NARDI FUNDULEA, ROMANIA ROMANIAN AGRICULTURAL RESEARCH, NO. 42, 2025
www.incda-fundulea.ro; doi.org/10.59665/rar4286 First Online: August, 2025. DII 2067-5720 RAR 2025-191

Perceptions and Awareness of Circular Bioeconomy among Field Crop Farmers

Steliana Rodino

Institute of Research for Agriculture Economy and Rural Development, District 1, Bucharest, Romania
National Institute of Research and Development for Biological Sciences, District 6, Bucharest, Romania
*Corresponding author. E-mail: steliana.rodino@yahoo.com

ABSTRACT

Farmers' perceptions and values are a fundamental part of development of circular bioeconomy transitions strategies. This study explores the level of knowledge, perceptions and barriers associated with the transition to a circular bioeconomy among farmers in the cereal sector in Romania. The analysis, based on a sample of 87 respondents, highlights a moderate familiarity with the term bioeconomy and a low level of factual knowledge, which indicates the need for training programs adapted to the agricultural specifics. Environmental benefits, especially sustainability and climate resilience, are perceived most favorably, while economic dimensions (market demand and profitability) are assessed more cautiously. Capital constraints (initial costs and access to financing) and the lack of advisory services represent the main barriers, confirming the importance of financial support and applied training. At the same time, the structure of information channels differs by age, which highlights the need for differentiated communication strategies. The results indicate that the success of the bioeconomy depends not only on technological innovation and public policies, but also on social engagement and building trust among farmers.

Keywords: farmers' perception, circular bioeconomy, knowledge, barriers, sustainability.

INTRODUCTION

The growing demand for sustainably produced food is driving significant transformations in agriculture and the way natural resources are used. In this context, circular bioeconomy is increasingly addressed in the literature as a strategic direction for promoting sustainability and reducing environmental pressure of agriculture sector.

Politically and strategically, bioeconomy is anchored in major European initiatives, from the EU Bioeconomy Strategy released in 2012 and updated in 2018 to the European Green Deal, which promotes the decoupling of economic growth from resource use and the transition to low-emission value chains. These strategic frameworks call for the integration of biological flows and cascading uses, the stimulation of innovation and the strengthening of short chains, all with direct implications for large-scale agriculture. In Romania, the Common Agricultural Policy guidelines and related support instruments create opportunities for the valorization of residues, biofertilizers, bioenergy and value-added products, but the materialization of these opportunities depends on the capacity of the value chain actors to understand and adopt bioeconomy practices (Oltenacu et al., 2024; Todirica et al., 2024). Diversifying agricultural production, even on small areas by introducing high-value-added crops, can be an important strategy for increasing farmers' resilience and integrating them into bioeconomy chains (Nastić et al., 2024).

The scientific literature highlights the existence of an asymmetry in knowledge and representation within the circular bioeconomy field. Recent reviews indicate that regions such as the United States, Germany, and China have already advanced on this path, implementing strategic policies and fostering industrial developments that support the transition towards a bio-based economy. By comparison, Eastern Europe has so far been less visible in this landscape, which points not only to an imbalance but also to the need for a clearer understanding of local priorities and capacities (Sadeghzadeh et al., 2025).

Received 27 May 2025; accepted 28 August 2025.

Recent research also highlights a low level of familiarity among farmers with this concept, which underlines the importance of continuous training programs, adapted to the specifics of the agricultural sector (Paltaki et al., 2024; Pink et al., 2025).

At the same time, the success of the bioeconomy does not depend exclusively on technological innovations or public policies, but also on the degree of social acceptance and the active involvement of relevant actors (Sadeghzadeh et al., 2025). Failure to include a societal perspective can lead to reluctance and limited engagement, necessitating a participatory approach and a better understanding of how farmers, consumers and other stakeholders perceive the bioeconomy.

