressive cleaning methods. They not only reduce the frequency of membrane cleaning, hence replacement, but also increase process efficiency. Metawater (Tokyo, Japan) has installed more than hundred water treatment plants using inorganic membranes shows their competitiveness. In an era where sustainability is increasingly important, inorganic membranes hold great promise for more efficient water and wastewater treatment, offering long-term cost savings and water conservation (Chen *et al.*, 2017).

Considering the high temperature, complex composition, and fouling potential of rose processing wastewater, ceramic membranes offer an ideal solution that allows both efficient wastewater treatment and polyphenol recovery due to their exceptional thermal, chemical, and mechanical stability.

5. ROSE PROCESSING WASTEWATER FILTRATION

5.1. Methodology

Rose processing wastewater was collected directly from a rose oil production facility in Isparta, Türkiye. Before ceramic membrane filtration, rose processing wastewater was subjected to a pre-treatment by using mesh-filter to remove large rose petal fragments. For characterization of the rose processing wastewater, alkalinity, dissolved organic carbon (TOC), COD, biochemical oxygen demand (BOD), and total Kjeldahl nitrogen (TKN) were determined following the Standard Methods for the Examination of Water and Wastewater (APHA, 2005).

The core of the methodology involves a two-stage ceramic membrane filtration process, microfiltration and nanofiltration. The prefiltered rose processing wastewater first filtered via microfiltration membranes. The microfiltration membranes used were 2.5 mm thick, 90 mm in diameter, and consisted of zirconium oxide with a pore size of 150 kDa. The filtration was carried out at room temperature for 4 hours at a constant pressure of 0.5 bar.

After microfiltration the permeate was filtered via nanofiltration membranes. The nanofiltration membranes used had a thickness of 2.5 mm, a diameter of 90 mm, and were composed of zirconium oxide with a pore size of 1 kDa. The

nanofiltration was carried out for 4 hours at a constant pressure of 1 bar under room temperature.

A tangential flow membrane test unit was used for all filtration experiments. The system was equipped with a pump, relief valves and a pressure gauge. Flux, the amount of water passes through per unit area of membrane per unit time, flux recovery ratio (FRR), the ratio of the flux recovered after backwashing to the initial flux were determined as described elsewhere (Celik Madenli *et al.*, 2025).

5.2. Filtration Results

As shown in Table 1, rose processing wastewater is dense in organic content with high COD, BOD values. These high values indicate a pollution load that requires significant effort for treatment. High TOC content indicates the presence of a wide variety of carbon-based compounds. High TKN concentration indicates a significant nitrogen content that may contribute to environmental problems if not treated. High total solids content, a significant portion of which is volatile solids, indicates a high organic particle content. These characteristics emphasize the need for effective treatment.

Table 1. Rose Processing Wastewater Characterization

Parameter	Value
pH	4.77
Alkalinity (mg CaCO ₃ /L)	300
Total solids (mg/L)	6,620
Suspended solids (mg/L)	1,005
Volatile solids (mg/L)	5,760
COD (mg/L)	47,800
TKN (mg/L)	3,080
BOD (5 days, mg/L)	23,920
TOC (mg/L)	21,210

Source: Tosun *et al.*, 2002; Celik Madenli *et al.*, 2025

Rose processing wastewater is a rich source of several polyphenols. It has high concentrations of quinic acid and gallic acid, which are known for their antioxidant properties. It also includes a number of other phenolic compounds, such as quercetin, ellagic acid, cyanidin-3-o-glucoside (Celik Madenli *et al.*, 2025). The presence of these polyphenols demonstrates the potential of rose processing wastewater for polyphenol recovery. This polyphenol content strongly strengthens the economic value for the treatment and valorisation of wastewater. In addition, this supports the development of circular approaches in the rose oil industry.

The comparative performance of ceramic microfiltration and nanofiltration membranes in terms of flux and FRR are shown in Fig. 2. The microfiltration membrane had a higher flux compared to the nanofiltration. The higher flux is expected for membranes with larger pores whereby water undergoing treatment passes but larger compounds are blocked. But the most significant measure of membrane sustainability is the FRR, which explains the extent to which the permeability of the membrane is restored upon fouling and cleaning. In the microfiltration membrane, the FRR was 25%. While it indicates some recovery, it also reveals that much of the initial flux was lost, attributed to irreversible fouling. This result highlights the treatment difficulties of rose processing wastewater due to the complex structure.

The nanofiltration membrane had a lower flux compared to the microfiltration. Lower flux in nanofiltration is expected with its smaller pore size, allowing more selective fractionation of smaller molecules including polyphenols. However, higher selectivity usually leads to a lower permeation rate. Similar to microfiltration, the nanofiltration membrane also had a lower FRR. This decreased recovery, is expected for membranes with smaller pore sizes handling complex feeds. The smaller pores are more susceptible to fouling by still smaller molecules that pass through the microfiltration step, and the foulants can be more difficult to be removed completely. While nanofiltration provides improved separation, more aggressive or optimized cleaning protocols should be explored to achieve maximum long-term flux stability and lower overall operating costs.

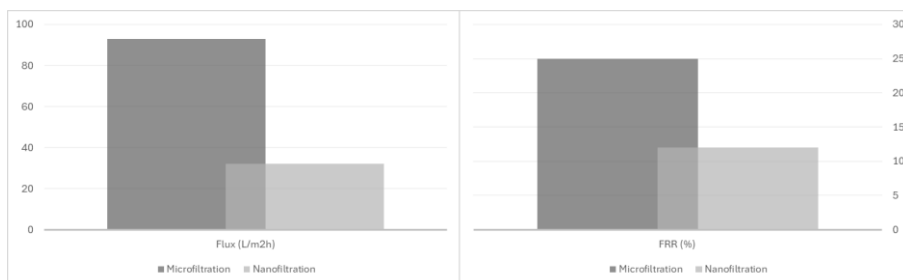


Figure 2. Flux and FRR results of the filtration

Mudimu *et al.* (2012), in their review, explored the use of membrane processes for treating olive mill wastewater and recovering polyphenols. Their findings indicated that microfiltration and ultrafiltration could be used for COD removal, while nanofiltration and reverse osmosis systems were effective for polyphenol recovery from olive mill wastewater. Garcia-Castello *et al.* (2010) used an Al₂O₃ microfiltration membrane with a 200 nm pore size, a Nadir N30F nanofiltration membrane with a 578 Da pore size, osmotic distillation, and vacuum membrane distillation for polyphenol recovery from olive mill

wastewater. Their work showed that a microfiltration-nanofiltration and osmotic distillation system recovered 56% of low molecular weight polyphenols.

Gebreyohannes *et al.* (2015) studied treating olive mill wastewater with a forward osmosis system. They showed that a system with only a forward osmosis unit achieved a 71% volume reduction and a 98% removal of colour, biophenols, and ions. When a membrane bioreactor was used as a pretreatment, they saw a 30% increase in flux and a 92.3% pectin removal. They also demonstrated 83% recovery from the ultrafiltration system and 92% recovery from the nanofiltration system for polyphenol recovery from the forward osmosis concentrate, using ultrafiltration (100 kDa) and nanofiltration (10 nm) membranes.

6. INTEGRATING CERAMIC MEMBRANES INTO ROSE PROCESSING PLANTS

Beyond the lab scale tests, the practical benefit of developed ceramic membrane system depends on its ability to adapt to the intense and challenging operational environment of a rose oil production facility. In an industrial rose processing facility, a significant amount of hot, polyphenol-rich wastewater is generated after the distillation. The ceramic membrane system is proposed to be integrated into the existing production flow. The wastewater resulting from distillation can be directed to the membrane unit. The microfiltration step used in this study may be useful for removing larger suspended solids and particles. This critical step prevents fouling of downstream membranes. This will ensure optimum performance and longevity during continuous operation.

The scope of this work goes beyond wastewater treatment and aims to create new income streams and promote operational sustainability. The polyphenols recovered using membranes are high-value bioactive compounds that are in great demand in the functional food, cosmetics and pharmaceutical sectors. Projected uses include reintegrating recovered polyphenols back into existing rose-based products to increase their worth or marketing them as an independent commercial product. Moreover, depending upon permeate quality obtained, treated water can be recycled within the plant for non-critical purposes as well. Usage of treated water in industry will reduce the need for fresh water, reduce waste discharge, and close the loop.

Membrane technology is a new solution to wastewater treatment from agriculture and food industries. These technologies are flexible, presenting new ways of extracting valuable compounds, protecting the environment, and recycling water. Membranes do not generally require complex phase transitions, so they are quite energy efficient. They are also relatively simple to control and need less physical space for a given separation task. When membrane processes are integrated into industrial operations, they can unlock solutions that are both economically sound and environmentally sustainable on a larger scale. They promise a high recovery of precious, added-value chemicals from waste streams,

while keeping energy consumption low. By efficient and successful recycling of valuable biomolecules and water, membranes ultimately lead to better environmental protection and a positive impact on society as a whole (Papaioannou *et al.*, 2022; Teodora *et al.*, 2022).

Even though this paper is about rose processing wastewater, results can be applied to other agro-industrial sectors as well. Innocenzi *et al.* (2021) applied membrane processes in the olive oil wastewater and have proved to be efficient for both water recovery and valorisation of polyphenols. This provides a strong and relevant comparison for the rose industry, demonstrating that successful industrial application of ceramic membranes is not a theoretical promise, but has a proven track record of success in similar industrial applications.

7. ECONOMIC AND ENERGY CONSIDERATIONS

In comparison to traditional and advanced treatment systems, one of the advantages of membrane technology is that it is less energy intensive (Keyvan Hosseini *et al.*, 2022). Long-term sustainability of any industrial solution depends on initial capital cost and operating and maintenance cost. The maintenance and operating cost for membrane technology would be energy consumption, replacement of the membranes, cleaning chemicals cost, and personnel cost. While fouling would be a concern for any membrane system, leading to increased transmembrane pressure and increased frequency of cleaning, there are certain benefits ceramic membranes possess in this area. Their increased longevity and resistance to strong cleaning agents mean that they don't need to be replaced quite so often and can survive more severe cleaning practices, potentially saving overall maintenance costs compared to their polymeric counterparts (Chen *et al.*, 2024).

Innocenzi *et al.* (2021) applied membrane processes to treat olive oil wastewater and carried out life cycle assessment to examine the economic feasibility of the membrane-based treatment scheme. They showed an overall cost of treatment equal to 253 €/m³. Cost analysis also showed that the utility and personnel cost was a substantial factor in the total annualized cost. The economic analysis shows that the suggested membrane scheme is feasible economic solution for the olive processing industry.

The true measure of the value of this technology is its capacity to give a strong return on investment for rose oil and water producers. The value of extracting high-purity polyphenols from a stream that was otherwise considered waste is significant. Ceramic membrane filtration not only reduce disposal costs, but it generates entirely new income streams from an otherwise saleable product. Secondly, aside from the benefits to the environment, such as reduced wastewater outflow and possible water reuse, the public image is also boosted, possibly making producers eligible for environmental incentives or certification. This complete resource management strategy, turning waste into assets, of ceramic

membrane technology makes it a very economically sound and favourable technique for achieving a more sustainable, profitable rose industry.

8. CONCLUSION

This study demonstrates the potential of ceramic membrane filtration as an economical solution for the treatment of rose processing wastewater and recovery of polyphenols.

Rose oil production wastewater characterization showed that it is a highly rich organic effluent, with varying polyphenols. This further verified the necessity of efficient treatment. The two-stage ceramic membrane filtration process, microfiltration and nanofiltration, was used. Our findings suggest that ceramic membranes have the potential to be used for polyphenol recovery and wastewater filtration in the rose oil production industry. These membranes have potential for recovery of water used in distillation during rose oil production, thus reducing freshwater demand and wastewater discharge. Therefore, ceramic membrane filtration supports the circular and sustainable practices in the rose oil production industry. The wider implications of scaling up ceramic membranes is also examined by taking into consideration the potential for integration into existing production systems, energy requirements, and operational costs. As a result, this study supports sustainability goals and circular economy by highlighting the potential of ceramic membranes usage for water recovery in rose oil production.

Further research shall be focused on the optimization of operating conditions of the membrane for maximizing stability of flux as well as the recovery efficiency of polyphenols. Pilot-scale operations over a long-term duration are also necessary to support these findings under continued industrial operating conditions and to generate more precise data for the overall life cycle assessment.

References

- 1) APHA. (2005). *Standard methods for the examination of water and wastewater*. 21st edn. Washington, DC: American Public Health Association, American Water Works Association, and Water Environment Federation.
- 2) Avsar, Y., Kurt, U., Gonullu, T. (2007). Comparison of classical chemical and electrochemical processes for treating rose processing wastewater. *Journal of Hazardous Materials*, 148(1-2), pp. 340–345. <https://doi.org/10.1016/j.jhazmat.2007.02.048>
- 3) Cendrowski, A., Scibisz, I., Mitek, M., Kieliszek, M., Kolniak-Ostek, J. (2017). Profile of the Phenolic Compounds of *Rosa rugosa* Petals. *Journal of Food Quality*, 7941347, pp. 1–10. <https://doi.org/10.1155/2017/7941347>
- 4) Çelik Madenli E., Kaleli, M., Kitis, M., Kesiktas, D. (2025). Polyphenol Recovery by Ceramic Membranes from the Rose Processing Wastewater. *ASCE Journal of Environmental Engineering*. *in press*.
- 5) Chen, L.H., Chen, Y.R., Chou, C.Y., Chen, C.H., Ko, C.C., Tung, K.L. (2017). Inorganic Membranes in Water and Wastewater Treatment. in Figoli, A., Criscuoli, A. (eds) *Sustainable Membrane Technology for Water and Wastewater Treatment*.

- Singapore: Springer Singapore. pp. 121-154. https://doi.org/10.1007/978-981-10-5623-9_5
- 6) Chen, M.L., Heijman, S.G.J., Rietveld, L.C. (2024). Ceramic membrane filtration for oily wastewater treatment: Basics, membrane fouling and fouling control. *Desalination*, 583, p. 117727. <https://doi.org/10.1016/j.desal.2024.117727>
 - 7) Choi, J.K., Lee, Y.B., Lee, K.H., Im, H.C., Kim, Y.B., Choi, E.K., Joo, S.S., Jang, S.K., Han, N.S., Kim, C.H. (2015). Extraction Conditions for Phenolic Compounds with Antioxidant Activities from White Rose Petals. *Journal of Applied Biological Chemistry*, 58(2), pp. 117–124. <https://doi.org/10.3839/jabc.2015.021>
 - 8) Garcia-Castello, E., Cassano, A., Criscuoli, A., Conidi, C., Drioli, E. (2010). Recovery and concentration of polyphenols from olive mill wastewaters by integrated membrane system. *Water Research*, 44(13), pp. 3883–3892. <https://doi.org/10.1016/j.watres.2010.05.005>
 - 9) Gebreyohanes, A.Y., Curcio, E., Poerio, T., Mazzei, R., Profio, G.D., Drioli, E., Giorno, L. (2015). Treatment of Olive Mill Wastewater by Forward Osmosis. *Separation and Purification Technology*, 147, pp. 292–302. <https://doi.org/10.1016/j.seppur.2015.04.021>
 - 10) Goh, P.S., Ismail, A.F. (2018). A review on inorganic membranes for desalination and wastewater treatment. *Desalination*, 434, pp. 60–80. <https://doi.org/10.1016/j.desal.2017.07.023>
 - 11) GRV, Grand View Research (2025). *Polyphenols Market Size, Share & Trends Analysis Report by Product (Grape Seed, Green Tea, Cocoa), By Application (Beverages, Food, Feed, Dietary Supplements, Cosmetics), And Segment Forecasts, 2023 - 2030*. [online] Available at: <https://www.grandviewresearch.com/industry-analysis/polyphenols-market-analysis>. [Accessed 15.06.2025].
 - 12) KGM, Kooperatifçilik Genel Müdürlüğü (2020). 2019 Yılı Gül Çiçeği Raporu. T.C. Gümrük ve Ticaret Bakanlığı. [online] Available at: https://esnafkoop.ticaret.gov.tr/data/5d44168e13b876433065544f/2019_Gul_Cicegi_Raporu.pdf [Accessed 15.06.2025].
 - 13) Koczka, N., Stefanovits-Banyai, E., Ombodi, A. (2018). Total Polyphenol Content and Antioxidant Capacity of Rosehips of Some Rosa Species. *Medicines*, 5(3), p. 84. <https://doi.org/10.3390/medicines5030084>
 - 14) Keyvan Hosseini, M., Liu, L., Keyvan Hosseini, P., Bhattacharyya, A., Lee, K., Miao, J., Chen, B. (2022). Review of Hollow Fiber (HF) Membrane Filtration Technology for the Treatment of Oily Wastewater: Applications and Challenges. *Journal of Marine Science and Engineering*, 10(9), p. 1313. <https://doi.org/10.3390/jmse10091313>
 - 15) Mudimu, O.A., Peters, M., Brauner, F. (2012). Overview of Membrane Processes for the Recovery of Polyphenols from Olive Mill Wastewater. *American Journal of Environmental Sciences*, 8(3), pp. 195–201. <https://doi.org/10.3844/ajessp.2012.195.201>
 - 16) Papaioannou, E. H., Mazzei, R., Bazzarelli, F., Piacentini, E., Giannakopoulos, V., Roberts, M. R., Giorno, L. (2022). Agri-Food Industry Waste as Resource of Chemicals: The Role of Membrane Technology in Their Sustainable Recycling. *Sustainability*, 14(3), p. 1483. <https://doi.org/10.3390/su14031483>.

- 17) Pulido, J.M.O. (2016). A review on the use of membrane technology and fouling control for olive mill wastewater treatment. *Science of the Total Environment*, 563-564, pp. 664–675. <https://doi.org/10.1016/j.scitotenv.2015.09.151>
- 18) Rusanov, K., Garo, E., Rusanova, M., Fertig, O., Hamburger, M., Atanassov, I., Butterweck, V. (2014). Recovery of Polyphenols from Rose Oil Distillation Wastewater Using Adsorption Resins – A Pilot Study. *Planta Medica*, 80(17), pp. 1657–1664. <https://doi.org/10.1055/s-0034-1383145>
- 19) Slavov, A., Vasileva, I., Stafanov, L., Stoyanova, A. (2017). Valorization of wastes from the rose oil industry. *Reviews in Environmental Science and Bio/Technology*, 16(2), pp. 309–325. <https://doi.org/10.1007/s11157-017-9430-5>
- 20) Teodoro, J.A., Arend, G.A., Proner, M.C., Verruck, S., Rezzadori, K. (2023). A review on membrane separation processes focusing on food industry environment-friendly processes. *Critical Reviews in Food Science and Nutrition*, 63(32), pp. 11275–11289. <https://doi.org/10.1080/10408398.2022.2092057>
- 21) Tosun, İ., Gönüllü, M.T., Arslankaya, E. (2002). Gülyağı Sanayi Proses Atıkları Özelliklerinin Belirlenmesi. in *1. Ulusal Çevre Sorunları Sempozyumu, Atatürk Üniversitesi, Çevre Sorunları Araştırma Merkezi Müdürlüğü*, 1, pp. 864–873. Erzurum, 16-18 October.

EMPOWERING CONSUMERS THROUGH CIRCULAR ECONOMY: BENEFITS AND CHALLENGES

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Abstract

In Society 5.0, the circular economy concept is crucial in shaping sustainable consumer practices. With the advancement of technology and the growing demands of consumers, understanding their role in the circular economy is becoming increasingly important. As an indispensable part of this system, consumers use products and actively contribute to shaping a sustainable market. Their rights include access to environmentally responsible products, transparent information about sustainability, and the ability to return, repair, or exchange products. Therefore, this paper analyses how consumers can exercise their rights, the benefits of a circular economy, and what obligations and challenges they must overcome. The research includes data collected through surveys in 31 countries and members of the ECO4ALL COST action. The results obtained will be analyzed using statistical methods to identify the benefits and challenges customers in these countries face within the circular economy framework. Through this analysis, the paper provides recommendations for improving circular mechanisms that benefit consumers and contribute to a sustainable future.

Keywords: Circular economy, consumer, benefits, challenges

JEL Classification: Q56, D12, Q01, M14, D18

1. INTRODUCTION

The circular economy (CE) aims to radically transform production and consumption systems by optimizing resource use to reduce dependence on new raw materials (Camacho-Otero *et al.*, 2018; Kirchherr *et al.*, 2017). This concept enhances sustainability by offering economic benefits to organizations through improved competitive advantage, fostering innovation, boosting sales, and attracting top talent (Kirchherr *et al.*, 2017).

The circular economy (CE) is an approach to the systemic redesign of economies such that they minimize the use of new natural resources and maximize the duration of use of all products and services (Camacho-Otero *et al.*, 2018; Kirchherr *et al.*, 2017). This concept also enhances sustainability by contributing economic value to organisations by improving their competitive position, enhancing innovation, increasing sales, and attracting skilled personnel (Kirchherr *et al.*, 2017).

The transition to a circular economy also significantly benefits consumers through economic savings, better access to environmentally friendly and long-lasting products, and increased awareness of sustainability and the possibilities of reuse and repair (Camacho-Otero *et al.*, 2018). Considering the circular economy aims for sustainable growth (Kirchherr *et al.*, 2017), positioning consumption as a form of sustainable consumption is important (Camacho-Otero *et al.*, 2018) to align with circular economy principles.

The circular economy is a concept that enables consumers to make a difference in resource conservation and waste reduction through their consumption. As the concept of the circular economy gains more momentum worldwide, consumers are now more than ever aware of their consumption's effects on the planet's sustainability (Vidal-Ayuso *et al.*, 2023).

The traditional linear model of buying, using, and then disposing of a product is replaced by the circular economy, which allows consumers to participate in more sustainable practices such as repairing, reusing, and recycling products. This is not only an industrial or regional phenomenon. It also means that consumers have to get involved in understanding the new business models and product use (Hunka *et al.*, 2021).

New product design and business model innovations provide consumers with more durable and environmentally friendly products (de Kwant *et al.*, 2021). The act of buying products and the awareness of making the right decisions towards a sustainable future are relieving the pressure on the environment and encouraging companies to adopt circular principles (Rizos *et al.*, 2016).

Most of the literature on the circular economy has focused on strategies for developing circular economies (Lewandowski, 2016) and optimizing production by exploring circular business models (Rizos *et al.*, 2017), but less attention has been paid to how consumption and consumers can be actively involved in circular practices. This paper aims to explore how consumers can exercise their rights, the

benefits of a circular economy, and the obligations and challenges they need to overcome. For this purpose, it is necessary to examine the impact of incentives for the circular economy, the financial responsibility of institutions, and consumer education on consumer behaviour in the context of the circular economy.

The remainder of the paper is structured as follows. Section 2 presents a literature review and introduces the hypotheses. Section 3 presents the data and methodology employed in the paper. Section 4 presents and discusses the main results. The last section is the conclusion.

2. LITERATURE REVIEW

In recent decades, the role of consumers in sustainable consumption has been increasingly decisive because consumers are considered active participants in achieving sustainability goals and environmental policies (McGregor, 2002). Consumer engagement in the circular economy is reflected in their ability to encourage sustainable production and consumption through informed decisions, changing habits and active participation in recycling and reuse (Mak & Terryn, 2020). Circular models can provide incentives to producers and consumers to use resources in a more sustainable way (Hojnik, 2018). Hence, consumer incentives to adopt circular behavior patterns depend on their attitudes, perceptions and willingness to accept them (Vidal-Ayuso *et al.*, 2023). Although consumers' interest in circular solutions is growing (Vehmas *et al.*, 2018), they simultaneously express the need for clear information about the circular economy and how their behavior can contribute to environmental protection, as they consider it a key guide for making consumer decisions (Testa *et al.*, 2020; Vehmas *et al.*, 2018). Therefore, in light of the preceding discussion, the proposed hypothesis is as follows:

Hypothesis 1: Circular economy incentives positively influence consumer behaviour.

According to research, financial support in the circular economy has become increasingly important as a key concept of sustainable development because investors want more environmentally friendly production and sale of goods (Dirk & Nett, 2022; Saleem *et al.*, 2022). Financial institutions which support circular consumption can help producers provide eco-friendly products to customers (Gu *et al.*, 2023). Many studies have addressed the impact of financial instruments, such as green financing, on consumer behavior (Machova *et al.*, 2022; Mogaji *et al.*, 2022; Amalia *et al.*, 2021). Financial support provided by policymakers influences consumers' intention to adopt sustainable practices and products in the circular economy. According to Gu *et al.* (2023), financial support can increase consumers' willingness to engage in circular consumption. The theory of planned behavior supports this fact, as external factors can influence consumer behavior regardless of their original intention (Yuriev *et al.*, 2020). Therefore, the following hypothesis is proposed:

Hypothesis 2: Consumer perceptions of financial support for circular practices influence their behaviour.

Although the availability of sustainable products and services on the market is necessary, it is insufficient to encourage circular consumer behavior (Mak & Terryn, 2020). Consumer education is key in applying circular practices by engaging other participants in the circular economy loop (Kakadellis *et al.*, 2021; Borrello *et al.*, 2020). Therefore, by educating consumers, it is possible to increase awareness and shape their attitudes and thinking when making informed decisions in accordance with the principles of circularity. Information consumers receive through education can empower them to make decisions about circular consumption (Vidal-Ayuso *et al.*, 2023). Furthermore, regulation can contribute to directing demand, but education enables consumers to understand the benefits of sustainable choices and actively participate in the circular economy (Mak & Terryn, 2020). From this perspective, the next hypothesis is proposed as follows:

Hypothesis 3: Consumer education about reducing, reusing, and repairing influences their behaviour.

The conceptual model that illustrates proposed relations among defined factors is depicted in Figure 1.

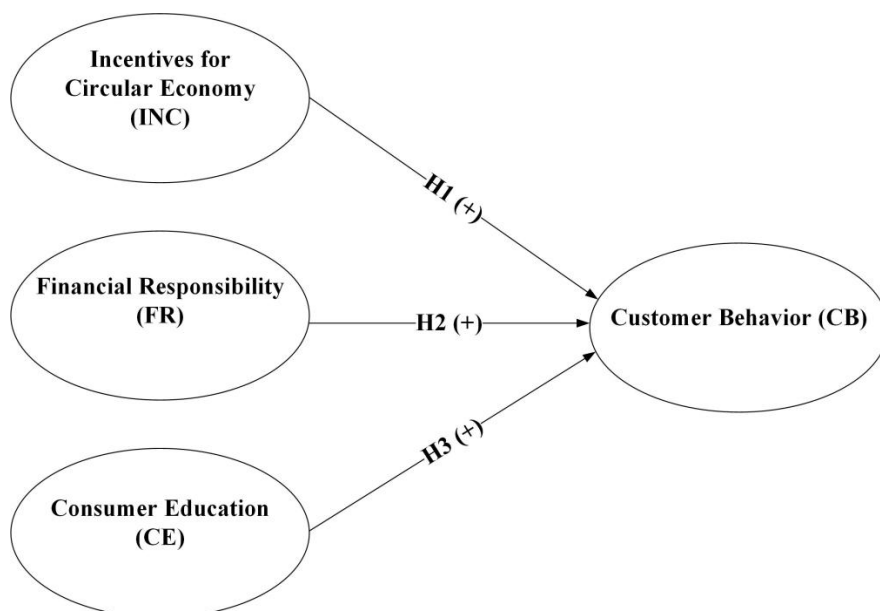


Figure 1. Conceptual model

3. METHODOLOGY

In order to collect data on the development of consumer capacities in circular practices such as reduction, reuse and repair through virtual collaboration and networking in a pan-European framework, an initial survey was conducted within the COST Action CA22124 - ECO4ALL. The action research group prepared a measurement scale, and questionnaire to assess the role of consumers in circular practices in the countries involved in the ECO4ALL action. The survey highlighted the importance of empowering consumers by informing them about their rights, obligations and opportunities in the circular economy context. A five-point Likert scale was used to express the respondents' opinions. Participants were consumers who engaged in circular consumption. A structured online questionnaire surveyed 165 respondents from 30 countries participating in the ECO4ALL action. The data obtained were further prepared for statistical processing, which was carried out using the SPSS v.25 software package.

More women (65.5%) than men (34.5%) participated in this study. Respondents represent a wide age range: 25.5% are between 18 and 30 years old, 24.8% are 31 to 40 years old, 30.3% are in the 41 to 50 year-old range, 14.5% are 51 to 60 years old, 0.6% are 61 to 65 years old, and 4.2% are over 65 years old. The respondents' education level indicates that the most significant percentage completed doctoral studies (60.5%), while the smallest percentage (6.1%) completed high school or lower. Work experience also varies: the smallest percentage of respondents (3.6%) has no experience, while the most significant percentage of respondents is in the range of 11 to 20 years (30.3%), followed immediately by the following group of respondents from 21 to 30 years (18.8%). Participants come from 30 countries and participate in the ECO4ALL COST action. The highest percentage answered the questionnaire from Turkey (17.0%), Serbia (12.7%), the Czech Republic (9.7%), and Albania (7.3%), while the other countries have a smaller share.

4. RESULTS AND DISCUSSION

Cronbach's alpha coefficient was used to check the accuracy of the measuring instrument. This is the most popular coefficient used to measure the internal consistency of the questionnaire and provides a unique assessment of its reliability. Cronbach's coefficient α was determined for each group of questions (Table 1), and the results show that the values are over the recommended values of 0.7 (Cronbach, 1951), which fulfils the consistency condition.

Table 1. Cronbach coefficient alfa (α)

Constructs	Cronbach coefficient alfa (α)
Incentives for Circular Economy (INC)	0.840
Financial Responsibility (FR)	0.877

Constructs	Cronbach coefficient alfa (α)
Consumer Education (CE)	0.925
Customer Behavior (CB)	0.822

Statistical research of the links between the defined constructs is carried out using correlation and regression analysis. For this purpose, the correlations between the defined factors have been calculated to reveal the nature and degree of quantitative agreement of the analysed factors (Moore *et al.*, 2009). The intensity of the link is determined based on the size of the correlation coefficient. The results of the correlation analysis indicate that all relationships between the observed constructs have high values with statistical significance, which can be seen in Table 2.

Table 2. Correlation analysis

	INC	FR	CE	CB
INC	1			
FR	0.617**	1		
CE	0.668**	0.675**	1	
CB	0.626**	0.558**	0.570**	1

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

The next step is regression analysis, one of the most commonly used statistical methods for determining the functional dependence between two or more variables (Ho, 2006). This research used regression analysis to examine the relationship between independent variables such as incentives for a circular economy, financial responsibility, consumer education, and the dependent variable, customer behavior.

Table 3 shows that the R Square Change value is 0.454, pointing out that the independent variables explain 45.4% of the variance in the dependent variable. This prompts customer behavior to be affected by incentives for a circular economy, financial responsibility, and consumer education.

Table 3. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.674 ^a	0.454	0.444	0.43715	0.454	44.579	3	161	0.000
a. Predictors: (Constant), INC, FR, CE									
b. Dependent Variable: CE									

Table 4 and Figure 2 depict the regression analysis used to determine whether incentives for a circular economy, financial responsibility, and consumer

education significantly impact customer behavior. The Variance Inflation Factor (VIF) is used to estimate the level of multicollinearity (Cohen *et al.*, 2013). Multicollinearity indicates linear relationships among independent variables. The results (Table 4) show that the VIF values for incentives for a circular economy, financial responsibility, and consumer education are low, which indicates a low mutual influence of these independent variables in predicting customer behavior. According to Ho (2006), VIF values greater than 10 indicate a multicollinearity problem, which was not identified in this analysis.

Table 4. Regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.769	0.176		10.064	0.000		
	INC	0.258	0.055	0.382	4.646	0.000	0.503	1.988
	CON1	0.116	0.047	0.203	2.446	0.016	0.495	2.020
	RRR	0.098	0.048	0.179	2.039	0.043	0.442	2.263

a. Dependent Variable: CB

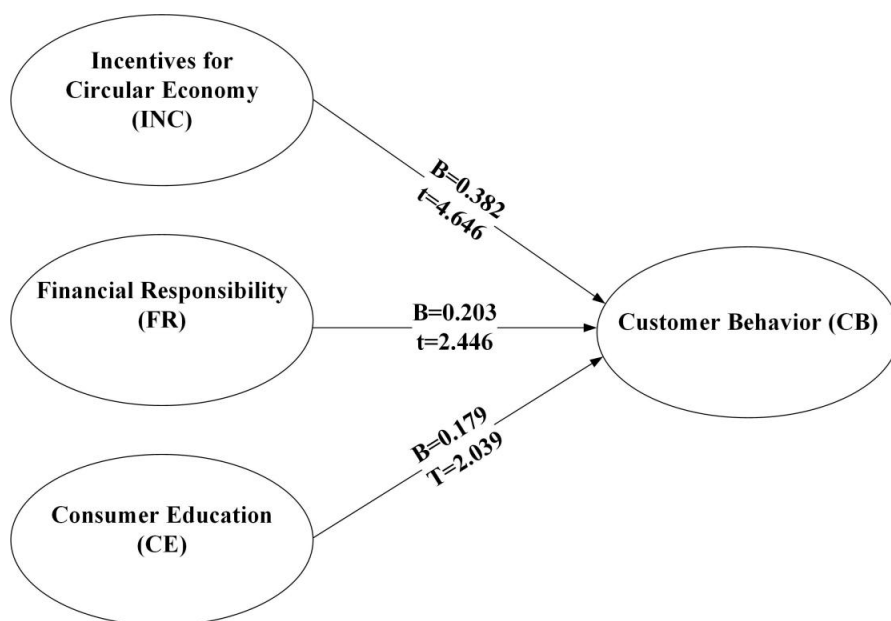


Figure 2. Regression model

This research indicates a more profound assessment of the relationship between incentives for a circular economy, financial responsibility and consumer education in relation to consumer behavior in a circular economy. The results show that all independent factors positively influence customer behavior with

statistical significance (Table 3 and Figure 2). It is necessary to emphasize that incentives for a circular economy have the strongest impact on consumer behavior in the circular economy and the hypothesis H1 is accepted. This finding is consistent with research by Wei (2025), which points to incentive mechanisms, such as an eco-taxation system including a price mechanism, cost effects and incentives for innovation, playing a key role in promoting the principle of sustainable consumption.

Furthermore, the results show the impact of financial responsibility on consumer behavior. Thus, hypothesis H2 is confirmed. In addition to the regulatory framework, the state must play an enabling role through various financial mechanisms, as it enables the creation of incentives, supports the development of infrastructure and implements policies that facilitate access to sustainable choices and raise awareness of the importance of responsible resource use. This result can be found in the literature indicating that financial responsibility, which encompasses various institutions from state authorities to private investors and international organisations, has an impact on consumer behavior in the circular economy and sustainable consumption (Gu *et al.*, 2023; Machova *et al.*, 2022; Mogaji *et al.*, 2022; Amalia *et al.*, 2021).

Finally, hypothesis H3, which examines the impact of consumer education on consumer behavior in the circular economy, is also accepted. This result is similar to the research conducted by Vidal-Ayuso *et al.* (20213) and Kakadellis *et al.* (2021), where consumer education and information are key factors shaping their behavior when making decisions about circular consumption.

The results of this study confirm all three hypotheses, indicating that incentives for the circular economy, such as tax relief, exemption from payment of environmental tax, government green bonds, etc., financial support from various institutions, both state and private, and consumer education, significantly impact shaping responsible consumer behavior regarding the consumption of resources, products, and services.

5. CONCLUSION

This research has provided useful insights into how consumers can exercise their rights, the benefits of a circular economy, and how they can overcome challenges to direct their behavior towards more sustainable consumption. By examining the impact of incentives for the circular economy, the financial responsibility of institutions, and consumer education on consumer behavior in the circular economy context, this study can have theoretical and practical implications. Given the observed lack of research on how sustainable consumption and consumers can be actively involved in circular practices, the theoretical implication is to fill a gap in the literature. The analysis of these results provides practical implications for advancing policies and practices that encourage a circular economy while contributing to understanding the factors that

shape consumer behavior. Also, this study can contribute to consumers by providing a road map for their active involvement in circular practices and more responsible consumption, all of which contribute to their well-being and a more sustainable lifestyle.

This research, like any other, has limitations. One of the main limitations of this study is the sample size, which could be overcome by extending the survey to a larger number of respondents, which would contribute to greater reliability of the results and enable broader generalization of the findings. Another limitation of this study lies in the limited number of factors that were considered when examining consumer behavior in circular consumption. In future research, it would be helpful to include a broader range of factors influencing consumer decisions to obtain a more comprehensive picture of their behavior.

References

- 1) Amallia, B. A., Effendi, M. I., & Ghofar, A. (2021). The effect of green advertising, trust, and attitude on green purchase intention: An evidence from Jogjakarta, Indonesia. *International Journal of Creative Business and Management*, 1(1), 66-79.
- 2) Borrello, M., Pascucci, S., Caracciolo, F., Lombardi, A., & Cembalo, L. (2020). Consumers are willing to participate in circular business models: A practice theory perspective to food provisioning. *Journal of Cleaner Production*, 259, 121013.
- 3) Camacho-Otero, J., Boks, C., & Pettersen, I. N. (2018). Consumption in the circular economy: A literature review. *Sustainability*, 10(8), 2758.
- 4) Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge.
- 5) Cronbach, L. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3), 297-334.
- 6) de Kwant, C., Rahi, A. F., & Laurenti, R. (2021). The role of product design in circular business models: An analysis of challenges and opportunities for electric vehicles and white goods. *Sustainable Production and Consumption*, 27, 1728-1742.
- 7) Dirk, J., & Nett, U. E. (2022). Uncovering the situational impact in educational settings: Studies on motivational and emotional experiences. *Learning and Instruction*, 81, 101661.
- 8) Gu, X., Firdousi, S. F., Obrenovic, B., Afzal, A., Amir, B., & Wu, T. (2023). The influence of green finance availability to retailers on purchase intention: a consumer perspective with the moderating role of consciousness. *Environmental science and pollution research*, 30(27), 71209-71225.
- 9) Ho, R. (2006). *Handbook of univariate and multivariate data analysis and interpretation with SPSS*. Chapman and Hall/CRC.
- 10) Hojnik, J. (2018). Ecological modernization through servitization: EU regulatory support for sustainable productservice systems. Review of European. Comparative & International Environmental Law (RECIEL), 27, 162–175.
- 11) Hunka, A. D., Linder, M., & Habibi, S. (2021). Determinants of consumer demand for circular economy products. A case for reuse and remanufacturing for sustainable development. *Business Strategy and the Environment*, 30(1), 535-550.

- 12) Kakadellis, S., Woods, J., & Harris, Z. M. (2021). Friend or foe: Stakeholder attitudes towards biodegradable plastic packaging in food waste anaerobic digestion. *Resources, Conservation and Recycling*, 169, 105529.
- 13) Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, conservation and recycling*, 127, 221-232.
- 14) Lewandowski, M. (2016). Designing the business models for circular economy – Towards the conceptual framework. *Sustainability*, 8(1), 43.
- 15) Machová, R., Ambrus, R., Zsigmond, T., & Bakó, F. (2022). The impact of green marketing on consumer behavior in the market of palm oil products. *Sustainability*, 14(3), 1364.
- 16) Mak, V., & Terry, E. (2020). Circular economy and consumer protection: The consumer as a citizen and the limits of empowerment through consumer law. *Journal of Consumer Policy*, 43(1), 227-248.
- 17) McGregor, S. (2002, April). Consumer citizenship: A pathway to sustainable development. In *Keynote at International Conference on Developing Consumer Citizenship*.
- 18) Mogaji, E., Adeola, O., Adisa, I., Hinson, R. E., Mukonza, C., & Kirgiz, A. C. (2022). *Green marketing in emerging economies: communication and brand perspective: an introduction* (pp. 1-16). Springer International Publishing.
- 19) Moore, D. S., McCabe, G. P., & Craig, B. A. (2009). *Introduction to the Practice of Statistics* (Vol. 4). New York: WH Freeman.
- 20) Rizos, V., Behrens, A., Van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., ... & Topi, C. (2016). Implementation of circular economy business models by small and medium-sized enterprises (SMEs): Barriers and enablers. *Sustainability*, 8(11), 1212.
- 21) Rizos, V., Tuokko, K., & Behrens, A. (2017). The Circular Economy: A review of definitions, processes and impacts. *CEPS papers*, (12440).
- 22) Saleem, H., Khan, M. B., & Mahdavian, S. M. (2022). The role of green growth, green financing, and eco-friendly technology in achieving environmental quality: evidence from selected Asian economies. *Environmental Science and Pollution Research*, 29(38), 57720-57739.
- 23) Testa, F., Iovino, R., Iraldo, F. (2020). The circular economy and consumer behaviour: the mediating role of information seeking in buying circular packaging. *Bus. Strat. Environ.* 29 (8), 3435–3448. <https://doi.org/10.1002/bse.2587>.
- 24) Vehmas, K., Raudaskoski, A., Heikkilä, P., Harlin, A., Mensonen, A. (2018). Consumer attitudes and communication in circular fashion. *J. Fash. Mark. Manag.* 22 (3), 286–300. <https://doi.org/10.1108/JFMM-08-2017-0079>.
- 25) Vidal-Ayuso, F., Akhmedova, A., & Jaca, C. (2023). The circular economy and consumer behaviour: Literature review and research directions. *Journal of Cleaner Production*, 418, 137824.
- 26) Wei, L. (2025). Incentive Mechanism and Policy Suggestions of Eco-Taxation System for Low-Carbon Transformation of Enterprises. *Risk and Financial Management*, 6(1), p8-p8.

- 27) Yang, Y., Su, X., & Yao, S. (2021). Nexus between green Vidale, fintech, and high-quality economic development: Empirical evidence from China. *Resources Policy*, 74, 102445.
- 28) Yuriev, A., Dahmen, M., Paillé, P., Boiral, O., & Guillaumie, L. (2020). Pro-environmental behaviors through the lens of the theory of planned behavior: A scoping review. *Resources, Conservation and Recycling*, 155, 104660.

LATVIAN CONSUMERS AND INDUSTRY INSIGHTS ON SUSTAINABLE PACKAGING

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Abstract

Each EU citizen generates an average of 190 kg of packaging waste annually, with projections indicating an increase to 209 kg by 2030. In 2022, the European Commission proposed a regulation to reduce packaging waste, promote reuse, and encourage sustainability across all packaging. This paper explores the perceptions and attitudes of Latvian consumers and packaging industry representatives towards sustainable packaging. Using both qualitative and quantitative methods, it examines current packaging practices, industry trends, regulatory impacts, and consumer willingness to adopt eco-friendly alternatives. A literature review highlighted environmental concerns, while interviews with six industry experts identified barriers such as cost, unclear standards, and regulatory adaptation. To assess consumer perspectives, a survey of 145 participants from various age groups was conducted. Results show that while many consumers understand the environmental impact of non-ecological packaging, a significant portion is not concerned with the issue and unwilling to pay more for sustainable options. The research culminated in the development of a long-term sustainability model tailored to the Latvian packaging sector. The findings emphasize the need for clearer policy frameworks, enhanced consumer education, and incentives for innovation, as well as the importance of industry adaptation to balance sustainability goals with economic feasibility.

Keywords: *sustainable packaging, consumer behaviour, packaging industry, Latvia, sustainability policy*

JEL Classification: Q53, M31, L66

1. INTRODUCTION

Packaging plays a critical role in protecting and transporting goods and represents a significant economic sector within the European Union (EU). However, regulatory inconsistencies among member states, such as differing labelling standards and definitions of recyclable or reusable packaging have fragmented the internal market (European Commission, 2022).

A growing environmental concern is the increasing volume of packaging waste, particularly plastics. Each EU citizen generates approximately 190 kg of packaging waste per year, with projections estimating this could rise to 209 kg by 2030 if no intervention occurs (European Commission, 2022). This problem is intensified by rapid growth in consumption, especially through e-commerce, contrasted by a simultaneous rise in consumer awareness of ecological and sustainability issues.

In response, the EU proposed a comprehensive regulation on packaging and packaging waste in 2022, aiming to reduce waste, minimize over-packaging, and promote reusable and recyclable solutions. By 2030, all packaging placed on the EU market must be recyclable, with specific types (e.g., coffee capsules) required to be compostable within two years of the regulation's adoption. The regulation also introduces design requirements to reduce empty space, mandates clearer labelling, and sets ambitious waste reduction targets: 5% by 2030, 10% by 2035, and 15% by 2040 compared to 2018 levels (Hodgson, 2024; Duarte *et al.*, 2024).

This evolving regulatory environment demands significant adaptation by producers and is driving innovation and investment in sustainable packaging technologies (Turkcu, Tura & Piscicelli, 2023).

As Dobson (2024) puts it, sustainable packaging reduces environmental impact while still fulfilling its purpose. Whether it's recyclable, reusable, or simply uses fewer materials, any type of packaging, used for displaying, protecting, transporting, or storing products, can be sustainable if thoughtfully designed. Sustainable packaging encompasses a variety of materials and methods designed to minimize environmental impact. Key types include recyclable materials like paper and cardboard, compostable options like corn-starch and mushroom packaging, biodegradable alternatives like plant-based plastics, and reusable containers.

From a business perspective, sustainable packaging is not only about eco-friendly materials, but also about the environmental impact of the packaging production process. Companies are striving to increase resource efficiency, reduce energy and water consumption, toxic emissions, waste generation, and packaging size to reduce environmental pollution.

Sustainable packaging research continues to expand significantly in scope and depth, integrating insights from environmental science, materials engineering, consumer behaviour, and policy studies. Sustainable packaging has evolved into a major focus of both environmental policy and industrial innovation. The

literature categorizes sustainability into three core pillars – environmental, economic, and social. From the environmental viewpoint, sustainability in packaging is often defined by recyclability, reusability, compostability, and minimal resource consumption (Ibrahim *et al.*, 2022).

Material innovation plays a vital role in improving packaging sustainability. Lin *et al.* (2025) explored consumer perceptions of bioplastic packaging, revealing a positive reception yet limited understanding of disposal requirements. Arriaga *et al.* (2025) reviewed how agri-food waste can be converted into volatile fatty acids and then into PHBV bioplastics, highlighting its potential to replace fossil plastics and support a circular bioeconomy. In turn, Morashti *et al.* (2022) analysed sustainable packaging in supply chains using data mining and interviews, revealing limited early research but growing interest since 2013, especially around circular economy and operational management.

Several researchers emphasize the importance of design and material choice in achieving sustainability. Coelho *et al.* (2020) reviewed trends in reusable packaging, highlighting its potential to reduce environmental impacts while noting the need for further research into design and system-level challenges. Using a supply chain lens, Lokesiztürk and Oflaç (2022) proposed a Sustainable Packaging Practices Model (SPPM), identifying nine key practices and highlighting barriers such as high costs, limited demand, and regulatory challenges. Research by Bocken *et al.* (2016) suggests integrating circular economy principles early in product development. Strategies such as 'design for disassembly' and 'product longevity' contribute to reducing environmental impact.

From a design efficiency angle, Georgakoudis *et al.* (2023) explored packaging re-design through a case study, showing that improved shape and space utilization can reduce waste, emissions, and costs, while maintaining product protection and user needs.

Focusing on consumer behaviour, Lu *et al.* (2020) examined overpackaging in Chinese e-commerce, finding strong support for solutions like packaging optimization, recycling systems, and large-scale packaging, while noting lower preference for material-based changes.

Turkcu, Tura and Piscicelli (2023) examined tensions in biobased packaging production, identifying 20 types of sustainability-related challenges and 12 strategies companies use, such as certifications, partnerships, and LCAs to manage high costs, regulatory gaps, and knowledge barriers.

The literature clearly demonstrates that the transition to sustainable packaging requires collaboration across supply chains, clear regulations, investment in innovation, and consumer engagement. While challenges persist, the combination of scientific research, business strategy, and public policy offers pathways to more sustainable solutions.

The aim of the research is to explore Latvian consumers' and industry representatives' experiences and opinions on sustainable packaging and to create a model to improve sustainability in the packaging manufacturing sector.

This study used a mixed-methods approach. Six semi-structured interviews were conducted with Latvian packaging industry stakeholders, including representatives from the Packaging Association and manufacturing firms. In addition, a quantitative survey involving 145 consumers provided insights into public perceptions of sustainable packaging. Data were analysed using thematic analysis for interviews and descriptive statistics for survey results.

2. METHODOLOGY

To achieve the research goal, a comprehensive mixed-methods approach was employed, combining qualitative and quantitative techniques. Literature review and interviews with industry experts were used to collect qualitative data. A survey was used to collect quantitative data.

Semi-structured interviews were conducted with six experts, including packaging company representatives and the chairperson of the Latvian Packaging Association. The interviews were guided by questions based on the literature review and focused on industry challenges, sustainable materials, anticipated impacts of EU regulations, consumer education, and the economic viability of eco-friendly packaging. The interviews were recorded, transcribed, coded, and thematically analyzed across eight categories, including sustainable criteria, costs, regulatory impact, and market trends.

In parallel, a consumer survey was conducted to assess public attitudes toward sustainable packaging. The questionnaire included demographic questions, multiple-choice items, Likert-scale evaluations, and an open comment section. A total of 145 responses were collected using Google Forms and distributed via social media and email. The survey sought to measure awareness, willingness to pay more for sustainable packaging, and consumer habits like using reusable bags or shopping at zero-waste stores. Quantitative data were visualized using pie and bar charts, while open-ended responses were grouped by keywords and analysed for recurring themes.

The study concludes with the development of a long-term model for sustainable packaging practices in Latvia, built upon the integrated results of the literature, expert insights, and survey data. This model outlines critical components for sustainable transformation in the sector and serves as the foundation for actionable recommendations aimed at businesses, policymakers, and consumers.

3. RESULTS AND DISCUSSION

3.1. Interviews analysis

To explore industry perspectives on sustainable packaging in Latvia, six expert interviews were conducted with representatives from packaging companies and professional associations: designer, leading technologist, general director, 2 sales department specialists of a packaging manufacturing company, and chairwoman of the Board of the Packaging Association. The advantage of expert interviews is the ability to obtain information that is not available from other sources. Expert interviews also allow for responses to be adapted based on the interviewee's answers and for questions to be adjusted in order to gather the necessary information (Brown, 2020). The interviews were conducted in person, with the conversations recorded for future use and analysis. Using the TurboScribe.ai tool, the recordings were transcribed into text, which was then processed by the author for further use. The average length of interviews is 29 minutes and 54 seconds. Experts' insights were grouped into eight thematic categories to identify consensus, differences, and priorities, i.e. sustainable packaging criteria, costs of sustainable packaging, alternative packaging materials, EU packaging regulation impact, challenges in the packaging industry, packaging waste issues, consumer education, market observations and trends.

Table 1. Expert Citations by Category

Category	Experts citation
Sustainable packaging criteria	<i>"Sustainable packaging must be clearly labeled so people know how to sort it."</i> (25.03.2024) <i>"Sustainable (packaging) is very simple - one is that it can be reused, reused. And the other is (using) a material that can be easily recycled."</i> (Interview, 26.03.2024) <i>"We try to reduce the amount of packaging and use simple materials that can be easily recycled."</i> (27.03.2024) <i>"[...] it is important for us to understand how, at the very end, when that packaging ends up in the trash, what we will do with it, whether it can be recycled or not."</i> (Interview, 28.03.2024) <i>"In my understanding, sustainable packaging is one that can be recycled, that is environmentally friendly, and that can be reused."</i> (03.04.2024)
Costs of sustainable packaging	<i>"The problem is that environmentally friendly packaging is always more expensive, and companies are not always willing to pay this price."</i> (25.03.2024) <i>"Very often, a few cents determine whether a person will choose a sustainable option. [...] Up to 5%, some people are still willing to pay, but if it is more, they will not be willing."</i> (Interview, 28.03.2024) <i>"If the customer is not willing to pay more, then we cannot switch to more expensive but greener packaging."</i> (29.03.2024) <i>"Right now, some (manufacturers) would be willing to even slightly compromise on the quality of their packaging to make it cheaper, not to</i>

	<i>mention that they certainly wouldn't be willing to pay extra for a sustainable solution."</i> (Interview, 03.04.2024)
Alternative packaging materials	<i>"This is a good example of how a by-product can be used as a resource for a new material. [...] But if we specifically grow mushrooms or corn, it is no longer sustainable."</i> (Interview, 28.03.2024) <i>"Coated paper is often not recyclable, but customers don't know that. This creates a false sense of eco-friendliness."</i> (26.03.2024) <i>"Bioplastics are a good idea, but they still have issues with compostability and price."</i> (29.03.2024)
EU packaging regulation impact	<i>"Regulation will force changes in production processes, but this will take time and investment."</i> (26.03.2024) <i>"[...] when the regulation comes into force and by raising taxes on those packaging that are not sustainable, there is a possibility that their prices will level out."</i> (Interview, 28.03.2024) <i>"Regulations will help standardize, but many companies are not ready for these changes."</i> (29.03.2024)
Challenges in the packaging industry	<i>"There is no unified system for implementing sustainable solutions – everyone does what they can."</i> (26.03.2024) <i>"Small businesses will find it very difficult to adapt to the new rules."</i> (27.03.2024)
Packaging waste issues	<i>"Many customers are not aware that composite materials are not recyclable, and this is a big obstacle."</i> (25.03.2024) <i>"We still have problems with multiple materials that cannot be recycled."</i> (03.04.2024)
Consumer education	<i>"A big problem is public ignorance. People don't know how to sort, even if the packaging allows it."</i> (25.03.2024) <i>"People need to be explained what sustainable packaging means and why it is important, because not everyone understands it."</i> (Interview, 27.03.2024) <i>"Without education, even the best packaging will not have the expected effect."</i> (29.03.2024)
Market observations and trends	<i>"Interest in sustainable packaging has grown in recent years, especially in the food and cosmetics sectors."</i> (26.03.2024) <i>"There is still a lot of 'greenwashing'. Many use green colors and names, but the substance is missing."</i> (29.03.2024)

Source: (Authors developed based on the interviews, 2024)

1. Sustainable Packaging Criteria. Experts consistently emphasized that sustainability begins with the end-of-life management of packaging. A truly sustainable package is one that can be recycled, is made of eco-friendly materials, and ideally reusable. Experts highlighted minimalistic design, reduced empty space, and the use of mono-materials as key factors contributing to recyclability and resource efficiency.

2. Costs of Sustainable Packaging. Costs emerged as a major barrier. Experts noted that both manufacturers and consumers often hesitate to absorb the additional expenses of sustainable materials. Some producers expressed a willingness to compromise on quality to maintain price competitiveness. However, there was hope that policy instruments, like environmental taxes, might

help balance costs: “When the regulation comes into force and non-sustainable packaging is taxed, prices might equalize.”

3. **Alternative Packaging Materials.** Alternative materials were discussed with cautious optimism. Interviewees agreed that secondary materials or by-products, like mushroom, based or agricultural waste composites and hold promise. However, skepticism was expressed about materials that require dedicated cultivation, such as corn or fungi, due to environmental trade-offs. One expert noted: “Using waste is sustainable, but growing mushrooms or corn just for packaging is not.”

4. **EU Packaging Regulation Impact.** Experts viewed the upcoming EU regulation on packaging and packaging waste as a necessary but disruptive influence. The regulation is expected to raise production standards and drive change, yet some feared that small producers might struggle to comply. One interviewee highlighted that increased taxes on non-sustainable packaging could push the market toward greener alternatives: “When non-sustainable packaging becomes more expensive, sustainable choices will become more attractive.”

5. **Challenges in the Packaging Industry.** Interviewees noted structural challenges in Latvia’s packaging sector, including limited access to sustainable materials, underdeveloped infrastructure for recycling, and a lack of standardized guidelines. These issues hinder rapid transition, particularly for small and medium-sized enterprises. Moreover, the packaging life cycle, from raw material sourcing to post-use processing, was described as insufficiently integrated.

6. **Packaging Waste Issues.** The problem of waste was another critical topic. Experts lamented low recycling rates, especially for composite materials, and called for better sorting systems. They emphasized the importance of packaging designs that allow easy separation of materials. The inability to fully recycle multilayer packaging was viewed as a major sustainability obstacle.

7. **Consumer Education.** Experts unanimously agreed that public awareness is lacking. One respondent explained: “People need to be told what sustainable packaging is and why it matters, because not everyone understands.” They called for campaigns, labeling, and educational materials to foster behavioral change. It was widely accepted that better-informed consumers could generate market demand for sustainable options.

8. **Market Observations and Trends.** Finally, experts noted that the Latvian market is gradually adapting to sustainability trends observed in Western Europe. There is growing interest among producers and retailers, especially in food and cosmetics. However, there are still concerns about greenwashing and superficial compliance. Experts emphasized that genuine commitment requires not just rebranding but restructuring of supply chains and product development.

3.2. Survey results

The authors conducted a survey to understand consumer opinions and experiences regarding sustainable packaging. The survey was created using Google Docs and distributed via social media and email. The main results are presented below.

Of all respondents, 74.5% are women and 24.1% are men, and 2 respondents did not want to disclose their gender.

The survey was conducted with 145 people aged 18 and over (see Fig.1.).

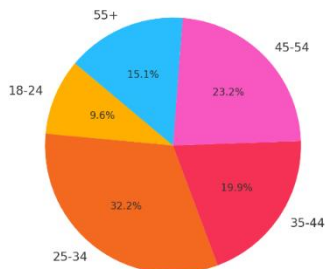


Figure 1. Age distribution of survey respondents
Source: (Authors developed based on the surveys, 2024)

The largest group of respondents (32.4%) is aged 25-34. 23.4% of respondents are aged 45-54. Almost 20% of respondents are aged 35-44. Slightly fewer (15.2%) are 55 and older survey participants. The smallest age group, which makes up only 9.7%, is 18-24 years old.

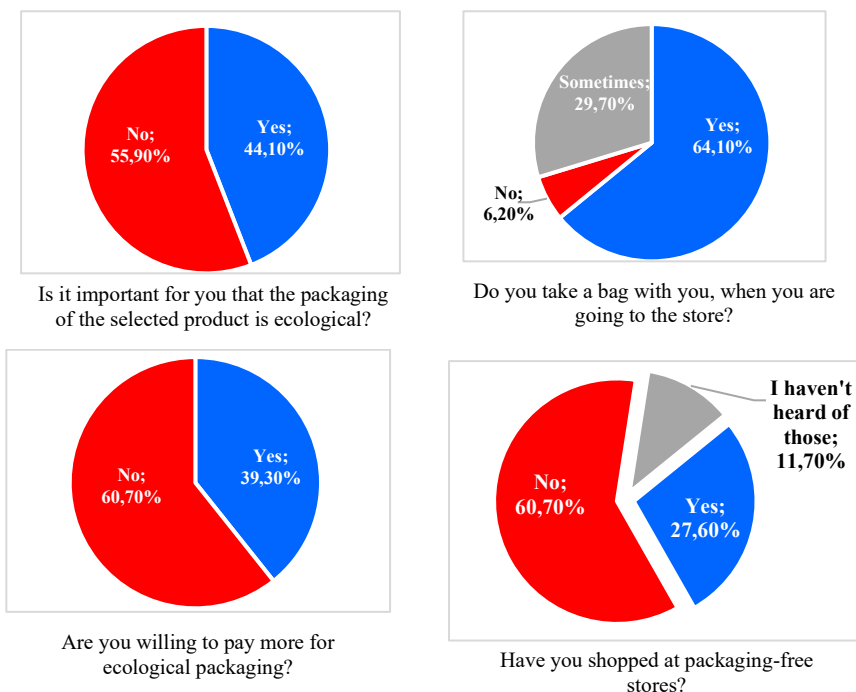


Figure 2. Respondents' answers for survey questions
Source: (Authors developed based on the surveys, 2024)

As presented in Figure 2, almost half of the respondents (44.1%) indicate that it is important for them that the packaging of the selected product is ecological. The rest answer that it is not important for them whether the packaging of the purchased product is ecological. From these results, it can be concluded that the issue of ecological packaging is not popular among consumers, and it is necessary to educate consumers about the impact of non-ecological packaging on the environment.

60.7% of respondents noted that they were not willing to pay more for packaging to be ecological. However, 39.3% of respondents said that they were willing to pay more for ecological packaging, which is slightly less than how many respondents consider the ecological packaging criterion important.

When asked whether respondents take a bag with them when going to the store, the majority, or 64.1%, answered positively. 29.7% noted that they sometimes take a bag with them, and only 9% answered that they do not take a bag with them.

The survey results show that 11.7% of respondents have not heard of packaging-free stores. More than half, or 60.7%, of those surveyed have heard of the existence of such stores, but have never shopped in them. Almost 30% of respondents have experience shopping in packaging-free stores.

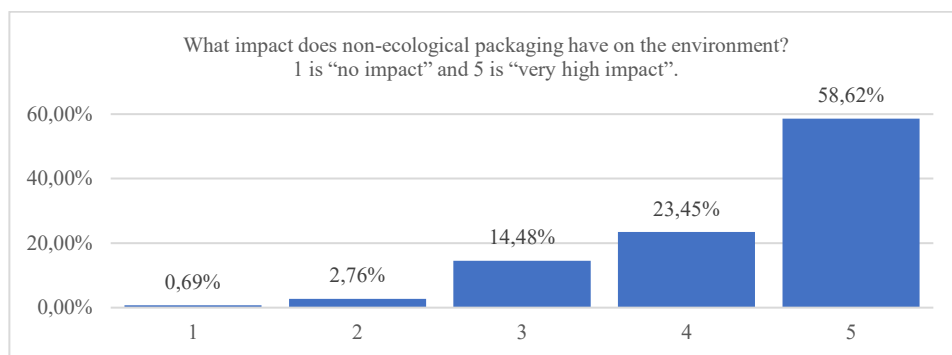


Figure 3. Respondents' views on Packaging Sustainability

Source: (Authors developed based on the surveys, 2024)

More than half of the respondents (58.6%) believe that non-ecological packaging has a very large impact on the environment and 23.4% of the respondents believe that it has a large impact on the environment (Figure 3). Only 1 person from the respondents believes that non-ecological packaging has no impact on the environment, and 4 respondents believe that it has a very minimal impact.

From these results, it can be concluded that consumers understand that packaging has a large impact on the environment, but, taking into account the

answers to the previous questions, the issue of ecological problems is not currently relevant among consumers.

This once again indicates that consumer education is necessary about the impact of non-ecological packaging on the environment.

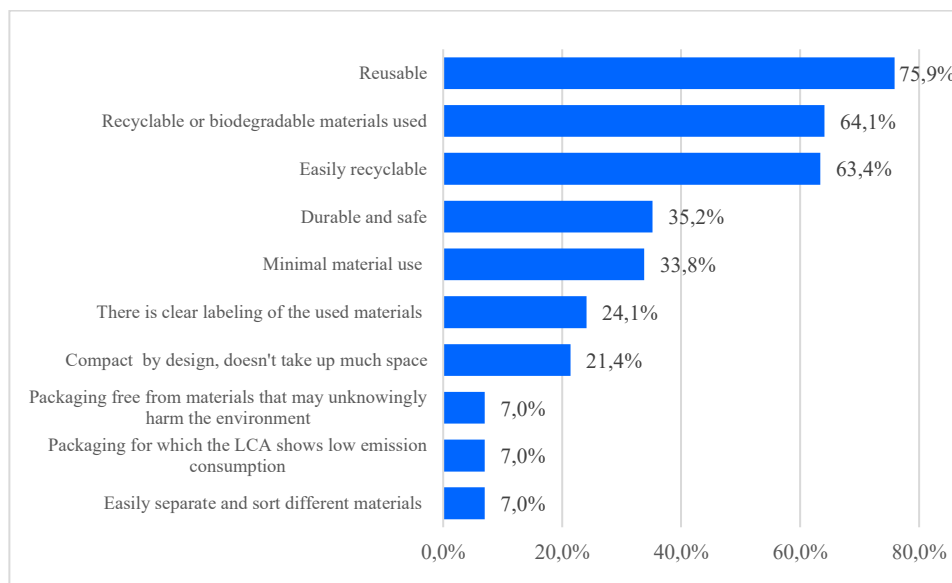


Figure 4. What do you think sustainable packaging is?

Source: (Authors developed based on the surveys, 2024)

Respondents identified several key factors that indicate whether packaging meets the criteria for sustainability (see Fig.4.). A primary indicator is that sustainable packaging avoids unnecessary components that do not serve the core purpose of protecting or containing the product. Minimizing empty space within the packaging is also seen as essential, as it reduces material usage and optimizes transportation efficiency. Another significant criterion is the use of recyclable or compostable materials, ensuring that the packaging can be processed through environmentally friendly waste streams after use. Moreover, all materials used should be easily separable to facilitate effective recycling. Clear labeling is considered crucial, as it informs consumers about the types of materials used and how to dispose of them properly. While reusability is viewed positively and may enhance the overall sustainability of packaging, respondents agreed that it is an optional attribute rather than a mandatory requirement. These criteria reflect a practical and informed consumer understanding of what constitutes sustainable packaging.

3.3. Model development

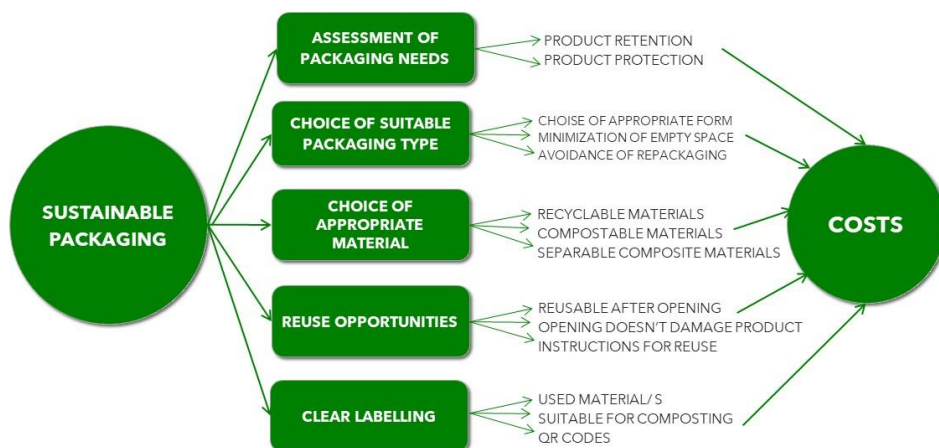


Figure 5. A long-term development model for improving the sustainability of the packaging industry

Source: (Authors developed)

Based on the analysis of the reviewed literature and the data obtained through interviews and surveys, a Long-Term Development Model was developed to improve sustainability in the packaging manufacturing sector (see Fig.5.). The model consists of five stages that must be considered and evaluated when designing new packaging.

The first stage of the model is the assessment of the necessity of packaging. This step is mostly related to primary packaging. Before starting any packaging development process for a new or existing product, it is necessary to understand what function the packaging will serve – whether it is for retaining the product, such as cereals, or for protecting a fragile product from external factors. Some products may not need primary packaging at all, such as reusable bottles.

If it is concluded in the first stage that packaging is necessary, then the appropriate type of packaging must be selected. When designing packaging, a suitable construction for the product must be chosen, minimizing empty space wherever possible. Both the interviews and literature sources often mention repackaging, so the packaging should avoid unnecessary elements to reduce material usage.

The next stage is selecting appropriate materials. According to the proposed EU regulation, all packaging will need to be recyclable, except for plastic, which will have a limited permissible percentage of non-recyclable material per unit. Compostable material use is certainly a sustainable solution. Ideally, packaging should be designed from monomaterials, but if composite materials must be used,

their layers should be separable for further recycling. However, using alternative packaging materials (e.g., packaging made from algae or mushroom mycelium) is currently disproportionately expensive, preventing widespread industrial adoption.

When developing new packaging, it is important to consider the possibilities for reuse, thereby extending the packaging's life cycle. To fulfill this requirement, the packaging and the product must not be damaged during use, and the packaging must continue to serve its function after the product is removed. It must also be clear to the consumer how the packaging can be reused. If this is not obvious, instructions or explanations should be printed on the packaging.

The European Commission plans to introduce a unified labeling system across all EU countries, which will be mandatory on product packaging and corresponding waste bins. To ensure consumers understand what to do with packaging after its life cycle ends, every package must have clear labeling. This should indicate what materials were used so the consumer knows in which bin to place it at end-of-life. It is also important for consumers to know whether the packaging is suitable for household composting.

However, cost must be considered at each stage of development and production, as it affects the final product price. As the survey conducted in this work shows, only about a third of consumers are willing to pay more for sustainable packaging.

The developed model consists of five stages: assessing the need for packaging, selecting an appropriate packaging type, selecting an appropriate material, reusability and clear labelling. Each of these stages should be considered and assessed when designing new packaging. The model can also be used to assess existing packaging for compliance with sustainability criteria. During packaging development, it is necessary to think about how to facilitate the process of sorting and disposing of packaging at the end of its life cycle for the end consumer, so that the packaging can be recycled. The consumer of packaging is the last person who comes into contact with the packaging before its life cycle ends, so packaging manufacturers must do as much as possible to facilitate the process of disposing of packaging for the consumer. As a result, the packaging is designed for recycling. This means that from the first stage of product development, consideration is given to how it will be prepared for recycling and disposal.

4. CONCLUSIONS

Responsibility for packaging waste lies with all participants in the chain, therefore, manufacturers must develop packaging that is easy to sort and recycle, while the end consumer must deliver the packaging waste to appropriate waste bins or compost.

Resources must be invested in educating consumers on waste sorting, as well as on the impact of packaging on the environment.

The expert interviews revealed that sustainable packaging is defined primarily by its recyclability, minimalistic design, and clear labeling. While there is a growing awareness and demand for eco-friendly solutions, cost remains a significant barrier for both producers and consumers. Alternative materials show promise but face limitations in functionality and affordability. The upcoming EU regulation is seen as a critical driver for change, though smaller companies may struggle to adapt. Experts emphasized the need for consumer education, better waste management systems, and cautioned against superficial “greenwashing” trends in the market.

Latvian consumers are becoming more aware of environmental issues, yet economic considerations continue to influence packaging choices. The industry faces structural and economic barriers, but with the right incentives and regulatory support, significant progress is possible. A unified approach involving all stakeholders is essential to drive sustainable innovation in the packaging industry.

Results show that while many consumers understand the environmental impact of non-ecological packaging, a significant portion is not concerned with the issue and unwilling to pay more for sustainable options.

The findings highlight the need for greater consumer awareness and the importance of industry adaptation to balance sustainability goals with economic feasibility.

References

- 1) Arriaga, M., Pinar, F. J., Izarra, I., Amo, J. d., Vicente, J., Fernández-Morales, F. J., & Mena, J. (2025). Valorization of Agri-Food Waste into PHA and Bioplastics: From Waste Selection to Transformation. *Applied Sciences*, 15(3), 1008. <https://doi.org/10.3390/app15031008>
- 2) Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, 33(5), 308–320. <https://doi.org/10.1080/21681015.2016.1172124>
- 3) Brown M. (2020) How to Effectively Conduct an Expert Interview [online]. GLG. [online] Available at: <https://glginsights.com/articles/how-to-effectively-interview-a-subject-matter-expert/> [accessed 28 May 2025]
- 4) Coelho, PM., Corona, B., ten Klooster, R. & Worrell, E. (2020). Sustainability of reusable packaging—Current situation and trends. *Resources, Conservation and Recycling: X*, vol. 6, 100037. <https://doi.org/10.1016/j.rcrx.2020.100037>
- 5) Dobson, M. (2024). What is sustainable packaging? And why it matters to your business. [online] Available at: <https://www.gwp.co.uk/guides/what-is-sustainable-packaging/> [accessed 25 May 2025]
- 6) Duarte P., Silva S. C., Roza A. S., Dias J. C., (2024). Enhancing consumer purchase intentions for sustainable packaging products: An in-depth analysis of key determinants and strategic insights. *Sustainable Futures*, 7, 100193. <https://doi.org/10.1016/j.sftr.2024.100193>.

- 7) European Commission (2022). Proposal for a regulation of the European parliament and of the council on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC. COM (2022) 677 final. [online] Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0677> [Accessed 10 Jun. 2025].
- 8) Georgakoudis, Elias D.; Pechlivanidou, Georgia G. and Tipi, Nicoleta S. (2023). The Packaging Redesign Issue – Space Exploitation and Environmental Benefits. *Management of Environmental Quality*, 34(1) pp. 1–20.
- 9) Hodgson R. (2024). MEPs approve law to reduce growing stream of packaging waste. EuroNews [online] Available at: <https://www.euronews.com/green/2024/04/24/meps-approve-law-to-reduce-growing-stream-of-packaging-waste> [Accessed 25 May. 2025].
- 10) Ibrahim, I.D., Hamam, Y., Sadiku, E.R., Ndambuki, J.M., Kupolati, W.K., Jamiru, T., Eze, A.A., Snyman, J. (2022). Need for Sustainable Packaging: An Overview. *Polymers*, 14(20):4430. <https://doi.org/10.3390/polym14204430>
- 11) Lekesiztürk, Derya & Oflaç, Bengü. (2022). Investigating sustainable packaging practices: a framework approach. *Present Environment and Sustainable Development*, 16. 171-186. 10.47743/pesd2022161013.
- 12) Lin, J., Jaiswal, A. K., & Jaiswal, S. (2025). A Critical Review of Consumer Perception and Environmental Impacts of Bioplastics in Sustainable Food Packaging. *Sustainability*, 17(4), 1358. <https://doi.org/10.3390/su17041358>
- 13) Lu, S., Yang, L., Liu, W., Jia, L. (2020). User preference for electronic commerce overpackaging solutions: Implications for cleaner production. *Journal of Cleaner Production*, 258, 120936. <https://doi.org/10.1016/j.jclepro.2020.120936>.
- 14) Morashti, J. A., An, Y., & Jang, H. (2022). A Systematic Literature Review of Sustainable Packaging in Supply Chain Management. *Sustainability*, 14(9), 4921. <https://doi.org/10.3390/su14094921>
- 15) Turkcü D., Tura N., Piscicelli L. (2023). The dark side of sustainable packaging: Battling with sustainability tensions. *Sustainable Production and Consumption*, 40, pp. 412-421. <https://doi.org/10.1016/j.spc.2023.07.007>

ENVIRONMENTAL REGULATIONS AND CONTRACTUAL RISK: WHEN CAN NON-PERFORMANCE BE JUSTIFIED?

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Abstract

In a global context marked by the intensification of environmental regulations and the transition to a circular economy, contractual relationships are increasingly subject to legal challenges related to the impossibility of fulfilling assumed obligations. Legislative changes driven by environmental policies can lead to situations where contracts become excessively onerous or even impossible to perform, raising the issue of invoking justifiable impediments. This topic is particularly important as it reflects current economic realities, where companies and consumers must adapt to a continuously evolving regulatory framework. This study aims to analyse how environmental regulations can constitute a justifiable impediment in contract law, providing insights into how current legislation allows for exemption from liability in such cases. Furthermore, it investigates the differences between international legal systems regarding the applicability of hardship and force majeure clauses, as well as their implications for contractual security.