Exploratory studies show that perceptions of this concept vary significantly across social groups, with farmers often showing a higher degree of scepticism, particularly regarding the feasibility and economic equity of the transition (Stern et al., 2018). These findings, together with evidence of farmers' low familiarity with the notion of bioeconomy (Rodino et al., 2019), support the need for participatory approaches.

Recent literature emphasizes that the adoption of technologies and new economic models does not only depend on their technical characteristics, but also on social, economic and political factors, which influence the degree of acceptance and involvement of actors (Cristache et al., 2025). Similarly, farmers' perceptions and awareness play a crucial role in the transition to the circular bioeconomy, as the success of this process requires the integration of social dimensions alongside technological and economic ones.

In this context, research on the perceptions and awareness of farmers becomes essential to inform policies and training programs that support the adoption of sustainable bioeconomy practices.

Against this background, the present study targets arable farmers in Romania, focusing on two dimensions: (i) mapping the level of awareness and knowledge (subjective and objective) regarding the bioeconomy; (ii) analyzing perceptions, attitudes and perceived barriers.

The aim was to answer the following research questions:

• How familiar are field crop farmers with the concepts and applications of the circular bioeconomy?

• What are farmers' perceptions of the usefulness, compatibility and risks of the transition to a circular bioeconomy in the agricultural sector?

MATERIAL AND METHODS

The present study was designed based on the application of a standardized questionnaire addressed to field crop farmers in Romania. We focused the analysis on field crop farmers because this sector generates the most consistent flows of agricultural biomass (e.g., straw, plant residues, stalks), with direct potential for cascade uses (bioenergy, biofertilizers, bio-based materials) and integration into bioeconomy value chains. In Romania, field crops occupy a significant share of the utilized agricultural area, and the technological and commercial decisions of these farmers can substantially influence the supply of bio-based raw materials and the feasibility of regional infrastructures for the collection, pre-processing, procurement contracts.

The survey was developed based on the existing literature related to state of the art of circular bioeconomy and the general adoption of innovations in agriculture. The sampling targeted active farmers and decision-makers on the farm. Data collection was carried out online and, complementary, face-to-face in professional contexts, with informed consent obtained and anonymity ensured. The questionnaire was structured in three sections: Socio-demographic and farm profiling; awareness and knowledge of the bioeconomy; perceptions and attitudes.

The profiling section collected socio-demographic and structural variables of the farm, used both for the description of the sample and as predictors/controls in the inferential analyses. The following were measured: age (years), gender, level of education, experience in agriculture (years) and role on the farm (owner/administrator/technical manager/other). At the farm level, the total

area, the production system, membership in a form of association, access to irrigation, degree of digitalization, main sources of information and recent participation in training was recorded.

In the second section, regarding awareness and knowledge of the bioeconomy, two types of measures were used: (i) self-reported perceptions/attitudes assessed on 5-point Likert scales and (ii) objective knowledge measured by a 6-item factual test.

In the third section, regarding perceptions, attitudes, we constructed composite indices by the arithmetic mean of the related items: pro-bioeconomy perceptions (perceived usefulness, compatibility, demand, profitability, contribution to climate resilience), perceived barriers (initial costs, market uncertainty, lack of knowledge/advice, regulations/bureaucracy, access to finance, technological risks).