The methodology employed combines doctrinal and comparative legal analysis, the study of environmental protection regulations, and an examination of relevant case law. Special attention is given to contracts in strategic sectors, such as sustainable industries and green supply chains. The research findings highlight the need for a proactive approach in drafting commercial contracts, incorporating mechanisms for adjusting and renegotiating obligations in response to major legislative changes. Solutions are proposed to mitigate contractual risk, including the introduction of flexible adaptability clauses and clear delineation of circumstances in which justifiable impediments may be invoked.

We consider that the impact of environmental regulations on contractual relationships is an increasingly relevant topic, with significant implications for both economic and legal stability. To prevent contractual deadlocks and commercial disputes, it is essential that both economic operators and legislators adopt a balanced perspective that ensures environmental protection and compliance with contract law principles.

Keywords: *environmental regulations, contractual risk, force majeure, hardship, legal security*

JEL Classification: K12, K32, Q58

1. INTRODUCTION

In recent years, commercial contracts have increasingly been tested by unforeseeable ecological events and restrictive regulatory interventions that have fundamentally affected the performance of obligations. Phenomena such as severe drought, wildfires, or landslides have had direct consequences on economic activity, creating the premises for non-performance of contracts under the conditions initially agreed upon (Ghestin, 2021, p. 78; Kirchherr *et al.*, 2017, p. 225).

This new legal reality is characterized by the intensification of environmental regulations, imposed both through international strategies such as the European Green Deal (European Commission, 2019) and through increasingly restrictive domestic legislation with immediate applicability and no transitional periods (Jaffa, 2023). In such situations, a legitimate question arises: can a contractual obligation be avoided or renegotiated when it is directly affected by an environmental regulation adopted after the conclusion of the contract?

The answer lies in the institution of the justifiable impediment, enshrined in the civil law of the Republic of Moldova under Article 904 of the Civil Code. According to this provision, the debtor is exempt from liability when non-performance is caused by an impediment beyond their control, which could not have been foreseen at the time of the contract's conclusion and whose consequences could not have been avoided (Băieșu, 2021, p. 113). This concept is close to similar mechanisms in comparative law, such as *imprévision* (France – Article 1195 of the Civil Code), *Störung der Geschäftsgrundlage* (Germany – §313 BGB), or frustration of contract (UK) (Treitel, 2020, p. 118).

The relevance of this legal institution is increasingly visible in the age of ecological risks, where contractual balance is affected not only by natural factors but also by mandatory legislative interventions that alter the substance of performance. In recent cases, courts in the Republic of Moldova have recognized the applicability of the justifiable impediment in the context of environmental regulations introduced after the signing of the contract (Judecătoria Chișinău, 2021), and international arbitral jurisprudence (ICC 25023/AC, 2021) confirms a global trend toward a broader interpretation of this legal mechanism.

The present study aims to analyze these trends by focusing on the conditions under which environmental regulations can constitute a justifiable impediment, the differences between civil law and common law systems regarding liability exemption, and the contractual and legislative solutions available to prevent commercial deadlocks.

2. DATA AND METHODOLOGY

The present analysis is based on an interdisciplinary methodology that combines tools of comparative law, doctrinal analysis, case study examination,

and assessment of the impact that environmental regulations have on the performance of commercial contracts. The research relies on both national and international legal sources, as well as on relevant judicial and arbitral practice.

First, the doctrinal analysis method is applied, with a focus on recent legal literature addressing the concept of justifiable impediment, force majeure, and contractual adaptability clauses. The sources consulted include leading authors from Romanian, Moldovan, French, German, and English law, who explore new perspectives on contractual risk in the era of ecological regulation (Băieșu, 2021; Ghestin, 2021; Kirchherr *et al.*, 2017; Treitel, 2020).

Second, the comparative method is employed to identify both differences and similarities between civil law systems (France, Germany, Moldova, Romania) and common law systems (United Kingdom, United States) regarding the applicability of exemption mechanisms – whether based on impossibility (justifiable impediment) or on significant imbalance (hardship). References are also made to uniform international legal instruments, such as Article 79 of the CISG and Article 7.1.7 of the UNIDROIT Principles, which provide a harmonized perspective on external and legal obstacles.

The methodology also includes legislative and normative analysis: relevant legal acts were examined, including Article 904 of the Civil Code of the Republic of Moldova, the European Green Deal (2019), the Paris Agreement (2015), and recent governmental decisions on ecological prohibitions, such as Government Decision No. 590/2022 regarding the ban on certain plastic packaging.

From a practical standpoint, national and international case law has been analyzed in relation to non-performance caused by environmental factors or unforeseen legislative interventions. In the jurisprudence of Moldovan courts, there is a growing trend of decisions recognizing that ecological modifications imposed by public authorities may constitute a valid ground for exemption from contractual liability under Article 904 of the Civil Code. For instance, in disputes involving the delivery of goods affected by prohibitions on hazardous materials or in cases of temporary restrictions on access to natural resources (such as irrigation water), courts have evaluated the applicability of the justifiable impediment not by requiring absolute impossibility but by analyzing criteria such as externality, unforeseeability, and inevitability.

Internationally, the ICC arbitral award No. 25023/AC (2021) stands out. In this case, an agricultural equipment supplier was exempted from liability under Article 79 CISG, as national environmental regulations adopted after the contract prohibited the delivery of certain hazardous chemical products. The arbitrators found the impediment to be legal, imperative, and reasonably insurmountable, thus justifying non-performance. In addition, British and American case law concerning frustration of purpose and commercial impracticability provide useful benchmarks on the high thresholds imposed for liability exemption in common law systems. In *Canary Wharf v. European Medicines Agency* (2019), English

courts emphasized that legislative changes must fundamentally alter the object of the contract in order to justify a release from obligations.

The research was further supported by an applied evaluation of adaptable contractual clauses, presented at the ECO4ALL conference, including mechanisms such as automatic adjustment, suspension, renegotiation, and reference to subsequent environmental regulations. These instruments are examined as legal solutions to prevent contractual breakdowns in strategic sectors affected by environmental legislation (agriculture, energy, transport, construction).

By combining these methods, the study offers an integrated, current, and practical vision of how ecological risk can be legally managed within contractual frameworks, contributing to the development of a more flexible and sustainable contract culture.

3. REVIEW OF THE LITERATURE

Contemporary legal scholarship reflects a growing concern with how commercial contracts can be adapted to the new legal risks generated by ecological, pandemic, or legislative crises. The notion of justifiable impediment has become central in debates regarding the reform of contract law and the reevaluation of classical theories of contractual liability.

In Moldovan legal doctrine, Professor Sergiu Băieșu examines the transition from the traditional regime of force majeure to the new institution of justifiable impediment, emphasizing the objective character of non-performance and the role of excluding fault (Băieșu, 2020, p. 52). Aurel Băieșu, in his commentary on the Civil Code, considers the justifiable impediment as a mechanism of contractual rebalancing in the face of unforeseen events, subject to the cumulative fulfillment of the legal conditions: externality, unforeseeability, inevitability, and impossibility to overcome (Băieșu, 2021, p. 113).

In recent studies, the author Valeria Praporșcic proposes a reassessment of traditional contractual clauses in light of modern ecological risks. In a 2022 article, she argues for the necessity of introducing automatic adjustment mechanisms for contractual obligations depending on the legal and environmental context (Praporșcic, 2022, p. 73). In another study, she stresses the importance of alternative dispute resolution methods, such as mediation or arbitration, when non-performance is caused by an ecological impediment (Praporșcic, 2024, p. 288).

At the international level, Kirchherr *et al.* (2017) emphasize that the circular economy exerts additional pressure on contractual relationships, and the absence of adaptability clauses may lead to deadlocks and disputes when new environmental regulations emerge. Their study is among the most cited works in the field of sustainable contracting.

In comparative doctrine, Ghestin (2021) analyzes the influence of climate issues on recent reforms of the French Civil Code, particularly through the

introduction of Article 1195 on hardship. He underlines the necessity of protecting contractual balance in the face of radical legislative changes. In Germany, Lurger (2016) offers an in-depth analysis of §313 BGB, the provision on the alteration of fundamental contractual circumstances, which applies also in ecological contexts.

In common law systems, Treitel (2020) studies the evolution of the concepts of frustration of contract and commercial impracticability, showing that although more rigid than in continental law, these mechanisms can be applied in cases of legislative environmental intervention.

A general conclusion is thus emerging: the justifiable impediment is no longer a theoretical exception but a real legal tool for contractual adjustment, increasingly invoked in the context of climate pressures and rapid ecological reforms.

4. THEORETICAL AND LEGAL FRAMEWORK OF THE JUSTIFIABLE IMPEDIMENT

The concept of justifiable impediment was introduced into the legislation of the Republic of Moldova through Article 904 of the Civil Code, in force since 1 March 2019, as part of a broad reform of the law of obligations. It replaces the traditional approach based on force majeure with a modern, functional formulation aligned with international standards. According to paragraph (1), “the debtor is not liable for non-performance if it is caused by an impediment beyond their control, which could not reasonably have been foreseen at the time of the conclusion of the contract and whose consequences could not have been avoided or overcome” (Civil Code RM, Art. 904).

This formulation is directly inspired by Article 79 of the United Nations Convention on Contracts for the International Sale of Goods (CISG), as well as by Article 7.1.7 of the UNIDROIT Principles on International Commercial Contracts. Thus, the Republic of Moldova has aligned itself with the modern trend of addressing contractual risk not only through the lens of natural catastrophes but also through normative, administrative, or economic obstacles, including high-impact environmental regulations (UNIDROIT, 2016; CISG, 1980).

The justifiable impediment requires the cumulative fulfilment of three conditions: externality – the event must be beyond the control of the affected party; unforeseeability – it could not have been reasonably anticipated at the time of the contract’s conclusion; and inevitability – the consequences could not have been avoided or overcome through reasonable measures.

These criteria are analyzed in legal doctrine not abstractly, but in relation to the specific context of the contractual relationship. For example, Sergiu Băieșu highlights that impossibility must be “objective and without fault,” and that the affected party must have acted diligently in attempting to fulfill their obligations (Băieșu, 2020, p. 55).

The distinction between the justifiable impediment and other legal institutions such as hardship or force majeure is essential. While the justifiable impediment presumes objective impossibility and leads to exemption from liability, hardship only intervenes when performance becomes excessively onerous and requires contractual adaptation. Force majeure, in its traditional sense, is a vague and often outdated notion, frequently associated with “absolute impossibility,” which is difficult to prove in the current legal context (Amarița, 2020, p. 81).

According to some authors, the justifiable impediment is a more flexible and equitable solution because it allows the court or arbitral tribunal to evaluate the proportionality between the nature of the event and the efforts undertaken by the debtor to avoid non-performance (Treitel, 2020, p. 127). As such, this concept is better suited to contemporary realities – from pandemics to global logistical blockages or legislative changes that directly affect the contractual object.

In the context of the ecological transition, the justifiable impediment becomes a key legal instrument. Regulations banning certain materials, setting emission standards, or requiring energy efficiency may render performance impossible even in the absence of a natural catastrophe. Here, the distinction between *de facto* impediment (natural event) and *de jure* impediment (legal regulation) becomes crucial: international doctrine and jurisprudence accept that a regulatory modification imposed by the state may also constitute a justifiable impediment (Jaffa, 2023; UNIDROIT, 2016). This modern theoretical framework thus allows for a rational and balanced application of liability exemption, without encouraging abuse and without undermining legal certainty.

5. COMPARATIVE ANALYSIS OF THE LEGAL REGIME OF THE JUSTIFIABLE IMPEDIMENT

The legal approach to the justifiable impediment in the context of environmental risks varies significantly depending on the legal system under consideration. Comparative law offers multiple perspectives on how the impossibility or difficulty of contractual performance, caused by environmental regulations, may lead to either adaptation, suspension, or exemption from obligations. The Republic of Moldova, through Article 904 of its Civil Code, aligns with the functional model promoted by uniform international law, but still requires further doctrinal and practical consolidation concerning the application of this mechanism in concrete environmental scenarios.

In French law, the institution of *imprévision*, introduced by the 2016 reform of the Civil Code (Article 1195), allows a party affected by an unforeseeable change that renders performance excessively onerous to request contract renegotiation. If the parties fail to reach an agreement, the court may adjust or even terminate the contract. In practice, French courts have handled cases in which the implementation of energy transition laws has required adjustments to

construction contracts affected by new energy efficiency standards (Ghestin, 2021). This approach favors rebalancing rather than exemption and reflects a legal culture oriented toward conflict prevention and contractual adaptability.

Germany has detailed provisions for contract modification in cases of significant imbalance between performances, through §313 BGB. The institution of *Störung der Geschäftsgrundlage* allows courts to intervene when the circumstances considered by the parties at the time of contracting have changed radically, and one of the parties can no longer be reasonably required to maintain the obligation in its original form. Its application has been particularly relevant in cases involving changes in EU legislation on product technical approvals or sustainability requirements, with German courts offering a predictable framework for adjusting obligations affected by environmental regulations (Lurger, 2016).

In Italy, Articles 1463–1467 of the Civil Code govern both fortuitous impossibility and excessive onerousness of performance. Unlike the previously mentioned systems, Italian courts tend to carefully examine the diligence of the parties in the face of regulatory changes. In applying Legislative Decree No. 116/2020 on the circular economy, the courts have assessed situations where performance became impossible due to the prohibition of using certain types of packaging materials. Although there is no express institution equivalent to the justifiable impediment, the broad interpretation of general legal principles allows for equivalent solutions, with a strong emphasis on contractual prevention and anticipatory risk management (Ghestin, 2021).

An interesting approach is found in the Netherlands, where, in the absence of an explicit provision on impossibility of performance, jurisprudence has developed a contractual adjustment mechanism based on the principles of fairness and good faith (*redelijkheid en billijkheid*). These principles allow for the suspension or renegotiation of obligations when a subsequent legal regulation significantly alters the contractual balance. In public contracts, particularly those managed by Rijkswaterstaat, ecological adjustment clauses are already standardized, allowing price or delivery term modifications based on future emission or recycling regulations. These practices demonstrate the efficiency of integrating regulatory risk preventively within contractual structures, without the need for court intervention (Kirchherr *et al.*, 2017).

In common law systems, the approach is notably different. In the United Kingdom, the doctrine of frustration of contract, established in the case of *Davis Contractors v. Fareham UDC* (1956) and reaffirmed in *Canary Wharf v. European Medicines Agency* (2019), applies only in situations where state intervention or other factors have fundamentally changed the nature of the obligation. While environmental regulations are rarely accepted as sufficient grounds, courts acknowledge that, in exceptional cases, they may contribute to the frustration of the contractual purpose. In the United States, the Uniform Commercial Code (UCC §2-615) codifies the doctrine of commercial

impracticability, which allows the debtor to be exempted when performance has become impossible or unreasonably costly due to government regulation. For example, EPA-imposed bans on the use of hazardous chemicals have been accepted as legitimate grounds for non-performance (Treitel, 2020).

An analysis of uniform international law confirms this trend. Both Article 79 of the CISG and Article 7.1.7 of the UNIDROIT Principles recognize legal obstacles, including environmental regulations, as legitimate grounds for exemption. ICC Arbitral Award No. 25023/AC (2021) is particularly relevant in this context: the tribunal held that national legislative bans on the export of environmentally harmful products constituted justifiable impediments under the convention (Yearbook Commercial Arbitration, 2022).

For the Republic of Moldova, these examples offer clear guidance. It would be appropriate to promote a contract culture that explicitly incorporates environmental risks, either through automatic adjustment clauses or through renegotiation or suspension mechanisms. In addition, the practical application of Article 904 of the Civil Code should be strengthened, not only in the face of natural disasters but also in the case of normative environmental interventions. The development of official guidelines for adapting contracts to environmental regulations, along with the introduction of model clauses into legislation, would significantly contribute to preventing disputes and preserving contractual balance in a continuously evolving legal environment.

6. CLAUSES FOR CONTRACTUAL ADAPTABILITY TO ENVIRONMENTAL REGULATIONS

In the context of increasingly stringent environmental regulations, preserving the stability of commercial contracts requires a preventive legal approach. It is no longer sufficient to invoke the justifiable impediment retroactively; parties must expressly provide mechanisms for adjusting obligations in the event of environmental norms that impact performance. In legal scholarship, this preventive dimension of contractual risk is increasingly associated with the concept of “contractual legal resilience,” reflecting the agreement’s capacity to absorb and adapt to exogenous shocks without collapsing (Kirchherr *et al.*, 2017; Lurger, 2016).

Contracts drafted without anticipating ecological risks are exposed to non-performance or to costly legal disputes. In both civil law systems and uniform international law, a category of contractual clauses has emerged that allows for automatic or negotiated adjustment of obligations in the event of legislative changes related to the environment. These clauses do not replace the justifiable impediment, but rather complement it by offering parties an internal, contractual solution before resorting to courts or arbitration.

Automatic adjustment clauses are most found in regulated sectors such as construction, energy, or public procurement. They allow for the modification of

price, deadlines, or even the object of the obligation, based on specific parameters defined in the contract – for example, the adoption of a law banning a certain material, or the introduction of emission limits that render the contracted product non-compliant. In French and German jurisprudence, such clauses are regularly accepted and enforced by the courts, even when formulated in general terms, as long as they are clearly stipulated in the contract (Ghestin, 2021; Lurger, 2016).

Another category is represented by negotiated renegotiation clauses. In these cases, the parties do not predetermine the consequences of regulatory intervention but instead undertake to meet again and renegotiate the contract in good faith if major legal changes occur. In France, this practice was codified through Article 1195 of the Civil Code, while in the Netherlands, it derives from the principles of fairness and reasonableness, established in the Dutch Civil Code and consistently applied in administrative contracts (Kirchherr *et al.*, 2017).

Clauses allowing for suspension of performance represent a useful transitional mechanism, particularly when the effects of the legal change are not yet fully clear or when a period of technical or financial adaptation is needed. In international arbitral jurisprudence, clauses permitting the temporary postponement of delivery or performance in cases of immediate legislative intervention are considered valid and reasonable, provided they do not affect the core of the consideration (UNIDROIT, 2016; ICC, 2021).

In addition, certain contracts contain so-called future regulation reference clauses, through which the parties agree that legal provisions entering into force after the signing of the contract shall automatically apply and affect performance. These clauses are frequently used in commercial agreements in the Netherlands, Germany, and Nordic countries, especially in areas where environmental regulation is in constant evolution (Kirchherr *et al.*, 2017).

In the context of the Republic of Moldova, the integration of such clauses into contractual practice is still in its early stages. The Civil Code provides sufficiently broad contractual freedom (Articles 993 *et seq.*), but official guidelines, standard contract templates, and an applied legal culture of ecological clauses are lacking. In this regard, public authorities and the business sector could collaborate in developing green model contracts, which include explicitly formulated provisions for automatic adjustment or renegotiation of obligations in the event of environmental legislative interventions. Such an initiative could be supported by the Ministry of Justice and the Chamber of Commerce, in collaboration with environmental regulatory agencies and academic institutions.

Furthermore, courts should encourage the functional interpretation of such clauses in commercial litigation, avoiding their dismissal on grounds of uncertainty. Moldovan jurisprudence could thus draw from the good practices of German or French courts, which prioritize preserving contracts through adaptation rather than termination, when clauses are reasonably and clearly drafted.

In conclusion, the development and implementation of contractual clauses for adaptability to environmental regulations represent an essential direction for strengthening legal security in commercial relations. In a continuously changing regulatory environment, contractual prevention is no longer merely an option but a legal and economic necessity.

7. RECOMMENDATIONS FOR PRACTITIONERS AND LEGISLATORS IN THE CONTEXT OF CONTRACTUAL RISK ARISING FROM ENVIRONMENTAL REGULATIONS

As environmental standards become increasingly restrictive, the legal system of the Republic of Moldova is called upon to respond through effective contractual and legislative mechanisms capable of maintaining the balance between the stability of commercial agreements and the imperatives of environmental protection (Plotnic, 2022). The comparative analysis and international practice reveal a gap between the complexity of the risks generated by environmental legislation and the current level of legal adaptation in Moldovan commercial contracts. In this regard, both practitioners and legislators play a crucial role in strengthening a functional framework for preventing and resolving contractual conflicts (Iarmenco, 2020).

First, there is a need to acknowledge environmental risk as a fundamental element of the contract. This requires lawyers, business consultants, and contract negotiators to identify relevant environmental regulations and assess the likelihood of legal change during the contract's execution period from the pre-contractual stage. Such an approach is not only prudent but constitutes a minimum standard of legal diligence in today's international context. For instance, in supply or service contracts in sensitive sectors (energy, agriculture, construction), it is necessary to conduct a preliminary assessment of compliance with the National Environmental Strategy 2030 as well as the action plans for transitioning to a circular economy (Ministry of Environment RM, 2023).

Second, it is recommended that commercial contracts include specialized clauses for legal adaptability. These may take the form of renegotiation clauses, temporary suspension of performance, or automatic adjustment based on relevant legislative changes. For example, contracts concluded with public authorities or financed through external funds could require the introduction of standardized technical annexes that outline possible scenarios of regulatory intervention and the corresponding mechanisms for obligation adjustment. Such practices may be inspired by European FIDIC contract models or NEC (New Engineering Contract) frameworks, adapted to the national context.

From a legislative standpoint, it would be useful to clarify in Moldovan law the effects of legislative changes on ongoing contracts. Currently, Article 904 of the Civil Code provides a basis for invoking a justifiable impediment in the event of legal impossibility of performance but does not explicitly regulate the

consequences of legal modifications that make performance excessively onerous without rendering it impossible. The addition of provisions like Article 1195 of the French Civil Code or §313 BGB in German law could be considered, allowing courts to adapt the contract in cases of contractual imbalance resulting from significant legislative changes.

At the same time, the development of best practice guidelines on the inclusion and interpretation of ecological adaptability clauses is encouraged. These could be drafted under the auspices of the Ministry of Justice, in collaboration with the Chamber of Commerce and Industry, and supported by academic institutions. The purpose of such guidelines would be to provide practitioners with model clauses, applicability criteria, and examples of amicable solutions, thereby avoiding the escalation of disputes in court. A similar initiative has been successfully implemented in Austria and in the Nordic countries in the field of green public procurement (UNEP, 2022).

Moreover, continuous professional development for lawyers, arbitrators, and judges in environmental law and green contracts is essential. In this regard, the National Institute of Justice should consider including modules on analysing contracts affected by environmental regulations in its training programs, supported by case studies and real-world scenarios. A judiciary well-versed in this field will ensure a coherent and uniform interpretation of the concept of justifiable impediment and the legal effects of legislative change on contract execution.

Finally, it is advisable for Moldovan authorities to support the implementation of a public registry of standardized green contracts applicable in public projects and recommended for the private sector. This registry could operate under the authority of the Public Property Agency and contain model ecological clauses tailored to different industries. In an economic climate where investors are increasingly attentive to sustainability and non-compliance risks, the availability of robust contractual tools will be a factor in both legal stability and economic attractiveness.

Thus, consolidating the legal framework of the Republic of Moldova in response to ecological challenges requires a joint effort between theory and practice, between normative and contractual dimensions, but most importantly, between the will of the parties and institutional responsibility. Only through an integrated and forward-looking approach can contractual deadlock be prevented and a fair balance ensured between economic interests and environmental protection requirements.

8. CONCLUSIONS

This study analysed the impact of environmental regulations on the performance of commercial contracts, focusing on the conditions under which impossibility or excessive onerousness may justify exemption from liability. The research has shown that, in the context of intensifying ecological transition

policies, legal relationships have become increasingly vulnerable to unforeseeable legislative changes, which necessitates the strengthening of contractual mechanisms for adaptation and protection.

We have demonstrated that modern legal systems, such as those of France, Germany, Italy, and the Netherlands, as well as international instruments like the CISG and the UNIDROIT Principles, provide a coherent framework for the legal management of environmental risks. These solutions include both judicial interventions based on principles of equity and unforeseeability and pre-defined contractual clauses allowing for the adjustment or renegotiation of obligations in cases where newly adopted legal norms have a disruptive effect.

In the case of the Republic of Moldova, although Article 904 of the Civil Code permits the recognition of a justifiable impediment, its application remains fragmented, and the normative framework does not offer sufficiently proactive instruments for the contractual management of regulatory risk. On this basis, the study supports the need to reform and clarify the legal framework, promote an anticipatory contract culture, and establish standardized practices for drafting commercial contracts that include adaptability clauses addressing environmental regulations.

The results of the research underline the importance of closer cooperation between legal professionals, the business community, and regulatory authorities to ensure balanced legal protection in the face of the challenges posed by the green transition. In the absence of effective contractual and legislative instruments, both economic stability and environmental objectives risk being compromised.

This paper provides not only an analytical framework for current regulations but also a direction for action aimed at the national legislator and legal practitioners, advocating for a model of resilient contract law capable of responding to the inevitable transformations of the contemporary regulatory environment.

References

- 1) Alistar, J. (2008). *Web page*. [online] Available at: <http://www.apastyle.org/elecsource.html> [Accessed 14 Jan. 2008].
- 2) Amariei, D. (2020). *Contractual clauses on hardship*. Bucharest: C.H. Beck.
- 3) Amariei, D. and Țurcanu, C. (2022). Commercial contracts in the era of ecological transition: from rigidity to adaptability. *Pandectele Române*, 5, pp.73–83.
- 4) Amarița, A. (2020). Contractual liability: from force majeure to justifiable impediment. *Revista de Drept Civil*, 3, p.81.
- 5) Băieșu, A. (2021). *Commentary on the Civil Code*. Chișinău: Tipografia Centrală.
- 6) Băieșu, S. (2020). *Civil Law. General Part*. Chișinău: USM, pp.52–55.
- 7) CISG (1980). *United Nations Convention on Contracts for the International Sale of Goods*. [online] Available at: https://uncitral.un.org/en/texts/salegoods/conventions/sale_of_goods [Accessed 4 Jun. 2025].

- 8) Civil Code of the Republic of Moldova (in force since 1 March 2019), Articles 993 et seq.
- 9) European Commission (2019). *The European Green Deal*. [online] Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en [Accessed 4 Jun. 2025].
- 10) European Commission (2020). *European Climate Law*. Brussels: European Commission. [online] Available at: <https://climate.ec.europa.eu> [Accessed 3 Jun. 2025].
- 11) European Commission (2021). *EU Taxonomy for Sustainable Activities*. Brussels: European Commission. [online] Available at: https://ec.europa.eu/info/publications/210421-sustainable-finance-communication_en [Accessed 3 Jun. 2025].
- 12) Ghestin, J. (2021). The evolution of contract law under the influence of climate issues. *Revue des Contrats*, 2, pp. 77–84.
- 13) ICC (2021). Arbitral Award No. 25023/AC. In: *Yearbook Commercial Arbitration*, Vol. XLVII. The Hague: ICCA, pp. 372–379.
- 14) Jaffa, L. (2023). War and Force Majeure – Implications for contract performance. *Lexology*.
- 15) Judecătoria Chișinău (2021). Case No. 3-1492/2021. [online] Available at: <https://instante.justice.md/> [Accessed 4 May 2025].
- 16) Kirchherr, J., Reike, D. and Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, pp.221–232.
- 17) Iarmenco Mihaela, Donos Evlampie, Plotnic Olesca, (2020), Promotion of renewable energy in the European Union, International Conference on “European Finance, Business and Regulation-(EUFIRE 2020), pp. 709-716
- 18) Lurger, B. (2016). Changed circumstances and adjustment of contracts in German law. *European Review of Private Law*, 2, pp. 163–180.
- 19) Ministry of Environment RM (2023). *National Environmental Strategy 2030*. Chișinău: Government of the Republic of Moldova. [online] Available at: <https://mediu.gov.md/> [Accessed 4 Jun. 2025].
- 20) Platonic Olesca, Popescu Lucia (2022), Climate change and sustainable development: issues for international trade system, European Finance, Business and Regulation. Challenges of Post-Pandemic Recovery. Proceedings of the International Conference EUFIRE 2022, 313
- 21) Praporșcic, V. (2022). Environmental regulations and contractual imbalance. In: *National Doctoral Conference, USM*. Chișinău: CEP USM, pp. 72–74.
- 22) Praporșcic, V. (2024). The impact of environmental regulations on commercial contracts. In: *Integration through Research and Innovation*. Chișinău: State University of Moldova, pp. 284–289.
- 23) Sandu, C. (2021). Interpretation and application of hardship clauses in commercial contracts. *Revista de Drept Comercial*, 6, pp. 101–112.
- 24) Treitel, G.H. (2020). *Frustration and Force Majeure*. Oxford: Oxford University Press.
- 25) UNEP (2022). *Legal Guide for Green Public Procurement: A Comparative Analysis of EU and OECD Models*. Geneva: United Nations Environment Programme.

- 26) UNFCCC (2015). *Paris Agreement*. [online] Available at: <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement> [Accessed 4 Jun. 2025].
- 27) UNIDROIT (2016). *UNIDROIT Principles of International Commercial Contracts*. Rome: International Institute for the Unification of Private Law. [online] Available at: <https://www.unidroit.org/instruments/commercial-contracts/unidroit-principles-2016/> [Accessed 4 Jun. 2025].
- 28) Yearbook Commercial Arbitration (2022). Vol. XLVII. The Hague: ICCA, pp.372–379.

INNOVATIONS IN CIRCULAR ECONOMY DESIGN STRATEGIES FOR BUILDINGS

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Abstract

The construction industry faces increasing demands to reduce resource consumption and waste production while simultaneously supporting socio-economic growth. The concept of the Circular Economy (CE) offers a framework to establish new paradigms within the construction sector, enabling the achievement of goals related to environmental preservation and sustainable human habitats. However, this paradigm shift necessitates innovative approaches to building design. Although the application of CE principles to building design is still in its early stages, research on CE implementation and innovative design strategies is rapidly expanding within the scientific community. This research aims to explore innovative circular design strategies for buildings. This paper provides a comprehensive literature review of Circular Economy theories, design strategies, and implementation practices. The findings identify commonly applied design strategies and highlight those with significant potential that require further development. Strategies such as adaptability, prefabrication, cradle-to-cradle design, and others can substantially reduce the environmental impact of buildings. Additionally, this paper discusses future possibilities for advancing the development of circular buildings.

Keywords: *Circular Economy, Building Design, Innovative Design, Construction Industry.*

JEL Classification: R5

1. INTRODUCTION

The construction industry is a cornerstone of global economic development, contributing significantly to GDP and employment. However, it is also one of the most resource-intensive sectors, accounting for approximately 40% of global energy consumption, 30% of greenhouse gas emissions, and 50% of raw material extraction (UNEP, 2023). The linear "take-make-dispose" model prevalent in construction has led to significant environmental degradation, resource depletion, and waste accumulation. In response, the Circular Economy (CE) has emerged as a transformative framework to decouple economic growth from resource consumption by promoting resource efficiency, waste minimization, and the continuous use of materials (Ellen Macarthur Foundation, 2021).

The CE model emphasizes three core principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems (Ellen MacArthur Foundation, 2017). In the context of buildings, CE principles translate into innovative design strategies that prioritize longevity, adaptability, and material reusability. These strategies aim to create buildings that function as material banks, where components can be disassembled, reused, or recycled at the end of their lifecycle (Cheshire, 2016). However, the application of CE in building design is still nascent, with challenges such as regulatory barriers, high upfront costs, and a lack of standardized practices hindering widespread adoption (Adams *et al.*, 2017).

This paper explores innovative CE design strategies for buildings, focusing on their theoretical foundations, practical applications, and potential for scalability. Through a comprehensive literature review, the study identifies key strategies such as adaptability, prefabrication, and cradle-to-cradle design, and evaluates their environmental and socio-economic benefits. The research also highlights gaps in current practices and proposes directions for future development. The objectives are to: Review CE theories and their relevance to building design; Identify and analyse innovative CE design strategies; Discuss barriers to implementation and future opportunities for advancing circular buildings.

2. LITERATURE REVIEW

2.1. Circular Economy: Theoretical Foundations

The Circular Economy is rooted in industrial ecology, biomimicry, and cradle-to-cradle principles, which advocate for closed-loop systems that mimic natural cycles (McDonough & Braungart, 2002). Unlike the linear economy, which relies on finite resources, CE aims to create value through restorative and regenerative processes. Key frameworks, such as the ReSOLVE model (Regenerate, Share, Optimize, Loop, Virtualize, Exchange), provide actionable strategies for implementing CE in various sectors, including construction.

In the construction sector, CE is operationalized through strategies that extend the lifecycle of buildings and materials. These include designing for disassembly, using renewable or recyclable materials, and integrating digital tools like Building Information Modeling (BIM) to track material flows (Pomponi & Moncaster, 2017). The concept of "buildings as material banks" (BAMB) has gained traction, emphasizing the storage and reuse of materials to reduce waste (BAMB, 2019).

2.2. CE Design Strategies for Buildings

Several design strategies have emerged to align building design with CE principles:

- Adaptability: Designing buildings with flexible layouts and modular components allows for reconfiguration to meet changing needs, extending the building's functional life (Geldermans, 2016).

- Prefabrication: Off-site construction of standardized components reduces material waste and enables disassembly for reuse (Jaillon & Poon, 2008).

- Cradle-to-Cradle (C2C): This approach prioritizes materials that are safe, recyclable, and capable of being reintegrated into biological or technical cycles (McDonough & Braungart, 2002).

- Design for Disassembly (DfD): Buildings are designed to be deconstructed, allowing components to be reused or recycled without significant loss of value (Ostapska *et al.*, 2024).

- Material Passports: Digital documentation of a building's materials facilitates tracking and reuse, enhancing circularity (Tuscher *et al.*, 2024).

Despite the potential of CE design strategies, implementation faces several barriers. These include a lack of regulatory incentives, high initial costs, and limited stakeholder collaboration (Adams *et al.*, 2017). Additionally, the construction industry's reliance on traditional practices and a fragmented supply chain complicates the adoption of circular principles (Pomponi & Moncaster, 2017).

3. METHODOLOGY

This study employs a systematic literature review to explore innovative CE design strategies for buildings. The methodology follows a three-stage process:

Literature Search: Academic databases (Scopus, Web of Science, and Google Scholar) were searched using keywords such as “circular economy,” “building design,” “sustainable construction,” and “design strategies.” The search was limited to peer-reviewed articles, books, and reports published between 2010 and 2025 to capture recent advancements.

principles and building design. A total of 85 sources were selected, including 60 journal articles, 15 reports, and 10 books. **Screening and Selection:** Articles were screened based on relevance to CE

Data Analysis: Selected sources were analysed to identify key CE design strategies, their applications, benefits, and limitations. A thematic analysis was conducted to categorize strategies and highlight gaps in current research.

The review was supplemented with case studies of circular buildings (e.g., Park 20|20 in the Netherlands and the Circular Pavilion in Paris) to provide practical insights into strategy implementation.

4. RESULTS

The systematic literature review and case study analysis revealed a diverse set of Circular Economy (CE) design strategies applied to building design,

categorized into commonly adopted strategies, emerging strategies with high potential, and their associated environmental and socio-economic benefits. This section provides an in-depth exploration of these findings, supported by quantitative and qualitative evidence from recent studies and practical implementations. The results underscore the transformative potential of CE principles in addressing the construction industry's environmental challenges while identifying areas for further development.

Authors (Eberhardt *et al.*, 2022), systematize design strategies, Figure 1, and the (a) number of the occurrences in (b) relation to CE, (c) to project stages, (d) building types, (e) application level and (f) readiness level.

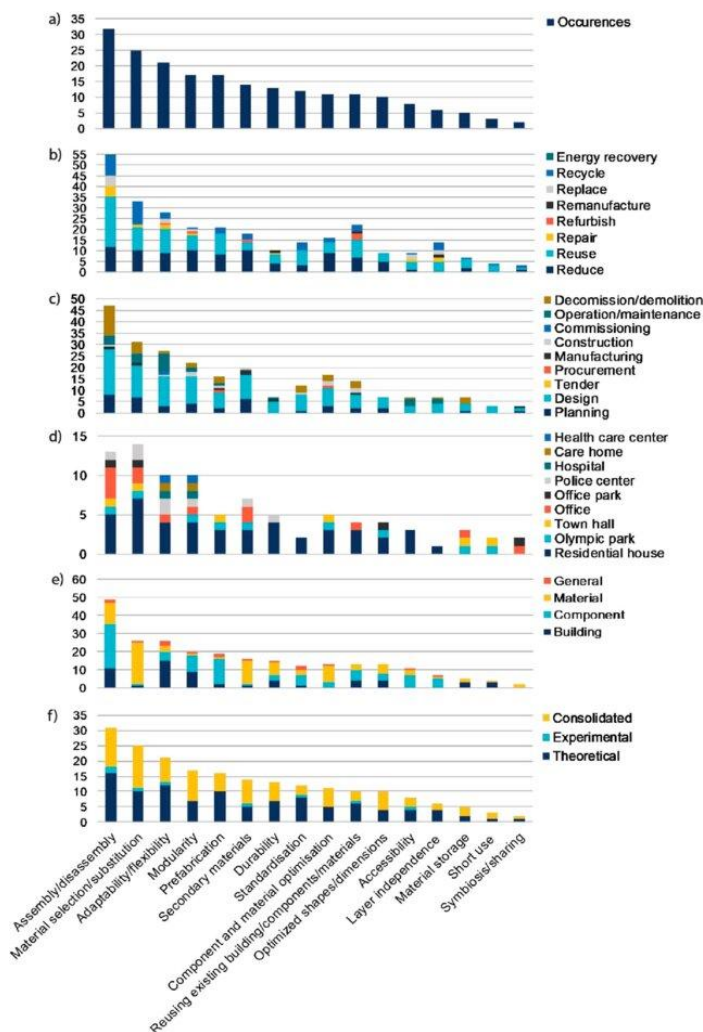


Figure 1. Circular design strategies
Source: (Eberhardt *et al.*, 2022)

The findings presented in Figure 1, show that the most encountered strategy in the literature is assembly/disassembly followed by material selection/substitution and material selection/substitution.

4.1. Commonly Applied CE Design Strategies

Adaptability refers to designing buildings with flexible layouts, modular components, and reconfigurable systems to accommodate changing functional requirements over time. This strategy extends a building's lifespan by reducing the need for demolition and reconstruction. Authors (Geldermans, 2016) note that adaptable buildings can achieve up to a 30% reduction in lifecycle carbon emissions by avoiding premature obsolescence. For instance, flexible floor plans and movable partitions allow buildings to transition between residential, commercial, or mixed-use purposes without significant structural alterations.

A notable example is the Allianz Tower in Amsterdam, which incorporates adaptable floor plans and modular façade systems. The building's design allows for internal reconfiguration to meet tenant needs, reducing the environmental impact associated with retrofitting (Geldermans, 2016). Quantitative studies suggest that adaptability can reduce material waste by 20-40% during renovations, as components are reused rather than discarded (UNEP, 2023). However, the strategy requires upfront investment in high-quality, durable materials, which can increase initial costs by 10-15% compared to conventional designs (Adams *et al.*, 2017).

Prefabrication involves the off-site manufacturing of standardized building components, which are then assembled on-site. This approach minimizes construction waste, improves quality control, and enables disassembly for reuse or recycling. Authors (Jaillon & Poon, 2008) found that prefabricated construction can reduce on-site waste by up to 80% and construction time by 20-30% compared to traditional methods. The use of prefabricated timber panels, steel frames, and concrete modules has gained traction in projects seeking CE alignment.

The Brock Commons Tallwood House in Vancouver, Canada, exemplifies prefabrication's potential. This 18-story mass-timber building utilized prefabricated cross-laminated timber (CLT) panels, achieving a 25% reduction in embodied carbon compared to a concrete equivalent. The panels were designed for disassembly, allowing future reuse in other projects. Despite these benefits, prefabrication faces challenges such as limited scalability in regions with underdeveloped manufacturing infrastructure and higher transportation-related emissions (Pomponi & Moncaster, 2017).

Design for Disassembly (DfD) prioritizes building systems that can be deconstructed at the end of their lifecycle, enabling the reuse or recycling of components. DfD employs reversible connections (e.g., bolts instead of welds) and standardized modules to facilitate material recovery. It is estimated that DfD

can recover 70-90% of a building's materials, significantly reducing landfill waste (Ostapska *et al.*, 2024; Tingley & Davison, 2011). The strategy also supports the concept of "buildings as material banks," where components retain value for future use. Researchers (Lima *et al.*, 2023) show that the operationalization DfD in a BIM environment supports the design process and the management of the buildings' deconstruction. Authors (Pristerà *et al.*, 2024) propose taxonomy to support users in the identification of available DfD measures in relation to the building material type and to link their impact on the circularity of the building.

The Circular Pavilion in Paris, constructed for the 2015 Paris Climate Conference, is a prime example. The pavilion used modular wooden panels and bolted connections, allowing complete disassembly and reuse of materials in subsequent projects. Life Cycle Assessment (LCA) studies indicate that DfD buildings can reduce embodied carbon by 15-25% over their lifecycle (UNEP, 2023). However, DfD requires precise documentation and skilled labor, which can increase design and construction costs by 5-10% (Adams *et al.*, 2017).

Further, BIM provides many possibilities for alleviating the design and construction of circular buildings. BIM that makes it suitable for the circular economy process is its capability to accumulate lifecycle information about a building (Eadie *et al.*, 2013). Authors (Akanbi *et al.*, 2018) develop BIM-based Whole-life Performance Estimator (BWPE) for value assessment of the salvaged performance of structural components of buildings right from the design stage. Also, BIM is utilized to assess a residential building-related social sustainability assessment framework and its implications for BIM (Ahmad & Thaheem, 2017).

4.2. Emerging Strategies with High Potential

While commonly applied strategies are well-established, several emerging strategies show significant promise for advancing circularity in building design. These include cradle-to-cradle (C2C) design, material passports, and the use of bio-based materials. These strategies are less widely implemented but offer innovative solutions to enhance resource efficiency and regenerative systems.

Cradle-to-Cradle (C2C) design focuses on using materials that are safe, recyclable, and capable of being reintegrated into biological or technical cycles. Unlike traditional recycling, which often downcycles materials, C2C emphasizes upcycling to maintain material value (McDonough & Braungart, 2002). The Venlo City Hall in the Netherlands, a C2C-inspired project, used non-toxic, recyclable materials such as glass, timber, and biodegradable insulation, achieving a 90% reduction in material waste during construction. LCA data suggest that C2C buildings can reduce environmental impacts by 20-30% compared to conventional buildings (Ellen MacArthur Foundation, 2017).

C2C design also promotes regenerative systems, such as green roofs and water recycling, which enhance ecosystem services. However, the strategy is limited by the availability of C2C-certified materials, which are currently less than

5% of the global construction material market lifecycle (UNEP, 2023). Research and development in scalable C2C materials are critical to mainstreaming this approach.

Material Passports are digital records that document a building's materials, including their composition, origin, and potential for reuse. By enhancing transparency, passports facilitate material recovery and circularity. The Buildings as Material Banks (BAMB) project demonstrated that material passports can increase the reuse rate of construction materials by 50% by providing stakeholders with detailed lifecycle information (*BAMB*, 2019). For example, the BAMB pilot project in Brussels used passports to track steel beams and concrete panels, enabling their reuse in new constructions.

Material passports also integrate with Building Information Modeling (BIM), creating a digital twin of the building to streamline deconstruction planning. However, their adoption is hindered by a lack of standardized formats and interoperability across platforms, with only 10% of European construction projects currently using passports (Tuscher *et al.*, 2024). Future advancements in blockchain technology could enhance the security and accessibility of material passports.

Bio-based materials, such as hempcrete, mycelium, and bamboo, offer renewable alternatives to carbon-intensive materials like concrete and steel. These materials align with CE's regenerative principle by sequestering carbon and supporting natural cycles (Ellen MacArthur Foundation, 2017). For instance, hempcrete, made from hemp fibers and lime, has a negative carbon footprint and is fully biodegradable (UNEP, 2023). Pilot projects, such as the Hemp House in Cambridge, UK, (Practice Architecture, 2020) demonstrated a 40% reduction in embodied carbon compared to traditional brick construction.

Bio-based materials also enhance indoor environmental quality due to their non-toxic properties. However, their scalability is limited by production costs, which can be 20-30% higher than conventional materials, and regulatory barriers in regions with strict building codes (Pomponi & Moncaster, 2017). Ongoing research into cost-effective production methods could unlock their potential.

4.3. Environmental and Socio-Economic Benefits

The application of CE design strategies yields significant benefits, supported by quantitative data from recent studies.

Environmental Benefits:

- **Material Efficiency:** Prefabrication and DfD reduce material consumption by 30-50% in modular projects (Jaillon & Poon, 2008) and Poon, 2014).
- **Carbon Reduction:** Adaptable and C2C designs lower lifecycle carbon emissions by 20-30% (UNEP, 2023).

- **Waste Minimization:** DfD and prefabrication can divert up to 80% of construction waste from landfills (Tingley & Davison, 2011).
 - **Resource Conservation:** Material passports and C2C materials promote the reuse of high-value components, reducing raw material extraction by 15-25% (Ellen MacArthur Foundation, 2017).
- **Socio-Economic Benefits:**
 - **Cost Savings:** Long-term savings from material reuse and reduced maintenance costs can offset initial investments, with payback periods of 10-15 years for adaptable buildings (Adams *et al.*, 2017).
 - **Job Creation:** The recycling and remanufacturing sectors associated with CE strategies create 10-20% more jobs than traditional construction (Ellen MacArthur Foundation, 2017).
 - **Community Resilience:** Adaptable buildings support socio-economic stability by accommodating diverse functions, such as emergency housing during crises (Geldermans, 2016)

The results underscore the transformative impact of CE design strategies on the construction sector. Commonly applied strategies like adaptability, prefabrication, and DfD are already achieving significant environmental and economic benefits, as demonstrated by projects like the Allianz Tower and Brock Commons. Emerging strategies, such as C2C design, material passports, and bio-based materials, offer even greater potential but require further investment in research, policy, and infrastructure. Addressing barriers through stakeholder collaboration, regulatory reform, and technological innovation will be critical to scaling these strategies globally.

4.4. Barriers to Adoption

Despite their potential, CE design strategies face several challenges:

- **Economic Barriers:** High upfront costs for circular materials (e.g., C2C-certified products) and technologies (e.g., BIM integration) can deter adoption, particularly for small-scale developers (Adams *et al.*, 2017).
- **Regulatory Barriers:** Inconsistent building codes and a lack of CE-specific certifications hinder the use of bio-based materials and DfD systems in many regions (Pomponi & Moncaster, 2017).
- **Knowledge Gaps:** Limited awareness and training among architects, engineers, and contractors restrict the implementation of advanced strategies like material passports (Tingley & Davison, 2011).
- **Supply Chain Fragmentation:** The construction industry's decentralized supply chain complicates the coordination required for circular practices, such as material tracking and reuse (BAMB, 2019).

4.5. Case Studies

Case Study 1: Venlo City Hall, Netherlands (Cradle-to-Cradle Design)

The Venlo City Hall, Figure 2, completed in 2016, is a flagship example of Cradle-to-Cradle (C2C) design in the construction sector. Designed by Kraaijvanger Architects (Kraaijvanger Architects, 2017), the building incorporates non-toxic, recyclable materials and regenerative systems to minimize environmental impact. Key features include a green façade that purifies air, a closed-loop water system, and materials like timber, glass, and biodegradable insulation that can be reintegrated into technical or biological cycles. The project achieved a 90% reduction in construction waste and a 20% decrease in lifecycle energy consumption compared to conventional buildings.



Figure 2. Venlo City Hall
Source: (Kraaijvanger Architects, 2017)

The C2C approach required extensive collaboration among architects, material suppliers, and local authorities to ensure material traceability and compliance with C2C certification. The building's green roof and photovoltaic panels contribute to biodiversity and renewable energy production, aligning with CE's regenerative principle. However, the project faced challenges, including a 15% higher initial cost due to specialized materials and a limited supply of C2C-certified products. The Venlo City Hall demonstrates the feasibility of C2C design but highlights the need for scalable material solutions and cost reductions to mainstream this strategy.

Case Study 2: Brock Commons Tallwood House, Canada (Prefabrication)

Brock Commons Tallwood House, Figure 3 (Acton Ostry Architects, 2017), an 18-story student residence at the University of British Columbia, is a pioneering example of prefabricated mass-timber construction. Completed in 2017, the building utilized cross-laminated timber (CLT) panels prefabricated off-site, reducing construction waste by 80% and construction time by 25% compared to a concrete equivalent (Jaillon and Poon, 2014). The CLT panels were designed for disassembly, enabling future reuse in other projects, which aligns with CE's principle of keeping materials in use.



Figure 3. Brock Commons Tallwood House
Source: (Acton Ostry Architects, 2017)

The project achieved a 25% reduction in embodied carbon, primarily due to timber's lower carbon footprint and the efficiency of prefabrication. The use of standardized components also improved quality control and reduced on-site errors. However, challenges included higher transportation costs for prefabricated elements and regulatory hurdles related to fire safety for tall timber buildings. Brock Commons highlights prefabrication's potential to advance CE goals but underscores the need for regional manufacturing hubs and updated building codes to enhance scalability.

Case Study 3: Circular Pavilion, Paris, France (Design for Disassembly)

The Circular Pavilion, Figure 4 (Encore Heureux Architects, 2015), constructed for the 2015 Paris Climate Conference, exemplifies Design for Disassembly (DfD). Designed by Encore Heureux Architects, the temporary structure used modular wooden panels, bolted connections, and reusable steel frames to ensure all components could be deconstructed and repurposed. Post-event, 90% of the pavilion's materials were reused in other construction projects, demonstrating the effectiveness of DfD in reducing waste.



Figure 4. Circular Pavilion
Source: (Encore Heureux Architects, 2015)

The pavilion's design prioritized simplicity and reversibility, with materials sourced from local suppliers to minimize transportation emissions. The project achieved a 15% reduction in embodied carbon compared to a conventional temporary structure. Challenges included the need for precise documentation to track materials and skilled labor for disassembly, which increased costs by 10%. The Circular Pavilion showcases DfD's potential for circularity but highlights the importance of digital tools like material passports to streamline material recovery processes.

5. DISCUSSION

The results and case studies demonstrate that CE design strategies, such as adaptability, prefabrication, DfD, C2C design, material passports, and bio-based materials, offer viable solutions to reduce the construction industry's environmental footprint. Commonly applied strategies are gaining traction due to their alignment with existing practices, as seen in projects like Brock Commons and the Circular Pavilion. Emerging strategies, exemplified by Venlo City Hall, push the boundaries of circularity but face scalability challenges due to cost, regulatory, and technical barriers.

Opportunities for advancement include leveraging digital technologies like BIM and blockchain to enhance material tracking, as demonstrated in the BAMB project. Policy incentives, such as tax breaks for circular construction, could accelerate adoption, while integrating CE principles into architectural education would build industry capacity. However, current research is limited by its focus on developed countries, with insufficient exploration of CE applications in developing regions. Longitudinal studies evaluating the performance of circular buildings over decades are also needed to validate their benefits.

Future research should prioritize cost-effective circular materials, global standards for CE construction, and applications in affordable housing to address socio-economic disparities. Collaboration among architects, policymakers, and industry stakeholders is essential to overcome cultural resistance and drive systemic change.

6. CONCLUSIONS

The transition to a Circular Economy in building design offers a transformative approach to addressing the construction industry's resource and environmental challenges. Strategies like adaptability, prefabrication, and DfD, as demonstrated by Brock Commons and the Circular Pavilion, are already reducing waste and emissions. Emerging strategies, such as C2C design and material passports, exemplified by Venlo City Hall, promise regenerative solutions but require further development. Despite barriers like high costs and regulatory gaps, advancements in digital tools, policy frameworks, and education can unlock the full potential of circular buildings. By fostering innovation and collaboration, the construction sector can lead the way toward a sustainable, regenerative future, ensuring that buildings serve as material banks for generations to come.

References

- 1) Acton Ostry Architects. (2017). *UBC Brock Commons Tallwood House*. <https://www.actonostry.ca/work/education/ubc-brock-commons-tallwood-house>
- 2) Adams, K. T., Osmani, M., Thorpe, T., & Thornback, J. (2017). Circular economy in construction: Current awareness, challenges and enablers. *Proceedings of the*

- Institution of Civil Engineers - Waste and Resource Management*, 170(1), 15–24. <https://doi.org/10.1680/jwarm.16.00011>
- 3) Ahmad, T., & Thaheem, M. J. (2017). Developing a residential building-related social sustainability assessment framework and its implications for BIM. *Sustainable Cities and Society*, 28, 1–15. <https://doi.org/10.1016/j.scs.2016.08.002>
 - 4) Akanbi, L. A., Oyedele, L. O., Akinade, O. O., Ajayi, A. O., Davila Delgado, M., Bilal, M., & Bello, S. A. (2018). Salvaging building materials in a circular economy: A BIM-based whole-life performance estimator. *Resources, Conservation and Recycling*, 129, 175–186. <https://doi.org/10.1016/j.resconrec.2017.10.026>
 - 5) BAMB. (2019). BAMB. <https://www.bamb2020.eu/>
 - 6) Cheshire, D. (2016). *Building Revolutions: Applying the Circular Economy to the Built Environment*. RIBA Publishing.
 - 7) Eadie, R., Browne, M., Odeyinka, H., McKeown, C., & McNiff, S. (2013). BIM implementation throughout the UK construction project lifecycle: An analysis. *Automation in Construction*, 36, 145–151. <https://doi.org/10.1016/j.autcon.2013.09.001>
 - 8) Eberhardt, L. C. M., Birkved, M., & Birgisdottir, H. (2022). Building design and construction strategies for a circular economy. *Architectural Engineering and Design Management*, 18(2), 93–113. <https://doi.org/10.1080/17452007.2020.1781588>
 - 9) Ellen MacArthur Foundation. (2017). *Cities in the circular economy: An initial exploration*. <https://www.ellenmacarthurfoundation.org/cities-in-the-circular-economy-an-initial-exploration>
 - 10) Ellen MacArthur Foundation. (2021). *Circular economy introduction – Overview*. Ellen MacArthur Foundation. <https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview>
 - 11) Encore Heureux Architects. (2015). *The Circular Pavilion*. ArchDaily. <https://www.archdaily.com/778972/the-circular-pavilion-encore-heureux-architects>
 - 12) Geldermans, R. J. (2016). Design for Change and Circularity – Accommodating Circular Material & Product Flows in Construction. *Energy Procedia*, 96, 301–311. <https://doi.org/10.1016/j.egypro.2016.09.153>
 - 13) Jaillon, L., & Poon, C. S. (2008). Sustainable construction aspects of using prefabrication in dense urban environment: A Hong Kong case study. *Construction Management and Economics*, 26(9), 953–966. <https://doi.org/10.1080/01446190802259043>
 - 14) Kraaijvanger Architects. (2017). *Municipal Office Venlo | Kraaijvanger*. <https://www.kraaijvanger.nl/en/projects/city-hall-venlo/>
 - 15) Lima, P. R. B. de, Rodrigues, C. de S., & Post, J. M. (2023). Integration of BIM and design for deconstruction to improve circular economy of buildings. *Journal of Building Engineering*, 80, 108015. <https://doi.org/10.1016/j.jobbe.2023.108015>
 - 16) McDonough, W., & Braungart, M. (2002). *Cradle to Cradle: Remaking the Way We Make Things* (First Edition). North Point Press.
 - 17) Ostapska, K., R  ther, P., Loli, A., & Gradeci, K. (2024). Design for Disassembly: A systematic scoping review and analysis of built structures Designed for Disassembly. *Sustainable Production and Consumption*, 48, 377–395. <https://doi.org/10.1016/j.spc.2024.05.014>

- 18) Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A research framework. *Journal of Cleaner Production*, 143, 710–718. <https://doi.org/10.1016/j.jclepro.2016.12.055>
- 19) Practice Architecture. (2020). *Flat House*. <https://practicearchitecture.co.uk/project/flat-house/>
- 20) Pristerà, G., Tonini, D., Lamperti Tornaghi, M., Caro, D., & Sala, S. (2024). Taxonomy of design for deconstruction options to enable circular economy in buildings. *Resources, Environment and Sustainability*, 15, 100153. <https://doi.org/10.1016/j.resenv.2024.100153>
- 21) Tingley, D. D., & Davison, B. (2011). Design for deconstruction and material reuse. *Proceedings of the Institution of Civil Engineers - Energy*, 164(4), 195–204. <https://doi.org/10.1680/ener.2011.164.4.195>
- 22) Tuscher, M., Hanák, M., Navrátilová, V., & Tichá, A. (2024). Usage of Building Passports and BIM in Multi-Criteria Evaluation. *Procedia Computer Science*, 239, 1086–1094. <https://doi.org/10.1016/j.procs.2024.06.273>
- 23) UNEP. (2023). *Global Status Report for Buildings and Construction*.

TOURISM COMPETITIVENESS, ENVIRONMENTAL QUALITY AND CIRCULAR ECONOMY: A PANEL APPROACH

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Abstract

Tourism as an important sector of the economy has significant impact on the GDP in certain countries. Tourism expenditure is a generator of employment and wealth in the whole economy, not only in tourism. Tourism has a positive impact on economic growth and development, but it can have a negative impact on the environment. With the increasing competition in the global tourism market, research on sustainability and competitiveness in tourism is attracting increasing attention. Environmental protection is one of the essential prerequisites for improving tourism competitiveness. Tourists are more likely to visit tourism destinations of high environmental quality. Circularity can be essential in increasing environmental protection. The purpose of this paper is to analyse the impact of Sustainable Development Goals (SDGs) and circular economy on tourism competitiveness. The analysis was conducted for 27 European Union countries during the period 2014-2023. The results indicate that the impact of Sustainable Development Goals on tourism competitiveness depends on the level of circular economy indexes. In European Union countries with lowest level of circular economy indexes, the Sustainable Development Goals have significant impact on tourism competitiveness while in European Union countries with highest level of circular economy indexes, the Sustainable Development Goals have not significant impact on tourism competitiveness.

Keywords: *Tourism industry, circular economy, environment, competitiveness, SDGs, EU-27.*

JEL Classification: Z32, Q56

1. INTRODUCTION

Tourism is an important sector of the world economy, as it significantly contributes to the growth of the GDP of certain countries. Despite the positive effects recorded on the economic and social level, there are also negative external effects that tourism generates on the environment through the degradation of air,

soil and water. The tourism industry is a large consumer of resources and a generator of waste.

Tourism is one of the most developed sectors in the world. The World Travel and Tourism Council predicts that by 2026 the tourism industry will reach 10.8% of world GDP (Khizar *et al.*, 2023). Although it brings significant economic benefits, tourism is a water- and energy-intensive sector, as well as a sector that generates waste and wastewater, but it is also one of the largest contributors to global greenhouse gas (GHG) emissions (Zorpas *et al.*, 2021; Kaszás *et al.*, 2022; Caponi, 2022). GHG emissions originating from tourism are estimated to represent approximately 8% of the global value, and alarmingly, are expected to triple by 2050 (Koçak *et al.*, 2024; Peeters *et al.*, 2024). According to Pablo-Romero *et al.* (2023), the link between tourism and GHG emissions should be attributed to the energy intensity of the sector, which comes from transport, commercial activities and ancillary services. Also, tourism has a significant impact on waste generation, as tourists generate twice as much waste as residents (Rodríguez *et al.*, 2020). Regarding wastewater, tourism contributes about 7% to water pollution in the Mediterranean basin (UNEP, 2003). Considering that it is the largest global tourist destination that attracts almost one third of the world's foreign tourists, its popularity is predicted to grow exponentially (Lanquar, 2011). According to the EU Green Deal, the green transition in tourism needs to reduce global emissions by 55% by 2030 (European Commission, 2021).

Bearing in mind that the linear business model prevails in tourism, this has a negative effect on the growth of tourism and the economy, but also on its resilience and sustainability. The circular economy offers a possible solution for mitigating the environmental externalities of the tourism industry to make tourism more sustainable by reducing environmental, social and economic effects. The role of the circular economy in tourism is emphasized by the possibility of achieving all the sustainable development goals (SDGs) directly and indirectly.

Circularity as a strategic approach applied in the tourism sector implies minimizing its impacts on the environment, including waste and pollution, as well as CO₂ emissions. Integrating the principle of circularity into business aims to improve the efficiency of resources in the tourism value chain so that the tourism sector accepts a sustainable and resilient path of development.

The introduction of a circular economy can contribute to competitiveness in tourism, not only in terms of opportunities for innovation, differentiation and diversification of revenue streams, but also governments and investors are increasingly committed to environmental, social, and governance (ESG) policies.

For tourism destinations, the circular economy contributes to tourism's positive impact on sustainable development, creating benefits for local populations through the creation of new jobs and more inclusive local value chains. For tourists, the circular economy encourages a change in their behaviour.

That is why the UN supports numerous initiatives aimed at a circular economy in tourism within the Global Tourism Plastics Initiative, the Global Roadmap for Food Waste Reduction in Tourism, as well as the Glasgow Declaration on Climate Action in Tourism, which aims to halve emissions in the next decade and reach net zero emissions by 2050.

The purpose of this paper is to analyse the impact of Sustainable Development Goals (SDGs) and circular economy on tourism competitiveness. The aim of this paper is to analyse whether the level of development of circular economy contributes to the impact of Sustainable Development Goals (SDGs) on tourism competitiveness.

2. THEORETICAL BACKGROUND

There are numerous scientific studies on the mutual influence of the circular economy, environmental quality and competitiveness in tourism. One part of the authors dealt with the relationship between the circular economy and tourism, while the other part dealt with the relationship between the quality of the environment and tourism.

There are numerous long-term socio-economic trends that affect the players of the tourism industry, both on the supply side and on the demand side. These trends highlight the growing need for innovation, sustainability, health and safety performance and cost optimization as important elements of competitiveness in the coming years (Einarsson and Sorin, 2020).

A study by Erdiaw-Kwasie *et al.* (2023) based on the analysis of time series data for 14 EU member states in the period 2000-2020 showed that the promotion of circular innovative practices, including recycling and the use of secondary raw materials in tourist destinations, can improve the quality of the environment and positively affect tourism revenues. They investigated how the transition to a circular economy has effects on tourism revenues. The results showed that increasing competitiveness and innovation in the circular economy drive circularity in the tourism industry across Europe. The authors believe that institutions play a significant role in the implementation of circular economy initiatives in the tourism sector. This study provides policy and practical suggestions for innovation in the circular economy, such as policy makers needing to implement and monitor the implementation of a strict environmental framework, investing more in waste reduction, promoting reusable packaging, recycling tourism waste and using secondary raw materials. Also, policy makers should consider heterogeneous country-specific effects when implementing tourism strategies based on circularity and use circular economy standards as part of the regulatory framework.

Gabor *et al.* (2023) investigated the total, direct and indirect effects of the several independent variables on the dependent variable (municipal waste) in the case of 30 European countries. The main conclusions are that, on the one hand,

the increase in the average stay/arrivals/nights of tourists and the decrease in the rank of tourism competitiveness (from the last to the first) has a negative impact on waste management and environmental pollution. On the other hand, the improvement of circular economy indicators (renewable resource consumption and rate of circular use of materials) has a positive impact on waste management and environmental pollution in European countries. They concluded that the paradigm shifts and transition from a linear to a circular economy requires consumer awareness of the role they play in promoting the principles of circularity, and in the field of tourism, hotels and tourist destinations can even be promoted as living labs of the circular economy. They propose a paradigm shift in terms of business goals, because the focus should not be on waste reduction, but on the renewal and use of certain materials, thus promoting the principles of a circular economy.

The concept of circular tourism economy is reinforced due to the importance of the tourism industry in certain European countries, considering the efforts of public authorities to promote the circular economy and the transition to a low-carbon economy (Rodríguez *et al.*, 2020). Strippoli *et al.* (2024) investigated circular economy (CE) strategies applicable in the tourism industry with reference to the management of plastic waste, food waste and wastewater. They believe that in addition to the 4R strategy (reduce, reuse, recycle, and recover), more strategies should be developed and promoted. Based on the review, the authors found that CE strategies that are effective from a social, environmental and economic point of view in tourism management are those related to mitigating GHG emissions, reducing waste, increasing revenue while reducing costs.

Environmental protection becomes an essential prerequisite for achieving a sustainable competitive advantage and an integral part of proactive management of the tourism industry (Bacoş and Gabor, 2021). In addition to positive economic and social effects, negative externalities are generated by tourism because tourism is a carbon-intensive industry, so there are many scientific studies on the relationship between the development of this sector and the CO₂ emissions generated by specific activities (Leitão and Lorente, 2020, Sharif *et al.*, 2020a, Campos *et al.*, 2021, Pata and Balsalobre-Lorente, 2022). Also, tourism generates water and soil pollution, which is why it is a highly discussed topic in scientific literature on the impact of tourism on the ecological footprint (Sinha *et al.*, 2020; Ghosh *et al.*, 2022).

Robaina *et al.* (2020) based on data for five European countries shows the correlation between air quality and tourist demand. They also specify the impact that the tourism industry has on air quality in the mentioned countries. Research conducted by Ciarlantini *et al.* (2022) shows indirect links between economic development and air quality. Bacoş and Gabor, (2022) claim that there is a causal relationship between macroeconomic indicators and quality, i.e. air pollution.

3. RESEARCH METHODOLOGY

The study deploys data for the period from 2014 to 2023 of 27 European Union members. Regression analysis has examined the impact of the circular economy and environmental quality on the tourism competitiveness of observed countries. Reliability issues are governed by using Breusch-Pagan test for testing the heteroscedasticity as well as Durbin Watson test and Breusch-Godfrey LM test for testing the autocorrelation. Research information base has included the data about number of tourists, circular material use rate and employees in circular economy sectors from Eurostat Database (The World Bank, 2014-2023) as well as data about sustainable development goals from World Development Indicators (World Bank). In the paper special attention was paid to the Sustainable Development Goals: Goal 1 (G1) – No poverty, Goal 2 (G2) – Zero hunger, Goal 3 (G3) – Good health and well-being, Goal 4 (G4) – Quality education, Goal 5 (G5) – Gender equality, Goal 6 (G6) – Clean water and sanitation, Goal 7 (G7) – Affordable and clean energy, Goal 8 (G8) – Decent work and economic growth, Goal 9 (G9) – Industry, innovation and infrastructure, Goal 10 (G10) – Reduced inequalities, Goal 11 (G11) – Sustainable cities and communities, Goal 12 (G12) – Responsible consumption, Goal 13 (G13) – Climate action, Goal 15 (G15) – Life on land, Goal 16 (G16) – Peace, justice and strong institutions and Goal 17 (G17) – Partnerships for the goals.

4. RESULTS AND DISCUSSION

Based on cluster analysis an investigation is conducted of the heterogeneity of the observed countries. The results of cluster analysis highlighted four clusters for 2014 (Table 1). The following countries belong to the first cluster: France, Germany, Italy, Poland and Spain. The observed cluster recorded the highest average values of circular material use rate and employed in circular economy sectors in 2014. The observed cluster recorded about 481 employees in circular economy sectors and about 13 circularity rates (the ratio of the circular use of materials to the overall material use).

The following countries belong to the second cluster: Bulgaria, Czechia, Hungary, Netherland, Portugal and Romania. The observed cluster recorded about 121 employees in circular economy sectors and about 7,6 circularity rates (the ratio of the circular use of materials to the overall material use).

The following countries belong to the third cluster: Austria, Belgium, Croatia, Denmark, Finland, Greece, Latvia, Lithuania, Slovenia and Sweden. The observed cluster recorded about 58 employees in circular economy sectors and about 6,9 circularity rates (the ratio of the circular use of materials to the overall material use).

The fourth cluster includes Cyprus, Estonia, Ireland, Luxemburg, Malta and Slovenia, i.e. the countries that recorded the lowest average value of circular material use rate and employees in circular economy sectors.

For 2023, the results of cluster analysis highlighted four clusters (Table 2). The same countries belong to the first cluster or cluster with the highest average values of circular material use rate and employees in circular economy sectors. These countries recorded the highest level of achievement of sustainable development goals. In 2023, the average level of achievement of the sustainable development goals of these countries is about 0,9.

Table 1. Members of Cluster and Distances from Cluster Center (2014)

Cluster 1		Cluster 2		Cluster 3		Cluster 4	
Members	Distances	Members	Distances	Members	Distances	Members	Distances
C_10	11.7748	C_3	16.66344	C_1	4.63155	C_5	6.34429
C_11	128.8088	C_6	5.54225	C_2	7.94548	C_8	4.42326
C_15	11.1539	C_13	16.63926	C_4	1.67094	C_14	13.14062
C_21	5.744	C_20	20.60490	C_7	10.47199	C_18	7.24226
C_26	79.5876	C_22	12.18513	C_9	8.69996	C_19	6.72500
		C_23	54.79322	C_12	14.57070	C_25	3.03885
				C_16	13.35494		
				C_17	3.315507		
				C_24	1.86400		
				C_27	13.17657		

Source: (Authors based on data, STATA 19)

Bulgaria, Denmark and Latvia recorded a worsening of their position compared to 2014. In 2023, Bulgaria belongs to the third cluster while Denmark and Latvia belong to the fourth cluster. Estonia recorded an improvement in its position compared to 2014. In 2023, it belongs to the third cluster. The fourth cluster includes Cyprus, Denmark, Finland, Ireland, Latvia, Luxemburg, Malta and Slovenia, i.e. the countries that recorded the lowest average value of circular material use rate and employees in circular economy sectors. In 2023, the average level of achievement of the sustainable development goals of these countries is about 0,8.

Table 2. Members of Cluster and Distances from Cluster Center (2023)

Cluster 1		Cluster 2		Cluster 3		Cluster 4	
Members	Distances	Members	Distances	Members	Distances	Members	Distances
C_10	4.9691	C_6	2.66144	C_1	3.84625	C_5	10.27093
C_11	170.1279	C_13	18.24382	C_2	8.62526	C_7	9.51061
C_15	17.3454	C_20	22.13791	C_3	18.56132	C_9	10.37397
C_21	85.0182	C_22	13.47114	C_4	3.70045	C_14	6.83366
C_26	72.8329	C_23	45.55780	C_8	11.97459	C_16	3.96190
				C_12	6.11443	C_18	5.00132
				C_17	7.30182	C_19	16.47545
				C_24	3.24577	C_25	1.12884
				C_27	6.91871		

Source: (Authors based on data, STATA 19)

Regression results after correction of heteroscedasticity and autocorrelation problems are given in Table 3 and Table 4. The heteroscedasticity is checked through Breusch-Pagan test while Durbin Watson test and Breusch-Godfrey LM test are used for testing the autocorrelation.

The results of regression analysis indicate that sustainable development goals have significant impact on tourism competitiveness in the EU member states with the lowest level of circular economy indexes (Table 3). Results indicate that G1, G4, G5, G8, G10, G11, G15 and G16 have significant impact on tourism competitiveness of EU members. Achieving the goals of sustainable development such as no poverty, quality education, gender equality, sustainable economic growth, sustainable cities and communities, protect, restore and promote sustainable use of terrestrial ecosystems and promote peaceful and inclusive societies for sustainable development has significant impact on tourism competitiveness of EU members with lower level of development of circular economy. The results of regression analysis indicate that sustainable development goals do not have a significant impact on tourism competitiveness of the EU member states with the highest level of circular economy indexes (Table 4).

Table 3. The impact of achieving sustainable development goals on tourism competitiveness of EU member states with the lowest level of circular economy indexes

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Iteration 37: rho = 0.9775
Iteration 38: rho = 0.9775
Iteration 39: rho = 0.9775
Iteration 40: rho = 0.9775
Iteration 41: rho = 0.9775

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Cochrane-Orcutt AR(1) regression -- iterated estimates

Source	SS	df	MS	Number of obs	=	72
				F(16, 55)	=	5.45
Model	108.273591	16	6.76709947	Prob > F	=	0.0000
Residual	68.25147	55	1.24093582	R-squared	=	0.6134
				Adj R-squared	=	0.5009
Total	176.525062	71	2.48626847	Root MSE	=	1.114

Tourists	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
G1	7.903901	2.434534	3.25	0.002	3.024986	12.78282
G2	4.033625	2.485037	1.62	0.110	-.9465006	9.013752
G3	-6.09478	6.242738	-0.98	0.333	-18.60551	6.415946
G4	4.204952	1.921454	2.19	0.033	.3542719	8.055632
G5	-4.713887	1.565893	-3.01	0.004	-7.852006	-1.575768
G6	-1.182435	4.992458	-0.24	0.814	-11.18754	8.822674
G7	1.796596	3.226064	0.56	0.580	-4.668581	8.261772
G8	7.564186	2.464104	3.07	0.003	2.626011	12.50236
G9	4.301102	2.417264	1.78	0.081	-.5432044	9.145408
G10	.7537223	2.143288	0.35	0.726	-3.541523	5.048968
G11	-3.744923	1.722499	-2.17	0.034	-7.196887	-.292959
G12	-1.412972	2.45051	-0.58	0.567	-6.323903	3.49796
G13	-1.133637	1.381026	-0.82	0.415	-3.901274	1.634
G15	-6.449829	3.121937	-2.07	0.044	-12.70633	-.1933274
G16	-5.088228	2.474008	-2.06	0.044	-10.04625	-.1302049
G17	-4.044051	2.719448	-1.49	0.143	-9.493948	1.405845
_cons	12.73261	14.13568	0.90	0.372	-15.59592	41.06114
rho	.9774759					

Durbin-Watson statistic (original) 0.506548

Durbin-Watson statistic (transformed) 2.003520

Source: (Authors based on data, STATA 19)

Table 4. The impact of achieving sustainable development goals on tourism competitiveness of EU member states with the highest level of circular economy indexes

Iteration 55: rho = 0.8484
 Iteration 56: rho = 0.8484
 Iteration 57: rho = 0.8484

Cochrane-Orcutt AR(1) regression -- iterated estimates

Source	SS	df	MS	Number of obs	=	45
				F(16, 28)	=	2.08
Model	22161.5201	16	1385.09501	Prob > F	=	0.0436
Residual	18656.0028	28	666.285814	R-squared	=	0.5429
				Adj R-squared	=	0.2818
Total	40817.5229	44	927.670976	Root MSE	=	25.813

Tourists	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
G1	55.61265	91.46385	0.61	0.548	-131.7426	242.9679
G2	24.22332	66.09231	0.37	0.717	-111.1606	159.6073
G3	11.21266	142.7971	0.08	0.938	-281.2939	303.7192
G4	-72.5609	55.84033	-1.30	0.204	-186.9446	41.82282
G5	-46.10409	70.74952	-0.65	0.520	-191.0279	98.81972
G6	110.0399	108.3882	1.02	0.319	-111.9833	332.0631
G7	93.03479	79.91344	1.16	0.254	-70.66047	256.73
G8	84.34182	71.88879	1.17	0.251	-62.9157	231.5993
G9	78.507	90.31416	0.87	0.392	-106.4932	263.5072
G10	-38.71311	46.4922	-0.83	0.412	-133.9481	56.52184
G11	48.26808	47.61331	1.01	0.319	-49.26337	145.7995
G12	21.99409	56.75462	0.39	0.701	-94.26247	138.2506
G13	-53.88152	47.39882	-1.14	0.265	-150.9736	43.21055
G15	-206.3843	113.9665	-1.81	0.081	-439.834	27.06547
G16	64.1385	93.00593	0.69	0.496	-126.3755	254.6525
G17	-53.05645	81.85513	-0.65	0.522	-220.7291	114.6162
_cons	-43.8925	130.5035	-0.34	0.739	-311.2168	223.4318
rho	.8483618					

Durbin-Watson statistic (original) 0.930541

Durbin-Watson statistic (transformed) 1.748191

Source: (Authors based on data, STATA 19)

5. CONCLUSION

Tourism is one of the most developed activities in the world. It has positive social, economic and cultural effects. But it causes the emission of greenhouse gases, creates difficulties in waste management and represents a higher consumer of resources. The circular economy can be a possible solution to mitigate these externalities (Strippoli *et al.*, 2024).