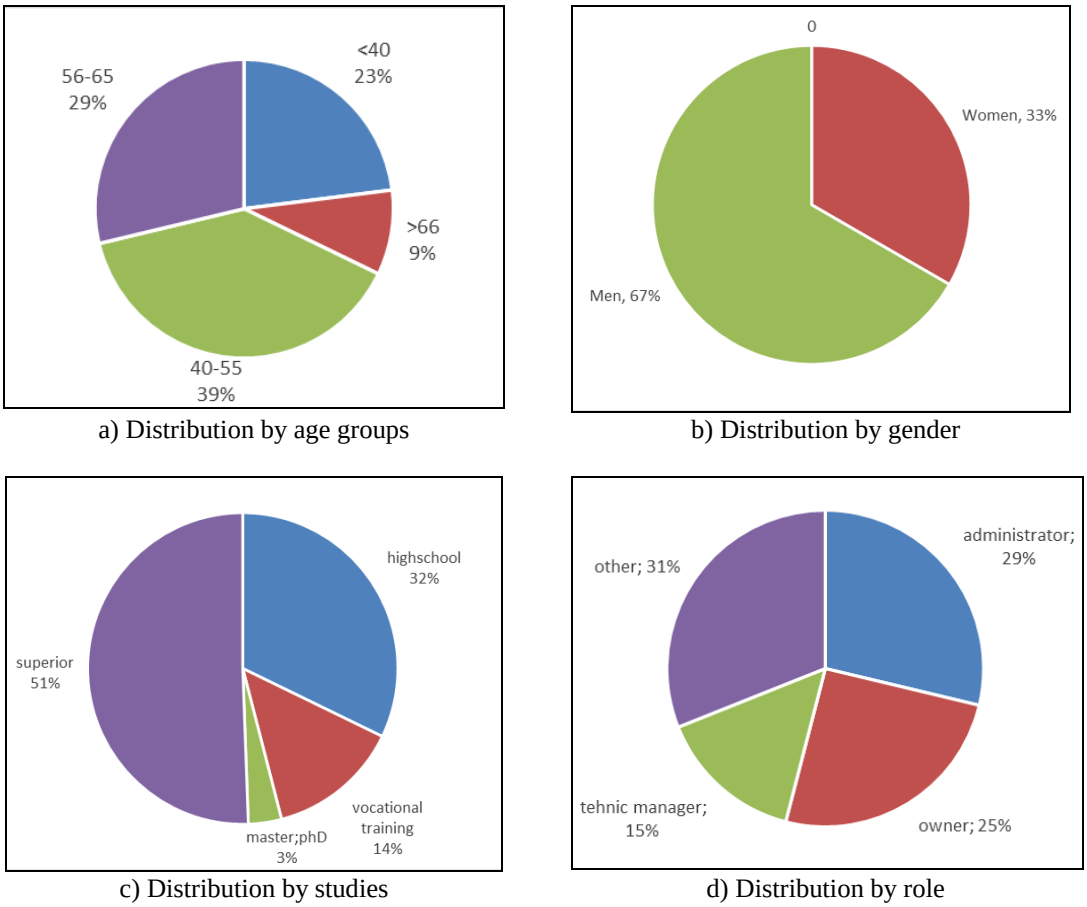
The response scale for most items used a 5-point Likert scale (1 - "strongly disagree"/ "not at all familiar" … 5 - "strongly agree"/ "very familiar"), and the factual questions had True/False/Don't know options.

The average time to complete the questionnaire was estimated at 10-15 minutes. The instrument was piloted on a group of 5 farmers to clarify the wording and calibrate the completion time. Responses were anonymous; informed consent was collected at the beginning of the questionnaire. No personal data that would allow direct identification were requested.

RESULTS AND DISCUSSIONS

The analysis of the collected responses outlined both the socio-demographic and structural profile of the investigated farms, as well as the levels of familiarity and objective knowledge regarding the bioeconomy, perceptions of utility and barriers, and declared adoption intentions. The following presents the descriptive results, followed by comparisons by subgroups and associations between key variables.

The sample consisted of 87 arable farmers. Regarding the age structure, it is noteworthy that the largest share of respondents (over 39%) is in the 40–55 age range, reflecting the predominance of an active generation at the maturity of their agricultural career. A significant segment, approximately 23%, is represented by young farmers, under 40 years old, indicating a notable presence of new generations in the sector. Almost a third of respondents fall into the 56-65 age category, confirming the significant role of farmers with long experience. At the same time, farmers over 66 years old represent 9% of the sample Figure 1a-d.



a) Distribution by age groups

b) Distribution by gender

c) Distribution by studies

d) Distribution by role

Figure 1. Socio-demographic profile of the surveyed responders

In terms of gender distribution, it is observed that men constitute the majority of respondents in the sample, representing over 67% of the total. In terms of educational level, the structure is dominated by people with higher education (51%) and secondary education (32%), to which is added a smaller segment with vocational training (14%) and a minority percentage of postgraduate graduates (3%). This distribution suggests that the analyzed population is relatively well qualified, with a consistent core of farmers who have a formal academic background.