Using a time series dataset from 27 selected European countries from 2014 to 2023, we investigated the effects of a circular economy and Sustainable Development Goals on tourism competitiveness. The results of research indicate

that the impact of Sustainable Development Goals on tourism competitiveness depends on the level of circular economy indexes. The Sustainable Development Goals have significant impact on tourism competitiveness in European Union countries with lowest level of circular economy indexes.

The findings of this study have important policy implications. First, the application of the circular economy in tourism should be increased. Second, by reducing environmental problems in tourism destinations, circular economy initiatives can help improve tourism competitiveness in countries with lowest level of circular economy indexes. Third, achieving the goals of sustainable development can contribute to increasing tourism competitiveness.

References

- 1) Bacoş, I. B. and Gabor, M. R. (2022). Comparative Quantitative Analysis of Air Quality Indicators and Macroeconomic Indicators for EU and Non-EU Member Countries. In: L. Moldovan and A. Gligor, eds., *The 15th International Conference Interdisciplinarity in Engineering, (Inter-Eng 2021) Lecture Notes in Networks and Systems*, vol. 386. Cham: Springer, pp. 213-223. [online] Available at: <https://doi.org/10.1007/978-3-030-93817-8> [Accessed 05.02.2025].
- 2) Bacoş, I. B. and Gabor, M. R. (2021). Air quality indices – case study: environmental sustainability pillar and Romania's positioning in the European and global context. *Acta Marisiensis. Ser. Technol.*, 18(1), pp. 22-27.
- 3) Balsalobre-Lorente, D., Driha, O.M., Shahbaz, M. and Sinha, A. (2020). The effects of tourism and globalization over environmental degradation in developed countries. *Environ. Sci. Pollut. Res.*, 27, pp. 7130-7144.
- 4) Campos C., Laso J., Cristobal J., Alberti J., Bala A., Fullana A., Fullana-i-Palmer P., Margallo M. and Aldaco R. (2021). Towards more sustainable tourism under a carbon footprint approach: The Camion Lebaniego case study. *Journal of Cleaner Production*. Available at: Towards more sustainable tourism under a carbon footprint approach: The Camino Lebaniego case study – ScienceDirect [Accessed 05.02.2025].
- 5) Caponi, V. (2022). The economic and environmental effects of seasonality of tourism: a look at solid waste. *Ecol. Econ.*, 192(C), 107262.
- 6) Ciarlantini, S., Madaleno, M., Robaina, M., Monteiro, A., Eusébio, C., João Carneiro, M. and Einarsson S. and Sorin, F. (2020). *Circular Economy in travel and tourism: A conceptual framework for a sustainable, resilient and future proof industry transition*. CE360 Alliance.
- 7) Erdiaw-Kwasie, M. O., Owusu-Ansah, K. K., Abunyewah, M., Alam, K., Hailemariam, A., Arhin, P., Zander, K. K. and Lassa, J. (2023). Circular economy, environmental quality and tourism receipts in Europe: A time series data analysis. *PloS one*, 18(11), e0288098. [online] Available at: <https://doi.org/10.1371/journal.pone.0288098> [Accessed 15.01.2025].
- 8) European Commission (2021). *“Fit for 55”: delivering the EU’s 2030 Climate Target on the way to climate neutrality*. [online] Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0550> [Accessed 05.02.2024].

- 9) Gabor, M. R., Panait, M., Bacoş, I. B., Naghi, L. E. and Oltean, F. D. (2023). Circular tourism economy in European Union between competitiveness, risk and sustainability. *Environmental Technology & Innovation*, 32, 103407. [online] Available at: <https://doi.org/10.1016/j.eti.2023.103407> [Accessed 15.01.2025].
- 10) Gama, C. (2023). Air pollution and tourism growth relationship: exploring regional dynamics in five European countries through an EKC model. *Environ Sci Pollut Res*, 30, pp. 42904–42922. [online] Available at: <https://doi.org/10.1007/s11356-021-18087-w> [Accessed 15.01.2025].
- 11) Ghosh, S., Balsalobre-Lorente, D., Doğan, B., Paiano, A. and Talbi, B. (2022). Modelling an empirical framework of the implications of tourism and economic complexity on environmental sustainability in G7 economies. *J. Clean. Prod.*, 376, 134281.
- 12) Kaszás, N., Keller, K. and Birkner, Z. (2022). Understanding circularity in tourism. *Soc. Econ.*, 44(1), pp. 65-82.
- 13) Khizar, H. M. U., Younas, A., Kumar, S., Akbar, A. and Poulova, P. (2023). The progression of sustainable development goals in tourism: a systematic literature review of past achievements and future promises. *Journal of Innovation & Knowledge*, 8(4), 100442.
- 14) Koçak, E., Ulucak, R. and Ulucak, Z. Ş. (2020). The impact of tourism developments on CO₂ emissions: an advanced panel data estimation. *Tourism Manag. Perspect.*, 33, 100611.
- 15) Lanquar, R. (2011). *Tourism in the mediterranean: scenarios up to 2030*. MEDPRO Report No. 1/July, 2011. [online] Available at: 10.2139/ssrn.2000717 [Accessed 24.07.2024].
- 16) Leitão, N. C. and Lorente, D. B. (2020). The linkage between economic growth, renewable energy, tourism, CO₂ emissions, and international trade: the evidence for the European Union. *Energies*, 13(18) (2020), p. 4838.
- 17) Pablo-Romero, M. P., Sánchez-Braza, A. and García-Soto, M. A. (2023). The impact of tourism on energy consumption: a sectoral analysis for the most visited countries in the world. *Economies*, 11(10), 263.
- 18) Pata, U. K. and Balsalobre-Lorente D. (2022). Exploring the impact of tourism and energy consumption on the load capacity factor in Turkey: a novel dynamic ARDL approach. *Environ. Sci. Pollut. Res.*, 29(9), pp. 13491-13503.
- 19) Peeters, P., Çakmak, E. and Guiver, J. (2024). Current issues in tourism: mitigating climate change in sustainable tourism research. *Tourism Manag.*, 100, 104820.
- 20) Robaina, M., Madaleno, M., Silva, S., Eusébio, C., Carneiro, M., Gama, C., Oliveira, K., Russo, M. and Monteiro, A. (2020). The relationship between tourism and air quality in five European countries. *Econ. Anal. Policy*, p. 67.
- 21) Rodríguez, C., Florido, C. and Jacob, M. (2020). Circular economy contributions to the tourism sector: a critical literature review. *Sustainability*, 12(11), p. 4338.
- 22) Sharif, A., Godil, D. I., Xu, B., Sinha, A., Khan, S. A. R. and Jermisittiparsert, K. (2020). Revisiting the role of tourism and globalization in environmental degradation in China: Fresh insights from the quantile ARDL approach. *J. Clean. Prod.*, 272, 122906.
- 23) Strippoli, R., Gallucci, T. and Ingrao, C. (2024). Circular economy and sustainable development in the tourism sector – An overview of the truly-effective strategies and

- related benefits. *Heliyon*, 10(17), e36801. [online] Available at: <https://doi.org/10.1016/j.heliyon.2024.e36801> [Accessed 15.01.2025].
- 24) UNEP (2003). *A manual for water and waste management: what the tourism industry can do to improve its performance*. [online] Available at: <https://www.unep.org/resources/report/manual-water-and-waste-management-what-tourism-industry-can-do-improve-its> [Accessed 14.03.2024].
- 25) Zorpas, A. A., Navarro-Pedreño, J., Panagiotakis, I. and Dermatas, D. (2021). Steps forward to adopt a circular economy strategy by the tourism industry. *Waste Manag. Res.: The Journal for a Sustainable Circular Economy*, 39(7), pp. 889-891.
- 26) World Bank (2025). *World Development Indicators*. [online] Available at: <https://databank.worldbank.org/source/world-development-indicators> [Accessed 15.05.2025].

FINANCIAL INCENTIVES TO SUPPORT CIRCULAR ECONOMY PRACTICES FOR ROMANIAN SMES: A COMPARATIVE ANALYSIS

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Abstract

The European Union is imposing increasing regulations on waste management, emission reduction, and resource efficiency. SMEs (small and medium-sized enterprises) that embrace the circular economy early will be better equipped to comply with these rules and avoid penalties or barriers to accessing European markets. Our study compares the circular economy practices of Romanian small and medium-sized enterprises with those of the European Union. The main findings indicate that Romanian SMEs are in the early stages compared to their EU counterparts, where the circular economy is already an integral part of business strategies. Additionally, we focus on the financial incentives that decision-makers provide to SMEs that implement circular economy practices. The primary emphasis of our study is on comparative data analysis between Romania and EU nations to identify the best models and learn from them. The findings reveal significant heterogeneity of circular economy policies among EU nations. Furthermore, Romania lags behind most examined countries in offering financial incentives to encourage SMES to adopt circular economy practices. Given that the enterprises analysed are SMEs, the sector in which these circular economy measures are most needed for improvement, we consider our findings to have substantial implications for the development of regulatory frameworks in Romania on this issue.

Keywords: *SMEs, circular economy, financial incentives, comparative analysis*

JEL Classification: L21

1. INTRODUCTION

The circular economy (CE) is a substitute for the traditional linear economy, which seeks to prolong the life cycle of products and materials through strategies such as sharing, leasing, reuse, recycling, remanufacturing, and sustainable design

(Geissdoerfer *et al.*, 2017; European Parliament, 2023). Due to their agility and innovation potential, SMEs play a critical role in implementing Circular economy practices at local and regional levels.

However, SMEs often face specific challenges, generated by both internal and external barriers (e.g. limited financial, human, and technological resources, risk aversion, legislative barriers), when transitioning toward circular models (Rizos *et al.*, 2016; Kirchherr *et al.*, 2018; Takacs *et al.*, 2022).

Although a growing body of research exists on the circular economy, the literature remains relatively fragmented in its specific analysis of financial incentives for SMEs. Most studies focus on large industries or general regulations, without providing sufficient empirical data on the concrete impact of incentive policies on SMEs during the ecological transition (Kirchherr *et al.*, 2018). Therefore, in-depth research is necessary to investigate the typology of effective incentives, the barriers faced by SMEs, and how these can be integrated into a coherent and sustainable policy framework.

In relation to previous aspects, the main objective of this paper is to identify the financial incentives available to Romanian SMEs adopting circular economy practices. We conduct this analysis after first attempting to ascertain the position of Romanian SMEs in implementing these practices compared to their counterparts in the European Union. Therefore, this paper has a largely descriptive role with some emphasis on comparisons between Romania and the European Union.

To achieve the paper's objectives, we begin by conducting a brief literature review, summarising the main findings from the literature regarding CE practices in SMEs. Next, we describe the methodology employed. Following that, we present the key results and discuss them. We conclude the paper with final remarks.

2. THEORETICAL BACKGROUND

The adoption of circular economy practices by SMEs may lead to superior environmental performance through increased energy and resource efficiency, as well as reduced waste (Dey *et al.*, 2002). In the literature, it has been shown that the most common CE practices among SMEs are waste reduction and recycling (Bassi and Dias, 2019; Sharma *et al.*, 2021), use of sustainable raw materials (Barón *et al.*, 2020) and Product-as-a-Service (PaaS) models and leasing (Linder and Williander, 2017; Vetrova and Ivanova, 2025; Ingle *et al.*, 2025).

A significant number of studies have discussed the barriers identified by firms in adopting circular economy practices, highlighting financial constraints and the lack of essential financial resources as key obstacles to their adoption (Demirel and Denisman, 2019; García-Quevedo *et al.*, 2020; Sartal *et al.*, 2020; De La Cuesta-González and Morales-García, 2022). However, the perception of barriers varies significantly depending on the types of activities implemented within the company. Firms that redesign the goods and services they provide to

minimise material usage perceive more barriers as important. In contrast, firms that implement activities related to waste reduction, energy consumption planning to minimise usage, and renewable energy adoption consider aspects related to administrative procedures and regulations as obstacles (García-Quevedo *et al.* 2020).

Financial incentives are recognised in the literature as a key factor in facilitating the smooth operation of SMEs' activities. These can take various forms: direct subsidies, low-interest loans, tax incentives, or public-private financing schemes (European Commission, 2020). However, Rizos *et al.* (2016) note that such programmes are often underutilised by SMEs due to administrative complexity and a lack of awareness.

Studies show that, especially for SMEs, financial support is decisive in the initial transition phase to circular economy, when implementation costs are perceived as high (Ghisellini *et al.*, 2016).

Recent literature highlights a diversity of approaches at national and regional levels regarding financial incentives. For example, Horizon Europe and the Structural Funds provide significant resources for eco-innovation in SMEs (European Investment Bank, 2022). However, the effectiveness of these instruments largely depends on the ability of SMEs to access and manage the funds, as well as on the alignment of economic policies with sustainability objectives (Caldera *et al.*, 2022). Bassi and Dias (2019) also emphasised that the business incentives and motivations to advance the transition towards a CE model may differ considerably, both qualitatively and quantitatively, depending on the sector, the company, and its geographical location.

Venture capital, private equity, green bonds, and sustainability-linked loans are emerging as significant instruments for circular economy practices. Several studies (Bocken *et al.*, 2016; Lüdeke-Freund *et al.*, 2019) indicate that investors are increasingly interested in circular economy innovations, particularly in sectors such as renewable materials and sharing platforms. The European Investment Bank provides financing opportunities for various circular economy projects and has a specific financing instrument aimed at SMEs in collaboration with local banks and other financial intermediaries (EIB, 2023). Additionally, alternative tools such as green leasing, product-as-a-service models, and crowdfunding are highlighted in recent case studies (Kalmykova *et al.*, 2018). A study conducted by Ghisetti and Montresor (2020) emphasised that inadequate access to finance is a significant obstacle to the adoption of circular economy practices, particularly for SMEs. The research suggests that addressing these financial barriers is crucial for promoting the widespread implementation of CE activities.

Analysing the types of financing sources targeting CE activities, it was observed that the traditional forms (debt and grants) have no or negative impact on the growth of SMEs, while equity finance (such as angel and venture capital investments) contributes positively to their development (Demirel and Denisman,

2019). Moreover, a study of Scarpellini *et al.* (2021) highlights that public subsidies are crucial for promoting renewable self-consumption and energy efficiency within the circular economy framework. The paper indicates that such financial support can mitigate investment risks and enhance the financial feasibility of circular economy projects.

3. METHODOLOGY

To achieve the purpose of this paper, we first considered analysing the data provided by the European Commission through reports on circular economy practices in SMEs from Romania. By analysing reports from several years, we formulate a series of conclusions regarding their evolution. Using graphic representations and the comparison method, we compare SMEs from Romania to those from the EU to highlight the gaps.

The next step was to search, list and analyse in detail the main financial incentives that SMEs from Romania can benefit from to stimulate them in implementing circular economy practices.

4. RESULTS AND DISCUSSIONS

4.1. Overview of the circular economy actions in SMEs

In 2015, 12.15% of EU firms did not undertake any substantive action to become more resource-efficient (European Commission, 2016), whereas in 2021, the percentage of inactive firms had decreased to 7.35% (European Commission, 2022). In 2015, 51.98% of European SMEs implemented between one and four actions, while 35.87% pursued more measures. Additionally, in 2021, 50.49% of these firms undertook between one and four actions, and the remaining 42.16% engaged in more than four actions.

In summary, 87.35% of SMEs took at least one of the CE actions in 2015, while in 2021, the active firms in the CE transition increased to 89% (European Commission, 2016; European Commission, 2022).

Compared to the evolutions from previous years, in 2024, most of the SMEs included in the survey declare that they are undertaking a range of resource efficiency measures. Therefore, 42% of SMEs from the European Union reported that they are undertaking five or more of the resource efficiency actions mentioned in the survey, 31% are undertaking three or four actions and 20% one or two actions; the remaining 6% of EU SMEs are not taking any action (European Commission, 2024). These comparative evolutions are presented in Figure 1.

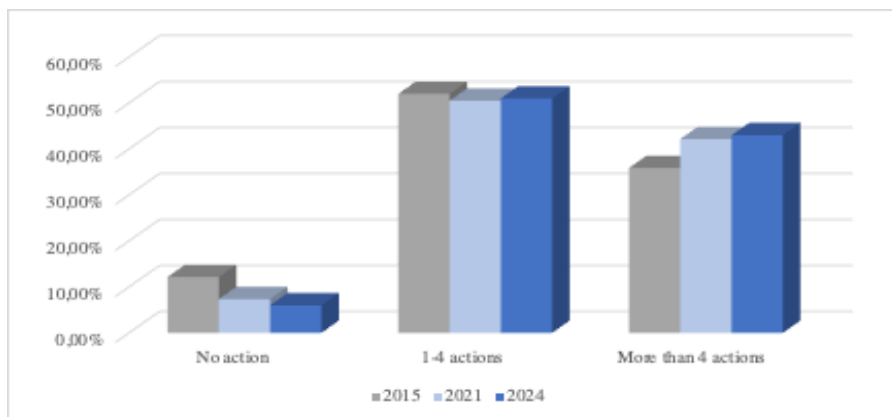


Figure 1. Number of CE actions taken by EU SMEs

Source: (authors' elaboration after data from European Commission (2016), European Commission (2022) and European Commission (2024))

These results show that CE actions are persistent over time, so that SMEs involved make the initial physical investments and the experiences accumulated in the CE management profitable.

Analysing the situation for Romania, the reports of the European Commission (European Commission, 2024) show that it is among the countries with the largest number of SMEs that do not take any action to be more resource efficient: Romania (16%), Estonia and Hungary (16%), Slovenia (18%) and Latvia (25). Another peculiarity is that in Romania (as well as in Latvia, Hungary and Sweden) a decrease in all measures adopted by SMEs was registered in 2024.

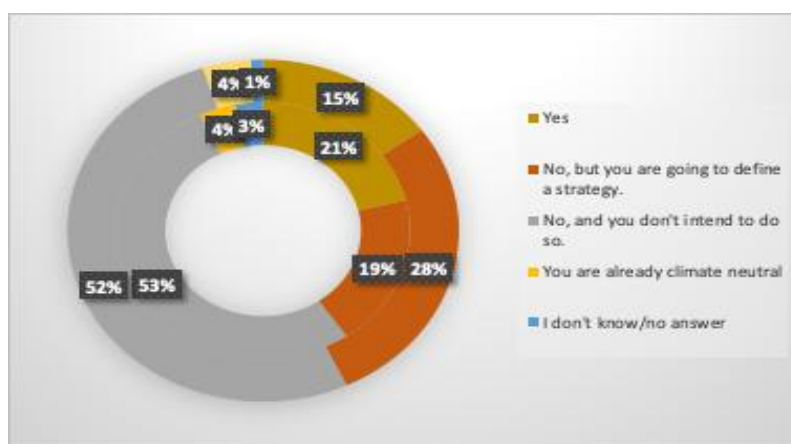


Figure 2. Strategies to reduce carbon footprint (% of SMEs)

Note: the external circle is for Romania, the internal circle is for the EU.

Source: (authors' elaboration after data from European Commission (2024))

When asked if their company has a concrete strategy to reduce its carbon footprint and become climate neutral or negative, 15% of SMEs from Romania said yes, compared to 21% of SMEs from the European Union. 28% of SMEs said they do not have a strategy, but they intend to define one. The highest share, 52% of SMEs in Romania, answered that they do not have a strategy and they do not intend to define one (see figure 2).

Therefore, the circular activities applied by the SMEs from Romania are still modest, as they also were a couple of years ago (Oncioiu *et al.*, 2018).

Regarding the financial side, the largest share of SMEs saying they rely on their own financial resources in becoming more resource efficient is obtained in Romania (86%). High shares are also registered for Austria (80%), Estonia, Greece and Slovakia (78%). In France, on the other hand, less than half of SMEs (42%) rely on their own financial resources. Furthermore, compared to 2021, there was a 6% decrease in the proportion of SMEs relying on external support to be more resource efficient (reaching 8%). These results highlight the need, in Romania, for targeted financial incentives to help SMEs adopt circular economy processes.

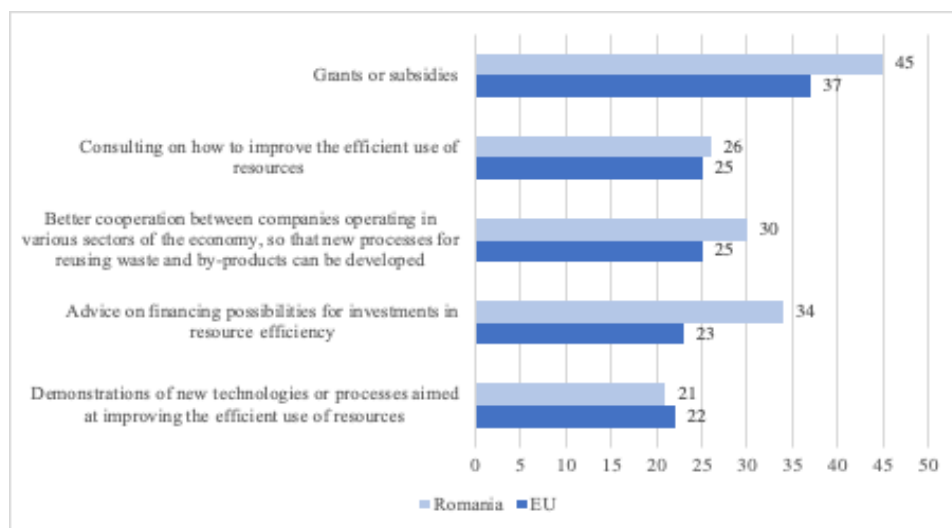


Figure 3. What instruments would most help the company in using resources more efficiently? (% of SMEs)

Source: (authors' elaboration after data from European Commission (2024))

Flash Eurobarometer 549 (European Commission, 2024) also focused on identifying which instruments would most help the SMEs use resources more efficiently. The top five answers to this question, in the case of Romania, showed that, almost half of SMEs mentioned grants and subsidies as instruments that would help them (45%), followed by consultancy on financing possibilities

available to SMEs to be invested in resource efficiency practices (34%), and better collaboration between companies from various sectors of activity (30%) (see figure 3).

In response to the question, what type of support would help you most to expand your range of green products or services? Half of the SMEs interviewed mentioned that financial incentives would help them in the development of new products, services or production processes. In second place as importance are marketing or distribution consulting services (mentioned by 39% of SMEs), and in third place are technical assistance or consulting in how to obtain new products, services or production processes (mentioned by 35% of SMEs) (see figure 4).

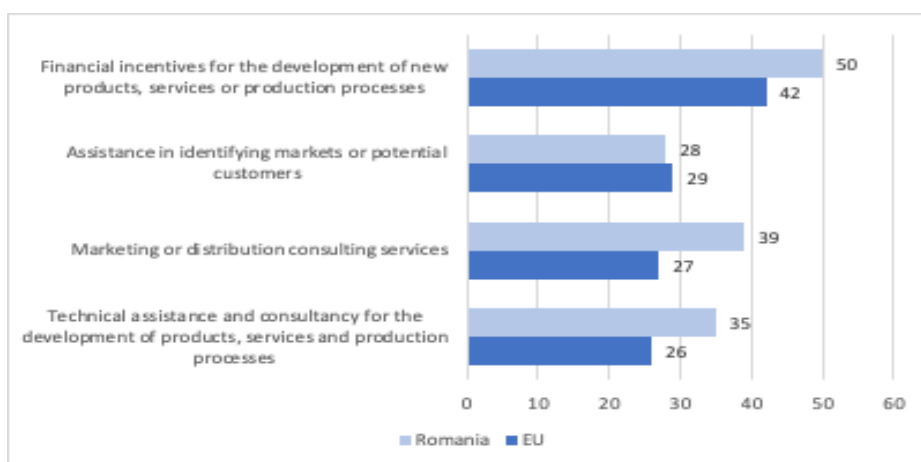


Figure 4. What type of support would help you most to expand your range of green products or services? (% of SMEs)

Source: (authors' elaboration after data from European Commission (2024))

These results show the significant role played by financial incentives in supporting SMEs in Romania in adopting circular economy practices. The transition to a green economy involves a profound change in the way companies operate, develop products and use their resources. However, these transformations involve significant costs, high initial risks and, often, a long payback period. In this context, financial incentives become a vital mechanism to accelerate the adoption of sustainable practices and encourage green innovation.

The results obtained above also highlight the vital need for consultancy related to the financing possibilities of these practices, as well as the efficient use of resources obtained within companies to expand the range of green products and services. Thus, specialised consultancy becomes a vital strategic resource, which allows companies to navigate in a complex, constantly changing environment. Access to green financing sources (grants, EU funds, sustainable lending instruments, public-private partnerships, etc.) requires a deep understanding of the

eligibility criteria, application procedures, and the national and European legislative framework. Companies that lack expertise in these areas risk losing valuable opportunities or not making the most of the available instruments. The efficient use of attracted financial resources is essential to ensure the real and sustainable impact of investments in green products and services. In the absence of a clear strategic plan, adapted to the company's sustainability objectives, there is a risk of inefficient allocation, fragmentation of efforts and even failure to achieve expected results. Through consulting, companies can develop sustainable financial and operational management mechanisms, relevant performance indicators and business models aligned with the requirements of the green market.

4.2. Brief review of the financial incentives available in Romania for SMEs and the main barriers in accessing them

In Romania, financial incentives for SMEs that adopt circular economy practices are diverse and come from several sources, including European funds, national programs and fiscal policies. In the following, we describe the main sources:

a. InvestEU Sustainability Guarantee

The European Investment Fund (EIF), in collaboration with Romanian banks, offers guarantees of around 500 million euros under the InvestEU Member State Compartment. This initiative aims to facilitate up to €700 million in financing for SMEs pursuing sustainable and circular economy projects. The participating banks are UniCredit Bank, Alpha Bank, Libra Internet Bank, BRD Groupe Société Générale, Patria Bank, Intesa Sanpaolo Bank, and Garanti BBVA. The guarantees enable these banks to provide improved financing terms, such as lower interest rates, reduced collateral requirements, and extended loan maturities, thereby enhancing access to finance for SMEs engaged in green and sustainable transformations (European Investment Fund, 2024).

The obstacles that SMEs may encounter in accessing this programme are due to the fact that, despite guarantees covering up to 80% of the loan value, SMEs must ensure their own contribution of at least 20%. For smaller SMEs, this requirement can pose a significant barrier, particularly in the context of limited financial resources. Furthermore, to benefit from the programme, SMEs must collaborate with partner financial institutions designated by the European Investment Fund. The availability of these partners and SMEs' familiarity with their procedures may differ, potentially making access to finance more challenging.

b. Regional Operational Programme (ROP) 2021–2027

This programme allocates substantial funds to support SME investments in various regions of Romania. It supports the implementation of the circular economy in SMEs through a series of specific measures, adapted to the regional and sectoral context. These measures aim to integrate circular economy principles into production processes, promote resource efficiency and reduce environmental impact.

The Regional Operational Programme provides for a series of specific measures to support the circular economy until 2027. These include: (i) investments in green and efficient technologies. SMEs can benefit from funding for: acquisition of equipment and technologies that support product design for durability, reparability and recyclability, implementation of solutions for the recovery and reuse of raw materials, materials and products, adoption of technologies for reducing greenhouse gas emissions and for producing energy with low carbon dioxide emissions; (ii) support for industrial symbiosis and the use of secondary materials. Funding is provided for: creation of industrial symbiosis networks, where waste or by-products of one enterprise become resources for another, and use of surpluses or secondary materials in the production processes of SMEs; (iii) developing skills in the field of circular economy by supporting professional training activities for employees, including: retraining and specialisation courses in the field of circular economy and developing technical and management skills necessary to implement circular solutions; (iv) support for research and innovation in the field of circular economy. SMEs can benefit from funding for developing new products and processes that integrate the principles of the circular economy and collaborations with research-development-innovation organisations to implement innovative solutions (Ministerul Investițiilor și Proiectelor Europene, 2021).

Although the amounts offered through this program could stimulate SMEs to increase the use of circular economy practices, a series of obstacles can also be mentioned: small SMEs do not dare to compete with larger companies, budgets per calls are limited so that only a part of those who apply obtain the funds, and the co-financing condition. SMEs must have their own contribution (co-financing) between 10 and 30%, which can represent a significant obstacle for micro and small companies.

c. De Minimis Aid Schemes

The Romanian government continues to implement de minimis aid schemes to support SMEs in various sectors, including those adopting circular economy practices. These schemes typically offer financial assistance covering up to 50% of eligible expenses for investments in green technologies, waste management systems, and energy efficiency improvements. The specific programs and their

details are announced periodically through official channels such as the Ministry of Finance and the Ministry of Economy.

d. State Aid for the Manufacturing Industry

The Romanian government has allocated 150 million euros in state aid for the manufacturing industry. This funding aims to support investments in sustainable manufacturing practices, including the adoption of circular economy principles. It has the following schemes: the state aid scheme for strategic investments in the manufacturing industry (2025–2030), the state aid scheme for the decarbonisation of industrial processes (2025–2030), the state aid scheme for small industrialists (2025–2030) and the state aid scheme for investments in biofuel production capacity (2024–2025).

These state aid schemes offer significant opportunities for SMEs in Romania that want to invest in sustainable technologies and processes. To benefit from these funds, projects must align with the decarbonisation and circular economy objectives, comply with the eligibility criteria, and are implemented within the established deadlines.

However, SMEs face challenges in accessing these state aid schemes. Many of the schemes focus on large-scale projects (e.g. investments of over EUR 150 million), making them unavailable to most SMEs. Additionally, SMEs may struggle to demonstrate the economic and environmental impact of the project, their capacity for co-financing, financial sustainability, and previous experience in circular economy projects. Although a significant portion of the project is covered by state aid (50–85%), SMEs must secure the remainder from their own resources or loans. Furthermore, SMEs are required to prove the availability of funds before approval.

Financial incentives are not only beneficial but essential for catalysing a functioning green economy. They allow companies to innovate, grow sustainably and actively contribute to protecting the environment and ensuring a sustainable future for society. But, although several programs and funding lines have been launched in recent years to support the green transition, SMEs in Romania face a series of systemic and operational obstacles that limit their effective access to these resources.

One such obstacle comes from the fact that information is often dispersed, difficult to understand and does not reach small entrepreneurs efficiently. Similar results were obtained by OECD (2021). SMEs, especially those in rural or non-technological areas, do not have easy access to sources of information on available grants or subsidies. Moreover, many companies do not understand the eligibility criteria or do not have the ability to quickly analyse the opportunity for financing in relation to their own business model. Other companies face a lack of specialised internal resources (development or funding departments), which makes them dependent on external consultancy, which is not always financially accessible.

Also, most of the time, the documentation required is extensive, technical and time-consuming, which is a major challenge for SMEs with limited staff. The fact that they do not have employees who are specialised in green transition reduces the number of resource-efficiency measures but also influences the number of actions that the SME was planning for the future (de Andrade *et al.*, 2025; Bassi and Dias, 2020; Yadav *et al.*, 2018).

Another major obstacle comes from the fact that sometimes guarantees, or co-financing are required that SMEs cannot support, especially in unstable economic contexts.

Selection and evaluation procedures can be slow, non-transparent and unpredictable, discouraging participation in competitive calls. Moreover, SMEs need stability to plan medium and long-term investments. However, in Romania, many funding programs are launched sporadically, with short deadlines and without a clear calendar, which affects strategic planning.

Legislative changes or criteria changed between calls represent another obstacle to SMEs accessing financial incentives and create uncertainty and a lack of trust in the public support mechanism.

On the other hand, for SMEs that manage to obtain funding; after obtaining it, they often face difficulties in effectively implementing the projects, due to a lack of qualified staff or inadequate internal procedures. Moreover, monitoring, auditing and reporting requirements can exceed the administrative capacity of a small company, putting pressure on existing resources.

SMEs in urban areas or developed regions generally have more access to support infrastructure, networks of consultants and information, while firms in rural or underdeveloped areas are more isolated and less competitive in attracting funds.

5. CONCLUSIONS

The main objective of our study was to analyse the circular economy practices employed by SMEs in Romania, compared to those in the European Union. We also aimed to highlight the financial incentives available to support SMEs in making the green transition. To achieve these objectives, we examined the data provided by European Commission reports and concluded that SMEs in Romania are lagging other member states of the European Union in terms of the green transition.

We also identified the main financial incentives available to SMEs in Romania focused on the circular economy, and we identified the main obstacles that arise in accessing them.

Therefore, the main conclusion of our study is that although some financial support programmes for companies have emerged in recent years with the aim of applying circular economy practices, many obstacles hinder SMEs from accessing them. Consequently, there is a need for increased information about their

availability, as well as consultancy services both for accessing these programmes and for using the funds after obtaining them.

Both literature and our findings indicate that, although various financing sources are available to SMEs for circular economy activities, challenges such as limited access to information, complex application procedures, and a lack of awareness hinder their effective utilisation. Addressing these barriers through targeted policies and support mechanisms is crucial to facilitate the transition towards a circular economy.

This is an initial study on this topic, driven by our research interests in this issue. In future research, we aim to expand this analysis by applying econometric methods to assess the impact of incentives and financial aid on the number of circular economy practices adopted by SMEs. Naturally, this will also rely on the availability of data.

References

- 1) Barón, A., de Castro, R., and Giménez, G. (2020). Circular economy practices among industrial EMAS-registered SMEs in Spain. *Sustainability*, 12(21), 9011.
- 2) Bassi, F., and Dias, J. G. (2019). The use of circular economy practices in SMEs across the EU. *Resources, Conservation and Recycling*, 146, 523-533.
- 3) Bassi, F., and Dias, J. G. (2020). Sustainable development of small-and medium-sized enterprises in the European Union: A taxonomy of circular economy practices. *Business strategy and the environment*, 29(6), 2528-2541.
- 4) Bocken, N. M., De Pauw, I., Bakker, C., and Van Der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of industrial and production engineering*, 33(5), 308-320.
- 5) Caldera, S., Hayes, S., Dawes, L., and Desha, C. (2022). Moving beyond business as usual toward regenerative business practice in small and medium-sized enterprises. *Frontiers in Sustainability*, 3, 799359.
- 6) de Andrade, R. D., Benfica, V. C., de Oliveira, H. V. E., & Suchek, N. (2025). Investigating green jobs and sustainability in SMEs: Beyond business operations. *Journal of Cleaner Production*, 486, 144477.
- 7) De La Cuesta-González, M., & Morales-García, M. (2022). Does finance as usual work for circular economy transition? A financiers and SMEs qualitative approach. *Journal of Environmental Planning and Management*, 65(13), 2468-2489.
- 8) Demirel, P., and Danisman, G. O. (2019). Eco-innovation and firm growth in the circular economy: Evidence from European small-and medium-sized enterprises. *Business Strategy and the Environment*, 28(8), 1608-1618.
- 9) Dey, P. K., Malesios, C., Chowdhury, S., Saha, K., Budhwar, P., and De, D. (2022). Adoption of circular economy practices in small and medium-sized enterprises: Evidence from Europe. *International Journal of Production Economics*, 248, 108496.
- 10) European Commission (2016). *Flash Eurobarometer 441. European SMEs and the circular economy – Report*, Publications Office, Directorate-General for Environment and TNS Political & Social. Available at: <https://data.europa.eu/doi/10.2779/397947> [Accessed 30.05.2025].

- 11) European Commission (2020). Funding opportunities for small businesses. Available at: https://commission.europa.eu/funding-tenders/how-apply/eligibility-who-can-get-funding/funding-opportunities-small-businesses_en [Accessed 30.05.2025].
- 12) European Commission (2022). *Flash Eurobarometer 498. SMEs, green market and resource efficiency*. Available at: <https://europa.eu/eurobarometer/surveys/detail/2287> [Accessed 4.06.2025].
- 13) European Commission. (2024). *Flash Eurobarometer 549. SMEs, green market and resource efficiency*. Available at: <https://europa.eu/eurobarometer/surveys/detail/3221> [Accessed 4.06.2025].
- 14) European Investment Bank (EIB). (2022). The innovation response. Activity Report 2021. Available at: https://www.eib.org/files/publications/eib_activity_report_2021_en.pdf [Accessed 3.06.2025].
- 15) European Investment Bank (EIB). (2023). The EIB Circular Economy Guide. Supporting the circular transition. Available at: https://www.eib.org/attachments/lucalli/20230140_the_eib_circular_economy_guide_en.pdf [Accessed 4.06.2025].
- 16) European Investment Fund. (2024). Romanian banks to get an additional €500 million in financing under new EIF guarantee agreements. Available at: <https://www.eif.org/InvestEU/news/2024/romanian-banks-to-get-an-additional-eur500-million-in-financing-under-new-eif-guarantee-agreements.htm> [Accessed 30.05.2025].
- 17) European Parliament (2023). Circular economy: definition, importance and benefits. [online]. Available at: <https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits> [Accessed 23.05.2025].
- 18) García-Quevedo, J., Jové-Llopis, E., and Martínez-Ros, E. (2020). Barriers to the circular economy in European small and medium-sized firms. *Business strategy and the environment*, 29(6), 2450-2464.
- 19) Geissdoerfer, M., Savaget, P., Bocken, N. M., and Hultink, E. J. (2017). The Circular Economy—A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757-768.
- 20) Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner production*, 114, 11-32.
- 21) Ghisetti, C., & Montresor, S. (2020). On the adoption of circular economy practices by small and medium-size enterprises (SMEs): does “financing-as-usual” still matter? *Journal of Evolutionary Economics*, 30(2), 559-586.
- 22) Ingle, M., Khati, K., and Dahiya, K. (2025). The Rise of Product-as-a-Service Models in the Digital Era: Redesigning Business Models for Circular Innovation. In *Innovating Sustainability Through Digital Circular Economy* (pp. 107-132). IGI Global Scientific Publishing.
- 23) Kalmykova, Y., Sadagopan, M., and Rosado, L. (2018). Circular economy—From review of theories and practices to development of implementation tools. *Resources, conservation and recycling*, 135, 190-201.

- 24) Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., and Hekkert, M. (2018). Barriers to the circular economy: Evidence from the European Union (EU). *Ecological economics*, 150, 264-272.
- 25) Linder, M., and Williander, M. (2017). Circular business model innovation: inherent uncertainties. *Business strategy and the environment*, 26(2), 182-196.
- 26) Lüdeke-Freund, F., Gold, S., and Bocken, N. M. (2019). A review and typology of circular economy business model patterns. *Journal of industrial ecology*, 23(1), 36-61.
- 27) Ministerul Investițiilor și Proiectelor Europene (2021). Programe Regionale 2021-2027. Available at: <https://mfe.gov.ro/programe-regionale-21-27/> [Accessed 30.05.2025].
- 28) OECD (2021). No net zero without SMEs: Exploring the key issues for greening SMEs and green entrepreneurship. OECD SME and entrepreneurship papers no. 30. Available at: https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/11/no-net-zero-without-smes_4780309d/bab63915-en.pdf [Accessed 10.06.2025].
- 29) Oncioiu, I., Căpușeanu, S., Türkeş, M. C., Topor, D. I., Constantin, D.-M. O., Marin-Pantelescu, A., & Ștefan Hint, M. (2018). The Sustainability of Romanian SMEs and Their Involvement in the Circular Economy. *Sustainability*, 10(8), 2761.
- 30) Rizos, V., Behrens, A., Van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., Flamos, A., Rinaldi, R., Papadelis, S., Hirschnitz-Garbers, M., and Topi, C. (2016). Implementation of circular economy business models by small and medium-sized enterprises (SMEs): Barriers and enablers. *Sustainability*, 8(11), 1212.
- 31) Sartal, A., Özcelik, N., and Rodriguez, M. (2020). Bringing the circular economy closer to small and medium enterprises: Improving water circularity without damaging plant productivity. *Journal of Cleaner Production*, 256, 120363.
- 32) Scarpellini, S., Gimeno, J. A., Portillo-Tarragona, P., & Llera-Sastresa, E. (2021). Financial resources for the investments in renewable self-consumption in a circular economy framework. *Sustainability*, 13(12), 6838.
- 33) Sharma, N. K., Govindan, K., Lai, K. K., Chen, W. K., and Kumar, V. (2021). The transition from linear economy to circular economy for sustainability among SMEs: A study on prospects, impediments, and prerequisites. *Business Strategy and the Environment*, 30(4), 1803-1822.
- 34) Takacs, F., Brunner, D., and Frankenberger, K. (2022). Barriers to a circular economy in small-and medium-sized enterprises and their integration in a sustainable strategic management framework. *Journal of Cleaner Production*, 362, 132227.
- 35) Vetrova, M. A., and Ivanova, D. V. (2025). "Product as a Service" Business Model in the Context of the Development of a Digital Circular Economy: The Transition to a Circular Economy. In *Multidisciplinary Analysis of Digital Transformation and Global Market Dynamics* (pp. 1-24). IGI Global.
- 36) Yadav, N., Gupta, K., Rani, L., & Rawat, D. (2018). Drivers of sustainability practices and SMEs: A systematic literature review. *European Journal of Sustainable Development*, 7(4), 531-531.

SECURITY OF DEVELOPMENT INTO A KNOWLEDGE-BASED SOCIETY: EASTERN EUROPEAN CASE

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Abstract

For the Eastern European region, the destructive impact of the Russian Federation becomes emblematic and characteristic, especially in the last decades after the fall of the Iron Curtain. The Covid-19 pandemic in the period 2020-22, as well the global economic crisis in recent years and the war of Russian Federation in Ukraine that began on February 24, 2022, put enormous pressure not only on the political class and elites, but also on individuals, families and society and practically disrupt established social patterns, including in a region such as Eastern Europe, characterized for several centuries by poverty, instability, insecurity, economic and conflict challenges. The states of Eastern Europe, from a political point of view, have become much more vulnerable to external military and hybrid threats, but also more affected by internal instability in the conditions of increasingly divided societies and political, economic, religious and social polarization. In the current situation, securing the development of such an unstable and vulnerable area as Eastern Europe becomes of enormous urgency. But contemporary development is inconceivable without the modernization of society and its transformation into a knowledge-based society. The mere existence of numerous sides, facets and aspects of security, including for the states of Eastern Europe, denotes the multiple implications and challenges specific to the field of security, in a society totally focused on knowledge. Therefore, it is necessary to mention that the issue of security of a knowledge-based society acquires important conceptual-methodological valences in correlation with the perennial general objective of humanity to survive both physically and culturally, or psycho-socially.

Keywords: Eastern Europe, knowledge-based society, security, survival, development

JEL Classification: O15, O30, O52, H56, F52

1. INTRODUCTION

The situation in Eastern Europe has been affected in recent years by several factors that have contributed to the increase of the insecurity. Such phenomena as the 2020-22 pandemic of Corona-virus Covid-19, as well the global economic crisis of recent years, and the large-scale war launched by Russian Federation in Ukraine in February 24, 2022, put enormous pressure not only on the political class and elites, but also on simple persons, on families and society and practically disrupt established social connections, including in a such region as Eastern Europe, characterized for several centuries by such challenges as instability,

insecurity, economic decay and conflicts (Sprincean, 2019). From a political point of view, the states of Eastern Europe have become in this period of time much more vulnerable to external military and hybrid threats, but also more affected by internal instability in the conditions of increasingly divided societies and political, economic, religious and social polarization (Albu, 2020).

In the current situation, securing the development of such an unstable and vulnerable area as Eastern Europe becomes of enormous urgency. But contemporary development is inconceivable without the moralization, modernization of society and its gradual transformation into a knowledge-based society (Battersby & Siracusa, 2009).

2. CHALLENGES FOR KNOWLEDGE-BASED SOCIETY

The knowledge-based society represents a stage in the evolution of contemporary society, based on a capitalist economy that transforms the knowledge process into a basic resource for progress (Pîntea, 2017). In such a society, knowledge becomes the main source of power, prestige and well-being, in a social, economic and political sense (Enicov, 2006). Knowledge also becomes the field in which jobs are generated. In a knowledge-based society, knowledge is also positioned as the main modality and method of action of the main social actors, in the context in which social progress becomes possible only by amplifying knowledge and by its immediate implementation (Sprincean, 2017). On the other hand, knowledge also plays the role of the main area of new social conflicts (Giddens, 1991). Without knowledge, governance and innovative social management become impossible as new decision-making approaches. In such a society, knowledge means innovation through an unprecedented stimulation of competition but also a criterion of national wealth, by capitalizing on the intellectual potential of the nation (Buzan, 2000).

In order to operationally delimit the knowledge-based society from other types of societies, which is an eminently post-industrial one, Daniel Bell, more than 50 years ago, proposed a restructuring of the economy into five sectors (Bell, 1973). Sector 1 refers to the direct exploitation of nature: agriculture, mining, forestry, fishing, hunting. Sector 2 included industry and was divided into two subsectors: the new industry subsector (electronics, production of computers, robots, automated means, IT) and the traditional industry subsector. The sector 3 delimited the field of economic services (transport, trade, storage, etc.), sector 4 - of social services (health, banking, insurance, tourism, etc.) and sector 5 - of information services (research and development, education, information collection and processing, management, etc.).

3. SECURITY IN THE EASTERN EUROPEAN REGION

For the Eastern European region, the destructive impact of the Russian Federation becomes emblematic and characteristic, especially in the last decades after the fall of the Iron Curtain in 90s of the XX century (Fukuyama, 2018). Thus, we can deduce that the notion of "Eastern Europe", today, in terms of international relations, includes several categories of states, in addition to the Russian Federation and Turkey, states geographically located only partially in Europe, but with a very different impact on the regional security (Cuşnir and Albu, 2018). Therefore, in order to order its common foreign policy and to face the challenges, the European Union included some of the states in the Eastern European region in the Eastern Partnership (EaP) initiative, which started as a good neighbourly project of EU with these states, without any clear and express prospect for them of joining the EU. As a result of this military conflict in Ukraine, the post-Soviet states in the region have suffered a strict polarization of their geopolitical relations, as well as their economic model (Frunzeti, 1999).

Russia's unprovoked war against Ukraine, which began in February 2022, calls into question the future of the EU's two-tiered Eastern Partnership (EaP) initiative. In this context, we would like to mention that Russia's war against Ukraine challenges the very geopolitical premise underlying the Eastern Partnership (EaP) (Sprincean, 2025b). On the other hand, the EU's granting of candidate status to Ukraine and to the Republic of Moldova in June 2022, while postponing the decision on Georgia's application for membership, undermines the main *raison d'être* of the EaP: to maintain the impossibility for states in this category to ever join the EU (Plotnic, 2022). Although the war in Ukraine could lead to a reformatting of the EaP, its fundamental features are likely to remain in place for some time to come (Gribincea, 1998).

The concept of Eastern Europe today also includes some of the EU member states, such as the Baltic states, Poland, Romania, Hungary, the Czech Republic and Slovakia, Greece, Slovenia, Bulgaria and Croatia. Eastern Europe also includes states from the Western Balkans region, such as some former Yugoslav states and Albania (Cristescu, 2012).

The enlargement of the EU in 2004 has generated profound processes that address its new eastern neighbourhood as part of the threats to the EU's security (Sprincean, 2024b). Within the framework of the European Neighbourhood Policy, the EU has developed a very large number of political, legal and financial instruments, designed to facilitate improved customs and border management in order to combat security threats. One of the most emblematic in this regard is the EU Border Assistance Mission to Moldova and Ukraine (EUBAM), established in 2005 (Chirtoacă, 2005).

The Eastern Partnership (EaP), as a joint initiative involving the EU with its Member States and six partner countries from Eastern Europe: Armenia, Azerbaijan, Belarus, Georgia, the Republic of Moldova and Ukraine, has

undergone a major transformation following the outbreak of the war in Ukraine in February 2022, with a major impact on the security sector in Eastern Europe (Coropcean, 2023).

Officially, at the level of state leadership, for now, Belarus and, to some extent, Georgia have moved much closer to the Russian Federation, supporting the geopolitical actions of V. Putin's regime, but other states such as the Republic of Moldova, Ukraine or Armenia and, to some extent, Azerbaijan, have recently distanced themselves from the policy pursued by the Russian Federation (Thakur, 1997).

When the Eastern Partnership was launched in 2009, the EU did not see its relations with the six Eastern Partners as a vehicle for extending its governance model further east than its formal borders (Popescu, 2021). The EU's main justification was the need to consolidate the consequences of the 2004 and 2007 EU enlargements, which had considerably expanded the EU's borders in the Eastern Europe, by developing a new relationship that went beyond the existing one under the European Neighbourhood Policy (ENP). This offered the Eastern Partners the opportunity to conclude deep and comprehensive free trade agreements.

The Eastern Partnership (EaP) also opened cooperation in new areas, such as good governance and democracy (Sprincean, 2025a), economic convergence with EU legislation, energy security and, to a lesser extent, foreign policy and defence (European Commission 2008). The EU was trying to propagate the enlargement model among the Eastern Partners, but without offering the Eastern Partnership countries a substantial level of financial support or a clear path for their accession to the EU.

According to the document – A Strategic Compass for Security and Defence (EEAS), which presents new objectives for the EU in the field of security and defense, with reference to cooperation with the EaP in the fields of defense and security, these objectives were pursued by providing military assistance to the Republic of Moldova and Georgia through the new European Instrument for Stability for Peace and by launching, in October 2022, the EU Military Assistance Mission in Ukraine, by allocating 16 million euros to support capacity-building of the Ukrainian armed forces (Juc and Ungureanu, 2011).

In March 2022, the three most advanced Eastern Partners – the Republic of Moldova, Ukraine and Georgia – applied for EU membership. In June 2022, EU leaders, following a record-breaking speedy preparation of an opinion by the European Commission, agreed to grant candidate status to the Republic of Moldova and Ukraine, while postponing the decision for Georgia, due to the implementation of a new political reform with questionable consequences on some basic democratic mechanisms in the country. Granting EU candidate status to Ukraine and the Republic of Moldova was mainly due to the need to

demonstrate solidarity with these two countries facing the most immediate threat from Russia.

The future of the Eastern Partnership will certainly depend on the outcome of the war between Ukraine and Russia. Unless Russia suffers a crushing defeat followed by a possible internal collapse, it is likely to remain a threat to the EU's Eastern Partners. In this context, to anticipate geopolitical changes in Europe, French President Emmanuel Macron launched, in May 2022, an initiative called the European Political Community (EPC). It aims to bring together all democratic European nations in a new space for political cooperation, security, coordination in the fields of energy, transport, investment, infrastructure and movement of people (Cervu and Cioranu, 2019).

This initiative is limited to being a discussion forum rather than a strong provider of policies and security. Its impact on the Eastern Partnership is limited, and it is unlikely to replace it (Juc, 2009). Granting the status of EU candidate countries to two or three Eastern Partners is likely to have a limited impact on the future of the Eastern Partnership. Compared to the candidate countries in the Western Balkans, the three Eastern Partners, despite their better performance in terms of economic policy, lag behind in terms of political and legal reforms.

After the collapse of communism and, especially after the dissolution of the USSR in 1991, due to the dominance of the West over the international system (Chulitskaya *et al.* 2022), the Eastern European states that joined the EU and NATO no longer had to face major threats to their national security (Huntington, 1998). Moreover, since some Eastern European states (all EU Eastern European member states except Cyprus and some states in the Western Balkans region such as North Macedonia and Albania) became members of NATO, they could say that they had achieved the highest level of national security they had ever had. They are part of the strongest alliance, with national security guaranteed by Article 5 of the Washington Treaty. In addition, by joining the EU in 2004 and 2007, the respective states obtained funds and development assistance, which is another very important element in the national security equation.

Due to the favorable international context and the low level of threat, these Eastern European states have designed and developed a minimal national security policy, based mainly on effort. Due to a very low defense budget, the approach of these Eastern European states was based on effort, primarily that invested in international missions, especially under the aegis of NATO and the EU, participating in various operations, many of them with a high degree of risk. The overall cooperation of the respective states with the West was also based on effort, including in other important areas, such as diplomacy or intelligence. In return for this effort, these Eastern European states benefited from the security umbrella of the West, obtaining a good level of protection, commensurate with the quieter times of that time.

Due to a combination of factors, we are currently witnessing a serious degradation of the stability of the international system, a degradation that generates serious threats to NATO member states in Eastern Europe as well. Russia's strong return to the world arena, especially through the extensive use of its military force, the impressive rise of China, the aggravation of regional issues, access to new technological solutions, against the backdrop of strategic errors by the West and structural weaknesses, all these factors have led to the revival of great power geopolitical competition. In order to guarantee a minimum level of national security, it is necessary to rely on knowledge. And this additional knowledge must be incorporated into the correct identification of threats to the states of Eastern Europe, in the appropriate treatment of vulnerabilities, in the reorganization of the national security system, in the preparation of the population for the new complicated international situation and, last but not least, in the development of special bilateral relations with certain states of the world, especially with the USA. Thus, in order to ensure and secure development in Eastern Europe, it is necessary to evolve from a national security based on effort to a higher quality one based on knowledge. This requires the remodelling of several pillars of national security, especially the academic and political ones.

The construction of strong scientific research institutions around international relations and national security can only be done by politicians. However, for this, the political class, the main responsible for national security, must accept and publicly recognize the increased degree of danger that the states in Eastern Europe are currently facing. Against this background, the political class must reaffirm the civilizational Westernness of those states in Eastern Europe that affirm their membership in NATO and the EU as the only viable solution for prosperity and national security. The political class must avoid politicizing national security institutions and build a bridge to true specialists, thus professionalizing national security policy. In this way, one can avoid the trap of solving false problems, which around 1940 brought many Eastern European states into the tragic situation of losing national territories.

4. SECURITY IN THE ERA OF KNOWLEDGE

Security is not a given, it is not a state to which you are entitled without doing anything. Security is a difficult and unsustainable, fluid and capricious construction, which you must always maintain and in which you must always invest, because you always need it (Sprincean, 2022). However, you cannot have security if you do not have power. Security is an important function of the system, but the system does not receive it ready-made but must rebuild it every day. You can never be fully secure if you do not manage to correlate and integrate into a whole the four major components of power: knowledge, heritage, that is, value systems, potential, vital interest (Suhrke, 1999).

The defining characteristic of modern knowledge-based societies is the production and use of new knowledge and information in conditions of rapid erosion, of free diffusion of information and development resources, often unofficial and unedited. As a result of massive and continuous innovative transformations, modern knowledge-based societies are becoming increasingly digitalized, marked by uncertainty, complexity and ambiguity (Aydin and Triantaphyllou, 2020).

True power lies in knowledge. The process of knowledge is a very complex one, which involves perception, representation, sensitivity, memory, intuition, capacity to assimilate and adapt to a dynamic environment, information, communication, databases, capability to move from one reference system to another, from one state to another and even from one dimension to another, value systems, connections, interdependencies (Panța, 2024).

Over thousands of years, man has made important progress in the knowledge, but he has remained very far from knowing and establishing a safe and viable security environment for his own evolutionary projects in the future. Man cannot access other environments if he does not know and understand their existential dimensions, if he does not communicate in real terms with them. Perhaps he is not yet ready to do so, since he has not reached that level of knowledge that would allow him to do so (Farwell and Hamre, 2012). Man does not know himself very well, not to mention the difficulty of knowing and understanding the complicated mechanisms and processes in which he lives.

For researchers who deal with analysing, evaluating and estimating the evolution of the national and international security environment, some events can be surprising, and the phenomena and processes that underlie the dynamics of this environment can have, and do have, unpredictable developments. In general, the degree of uncertainty regarding the dynamics of social phenomena is quite high.

The degree of uncertainty is not and cannot be the same for everyone. Uncertainty is inversely proportional to the level of knowledge and information, especially that of strategic and operational information. The pyramid of knowledge and that of uncertainty are opposites. However, they can provide a model for understanding the relationships that are created between the elements and events of the security environment. The reality of the security environment lies somewhere between the two extremes and varies depending on them. Uncertainty and certainty are defined by the conditional probability of events, and these events that concern and define the security environment are, in turn, to a large extent, a product of human action, that is, of political decisions that are supported by all kinds of interests, from vital ones to those of networks and various circles, groups, organizations, etc.

If certainty and uncertainty are inversely proportional, in the sense that the decrease of one depends on or implies the increase of the other, reality remains constant (Waever, 1995). It is not reality that influences the degree of certainty

and that of uncertainty, but knowledge of it. Reality is neither certain nor uncertain. It is only dynamic. Certainty and uncertainty are notions that define the way in which man knows reality, in its past, present and future dynamics. Of course, knowledge is an oriented process and not just an independent reality. In this case, knowledge becomes its own reality, especially in the conditions of the technical-scientific revolution.

The technical-scientific revolution of the last centuries determines the unprecedented development of sciences and technologies, the development of which is, obviously, exponential.

New technologies are increasingly productive, thus allowing companies to sell increasingly better products, at increasingly lower prices. This has the effect of increasing the accessibility of industrial goods for a much wider range of people (Sprincean, 2024a). The most attractive investments are those in the high-tech fields. In this way, companies become increasingly interested in innovation (Smith, 2005).

The development of ITC determines the increase in communication between people, the development of new types of businesses, the development of online information centers, etc. (Mârzac, 2025).

Society is gradually becoming much more alert to existing problems. The accessibility of information makes it much easier for individuals to inform themselves and express themselves. The importance of the individual as an independent entity is growing in the new society, based on knowledge.

5. CONCLUSIONS

Due to the development of science, more and more people are engaged in the development of new activities. The number of interdisciplinary research fields, frontier sciences, is growing exponentially.

Although high-tech products and the effects of scientific knowledge find their purpose quite quickly in the lives of people and communities, influencing their way of living, people and the communities they are part of continue to generate and maintain, in their lives and in the environment in which they live, dissymmetric and asymmetric mechanisms based mainly on interests, but also on values. The value systems, which define their identity, community and life, values are irreplaceable supports of duration, constitute only an area.

Values constitute the foundations of culture and civilization, of the unity of the world. They do not generate conflicts and wars, but only unity, duration and connection. They are not power, but support for power. There is no power where there are no values. And there are no values where there is no hoarded knowledge. But it is not values that generate action, but interests. People group themselves not only on the principle of values that connect them, but especially since interests that constitute motives, reasons for action. Motivation is very important; it is essential in human action. And interests, as motives or impulses of human action,

generate the political field, understood as a synthesis of interests, as an expression of the generation of the goals and objectives of effective human action. The decisive level of effective human action is the political one. Here, at this level, power is constituted.

Main goal of the knowledge-based society, in the context of securing its development, becomes the objective of not only formal democratization of social and political relations, but also the implementation of good practices and models of good governance. In this sense, the example of the states of Eastern Europe is a relevant one. Security, in this context, for a knowledge-based society, becomes a path, a fundamental condition, for achieving the general-human objective of survival but also of upward development, in the name of which possible conflicts, compromises or concessions are regulated in a sustainable security context, well-defined, rigorous, but also flexible, implemented situational depending on the optimal path for a concrete community towards achieving the general objective of sustainable and progressive survival.

References

- 1) Aydin, M., Triantaphyllou, D. (2020). A 2020 vision for the Black Sea region: The Commission on the Black Sea proposes. In: *Southeast European and Black Sea Studies*, September, pp. 373-380.
- 2) Albu, N. (2020). Controlul democratic asupra sectorului de securitate: cine pe cine supraveghează? In: *Studii naționale de securitate: Revistă științifico-practică*, no. 1, pp. 28-52.
- 3) Battersby, P., Siracusa, J. M. (2009). *Globalization and Human Security*. New York: Rowman & Littlefield Publishers.
- 4) Bell, D. (1973). *The Coming of Post-Industrial Society: A Venture in Social Forecasting*. New York: Basic Books Inc.
- 5) Buzan, B. (2000). *Popoarele, statele și teama. O agendă pentru studii de securitate internațională de după războiul rece*. Chișinău: Cartier.
- 6) Cervu, V., Cioranu, V. (2019). Regiunea Mării Negre, zonă a schimbărilor geopolitice. In: *Gândirea Militară Românească*, pp. 166-189.
- 7) Chirtoacă, N. (2005). Tranziția spre Democrație și Reforma Sectorului de Securitate în Moldova. In: *Moldova pe calea democrației și stabilității: din spațiul post-sovietic în lumea valorilor democratice*. Chișinău: Cartier, pp. 51-70.
- 8) Chulitskaya, T., Matonyte, I., Gudelis, D. and Sprincean, S. (2022), From Scientific Communism to Political Science: The Development of the Profession in Selected Former Soviet European States. In: *Opportunities and Challenges for New and Peripheral Political Science Communities. A Consolidated Discipline?* / Eds. G. Ilonszki and Ch. Roux. Cham, Switzerland: Palgrave Macmillan, Springer International Publishing. Chapter 3, pp. 51-85.
- 9) Coropcean, I. (2023). Organizarea sistemului de conducere în domeniul securității și apărării naționale în situații de criză. In: *Cohorta*. Revista de Istorie Militară, nr. 1, pp. 143-158.
- 10) Cristescu, C. (2012). *Reformarea domeniului de inteligență prin intermediul educației universitare și implicații asupra învățământului militar superior*: rezumat

- tz. dr. Coord. Toma Pleșanu. București: Ed. Universității Naționale de Apărare „Carol I”.
- 11) Cușnir, V., Albu, N. (2018). Repere conceptuale și fundamente politico-juridice ale politicii de securitate și apărare națională. In: *Akadosmos*. Revistă de știință, inovare, cultură și artă, nr. 4, pp. 78-87.
 - 12) Enicov, V. (2006). Consiliul Suprem de Securitate în Sistemul de Asigurare a Securității Naționale. In: *Consiliul Securității Naționale în procesul de luare a deciziilor. Analiză comparată: Republica Moldova, România și Ucraina*, Chișinău: Cartier, pp. 46-52.
 - 13) Farwell, J., Hamre, J. (2012). *Persuasion and Power: The Art of Strategic Communication*. Washington, DC: Georgetown University Press.
 - 14) Frunzeti, T. (1999). *Securitatea națională și războiul modern*. București: Ed. Militară.
 - 15) Fukuyama, Fr. (2018). *Identity: The Demand for Dignity and the Politics of Resentment*. Ed. Farrar, Straus and Giroux.
 - 16) Giddens, A. (1991). *Fate, Risk and Security*. In: A. Giddens „Modernity and Self-Identity: Self and Society in the Late Modern Age”. Cambridge: Stanford University Press.
 - 17) Gribincea, M. (1998). *Trupele ruse în Republica Moldova. Factor stabilizator sau sursă de pericol?* Chișinău: Civitas.
 - 18) Juc, V. (2009). Dificultăți teoretico-metodologice în pronosticarea încheierii Războiului Rece. In: *Revista de Filozofie, Sociologie și Științe Politice*. nr. 1, pp. 66-76.
 - 19) Juc, V, Ungureanu, V. (2011). Reconfigurarea structurii sistemului internațional după încheierea Războiului Rece. In: *Revista de Filozofie, Sociologie și Științe Politice*, nr. 2 (156), pp. 163-182.
 - 20) Huntington, S. (1998). Securitatea națională și relațiile civil-militare. In: *Armata și societatea: culeg. de texte de sociologie militară / Coord.: Ionel Nicu SAVA et al.* București: Editura INFO-TEAM, pp. 213-335.
 - 21) Mârzac, E. (2025). Strategic communication in security and defence: essential for crisis management and national cohesion. In: *Resilient Multicultural Societies in the Face of Hybrid Threats*. București: Eikon, pp. 70-88.
 - 22) Panța, R. (2024). Strategic communication – a tool to counter hybrid threats in the context of accession to the European Union. In: *Universitas Europaea: Towards a Knowledge Based Society Through Europeanisation and Globalisation: International Conference Proceedings, October 16th -18th, 2024, Chișinău, ULIM*, pp. 75-80
 - 23) Pinte, I. (2017). Necesitatea reevaluării sectorului de securitate și apărării. In: *Revista Militară. Studii de securitate și apărare*, nr. 1, pp. 20-27.
 - 24) Plotnic, Olesia, Mihaela Tofan, and Elena Ciochina (2022). "Efficiency of Legal Framework for Corporate Governance in the Republic of Moldova." *Corporate Governance in Central Europe and Russia: Framework, Dynamics, and Case Studies from Practice*, pp: 261-280.
 - 25) Popescu, C. (2021). Regiunea Mării Negre - Identitate geografică, geopolitică, geostrategică, geo-economică. In: *Gândirea Militară Românească*, no. 3, p. 228-247.
 - 26) Smith, K. H. (2005). *Measuring innovation*. The Oxford Handbook of Innovation, New York, US: Oxford University Press.

- 27) Sprincean, S. (2017). *Securitatea umană și bioetica*. Chisinau: Tipografia Centrală.
- 28) Sprincean, S. (2019). Insecuritatea umană în contextul securității naționale: oportunități de evaluare. În: *Riscuri și amenințări la adresa securității naționale: tehnici de analiză și evaluare*. Ghid metodologic. Chisinau: F.E.P. "Tipografia Centrală". Subchap. 3.5, pp. 105-114.
- 29) Sprincean, S. (2022). Sustainability of public policies for strengthening personal safety and human security in conditions of political instability in the East-European region. In: *Evaluation of Policies on Social Inclusion, Migration, in particular interventions related to integration*. The 2nd PROFEEDBACK Conference. 12-13.09.2022. PROFEEDbook2. COST Action CA20112 PlatfoRm OF policy Evaluation community for improvED EU policies and Better ACKnowledgement - PROFEEDBACK. University of Maribor, Slovenia, pp. 156-164.
- 30) Sprincean, S. (2024a). Deepening human security and industrial symbiosis in the context of the EU enlargement. In: *Industrial Symbiosis from a technical perspective: challenges and opportunities*. Bruxelles, September 10, 2024. Yecla, Spain: Technological Centre of Furniture and Wood of the Region of Murcia. COST Action CA22110 Cooperation, development and cross-border transfer of Industrial Symbiosis among industry and stakeholders (LIAISE), pp. 21-27.
- 31) Sprincean, S. (2024b). Human security priorities in new candidate states through the lens of the EU enlargement perspective. In: *Challenges of Plural Societies*. IPSA Research Committees' Colloquium. 28-31 mai 2024, Chișinău, USM. Chisinau: Centrul Editorial-Poligrafic al USM, pp. 34.
- 32) Sprincean, S. (2025a). Development of conceptual apparatus of the contemporary security studies for better analysis of securing good governance and democracy. In: *Election Integrity and the Quality of Democracy: Challenges and Pathways to Good Governance*. The work of the materials of the international scientific conference. Chisinau: CEP USM, pp. 110-123.
- 33) Sprincean, S. (2025b). Evoluția metodologiei de cercetare în studiile de securitate în contextul noilor provocări geopolitice. In: *Promovarea valorilor social-economice în contextul integrării europene*. Ed. 7. 6-7.12.2024, Chisinau. / coord. Șargu Lilia; Chisinau: USEM (Pulsul Pieței), pp. 542-553.
- 34) Suhrke, A. (1999). Human Security and the Interests of States. In: *Security Dialogue*, vol. 30, no. 3, pp. 265-276.
- 35) Thakur, R. (1997). From National to Human Security. In: *Asia-Pacific Security: The Economics-Politics Nexus*. / Eds. St. Harris and A. Mack. Sydney: Allen & Unwin, pp. 53-54.
- 36) Waever, O. (1995). Securitization and Desecuritization. In: *On Security*, edited by Ronnie D. Lipschutz. New York: Columbia University Press, pp. 46-86.

THE ROLE OF SOCIAL ENTERPRISES IN THE CIRCULAR BIOECONOMY

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Abstract

According to unofficial data based on the principles of social entrepreneurship in Bulgaria, over 85 non-governmental organizations are already operating at the local level. In most cases, they sell services that are associated with a high economic risk and do not generate a profit. An important feature of all social enterprises is the special symbiosis they establish a priori between financial profitability and the ability to achieve social impact. In this way, they achieve an economic, financial and social objective that brings them even more value and benefit for society. Depending on the sector in which they operate, social enterprises may function as providers of social and health services, educational and training institutions, employers of people from marginalized groups or of people with disabilities, or as entities engaged in production and marketing. Depending on their objectives, a social enterprise can aim to achieve economic development – through job creation and improving the well-being of target groups, work integration of socially disadvantaged people or marginalized groups, business orientation, and social protection. In this paper we explore the role of the forestry cooperative as a social enterprise in the circular bioeconomy.

Keywords: *social enterprise; forestry cooperative; circular bioeconomy; marginalized groups.*

JEL Classification: L31, Q01, Q57

1. INTRODUCTION

The transition toward a circular bioeconomy has emerged as a central element of the European Union's Green Deal and global efforts to address climate change, biodiversity loss, and resource scarcity. This paradigm shift seeks to replace the traditional linear economic model – based on extraction, consumption, and disposal – with regenerative systems that retain the value of products, materials, and resources in the economy for as long as possible. At its core, the circular bioeconomy emphasizes the sustainable use of renewable biological resources – such as forests, agricultural residues, or aquatic biomass – to produce food, materials, energy, and ecosystem services. However, realizing this vision requires more than technological innovation or regulatory intervention. It

demands inclusive economic models that actively involve communities, promote equity, and build local resilience.

In this context, social enterprises are increasingly recognized as key agents of transformation. These organizations blend business operations with a social mission, reinvesting profits to advance community well-being, environmental protection, and social inclusion. Unlike traditional profit-driven companies, social enterprises place people and purpose at the center of their activities. Their hybrid nature – operating between the market, the public sector, and civil society – positions them to respond effectively to local needs, particularly in marginalized rural and forest-dependent regions.

Socially driven business models are indispensable for ensuring that the bioeconomy serves not only environmental and economic objectives but also contributes to social sustainability. By fostering community ownership, enhancing access to employment and education, and enabling participatory governance, social enterprises can help anchor circular practices in the everyday lives of citizens. In contrast to large-scale bioeconomic initiatives that may risk recentralizing control over natural resources, grassroots social enterprises offer a bottom-up approach grounded in territorial knowledge and social cohesion.

In Bulgaria, the landscape of social enterprises is still emerging but demonstrates considerable potential. Although there is no formal legal definition of “social enterprise” in Bulgarian legislation, more than 85 registered non-governmental organizations (NGOs) function as *de facto* social enterprises. Many of these are small, community-based organizations working in rural or mountainous areas where state presence is limited and market opportunities are scarce. They typically provide services in areas such as social assistance, informal education, cultural preservation, environmental restoration, or employment of marginalized populations. Importantly, their activities are often characterized by high economic risk, limited financial return, and strong reliance on volunteer labor or public goodwill.

Despite these constraints, social enterprises in Bulgaria continue to fill vital social and environmental gaps. For instance, cooperatives in forest regions support firewood provision, forest maintenance, and local employment – services that would otherwise be inaccessible to vulnerable populations. In other cases, NGOs have initiated training centers for youth in remote areas, combining vocational education with ecological literacy and civic engagement. These initiatives demonstrate that profit is not the sole driver of economic activity – value creation in the circular bioeconomy can and should encompass social and environmental dimensions.

Globally, there is growing evidence that social enterprises contribute to all three pillars of sustainability: economic viability, social equity, and ecological responsibility. Studies from the OECD (2023), FAO (2021), and CIRIEC (2016) suggest that social enterprises are particularly effective in mobilizing local assets,

strengthening social capital, and promoting inclusive governance structures. In forest-based regions, where land and resource management is often contested, the legitimacy and accountability of social enterprises make them attractive partners in circular economy transitions.

Yet, the potential of social enterprises to contribute to the circular bioeconomy remains underexploited. One key reason is the lack of integrated policy frameworks that explicitly link the social economy with the bioeconomy and circularity agendas. While the EU's Social Economy Action Plan (2021) and the updated Bioeconomy Strategy (2018, revised in 2022) recognize the need for more inclusive approaches, national implementation in many member states – including Bulgaria – lags. Moreover, financial instruments designed to support innovation and green transition often fail to reach small, community-based actors due to bureaucratic barriers, limited awareness, or lack of technical capacity.

To overcome these challenges, a systemic approach is needed – one that embeds social enterprises in the design and governance of circular bioeconomy policies. This includes legal recognition of their status, tailored funding mechanisms, and cross-sectoral partnerships with municipalities, research institutions, and private sector actors. In the forestry sector, for example, cooperatives and community enterprises can play a central role in sustainable forest management, non-timber product development, and local energy systems. By integrating social innovation with circular practices, these organizations offer replicable models that align ecological integrity with social justice.

In summary, the transition to a circular bioeconomy is not merely a technical or industrial shift – it is also a social transformation. It challenges us to rethink not only how we produce and consume but also how we govern and share resources. Social enterprises, and particularly those embedded in forest and rural communities, have the potential to make this transformation more equitable, participatory, and enduring. Their role must be more than complementary – it should be central to the transition.

1. LITERATURE REVIEW

The integration of social enterprises in the circular bioeconomy has gained attention across Europe, particularly in rural and forest-based regions. According to the European Commission (2018), the bioeconomy encompasses the sustainable use of renewable biological resources for industrial and energy purposes, requiring inclusive governance and localized innovation. Social enterprises, defined by their dual mission to generate economic value and social impact, have been recognized as drivers of sustainability and community resilience (OECD, 2023).

Forest-based social enterprises, such as cooperatives, have been effective in addressing the 'triple bottom line' – economic viability, social equity, and environmental stewardship (FAO, 2021). They engage in sustainable forest

management, develop value chains from timber and non-timber products, and provide employment in marginalized rural areas. In the context of Central and Eastern Europe, studies show that such enterprises often emerge where state capacity is limited and civil society organizations step in to fill social and ecological service gaps (Borzaga & Galera, 2016).

Challenges include limited policy recognition, restricted access to financing, and lack of technical capacity. However, instruments under the European Green Deal, such as the Circular Economy Action Plan (EC, 2020), offer new opportunities for support.

Nicholls (2010) defines social entrepreneurship as the pursuit of social objectives through market-based approaches. Pires *et al.* (2021) argue that social enterprises are well-suited to address the challenges of sustainability transitions due to their hybrid nature. Studies from the Baltic region and the Balkans confirm the viability of cooperative forestry models in advancing both environmental and social goals.

2. DEFINING SOCIAL ENTERPRISES IN THE CONTEXT OF BIOECONOMY

Social enterprises are hybrid organizations that pursue both social and economic objectives. They operate in the space between traditional businesses and nonprofit organizations, combining the entrepreneurial spirit with a mission to create positive social and environmental outcomes. In practice, this means that social enterprises reinvest their profits back into their mission-driven activities rather than distributing them to shareholders. This reinvestment is often aimed at addressing systemic challenges such as poverty, unemployment, social exclusion, and environmental degradation.

In the context of the bioeconomy, social enterprises have a unique and strategic role. The bioeconomy relies on renewable biological resources from land and sea, such as forests, agricultural waste, algae, and organic residues. Social enterprises contribute by creating value from these resources in ways that are socially inclusive and environmentally sustainable. They often work at the grassroots level to support circular practices – extending the life cycle of materials, promoting zero waste systems, and enabling decentralized production models that benefit local communities.