The structure of the farms in the analyzed sample indicates a predominance of small and medium-sized farms, with 23% under 100 ha and 48% in the range of 100-499 ha. A quarter of the respondents own farms of 500-999 ha, and only 4% exceed the threshold of ≥1000 ha. From a technological point of view, conventional production is clearly predominant (91%), while mixed systems (6%) and organic (3%).

Approximately 38% of farmers declare membership in associative/cooperative forms, a relevant aspect for the coordination of bio-based value chains and the negotiation of sales contracts. Regarding water infrastructure, 90% do not have irrigation. This profile indicates a significant climate vulnerability for part of the sample, with direct implications for the stability of biomass flows. The self-assessed degree of digitalization is moderate (average 3.08, on a scale of 1-5) Figure 2, suggesting room for growth for monitoring, traceability and resource optimization solutions, also useful for the valorization of by-products.

Almost 35% have recently participated in training activities, indicating an openness to learning that can be harnessed through practically oriented modules (cascading uses, business models, access to financing), adapted to the profile of small and medium-sized farms and, where appropriate, integrated through cooperatives.

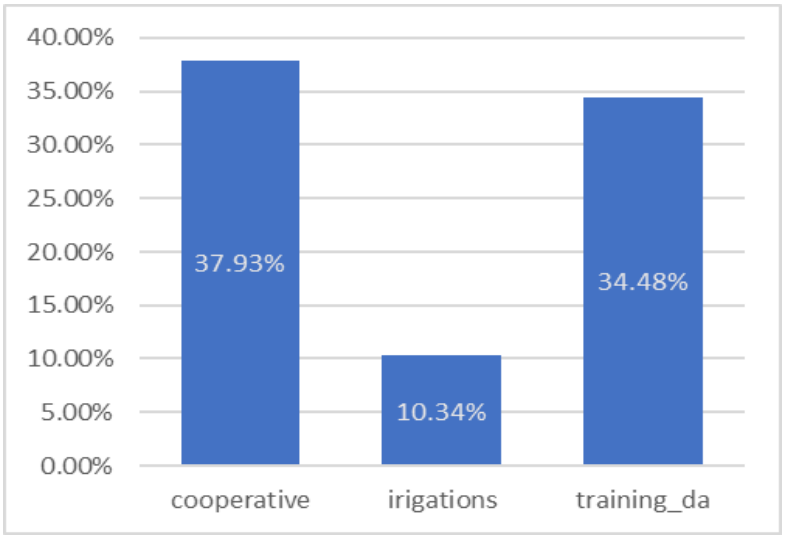


Figure 2. Profile of the sample farms

The next step was to assess the level of understanding of the bioeconomy, measured by self-reported familiarity and a factual test. The average level of familiarity with the term bioeconomy was 2.99 on a scale of 1-5, reflecting a moderate level of knowledge. Only 37.9% of respondents declared a high level of familiarity (≥4). Regarding objective knowledge, measured by a test of 6 factual questions, the average score was 2.61. This corresponds to a low level of knowledge, confirming the discrepancy between declared familiarity and actual understanding of the bioeconomy concept.

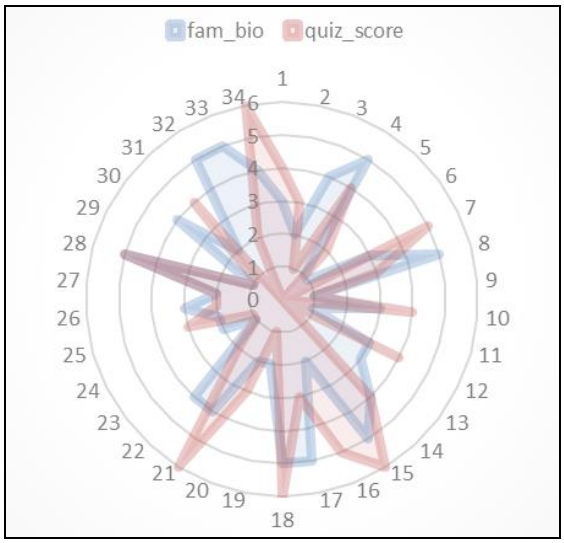


Figure 3. Individual profiles for declared familiarity vs. factual knowledge of the bioeconomy