Moreover, social enterprises bring participatory governance into the core of bioeconomic practices. Their community-based structures make them more responsive to local needs and environmental conditions. By engaging citizens in planning, production, and monitoring activities, social enterprises contribute to democratizing the green transition. This is especially important in rural areas, where top-down policy approaches may fail to recognize specific local constraints or opportunities.

Depending on their specific mission and operational model, social enterprises in the bioeconomy typically fall into the following categories:

- **Providers of social and healthcare services:** These organizations deliver essential services to vulnerable populations, often in underserved regions. In the bioeconomy, they may integrate health and nature-based services, such as therapeutic horticulture or eco-social farming.
- **Educational and training institutions:** These social enterprises provide vocational training, ecological education, and lifelong learning opportunities. They are key actors in building the green skills needed for the circular bioeconomy, from composting and permaculture to biomass processing and eco-design.
- **Employers of marginalized or disadvantaged groups:** One of the defining features of many social enterprises is their commitment to inclusive employment. In the forestry and bio-based sectors, this can involve training and employing long-term unemployed individuals, Roma communities, or people with disabilities in meaningful, sustainable work.
- **Producers and marketers of goods and services linked to the green economy:** These enterprises create eco-friendly products, such as organic food, herbal cosmetics, recycled wood products, or renewable energy solutions. Their business models are often built on principles of circularity, local sourcing, and transparency.

3. FORESTRY COOPERATIVES AS SOCIAL ENTERPRISES

Forestry cooperatives are a distinctive form of social enterprise that have historically contributed to rural development, natural resource stewardship, and community resilience. They are typically community-owned organizations that manage forests for the benefit of their members and local populations, often balancing multiple goals – economic viability, ecological sustainability, and social inclusion.

In many European countries, including Bulgaria, forestry cooperatives emerged in response to fragmented land ownership, marginalization of rural areas, and the need for collective action in forest management. These cooperatives are rooted in principles of democratic governance, member participation, and local accountability. They provide services such as forest thinning, harvesting, fire prevention, and reforestation, while ensuring that revenues stay within the community.

What sets forestry cooperatives apart is their ability to integrate circular economy principles into practice. For example, residues from wood processing are often repurposed for pellet or biochar production, contributing to renewable energy solutions. In some cases, cooperatives engage in agroforestry, sustainable tourism, or the collection and marketing of non-timber forest products (NTFPs) like mushrooms, herbs, and forest fruits.

In addition to economic activities, these cooperatives play an important social role. They often employ individuals from vulnerable backgrounds, provide on-the-job training, and foster intergenerational knowledge exchange about forest stewardship. Their embeddedness in the local context gives them the flexibility to adapt to changing ecological and social conditions.

The governance structure of forestry cooperatives usually includes an elected board of directors, general assemblies, and working groups or commissions on specific issues. Decision-making is typically transparent and participatory, reinforcing social cohesion and trust within the community. Furthermore, many cooperatives engage in partnerships with municipalities, NGOs, and research institutes to access funding, build capacity, and implement innovative practices.

4. ECONOMIC AND SOCIAL CONTRIBUTIONS

The contributions of forestry cooperatives as social enterprises are multifaceted. Economically, they generate income for members and employees, stimulate local value chains, and enhance rural development. Their operations often lead to the creation of stable, year-round jobs, especially in areas where employment opportunities are scarce.

Through activities such as sustainable logging, firewood production, and ecotourism, cooperatives provide both direct and indirect income streams. They also support the development of small-scale enterprises and cottage industries, such as woodworking, beekeeping, and herbal processing, which further diversify rural economies.

Socially, forestry cooperatives are key actors in promoting equity and inclusion. They often prioritize the employment of disadvantaged groups, including ethnic minorities, long-term unemployed individuals, and people with disabilities. By providing training and educational opportunities, they enhance local capacities and enable residents to participate more fully in the bioeconomy.

Many cooperatives reinvest a portion of their profits into community development projects – such as road improvements, school renovations, or reforestation initiatives – thereby generating positive externalities that extend beyond their membership. Their role in preserving cultural landscapes, local traditions, and biodiversity further underscores their societal value.

Overall, forestry cooperatives contribute not only to economic growth but also to the social fabric of forest-dependent communities. They embody a localized, inclusive, and regenerative model of development that aligns closely with the goals of the circular bioeconomy.

5. CHALLENGES AND OPPORTUNITIES

Despite their growing relevance, social enterprises – particularly forestry cooperatives – face numerous challenges that hinder their development and

scaling. One of the most significant barriers is the lack of formal recognition in national legal and policy frameworks. In Bulgaria, for instance, there is still no specific legal definition or status for social enterprises, which creates uncertainties regarding taxation, access to public funding, and participation in government programs.

Additionally, many social enterprises struggle with financial sustainability. Unlike conventional businesses, they often operate in high-risk sectors with thin profit margins. This is especially true in forestry, where upfront investments in equipment, training, and certification can be substantial. Access to finance remains limited, as traditional banks may view them as risky borrowers due to their social missions and limited collateral. While EU funding programs exist, navigating their application processes requires administrative capacity that many small cooperatives lack.

Institutional support structures – such as incubators, technical assistance providers, and social finance intermediaries – are underdeveloped in many rural regions. Social enterprises are frequently isolated, lacking networks or platforms to share knowledge, advocate for policy change, or form partnerships. This weakens their ability to innovate, attract investment, or scale their impact.

Human capital also presents a challenge. Many cooperatives rely on aging leadership, volunteer labor, or informal governance systems that are not easily transferable to younger generations. The limited availability of training in cooperative management, forest entrepreneurship, and circular bioeconomy practices further constrains their potential.

Despite these obstacles, significant opportunities are emerging. The European Union's policy landscape is increasingly supportive of both the social economy and the green transition. The Green Deal, the Circular Economy Action Plan, and the Social Economy Action Plan explicitly call for the inclusion of community-based and mission-driven enterprises in climate adaptation and rural revitalization strategies.

Funding instruments such as the European Social Fund+, Horizon Europe, and the LIFE program offer targeted support for innovation, skills development, and environmental sustainability. At the national level, rural development measures under the Common Agricultural Policy (CAP) can be tailored to include forestry cooperatives as beneficiaries for public investment, training, and technical support.

There is also a growing interest in impact investing and blended finance mechanisms that combine public and private capital to support social enterprises with measurable outcomes. Tools like social impact bonds, revolving funds, and cooperative banks can be adapted to the specific needs of forestry-based enterprises.

Moreover, digitalization and green technologies open up new pathways for transformation. For example, cooperatives can adopt GIS-based forest

monitoring, mobile applications for worker coordination, or online platforms for marketing local products. These innovations can enhance transparency, efficiency, and market access, especially for younger entrepreneurs attracted to sustainability-driven models.

In summary, while the road ahead is complex, forestry cooperatives and other social enterprises in the bioeconomy are well positioned to capitalize on a wave of supportive policies and technological advancements. Unlocking their full potential will require a multi-level approach involving legal reform, financial innovation, capacity building, and inclusive governance frameworks.

6. POLICY IMPLICATIONS

To fully leverage the transformative potential of social enterprises in the circular bioeconomy, targeted policy support is essential. Effective policy frameworks can address systemic barriers and create an enabling environment that fosters innovation, resilience, and inclusive development. These frameworks must reflect the hybrid nature of social enterprises, acknowledging both their economic role and their societal contributions.

First and foremost, there is a need for legal recognition. In many countries, including Bulgaria, the lack of a formal legal status for social enterprises hinders their ability to access public procurement, social investment, and state-supported programs. Establishing a legal definition and status – either through standalone legislation or amendments to cooperative laws – would provide clarity, visibility, and legitimacy to social enterprises. It would also allow governments to monitor and support their growth and ensure that they benefit from relevant policy instruments.

Second, access to finance must be improved. Social enterprises require tailored financial instruments that account for their unique business models. These may include patient capital, low-interest loans, grant funding, and blended finance solutions. National governments can support this through public guarantee schemes, impact investment incentives, and partnerships with cooperative banks or credit unions.

Third, capacity building is vital. Many social enterprises lack the managerial, technical, or strategic skills needed to thrive in the bioeconomy. Public agencies, universities, and civil society organizations should collaborate to deliver training in areas such as green entrepreneurship, circular business models, impact measurement, and cooperative governance. Technical assistance programs should also support digitalization and innovation adoption.

Fourth, social enterprises must be integrated into broader rural development and forest policy planning. They should be explicitly included in national and regional strategies related to forestry, climate adaptation, and sustainable development. Local authorities can facilitate this by creating territorial

partnerships, offering co-working spaces or resource centers, and supporting multi-stakeholder platforms for dialogue and coordination.

At the EU level, Member States should make full use of available tools such as the Social Economy Action Plan, the updated Bioeconomy Strategy, and the EU Rural Observatory. Cross-sectoral synergies can be enhanced through joint programming between environmental, agricultural, and social policy departments.

Finally, monitoring and evaluation mechanisms should be strengthened. Policymakers need robust data on the impact of social enterprises to guide funding, regulation, and replication. This requires developing national registries, supporting research, and encouraging participatory evaluation methods that reflect both quantitative and qualitative dimensions of social value.

In conclusion, policy interventions that combine legal clarity, financial innovation, skills development, and strategic inclusion will empower social enterprises to become key actors in the transition toward a circular and socially just bioeconomy.

References

- 1) Borzaga, C., & Galera, G. (2016). Social enterprises and their eco-system: A European mapping report. European Commission.
- 2) Brune, M., & Bansal, P. (2020). Social enterprises in the forest sector: Linking livelihoods and conservation. *Ecological Economics*, 174, 106664.
- 3) European Commission. (2018). A sustainable bioeconomy for Europe: Strengthening the connection between economy, society and the environment. [SWD(2018) 431].
- 4) European Commission. (2020). Circular Economy Action Plan: For a cleaner and more competitive Europe. Brussels.
- 5) European Commission. (2021). Social economy and the green transition. Brussels: Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs.
- 6) FAO. (2021). Social forestry enterprises in action: Strengthening community-based approaches for sustainable forest management. Rome: FAO.
- 7) Nicholls, A. (2010). The legitimacy of social entrepreneurship: Reflexive isomorphism in a pre-paradigmatic field. *Entrepreneurship Theory and Practice*, 34(4), 611–633.
- 8) OECD. (2023). Social enterprises in the green transition: Leveraging social innovation for inclusive climate action. OECD Publishing.
- 9) Pires, A. L., Martinho, G., & Domingos, T. (2021). Social enterprises in sustainability transitions: A conceptual framework. *Journal of Cleaner Production*, 280, 124841.
- 10) Westley, F., & Antadze, N. (2010). Making a difference: Strategies for scaling social innovation for greater impact. *Innovation Journal*, 15(2), 2–19.

LEGAL FRAMEWORKS FOR AN INCLUSIVE GREEN TRANSITION: CHALLENGES AND OPPORTUNITIES IN THE REPUBLIC OF MOLDOVA

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Abstract

The green transition is not only an environmental and economic imperative but also a legal and institutional one. The Republic of Moldova, being among the most climate-vulnerable countries in Europe, faces unique challenges in aligning its legal frameworks with sustainable and inclusive climate objectives. This article analyses Moldova's progress and gaps in building an inclusive green legal architecture. It examines major legislative instruments in energy, climate change, and adaptation, as well as the institutional reforms initiated after 2016 in alignment with EU standards. The research highlights the fragmented institutional landscape, the limited inclusion of vulnerable groups in decision-making processes, and the absence of climate litigation mechanisms. Key findings emphasize the importance of legal empowerment, decentralized adaptation, and capacity-building in local governments. The paper concludes with strategic recommendations, including the creation of environmental courts, liberalization of energy markets, legal safeguards for rural populations, and operationalization of national coordination bodies. Moldova's legal experience may serve as a reference for other transitioning economies seeking a socially just climate transformation.

Keywords: *climate governance, energy law, adaptation policy, institutional reform, Moldova*

JEL Classification: K32, Q28, Q48

1. INTRODUCTION

The Republic of Moldova faces a unique convergence of environmental, economic, and institutional vulnerabilities, positioning it among the most climate-sensitive states in Europe. According to the Notre Dame Global Adaptation Initiative (ND-GAIN) index, Moldova ranks lowest on the continent in terms of

its ability to cope with climate change risks. This ranking is not merely symbolic – it reflects the country’s high exposure to extreme weather events such as prolonged droughts, sudden floods, land degradation, and soil erosion, combined with limited institutional and infrastructural resilience (1).

The nation’s dependence on agriculture, which contributes significantly to GDP and employment – particularly in rural areas – exacerbates its vulnerability. Recurring climate events such as the droughts of 2007, 2012, and 2020 have not only reduced harvests but also triggered migratory patterns, food insecurity, and rising costs for adaptation in the agricultural sector (7). Moreover, Moldova’s energy infrastructure, much of it outdated and reliant on imported sources, is increasingly at risk due to heatwaves, floods, and other extreme weather events that impact transmission and distribution systems.

Recognizing the scale of these threats, Moldova has made considerable efforts in recent years to institutionalize climate adaptation and mitigation. One of the cornerstone documents in this process is the National Climate Change Adaptation Programme until 2030, approved by Government Decision No. 624/2023. This strategy sets forth a multisectoral and multilevel approach to climate resilience, targeting priority areas such as agriculture, water resources, public health, infrastructure, and disaster risk management. Its provisions call for enhanced monitoring and early warning systems, rehabilitation of critical infrastructure, integration of climate risks into local planning, and capacity building among local authorities and civil society.

The implementation of the programme relies on data-driven planning, public awareness campaigns, and close collaboration between national and subnational institutions. One of the notable innovations is the integration of nature-based solutions – such as afforestation, restoration of degraded lands, and promotion of agroecological practices – which are cost-effective and sustainable over the long term (6).

In parallel, Moldova has adopted the Low Emission Development Programme (LEDP) until 2030, via Government Decision No. 659/2023. This document outlines the roadmap toward decarbonization of key sectors, especially energy, transport, industry, and waste management. The LEDP promotes the development of renewable energy sources, enhancement of energy efficiency across residential and industrial sectors, and the creation of incentives for green technology uptake. Importantly, the LEDP is aligned with Moldova’s international commitments under the Paris Agreement, particularly its updated Nationally Determined Contribution (NDC) submitted in 2020, which aims to reduce GHG emissions by 70% by 2030 compared to 1990 levels.

These national strategies are reinforced by growing local government engagement. By mid-2024, 13 local public authorities had already developed and approved Local Climate and Energy Action Plans (LCEAPs), with support from the Ministry of Environment, the European Union, and regional development

programs. This localized governance approach allows for a better reflection of community-specific vulnerabilities and the design of tailored adaptation measures that reflect the socio-economic realities of each region.

Moldova's progress in climate governance is also supported by international partnerships and climate finance mechanisms. The country has accessed funds from the Green Climate Fund (GCF), the EU4Climate Programme, and the World Bank, which have enabled the launch of pilot projects in sustainable farming, solar energy, and resilient urban planning. These projects demonstrate a shift from isolated interventions to a coherent, cross-sectoral climate policy architecture, which is essential for systemic change.

In summary, Moldova's current policy landscape reflects a transition from reactive responses to climate events toward a proactive and integrated resilience strategy. The alignment of national plans with international frameworks, the involvement of local governments, and the mobilization of climate finance are all encouraging signals. However, the effectiveness of these strategies will depend on institutional continuity, transparency, and public participation. Climate vulnerability in Moldova is not only a scientific or technical challenge – it is a governance and equity issue. Ensuring that adaptation measures reach the most vulnerable populations, especially in rural and marginalized communities, remains a central priority for a truly inclusive green transition.

2. LEGAL ARCHITECTURE FOR THE ENERGY TRANSITION

Moldova's legal framework is designed around five energy policy pillars: decarbonization, energy efficiency, energy security, internal market integration, and innovation.

The main legal instruments that define this framework include:

- a) Law no. 107/2016 on electricity,
- b) Law no. 108/2016 on natural gas,
- c) Law no. 10/2016 on renewable energy (amended in 2023 to align with RED II),
- d) Law no. 139/2018 on energy efficiency,
- e) Law no. 461/2001 on petroleum products.

These laws provide the basis for Moldova's commitment to liberalization, market competition, and alignment with the EU acquis (13).

Since 2010, Moldova has been a Contracting Party to the Energy Community and has progressively transposed the EU's Third Energy Package into national legislation. Recent amendments have brought Moldova in line with the REMIT Regulation, promoting transparency and fairness in wholesale energy markets.

Moldova committed to a 27% renewable share by 2030, reducing GHG emissions by 68.6%, and capping final energy consumption at 2.8 Mtoe. Government Decision No. 401/2021 regulates renewable energy capacities, facilitating a predictable investment environment (14). To achieve these targets,

Moldova uses support schemes such as feed-in tariffs and renewable energy auctions. The government has approved capacity allocations for 230 MW of wind, 165 MW of photovoltaic, and additional capacity for biogas and biomass-based thermal electric centers (TECs). Government Decision No. 401/2021 caps the total renewable energy source (RES) capacity at 510 MW under support mechanisms, promoting a predictable investment environment.

With over 75% dependence on energy imports, Moldova has prioritized interconnectivity and diversification. In 2022, the country successfully synchronized with the ENTSO-E grid, enabling operational electricity exchange with Romania. Moldelectrica was officially designated as a Nominated Electricity Market Operator (NEMO) in April 2024 and is piloting a day-ahead market mechanism. Gas security improved with the completion of the Iași–Ungheni–Chișinău pipeline, though regulatory harmonization and capacity upgrades remain ongoing. Strategic gas reserves are being developed following amendments to Law 108/2016, introducing obligations for minimum storage and import diversification. Market liberalization continues under the supervision of the National Agency for Energy Regulation (ANRE), promoting transparency and competition (18, 15).

3. CLIMATE ADAPTATION AND LOCAL RESILIENCE

The National Adaptation Plan (NAP Moldova 2024) marks significant progress in decentralized adaptation planning. With support from the UNDP and the Green Climate Fund, 13 localities have developed and adopted Local Adaptation Plans. The operational national portal clima.gov.md provides real-time risk data and tools for public and institutional use. The Law on Meteorological and Hydrological Activity sets national standards for monitoring and early warning systems. Although sectors such as agriculture, water, and health have begun integrating climate resilience, disparities in implementation persist across regions (19, 5).

Recent legal reforms promote innovation and inclusiveness in the green transition. ANRE establishes new feed-in tariffs for renewable energy investments, including for energy communities and prosumers. Digital licensing platforms facilitate decentralized energy generation. Moldova, as a party to the Aarhus Convention, has a legal obligation to ensure environmental justice and public participation. However, participation in rural consultations remains below 20%, calling for legal aid and targeted reforms to enhance inclusion in energy decision-making and to uphold green rights for vulnerable groups (16, 20).

The draft Integrated National Energy and Climate Plan (PNIEC) 2025-2030, a document that represents a roadmap for achieving the country's decarbonization goals, was publicly consulted on 16 February 2024. The document was developed by the Ministry of Energy with the support of the European Union, provided

through the program "Addressing the Impact of the Energy Crisis in the Republic of Moldova", implemented by UNDP Moldova.

PNIEC sets targets on renewable energy, energy efficiency and greenhouse gas emissions. The plan is a legal commitment of the Republic of Moldova and only covers commitments concerning the territory controlled by the constitutional authorities. All member countries of the European Union and the Energy Community are developing such Plans with implementation until 2030, which are reviewed every 5 years in accordance with the Regulation on the Governance of the Energy Union and Climate Action (part of the "Clean Energy for All Europeans" package). Thus, by 2030, Moldova commits to a 27% share of renewable energy in final energy consumption; to maintain the growth of primary energy consumption at 3000 ktoe and final energy consumption at 2800 ktoe (2770 ktoe and 2592 ktoe respectively in 2022); to reduce greenhouse gas (GHG) emissions by 68.6% compared to 1990 (8, 17).

One of the critical challenges in Moldova's green transition is the fragmentation of institutional responsibilities across ministries and agencies. Despite the existence of national strategies, their implementation often suffers from lack of intersectoral cooperation and overlapping mandates. Strengthening the role of the National Council for Sustainable Development, along with permanent inter-ministerial working groups, could provide greater coherence (Iarmenco Mihaela, 2020). Regular capacity-building programs for civil servants and local government staff, particularly in climate finance, procurement of green infrastructure, and project management, remain underfunded and underutilized. Integrating climate competencies into the civil service curriculum and rewarding institutional performance in adaptation and emissions reduction are crucial steps to ensure results (4, 9).

4. GENDER, EQUITY, AND JUST TRANSITION PRINCIPLES

The inclusive green transition also requires a gender-sensitive and justice-based approach. Moldova's climate and energy frameworks acknowledge vulnerable groups, but implementation often fails to incorporate gender-disaggregated data, targeted outreach, and participatory design. Women in rural areas, elderly populations, and Roma communities are disproportionately affected by energy poverty and climate hazards. A just transition framework must integrate social protection policies, reskilling programs for carbon-intensive industries, and inclusive employment strategies in the renewable sector. International funding proposals submitted by Moldova should include clear equity indicators, and monitoring systems should track the social impact of mitigation and adaptation policies (World Bank (2022). Climate Risk Country Profile 6).

As environmental governance evolves, so does the need for legal redress mechanisms. Climate litigation has become an emerging tool in many jurisdictions to hold governments and corporations accountable for environmental

damage and policy inaction. Moldova lacks a dedicated environmental court or specialized chambers within its judiciary to handle such claims (Plotnic Olesea, 2022). Strengthening access to justice through capacity-building for judges, public interest litigation training for lawyers, and legal standing for NGOs can bridge this gap. Moreover, the inclusion of environmental rights in Moldova's Constitution or civil code reforms could solidify the legal basis for future claims (20).

Given its geographic position, Moldova is highly influenced by climate and energy dynamics in Ukraine, Romania, and the Black Sea region. Regional integration into energy markets and climate adaptation networks offers a strategic opportunity for Moldova to leverage technical know-how, financing, and shared infrastructure. Cross-border river basin management (e.g., Prut and Dniester rivers), joint disaster risk reduction exercises, and transboundary environmental impact assessments should be prioritized. The alignment of Moldova's legal instruments with EU directives on water, air quality, and biodiversity also strengthens its international credibility and preparedness for future EU accession (21).

5. INSTITUTIONAL CAPACITIES AND INTERSECTORAL COORDINATION. FUTURE OUTLOOK AND IMPLEMENTATION GAPS

One of the critical challenges in Moldova's green transition is the fragmentation of institutional responsibilities across ministries and agencies. Despite the existence of national strategies, their implementation often suffers from lack of intersectoral cooperation and overlapping mandates. Strengthening the role of the National Council for Sustainable Development, along with permanent inter-ministerial working groups, could provide greater coherence. Regular capacity-building programs for civil servants and local government staff, particularly in climate finance, procurement of green infrastructure, and project management, remain underfunded and underutilized. Success in Moldova's green transition will rely on robust accountability frameworks, alignment with EU legislation, transparency, and participatory governance. Strategic actions include enhancing climate litigation mechanisms and developing detailed secondary legislation (8, 17). Legal continuity, data transparency, and sustained international engagement remain vital.

To consolidate the inclusive legal framework for the green transition, the following strategic actions are recommended:

1. Institutionalize climate litigation and environmental courts
2. Integrate NECP objectives into all sectoral planning laws
3. Expand public legal education on environmental rights
4. Improve transparency in energy auctions and licensing

Securing adequate financing remains critical to Moldova's successful transition towards sustainability. Moldova has leveraged international climate finance mechanisms, including significant contributions from the Green Climate

Fund (GCF), the European Union's EU4Climate Programme, and the World Bank (5, 6). These financial streams have been pivotal for initiating pilot projects and larger-scale implementations of sustainable agricultural practices, renewable energy developments, and urban resilience programs.

However, effective utilization of these funds often encounters institutional and administrative hurdles. Enhanced transparency, clear governance mechanisms, and streamlined administrative procedures are needed to optimize these financial flows. Additionally, expanding national financial mechanisms, such as green bonds and sustainable investment funds, could attract private sector investment, promoting broader economic engagement in Moldova's green initiatives. Public-private partnerships (PPPs) have demonstrated significant potential in sectors like renewable energy and infrastructure. Yet, to fully harness this potential, Moldova must improve regulatory frameworks to protect investor interests and incentivize sustainable investments. Capacity-building initiatives aimed at equipping local institutions and businesses with the necessary financial and technical expertise are equally crucial.

Public education and awareness form the backbone of effective climate governance. Moldova's efforts in public engagement, however, need considerable strengthening. Despite various campaigns and local government initiatives, general awareness of climate issues remains relatively low. Targeted education programs at all academic levels – from primary education to higher institutions – should integrate sustainability and climate resilience topics. Community-level engagement strategies, particularly in rural and marginalized areas, are essential for fostering broad-based support and participation in climate policies. Effective communication strategies that clearly articulate the benefits of the green transition to the broader public can significantly enhance societal buy-in. Moreover, civil society organizations play a vital role in bridging the gap between governmental policies and community actions. Supporting and strengthening these organizations through capacity-building and adequate funding will amplify their impact in advocacy, education, and mobilization efforts.

Effective monitoring, reporting, and evaluation (MRE) systems are fundamental to ensuring transparency, accountability, and continuous improvement in Moldova's green transition efforts. While Moldova has initiated various MRE mechanisms, significant gaps remain in their comprehensiveness and reliability. Developing robust indicators aligned with international standards, and integrating these into existing national statistical frameworks, can significantly enhance Moldova's ability to track progress effectively. Transparent and publicly accessible reporting mechanisms, such as national climate dashboards and regular status reports, can improve accountability and public trust. International cooperation and partnerships in the MRE domain can also provide critical support through shared technical expertise, capacity-building, and financial resources. Moldova's integration into broader regional and international

climate governance frameworks further reinforces the importance of robust MRE systems.

6. FINAL REFLECTIONS AND LONG-TERM PERSPECTIVES

In reflecting upon Moldova's inclusive green transition journey, several key insights emerge. Legal and institutional frameworks have significantly advanced, laying a strong foundation for future progress. However, sustained success requires ongoing commitment to equity, transparency, and comprehensive community engagement. Future policy and governance efforts must emphasize systematic integration of climate considerations across all sectors. Strengthening the judicial and legal systems through the establishment of specialized environmental courts and enhancing legislative support for vulnerable communities will be essential in ensuring equitable outcomes.

In conclusion, Moldova's ongoing green transition underscores a critical balance between national aspirations and international commitments. By maintaining a strong focus on inclusivity, resilience, and effective governance, Moldova can achieve meaningful and lasting sustainability outcomes, providing valuable lessons for similar transitioning economies globally.

References

- 1) ND-GAIN (2023). Notre Dame Global Adaptation Index Country Rankings. Available at: <https://gain.nd.edu/our-work/country-index/> [Accessed 10 Jun. 2025].
- 2) Government of the Republic of Moldova (2023). DG nr. 624/2023 on the national climate change adaptation programme by 2030. Monitorul Oficial al Republicii Moldova, nr. 378.
- 3) Government of Moldova (2023). Hotărârea Guvernului nr. 659/2023 privind Programul de dezvoltare cu emisii reduse până în anul 2030. Monitorul Oficial al Republicii Moldova, nr. 386.
- 4) Government of Moldova (2016). Law no. 136 regarding the reorganization of the central public administration. Monitorul Oficial al Republicii Moldova, nr. 253–264.
- 5) UNDP Moldova (2023). Strengthening Moldova's Climate Resilience. Available at: <https://www.undp.org/moldova> [Accessed 10 Jun. 2025].
- 6) World Bank (2022). Climate Risk Country Profile: Moldova. Available at: <https://climateknowledgeportal.worldbank.org/country/moldova> [Accessed 10 Jun. 2025].
- 7) UNFCCC (2020). Republic of Moldova Updated Nationally Determined Contribution. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Republic%20of%20Moldova%20First/Moldova_NDC_2020.pdf [Accessed 10 Jun. 2025].
- 8) Government of Moldova (2025). Hotărârea Guvernului nr. 86/2025 privind Planul Național Integrat în domeniul Energiei și Schimbărilor Climatice 2025–2030. Monitorul Oficial al Republicii Moldova, nr. 57.

- 9) Government of Moldova (2017). Legea nr. 136 privind reorganizarea administrației publice centrale de specialitate. Monitorul Oficial al Republicii Moldova, nr. 253–264.
- 10) UNDP Moldova (2023). Strengthening Moldova’s Climate Resilience. Available at: <https://www.undp.org/moldova> [Accessed 10 Jun. 2025].
- 11) World Bank (2022). Climate Risk Country Profile: Moldova. Available at: <https://climateknowledgeportal.worldbank.org/country/moldova> [Accessed 10 Jun. 2025].
- 12) UNFCCC (2020). Republic of Moldova Updated Nationally Determined Contribution. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Republic%20of%20Moldova%20First/Moldova_NDC_2020.pdf [Accessed 10 Jun. 2025].
- 13) Energy Community Secretariat (2022). Decision 2022/02/MC-EnC on Moldova’s Energy Targets. Available at: <https://www.energy-community.org> [Accessed 10 Jun. 2025].
- 14) Iarmenco Mihaela, Donos Evlampie, Plotnic Olesia, (2020), Promotion of renewable energy in the European Union, International Conference on “European Finance, Business and Regulation-(EUFIRE 2020), pp. 709-716
- 15) Platonic Olesia, Popescu Lucia (2022), Climate change and sustainable development: issues for international trade system, European Finance, Business and Regulation. Challenges of Post-Pandemic Recovery. Proceedings of the International Conference EUFIRE 2022, 313
- 16) Government of Moldova (2021). Hotărârea Guvernului nr. 401/2021 privind mecanismele de sprijin pentru producerea energiei din surse regenerabile. Monitorul Oficial al Republicii Moldova, nr. 198.
- 17) ANRE Moldova (2024). Decizia nr. 468/2024 privind tarifele reglementate pentru energia electrică din surse regenerabile. Available at: <https://www.anre.md> [Accessed 10 Jun. 2025].
- 18) Government of Moldova (2024). Legea nr. 225/2024 privind mecanismul cu privire la spațiile de testare inovativă în materie de reglementare în domeniul energiei. Monitorul Oficial al Republicii Moldova, nr. 380-382.
- 19) Government of Moldova (2024). Legea nr. 74/2024 privind acțiunile climatice. Monitorul Oficial al Republicii Moldova, nr. 68.
- 20) Moldelectrica (2024). Market Operator Designation and Market Coupling Initiatives. Available at: <https://moldelectrica.md> [Accessed 10 Jun. 2025].
- 21) Clima.gov.md (2024). Platforma Națională pentru date climatice. Available at: <https://clima.gov.md> [Accessed 10 Jun. 2025].
- 22) European Union (2021). Regulation (EU) 2021/1119 - European Climate Law. Official Journal of the European Union, L243/1.
- 23) Energy Community (2023). Moldova Country Profile. Available at: <https://www.energy-community.org/implementation/Moldova.html> [Accessed 10 Jun. 2025].

REGULATORY FLEXIBILITY AND EXPERIMENTATION IN THE CIRCULAR ECONOMY TO PROMOTE EFFECTIVE COMPETITION FOR THE BENEFIT OF CONSUMERS

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Abstract

The lack of an accelerated innovation process is more relevant than ever for the development of the global economy, which has been characterised by a low level of innovation in recent decades. The ability to develop innovative products, services and business models creates social value and is essential for maintaining competitiveness, which ultimately benefits consumers.

Given that almost half of the CO₂ emission reductions required by 2050 will have to come from technologies that are not yet available on the market, a significant innovation effort will have to be launched within this decade. Regulatory flexibility and experimentation in the circular economy will be essential to encourage the development, testing and deployment of breakthrough solutions and ensure that the EU remains at the forefront of sustainable innovation and global competitiveness.

Key challenges in advancing the circular economy and achieving climate neutrality lie in striking a balance between encouraging innovation and ensuring robust consumer protection. One promising approach is the establishment of a Circular Economy Sandbox, which is a regulatory innovation space designed to test new models and technologies under controlled conditions. Any proposed project must demonstrate that consumer protection will be ensured throughout the implementation phase to be approved. The Sandbox operates under strict ethical and environmental standards to ensure that all innovations align with sustainability principles and respect consumer rights.

The article provides a basis for in-depth discussions on the development and implementation of transformative strategies in the circular economy sector. Key transformations such as digitalisation, decentralisation, decarbonisation, sustainability, consumer empowerment, innovative financing, low-carbon gases, circularity, sustainable raw material supply and carbon removal require extensive research, regulatory experimentation and innovation to drive effective and sustainable solutions.

Keywords: circular economy; regulatory flexibility; regulatory sandbox; innovation; consumer protection; sustainability; competition policy; climate neutrality

JEL Classification: K38, K38, Q 54

1. INTRODUCTION

A regulatory sandbox is a regulatory framework that allows market participants to test new services or models with live customers, subject to certain safeguards and oversight. Sandboxes help to develop and test market innovations, achieve legal security, and foster innovation and regulatory learning. Sandboxes have gained prominence as an intervention across the world. Currently, 73 regulatory sandboxes are operational across 57 jurisdictions. FinTech is the area in which regulatory sandboxes are most used. The first sandbox was implemented in the United Kingdom in 2016. It offered fintech enterprises a less rigorous environment in which to innovate while being supervised.

In accordance with the *Regulatory Sandboxes: A Practical Guide for Policymakers* (Michael Rizzo, 2021) the advantages of operationalising sandboxes are follows: (i) regulators can obtain first-hand empirical evidence on the implications of emerging technologies; (ii) innovators and companies can develop a better understanding of the regulations governing their products and adapt them accordingly; (iii) sandbox participants can also test their products' viability without the need for a larger, more expensive rollout. While up to 80% of products' environmental impacts are determined at the design phase, the linear pattern of "take-make-use-dispose" does not provide producers with sufficient incentives to make their products more circular. Many products break down too quickly, cannot be easily reused, repaired or recycled, and many are made for single use only. (European Commission, 2012)

The new Circular Economy Action Plan, titled *For a Cleaner and More Competitive Europe*, puts consumers at the heart of the transition towards sustainable growth and the EU's goal of achieving climate neutrality by 2050. Circular strategies can reduce emissions by 9.3Gt CO₂e in 2050, around 40-45% of emissions from the production of goods. (Johan Rockström *et al.*, 2018). Moreover, (Ghisellini *et al.*, 2016, p.19) emphasize that "the promotion of consumer responsibility is crucial," while (Lieder and Rashid, 2016, p.45) highlight that circular supply chains should account not only for production and distribution, but also for consumption processes.

Consumers play a pivotal role in enabling circular business models (Gallaud and Laperche, 2016), making the consumer perspective an essential counterpart to the innovative business model aspect of the circular economy. The innovation performance of the EU has increased by 8.5 percentage points since 2016. Between 2016 and 2023, performance differences among the 27 Member States have become somewhat smaller. (European Innovation Scoreboard 2023)

Demand is an important driver of innovation. Trust is important for developing the idea of a circular economy sandbox that uses consumer demand to drive innovation. This sandbox would have a built-in feedback mechanism to test and refine eco-innovative products in a real yet protected environment. This study highlights that circular innovation involves more than just supply-side efforts, it critically depends on consumers' willingness to adopt and maintain sustainable behaviours.

2. DATA AND METHODOLOGY

In order to fulfil the objective of this article, which is to evaluate the significance of the circular economy as an approach to sustainable development policies and the development of innovations in this area based on consumer interests and rights protection, primary information on the circular economy was gathered from official European Commission websites, specialized digital journals and other pertinent sources.

This analysis uses an interdisciplinary approach, combining EU legal instruments, doctrinal analysis, examination of good practices and assessment of the impact of environmental regulations on consumer rights effectiveness. The research draws on legal sources at EU, national and international levels, as well as on relevant regulatory sandbox practices in other countries. From a practical standpoint, the creation of a regulatory circular economy sandbox is inspired by a thorough review of various regulatory sandbox concepts (Australia, Dubai, India, etc.).

In addition, the methodology integrates comparative analysis and desk research techniques to identify transferable elements and contextual barriers for implementing circular economy innovation frameworks tailored to consumer needs. Furthermore, the research employs a multi-level governance approach to examine how consumer protection objectives can be incorporated into experimental regulatory frameworks without compromising legal certainty or market integrity. This layered methodology enables both conceptual exploration and the formulation of policy-relevant recommendations for advancing a consumer-centric circular economy through innovative regulatory instruments.

3. REVIEW OF THE LITERATURE

Introducing a regulatory sandbox in the circular economy sector will offer significant benefits to innovative companies and entrepreneurs looking to implement experimental projects, as well as to foreign investors who are attracted by a more flexible regulatory framework. The resulting influx of foreign investment will generate broader positive impacts on the sustainable economy, including boosting GDP, creating jobs and fostering a higher level of innovation.

The sandbox approach originated in the financial technology sector and has since begun to be adopted in healthcare for the development of regulatory policies relating to innovative technologies. Sandboxes are being used increasingly in healthcare regulation to facilitate the development of policies, methods, and processes for innovative and disruptive health technologies. This approach has considerable potential for use in low- and middle-income countries (Emily Leckenby *et al.*, 2021).

An overview of global sandbox programmes in the financial sector notes that they enable innovations aimed at consumers to be tested under lighter regulation, thereby improving regulatory oversight and consumer protection. Although these core principles, regulated experimentation, built-in consumer protection and data-driven policymaking, are focused on financial technology, they can be applied directly to circular economy sandboxes involving packaging, reuse and resource recovery (Ryan Nabil, 2022). In addition to the benefits, each testing framework should incorporate mechanisms that fulfil the general regulatory objectives, particularly those relating to consumer protection. Gertraud Leimüller *et al.* (2020) emphasises that sandboxes must include safeguards for health, consumers and the environment.

By creating innovative circular products and circular business models from scratch, entrepreneurs can offer efficient and coordinated solutions to environmental problems (Blomsma *et al.*, 2023). However, how entrepreneurs design circular products and business models in parallel, given their complete freedom of design, remains largely unknown (Blomsma *et al.*, 2023). In his work, Henry Willem Müller (2025) analyses the application of the sandbox model in the circular economy. He concludes that five out of a total of 15 analysed projects made intensive use of the Circular Systems Sandbox mechanism. Empirical results demonstrated superior performance compared to projects that applied alternative tools, particularly in terms of design consistency, business model viability and reduction of rebound effects.

Circular economy sandboxes allow innovative business models, such as reusable packaging and waste-to-resource systems, to be tested in the real world within a controlled regulatory framework that encourages innovation and fosters competition. These environments are designed with built-in safeguards, including defined coverage limits, continuous monitoring, and clear exit strategies, to protect consumers and prevent potential risks.

4. THE CHALLENGES ASSOCIATED WITH THE CIRCULAR ECONOMY SANDBOX

4.1. Constraints in the implementation of innovations within regulatory sandboxes

It is important to note that pilot approaches are sometimes used in EU countries to experiment with innovation in the areas described below. However, only the 'innovative testing project or regulatory sandbox' approach delivers the benefits.

Participation constraints. The analysis of innovation developments has highlighted several issues relating to participation in innovative testing projects. In general, large enterprises have found it easier to engage in such projects, while smaller enterprises may be excluded. Smaller businesses have faced multiple challenges in participating, including a lack of awareness of existing innovative testing programmes, confusion regarding their objectives and outcomes, and limited internal capacity to develop, implement and comply with the associated regulatory requirements.

Promoting innovation in business. Consequently, while many sandboxes have enjoyed some degree of success, others have faced bottlenecks and challenges, including failing to encourage firms to participate (The World Bank, 2020). This is one of the two main objectives of innovative testing projects, and the intention to derogate from the existing regulatory framework is most frequently requested for this purpose. Such derogations are often sought to create a more flexible environment for experimentation, particularly where traditional regulations may hinder the development or testing of novel approaches. Innovations and regulatory experiments are expected to become more prevalent in the field of reused, repaired or recycled products and materials, where existing legislation may not adequately support circular business models. These areas often involve complex value chains and cross-sectoral compliance requirements, necessitating the temporary relaxation of certain rules to facilitate the testing of innovative solutions (Iarmenco Mihaela, 2020).

Distortion of competition. The most frequently discussed risk associated with innovative testing projects is that they usually permit regulatory exemptions for certain businesses, but not for all market participants. This can lead to market distortions. If these distortions are maintained for too long, they can disrupt fair competition. Furthermore, businesses participating in such projects generally incur lower compliance costs, which gives them an implicit advantage. This could not only distort competition with existing market players, but also create higher barriers to entry, even after the project concludes.

To mitigate this risk, the regulatory framework for innovation should incorporate transparent eligibility criteria, transparent and objective selection procedures, and clear and robust knowledge-sharing obligations.

The need for a legal framework. A regulatory framework for innovative testing projects should define the conditions under which exemptions may be granted and specify the criteria for evaluating such requests. These evaluation criteria would ensure that applicants meet the minimum requirements for safe and appropriate testing activities. Applications for projects should be subject to a criterion stating that the applicant has consulted with relevant stakeholders.

4.2 Designing a Sandbox

Sandboxes are useful for boosting innovation and providing regulatory guidance. Designing and operationalising sandboxes requires an in-depth understanding of their context and objectives. The prominent types of sandbox around the world are given below.

Table 1. Types of Sandboxes

	Innovation-promoting Sandbox	Policy-promoting Sandbox	Thematic Sandbox
Objective	● Market development ● Regulatory learning	● Identify regulatory blockers to beneficial innovation	● Develop evidence to support regulatory enablers. ● Targeted market development
Capacity	● Process & manage large cohorts. ● Informal guidance & feedback	● Facilitative regulatory architecture	● Clear thesis on regulatory or policy objectives

Table 2. Regulatory Sandboxes Across the Globe

Country	Type of Sandbox	Sector	Authority/Regulator	Description
Australia¹	Singular Sandbox	Finance	Australia Securities and Investment Commission (ASIC)	Australia introduced the Australian Licensing Exemption Scheme, under which the Australian Securities and Investment Commission (ASIC) introduced a fintech licensing scheme. This scheme allows eligible fintech companies to test

¹ Australia Investment and Securities Commission

Country	Type of Sandbox	Sector	Authority/Regulator	Description
				certain products or services for up to 12 months without an Australian Financial Services licence or credit licence.
Thailand²	Three separate sandboxes under different authorities	Finance	Bank of Thailand (BOT), the Securities and Exchange Commission (SEC), and the Office of Insurance Commission (OIC)	The BOT sandbox has focused primarily on quick-response (QR) codes and cross-border payments. The OIC sandbox, on the other hand, targets InsurTech innovations. The SEC sandbox enables fintech companies to trial eKYC technologies. ³
Dubai⁴	Singular Sandbox	Finance	Dubai Financial Services Authority (DFSA)	Dubai has introduced an Innovation Testing Licence (ITL), which gives eligible fintech firms the chance to trial innovations in a controlled environment.
Lithuania⁵	Singular Sandbox	Blockchain in financial sector	Bank of Lithuania	Lithuania has launched a blockchain-based sandbox to accelerate the development of blockchain innovations in the financial sector.
Sierra Leone⁶	Singular Sandbox	Finance	Bank of Sierra Leone	This sandbox encourages responsible innovation, aiming to enhance the quality and accessibility of financial products for citizens of Sierra Leone.

² The Nation - Thailand

³ World Bank - Global experiences with regulatory sandboxes

⁴ Dubai Financial Services Authority

⁵ Bank of Lithuania

⁶ Bank of Sierra Leone

Country	Type of Sandbox	Sector	Authority/Regulator	Description
Rwanda ⁷	Three Sandboxes under Bank of Rwanda	Finance	Bank of Rwanda	In 2018, Rwanda established a sandbox focused on payment systems. This was followed by the creation of two more sandboxes, one dedicated to micro-insurance and the other to deposit-taking institutions. ⁸
Kenya ⁹	Singular Sandbox	Finance	Capital Markets Authority of Kenya (CMA)	This sandbox enables the development and implementation of innovative products, solutions and services related to capital markets.
Mozambique ¹⁰	Singular Sandbox	Finance	Banco de Moçambique (Central Bank of Mozambique)	This sandbox offers FinTechs, credit institutions, financial companies, payment service providers, and other financial institutions the chance to trial their innovative technologies and business models. It has also acted as an accelerator by enabling start-ups to implement their products and models in the real world.
Ghana ¹¹	Singular Sandbox	Finance	Bank of Ghana	The Bank of Ghana has launched a regulatory sandbox pilot programme in collaboration with Emtech Service LLC. The sandbox focuses on financial services, with a particular emphasis on

⁷ National Bank of Rwanda

⁸ World Bank - Global experiences with regulatory sandboxes

⁹ Capital Markets Authority

¹⁰ Bank of Mozambique

¹¹ Bank of Ghana - Press Release

Country	Type of Sandbox	Sector	Authority/ Regulator	Description
				blockchain technology solutions, electronic Know Your Customer (KYC) processes, remittances and crowdfunding.
Nigeria ¹²	Singular Sandbox	Finance	Central Bank of Nigeria	In 2020, the Central Bank of Nigeria (CBN) released the draft Framework for Regulatory Sandbox Operation. The sandbox was designed to support disruptive technology in the financial services sector.
Mexico ¹³	Sandboxes established under fintech law	Finance	Comisión Nacional Bancaria y de Valores (CNBV)	Mexico enacted its fintech law to encourage innovation and make its regulatory environment more favourable to new technologies. The law established a fintech supervision department within the Comisión Nacional Bancaria y de Valores (CNBV), responsible for setting up regulatory sandboxes.
India ¹⁴	Three parallel sandboxes under each regulator	Finance	Reserve Bank of India (RBI) ¹⁵ , Securities Exchange Board of India (SEBI) ¹⁶ and the Insurance Regulatory and Development	The three regulators have launched sandboxes to promote responsible fintech. However, their designs differ, particularly with regard to eligibility criteria and testing environments.

¹² Regulatory Sandbox - Central Bank of Nigeria

¹³ Fintech Business Weekly

¹⁴ World Bank - Global experiences with regulatory sandboxes

¹⁵ RBI - Sandbox

¹⁶ SEBI Sandbox

Country	Type of Sandbox	Sector	Authority/Regulator	Description
			Authority of India (IRDAI) ¹⁷ .	
Colombia ¹⁸	Singular Sandbox	Finance	Superintendencia Financiera de Colombia (SFC)	As part of its sandbox mechanism, the SFC issued temporary licences to participants in the sandbox before deciding on any permanent regulatory changes.
Hong Kong ¹⁹	Three separate sandboxes under each regulator	Finance	Insurance Authority, Securities and Futures Commission and Hong Kong Monetary Authority (HKMA)	The three financial sector regulators: the Insurance Authority; the Securities and Futures Commission; and the Hong Kong Monetary Authority (HKMA), have launched their own sandboxes, which focus on cross-sector fintech products.

Reasons for establishing sandboxes:

- Regulatory sandboxes and other related innovation frameworks provide innovators with temporary legal certainty, at the very least.
- Environmental regulators and other authorities are not otherwise empowered to implement regulatory experimentation mechanisms, as this is not explicitly mentioned in their mandates.
- Any experimentation must be designed to avoid distorting competition and protect consumers.
- Use the insights gained from the sandbox intervention to secure additional funding from the wider IFI/donor community and private sector.

Barriers to operationalising sandboxes in the aforementioned practical cases:

- Lack of innovation in the circular economy sector.
- Lack of policy and regulatory mechanisms surrounding energy sandboxes.
- Undemonstrated technical and financial viability of innovative technologies and business models in the circular economy.
- Lack of private sector investment in the circular economy sector.

¹⁷ IRDAI Sandbox

¹⁸ Colombia Regulatory Sandbox

¹⁹ Hong Kong Regulatory Sandbox

- Lack of incentive for the development of innovative business models and technologies.
- Capacity issues in the circular economy sector.
- A gap between market needs and regulatory frameworks.

5. LEGAL FRAMEWORK FOR THE CIRCULAR ECONOMY SANDBOX

5.1. EU strategic regulatory framework

As previously mentioned, regulatory sandboxes are a well-established and widely implemented form of regulation at the European level. By way of example, the main European legal acts that refer to regulatory experimentation schemes are recalled below:

The revised *Better Regulation Toolbox*, published in 2021, includes regulatory sandboxes as part of Tool No. 69, “Emerging policy methods and tools”, and outlines best practices for their implementation. The Toolbox facilitates the identification and removal of barriers within the single market. The European Commission has emphasised that 'overregulation' often results in additional administrative or regulatory burdens for consumers and businesses, particularly affecting SMEs (European Commission, 2021),

The 2020 European Council conclusions on regulatory sandboxes emphasise the need to develop tools within a resilient, future-oriented regulatory framework capable of addressing the challenges of the digital age. The conclusions endorse the use of regulatory sandboxes and experimentation clauses and advocate their incorporation into EU legislation. The Council emphasises that sandboxes and experimentation clauses must consistently adhere to the principles of subsidiarity, proportionality and the precautionary principle, and actively promote their application. These mechanisms must ensure a high level of protection, particularly for citizens and consumers (European Council conclusions, 2020).

The 2022 communication, *A New European Innovation Agenda*, indicates that resources from the Horizon Europe programmes and the Interregional Innovation Investment Instrument under the European Regional Development Fund will be dedicated to promoting regional collaboration, including the use of regulatory sandboxes (COM, 2022).

The European Commission’s draft *Regulation, which establishes a framework of measures to strengthen the European ecosystem for producing technologies that contribute to the “zero emissions”* objective, includes a dedicated article on regulatory sandboxes for these technologies. It allows Member States to temporarily derogate from applicable regulatory rules to facilitate innovation and real-world testing. The strategic document also emphasises the essential role of end consumers in driving demand for final

products based on technologies that contribute to achieving the Union's net-zero emissions goal (COM, 2023).

Moreover, the recent report entitled "Much More Than a Market", prepared by Enrico Letta at the request of the European Council highlights that the Single Market should be built upon a fifth pillar, beyond the free movement of goods, capital, persons and services, namely the freedom to innovate. Only by ensuring a framework conducive to innovation can an ecosystem be created in which knowledge drives economic vitality and broader societal progress. The report also recommends the increased use of regulatory sandboxes as a tool for systemic flexibility, offering legal stability without rigidity (Enrico Letta, 2023).

5.2. The concept of the circular economy sandbox regulatory framework to ensure consumer protection

The draft Law on Regulatory Sandboxes for the Circular Economy aims to stimulate innovation in this sector, accelerating the process by which its results are brought to market. This will benefit consumers and contribute to the Republic of Moldova's decarbonisation objectives.

The draft legislation also aims to introduce the concept of regulatory flexibility, which is already implemented in most EU Member States and recognised in European Union legal acts. This concept allows for improvements to the regulator's learning curve and encourages technological progress.

To stimulate innovation in the circular economy sector, the draft Law on Regulatory Sandboxes for the Circular Economy allows for exemptions from regulatory provisions that hinder the implementation of testing projects or innovation-focused experiments. To ensure consumer protection and safeguard public interest, the draft legislation sets out strict requirements and a clear decision-making framework to prevent any negative impact on the energy sector or other regulated areas where such exemptions are sought (Plotnic Olesca, 2022).

The mechanisms designed to guarantee neutrality and safety include:

- (i) the establishment of eligibility criteria for innovative testing projects, including the requirement that each project demonstrate the ability to ensure consumer protection from the implementation stage;
- (ii) a rigorous approval mechanism involving multiple layers of analysis and decision-making, specifically:
 - the creation of a collegial body (the Committee for Regulatory Sandboxes), composed of members with relevant expertise and supported by a technical secretariat of experts;
 - the final approval decision to be adopted by the Government, which has the necessary authority to issue informed and responsible decisions;
 - mandatory consultation with competent institutions and public authorities responsible for issuing opinions, approvals, or

authorizations in relation to the legal provisions for which derogation is requested;

- the inclusion of the option to consult interested third parties in the decision-making process.
- (iii) the possibility for the approval decision to impose specific conditions aimed at ensuring consumer protection;
- (iv) the establishment of clear monitoring mechanisms for the implementation of approved projects, allowing for early detection and correction of any deviation from the established conditions;
- (v) the enforcement of legal liability civil, administrative, or criminal, where legal provisions that are not subject to approved exemptions are violated.

Therefore, the draft Law proposes a robust framework for the verification and filtering of regulatory sandbox projects in the circular economy field, ensuring a balanced approach between fostering innovation and protecting the public interest.

At the same time, it should be emphasised that the draft Law aims to stimulate innovative testing projects which, due to current legal provisions (i.e. a lack of flexibility in the existing regulatory framework), cannot be implemented, or can only be implemented with significant difficulty and/or over a much longer timeframe.

The draft Law's mechanism involves identifying such legal provisions and integrating innovation into the economic cycle. These obstacles are encountered by applicants who drive the respective innovations. Therefore, it is impossible to anticipate the specific innovative testing projects or the exact legal provisions for which exemptions will be needed to implement them.

For this reason, the normative acts from which derogations may be granted are listed in general terms. However, it must be clearly stated that no general exemptions will be granted through the approval decisions for regulatory sandbox projects in the circular economy sector. In full respect of the principle of proportionality, the government will grant specific exemptions from legal provisions that hinder innovation, but only those strictly necessary for a project's implementation will be granted based on a case-by-case analysis.

6. CONCLUSIONS

In order to implement such innovative projects, it is necessary to establish a specific regulatory framework that allows for derogation from certain rules. This will enable innovative projects to be carried out under controlled and supervised conditions while ensuring consumer safety.

Overall, innovative testing projects can foster significant openness to innovation. As a result, competition is encouraged within the framework of a

given project. Furthermore, different projects can compete with one another, ultimately leading to improvements in the regulatory framework that enable more and better innovation and promote greater competition within and across markets.

In addition to the benefits outlined in *Regulatory Sandboxes: A Practical Guide for Policymakers* (Michael Rizzo, 2021), we can also emphasise the advantage of a controlled environment for safeguarding consumer interests. Innovative testing projects involve conducting experiments in real-world yet controlled conditions using rigorous analysis and verification mechanisms. This ensures that such initiatives do not negatively impact consumers and that their rights are fully protected throughout the innovation process.

Innovative testing projects are practical experiments that usually involve a small number of consumers. This ensures that any regulatory exceptions have a minimal impact on end users. Furthermore, the process of granting these exemptions includes verification and assessment filters to prevent negative impacts on consumers or distortions to competition among market operators.

In conclusion, there is a growing trend at the European level towards the use of regulatory sandboxes for innovative testing. The draft Law on Regulatory Sandboxes for the Circular Economy provides adequate verification and filtering mechanisms to protect consumers and safeguard the public interest. Therefore, to effectively implement such sandboxes and advance innovation more broadly, it is necessary to grant general derogations from certain legal provisions. (such as those relating to spatial planning, construction, environmental protection or tax procedures)

The Sandbox mechanism operates under strict ethical guidelines, ensuring that innovation is consistent with environmental sustainability and consumer rights. All projects tested in the Sandbox integrate a consumer-centric approach, prioritising transparency, safety and reliability. Companies participating in the Sandbox must demonstrate clear benefits for consumers, such as improved product circularity, cost reduction or improved service reliability.

To safeguard consumer rights while fostering innovation, circular economy sandboxes must incorporate robust protection mechanisms:

- rigorous project screening: only projects that pass a strict pre-assessment, demonstrating minimal risk to consumers, are admitted;
- ongoing consumer impact monitoring: consumer effects are tracked continuously during testing to detect any emerging issues early;
- rapid response protocols: clear clauses ensure immediate intervention in case of risks or violations of consumer protection standards.

Additionally, all sandbox-tested projects must deliver tangible consumer benefits, such as:

- enhanced product circularity through extended lifespan, reuse, reparability, or recyclability;

- lower costs for sustainable products and services by reducing waste and increasing efficiency;
- improved service reliability via testing in real-world conditions before full-scale rollout;
- greater transparency, with consumers having access to clear, accurate data on the environmental and social impacts of tested innovations.

References

- 1) Attrey, A., M. Leshner and C. Lomax (2020). "The role of sandboxes in promoting flexibility and innovation in the digital age", OECD Going Digital Toolkit Notes, No. 2, OECD Publishing, Paris, [online] Available at: <https://doi.org/10.1787/cdf5ed45-en> [Accessed 7 June. 2025].
- 2) Delphine Gallaud, Blandine Laperche (2016). Circular Economy, Industrial Ecology and Short Supply Chain [online] Available at: https://www.researchgate.net/publication/306344847_Circular_Economy_Industrial_Ecology_and_Short_Supply_Chain [Accessed 3 June. 2025].
- 3) European Commission (2020). A new Circular Economy Action Plan. [online] Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0098> [Accessed 3 June. 2025].
- 4) European Commission (2012). Ecodesign your future[online] Available at: <https://op.europa.eu/en/publication-detail/-/publication/4d42d597-4f92-4498-8e1d-857cc157e6db> [Accessed 2 June. 2025].
- 5) European Innovation Scoreboard 2023 [online] Available at: <https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/04797497-25de-11ee-a2d3-01aa75ed71a1> [Accessed 2 June. 2025].
- 6) European Commission (2021). Better regulation: guidelines and toolbox. [online] Available at: https://commission.europa.eu/law/law-making-process/better-regulation/better-regulation-guidelines-and-toolbox_en [Accessed 1 June. 2025].
- 7) European Council conclusions on regulatory sandboxes. (2020) [online] Available at: <https://data.consilium.europa.eu/doc/document/ST-13026-2020-INIT/ro/pdf> [Accessed 5 June. 2025].
- 8) European communication (2022). A New European Innovation Agenda. [online] Available at: <https://eur-lex.europa.eu/legal-content/RO/TXT/HTML/?uri=CELEX:52022DC0332&from=ET> [Accessed 7 June. 2025].
- 9) European Commission's draft Regulation, which establishes a framework of measures to strengthen the European ecosystem for producing technologies that contribute to the "zero emissions" (2023) [online] Available at: <https://eur-lex.europa.eu/legal-content/RO/TXT/?uri=CELEX:52023AP0401> [Accessed 7 June. 2025].
- 10) Emily Leckenby , Dalia Dawoud , Jacoline Bouvy , Páll Jónsson (2021). The Sandbox Approach and its Potential for Use in Health Technology Assessment: A Literature Review [online] Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC8545721/?utm_source=chatgpt.com [Accessed 2 June. 2025].

- 11) Enrico Letta (2023). Much More Than a Market [online] Available at: <https://www.consilium.europa.eu/media/ny3j24sm/much-more-than-a-market-report-by-enrico-letta.pdf> [Accessed 11 June. 2025].
- 12) F. Blomsma, M. Tennant, R. Ozaki. (2023). Making sense of circular economy: Understanding the progression from idea to action. *Business Strategy and the Environment*, 32 (3), pp. 1059-1084
- 13) Gertraud, Leimüller., Silvia, Wasserbacher-Schwarzer. (2020). Regulatory Sandboxes. Analytical paper for BusinessEurope [online] Available at: https://www.besuisseurope.eu/wp-content/uploads/2025/02/regulatory_sandboxes_-_winnovation_analytical_paper_may_2020-3e9-1.pdf?utm_source=chatgpt.com [Accessed 2 June. 2025].
- 14) Ghisellini, P, Cialani C, Ulgiati S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Volume 114. [online] Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0959652615012287> [Accessed 3 June. 2025].
- 15) Henry Willem Müller, Konstantin Remke. (2025). Circular Systems Sandbox: A process tool for circular systems design and rebound effect reduction. [online] Available at: <https://www.sciencedirect.com/science/article/pii/S2667277425000040#bib0007> [Accessed 8 June. 2025].
- 16) Iarmenco Mihaela, Donos Evlampie, Plotnic Olesea, (2020). Promotion of renewable energy in the European Union, International Conference on “European Finance, Business and Regulation-(EUFIRE 2020), pp. 709-716
- 17) Johan Rockström, Per-Anders Enkvist, Fredrik Hedenus, *et al.* (2018). The Circular Economy: A Powerful Force for Climate Mitigation [online] Available at: <https://www.sitra.fi/en/publications/circular-economy-powerful-force-climate-mitigation/> [Accessed 6 June. 2025].
- 18) Michael Rizzo (2021). Regulatory Sandboxes: A Practical Guide for Policymakers [online] Available at: <https://policycommons.net/artifacts/1571288/regulatory-sandboxes/2261067/#:~:text=The%20guide%20covers%20key%20aspects,and%20testing%20the%20proposed%20framework.> [Accessed 5 June. 2025].
- 19) Platonic Olesea, Popescu Lucia (2022). Climate change and sustainable development: issues for international trade system, European Finance, Business and Regulation. Challenges of Post-Pandemic Recovery. Proceedings of the International Conference EUFIRE 2022, 313
- 20) Ryan Nabil, (2022). How Regulatory Sandbox Programs Can Promote Technological Innovation and Consumer Welfare [online] Available at: https://cei.org/wp-content/uploads/2022/08/Ryan_Nabil_-_Regulatory_Sandboxes-3.pdf [Accessed 3 June. 2025].
- 21) The World Bank, (2020). Global Experiences from Regulatory Sandboxes [online] Available at: https://documents1.worldbank.org/curated/en/912001605241080935/pdf/Global-Experiences-from-Regulatory-Sandboxes.pdf?utm_source=chatgpt.com [Accessed 3 June. 2025].

TOWARDS INDUSTRY 5.0: CIRCULAR ECONOMY AND THE ROLE OF CONSUMER BEHAVIOUR

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Abstract

As the global economy shifts from classic industrial models to more circular frameworks, Industry 5.0 emerges as a transformative paradigm emphasizing human-centric, sustainable, and resilient systems. Central to this evolution is the circular economy, which seeks to minimize waste, maximize resource efficiency, and extend product lifecycles. This paper explores the intersection of Industry 5.0 and the circular economy, focusing particularly on the critical influence of consumer behaviour. By integrating insights from behavioural and systems thinking, the study highlights mechanisms to encourage more circular consumption pattern. Ultimately, the paper argues that aligning technological innovation with behavioural change is essential to realizing the full potential of Industry 5.0 and achieving a regenerative economic future.

Keywords: Industry 5.0, consumer behaviour, circular economy, systems thinking, system dynamics

JEL Classification: O33, Q56, D12, Q01, O31

1. INTRODUCTION

Industry 5.0 builds upon the technological advancements of Industry 4.0 by reintroducing human intelligence and creativity into the manufacturing process. It emphasizes collaboration between humans and machines to achieve sustainable and personalized production outcomes (Ghobakhloo *et al.*, 2022). This paradigm shift aims to create value through ethical considerations, customization, and the integration of advanced technologies like artificial intelligence (AI), the Internet of Things (IoT), and digital twins (Dwivedi *et al.*, 2023). The circular economy challenges the traditional linear model of "take, make, dispose" by promoting practices that extend the lifecycle of products and materials (Ellen MacArthur Foundation, 2013). The integration of circular economy principles within Industry 5.0 frameworks enables the development of closed-loop systems where products are designed for longevity, adaptability, and recyclability, thereby reducing the environmental footprint of industrial activities (Ghobakhloo *et al.*, 2022).

Research indicates that consumer awareness and attitudes towards sustainability are increasing, with many expressing a willingness to support businesses that prioritize environmental and social responsibility (PWC, 2023). However, despite these positive inclinations, there exists a notable gap between consumers' intentions and their actual behaviours – a phenomenon often referred to as the "intention-action gap" (Sustainable Brands, 2022). Factors such as convenience, cost, and accessibility continue to drive consumer choices, sometimes at the expense of sustainability considerations.

Strategies such as providing clear information about the environmental impact of products, offering incentives for sustainable behaviours, and creating convenient systems for recycling and product returns can encourage consumers to make choices that support circular practices (Sustainable Brands, 2022). Moreover, leveraging digital platforms and social media can amplify the reach of sustainability messages and foster community engagement around circular economy initiatives (GHD, 2022). To combat this, it is crucial to establish clear standards and certifications for sustainable products and to promote transparency in corporate sustainability practices.

This paper will be focusing on the fashion industry, valued at over \$2.5 trillion globally, is undergoing a major transformation, propelled by the need for environmental sustainability, ethical production, and a more conscious consumer base (Ellen MacArthur Foundation, 2017, and Niinimäki, 2020). Traditional models of production and consumption – especially those tied to fast fashion – have proven incompatible with ecological and social well-being. This context has paved the way for Industry 5.0, a new industrial paradigm emphasizing human-centric innovation, environmental responsibility, and long-term system resilience (Meadows, 2008). A crucial path to aligning fashion with Industry 5.0 is through the circular economy (CE), which rethinks resource use to eliminate waste and enable closed-loop systems. However, implementing CE in fashion is complex due to entrenched linear supply chains and unpredictable consumer behavior (Bocken, 2016 and European Commission, 2021).

This paper explores how system dynamics (SD) modeling can be employed to design, test, and optimize circular fashion systems, particularly emphasizing the influence of consumer behavior as a dynamic and strategic variable. This paper will be divided into the following sections: sections two will review how systems thinking supports the above-mentioned challenges, section 3 will illustrate through a fashion case study which illustrates the usefulness of systems thinking in the development of industry 5.0 concepts with focus on consumer behaviour, and then conclusion for the whole paper.

2. LITERATURE REVIEW

System thinking has been utilized as an effective management tool for modelling complex real-world systems, comprehending their behavior and

carrying out tactical policies. Lertpattarapong (2002) and Hihuchi and Troutt, (2004) argued that system dynamics can act as an effective technique to monitor the non-linear dynamic behavior of a system and aiding the understanding of ways in which structure and specifications of the system determines behavior patterns

The conceptual idea fueling system dynamics is the communication of all items within a particular system through casual relationships (Berry and Naim, 1996). System dynamics asserts that these relationships form the underlying structure for any system. The production of a dynamic design of a system needs the recognition of causal relationships and referral modes that make up the feedback loops of the system. The feedback system discussed here describes the circumstance where variable A impacts variable B and B in turn impacts A through a series of causes and effect (Canella *et al.*, 2008 and Torres and Maltz, 2010). System dynamics differs to other methods employed to study systems that are complex. This is primarily because of its use of feedback loops extensively. The foundation of system dynamics models are Stocks and Flows, which best describes the connection formed by feedback loops (Georgiadis *et al.*, 2005). Performing simulation analysis termed "what-if" are carried out to examine several policies that significantly aid the understanding of changes in the system over time (Juntunen and Juga, 2009).

System thinking proposed solving the problem would improve awareness, education and communication. The bullwhip effect was a phenomenon of demand amplification experienced by Procter and Gamble (Lee *et al.*, 1997). Through simulation studies carried out in an upstream company, it was deduced that even under constrained supply, deliveries are high. In addition, it was noted that as shipment move downstream, they are decreased in the supply chain (Shukla *et al.*, 2009). The backlash impact reflected bullwhip effect and can lead to inefficient scheduling and high transportation cost. Various studies have been conducted to reduce and measure the variability in demand and the impacts on the supply chain performance such as financial performance, transportation and production operations (Potter and Lalwani, 2008).

The effect of system dynamics on supply chain performance was also explored in some case studies such as automobiles, food, grocery, electronics and toys industries (Kumar and Nigmatullin, 2011). Therefore, a dynamic framework where the causal relationships and feedback of these variables in the system as they run in real world over a long period needs to be highlighted. It enables the understanding of the variables and how various policies affect the behaviour of the system. The system dynamics model helps in understanding the system through the feedback structures in the system and shows the relationship of each variables linked (Sterman, 2000).

3. RESEARCH MODEL

The aim of carrying out this step in the modelling process is to understand the structural causes that trigger the changes of system performance arising from

inventory level, order fulfilling rates, the ability for the distributor to fulfil order, distributor own desired inventory levels, and the time to fill this desired inventory levels.

The stock and flow structure of the fashion supply chain in this research includes delay between orders and fulfilling order. The structure includes the distributor inventory of unfulfilled orders, those orders that have been placed but not yet received. The order fulfilling rate is now the firm decision rule. The fulfilling rate depends on the fashion distributor or retailer inventory of barrel that have been ordered but not yet received and the average inventory fulfilling delay. The distributor and retailer still order to replace expected flow out from their stocks and try to reduce the difference between the desired inventory and actual inventory.

Under the extreme condition test, the robustness of the model is tested under extreme circumstance. The extreme condition test suggests the behaviour of the model to be realistic despite the various policies or inputs in the model. The extreme test improves the validation process of the model by examining the beyond the initial boundaries. Despite the size of model, all the concerned variables such as zero can be tested to verify whether the system behaviour matches the expected results. Inventory should never be zero no matter the size of demand.

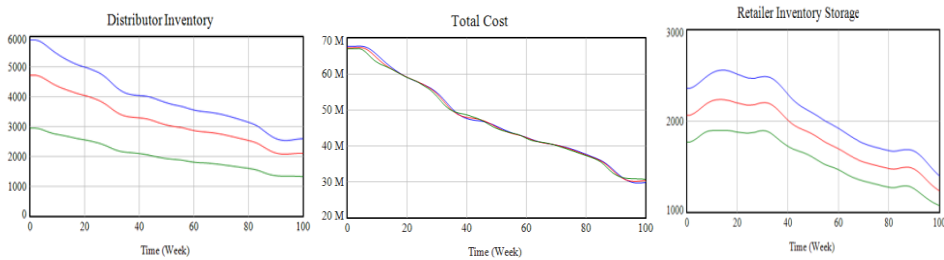


Figure 2. The tested results

As shown in Figure 2 the base case and low order pattern have the effect of increasing the inventory level and there is a significant rise in inventory level in the low order under retailer inventory storage. The model responds well to the base case and low order pattern with smaller level of fashion distributor inventory and retailer inventory storage, except under high order. Low order has the undesirable effect of increasing the level of retailer inventory storage. These results are important as they display that the test is sufficient to reveal the effect of the demand uncertainties under the different policies. The results from the sensitivity analysis of fashion distributor inventory, retailer inventory storage, total costs, and profit presents questions how managers can achieve best policy-decision in responding to the different ordering pattern. The purpose for

conducting an in-depth sensitivity analysis is to search and find the best policy. The performance metrics employed in the models were based on financial and non-financial metrics.

4. CONCLUSIONS

Industry 5.0 offers a compelling framework for transforming the fashion industry into a system that prioritizes human well-being and environmental stewardship. A circular economy is central to this vision, yet it cannot succeed without actively engaging consumers. Understanding and shaping consumer behavior – through education, digital tools, incentives, and social influence – is essential. System dynamics offers a unique approach to capture the complexity of this transformation, revealing feedback loops and leverage points that traditional linear models overlook. By combining technology, ethics, and design thinking, the fashion industry can not only reduce its environmental footprint but also redefine value creation in a world that urgently needs sustainable solutions.

References

- 1) Berry, D. and Naim, M.M. (1996). Quantifying the Relative Improvements of Redesign Strategies in a Personal Computer Supply Chain. *International Journal of Production Economics*, 46-47(1), pp. 181-196: 131–153.
- 2) Bocken, Nancy & Pauw, Ingrid & Bakker, C.A. & van der Grinten, Bram. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*. 33. 1-13. 10.1080/21681015.2016.1172124.
- 3) Cannella, S., Ciancimino, E. and M'arquez, A.C. (2008). Capacity constrained supply chains: a simulation study. *International Journal of Simulation and Process Modelling*, 4 (2), pp. 139–147.
- 4) Dwivedi, Y.K., *et al.* (2023). 'Beyond Industry 4.0: a systematic review of Industry 5.0 technologies and implications for social, environmental and economic sustainability', *Asia Pacific Journal of Business Administration*, 15(2), pp. 133-157.
- 5) Ellen MacArthur Foundation (2013). *Towards The Circular Economy: Economic and Business Rationale for an Accelerated Transition*. [pdf] Available at: <https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-volume-1> [Accessed 8 June 2025].
- 6) Ellen MacArthur Foundation. (2017). *A New Textiles Economy: Redesigning Fashion's Future*.]
- 7) European Commission. (2021). *Industry 5.0: Towards a Sustainable, Human-centric and Resilient European Industry*.
- 8) Georgiadis, P., Vlachos, D. and Iakovou, E. (2005). A system dynamics modeling framework for the strategic supply chain management of food chains. *Journal of Food Engineering*, 70 (3), pp. 351–364.
- 9) GHD (2022). 'Benefits of Industry 5.0 and the Circular Economy'. [online] Available at: <https://www.ghd.com/en-gb/insights/five-business-benefits-of-shifting-towards-industry-5-and-its-push-for-a-circular-economy> [Accessed 8 June 2025].

- 10) Ghobakhloo, M., *et al.* (2022). 'Beyond Industry 4.0: a systematic review of Industry 5.0 technologies and implications for social, environmental and economic sustainability', *Asia Pacific Journal of Business Administration*, 15(2), pp. 133-157.
- 11) Higuchi, T. and Troutt, M.D. (2004). Dynamic simulation of the supply chain for a short life cycle product. *Computers & Operations Research*, 31 (7), pp. 1097–1114.
- 12) Juntunen, J. and Juga, J. (2009). Controlling the bullwhip with transport capacity constraints. *International Journal of Services and Standards* 5, pp. 160-171.
- 13) Kumar, S. and Nigmatullin, A. (2011). A system dynamics analysis of food supply chains Case study with non-perishable products. *Simulation Modelling Practice and Theory* 19 pp. 2151-2168
- Meadows, D. (2008). *Thinking in Systems: A Primer*.
- 14) Lee, H.L., Padmanabhan, V. and Whang, S. (1997). The bullwhip effect in supply chains. *Sloan Management Review* 38 pp.93-102.
- 15) Lertpattarapong, C. (2020). *Applying System Dynamics Approach to the Supply Chain Management Problems* Msc. Thesis, Massachusetts Institute of Technology.
- 16) Niinimäki, Kirsi & Peters, Greg & Dahlbo, Helena & Perry, Patsy & Rissanen, Timo & Gwilt, Alison. (2020). The environmental price of fast fashion. *Nature Reviews Earth & Environment*. 1. 189-200. 10.1038/s43017-020-0039-9.
- 17) PWC (2023). 'Three industries where consumer behaviour is powering the circular economy'. [online] Available at: <https://www.pwc.co.uk/issues/esg/three-industries-where-consumer-behaviour-is-powering-circular-economy.html> [Accessed 8 June 2025].
- 18) Potter, A. and Lalwani, C. (2008). Investigating the impact of demand amplification on freight transport. *Transportation Research Part E* ,44(5), pp. 835–846.
- 19) Shukla, V., Naim, M.M. and Yaseen, E.A. (2009). Bullwhip'and'backlash' in supply pipelines. *International Journal of Production Research* 47, pp. 64-77
- 20) Sterman, J. D. (2000). *Business Dynamics: System Thinking and modeling for a complex World*. Irwin/McGraw Hill, Boston
- 21) Sustainable Brands (2022). 'How Does Consumer Behavior Challenge the Circular Economy?'. [online] Available at: <https://sustainablebrands.com/read/consumer-behavior-challenge-circular-economy> [Accessed 8 June 2025].
- 22) Torres, O.C. and Maltz, A.B. (2011). Understanding the financial consequences of the bullwhip effect in a multi echelon supply chain. *Journal of Business Logistics* 31 (pp. 23-41).

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