This discrepancy between declared familiarity and factual knowledge indicates the need for training interventions focused on applied content (operational definitions, examples of biomass cascade use, business models and support tools), capable of transforming exposure to terms and policy documents into an operational understanding of bioeconomic opportunities. As can be seen in Figure 3, overall, the curves for familiarity and factual knowledge do not fully coincide. This difference highlights a constructive space for intervention to strengthen both the level of awareness and the operational understanding of circular bioeconomy.

To identify dissemination vectors with different relevance between age segments, we examined the structure of information

channels by age category. The distribution by age group shows that events such as conferences and workshops represent a very important information channel for farmers. Approximately 22% of them mentioned this type of channel, which confirms the importance of face-to-face interactions. For the segment of young farmers, aged up to 40, the largest share belongs to information coming from the academic area, university, research followed by events and the press, a sign that proximity to universities and the research network functions as an anchor for literacy. The segment between 40-55 years has an heterogenous profile, meaning that in addition to events, social media and public policy documents, supported by associations/ cooperatives matter the most. At 56-65 years old, the role of face-to-face channels is maintained but social media and academia increase, while policies almost disappear as a declared source (approximately 2%). For the responder of above 66 years old, information still comes predominantly from events but there is also a signal of limited exposure. The category “haven't heard” rises to 16%, along with a moderate interest in social media and policy documents. Overall, the data suggest a differentiated communication strategy: demonstrations and workshops as a common axis, complemented by universities/extension for young farmers, social media, policies and associations for 40-55, respectively direct contact and targeted counselling for farmers above 56.

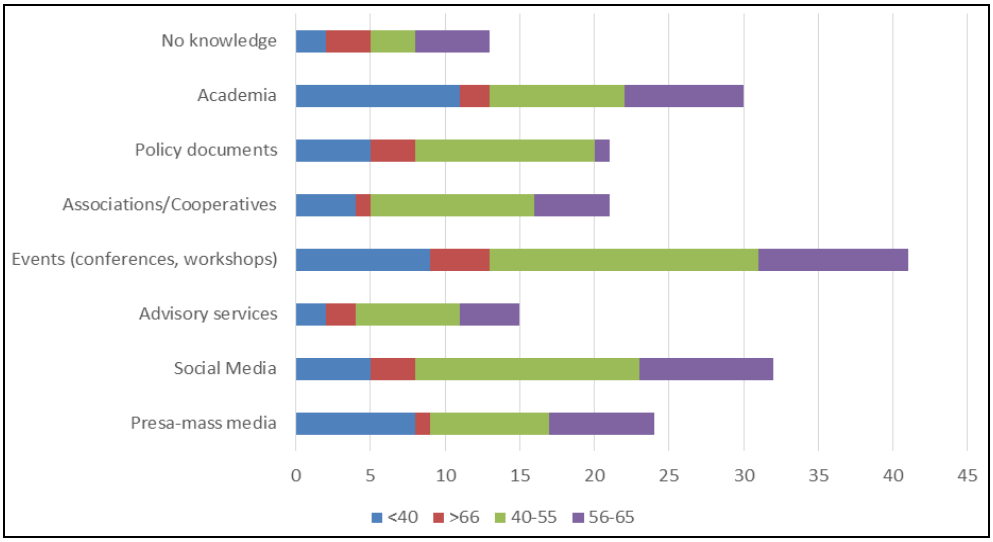


Figure 4. Information channels for bioeconomy dissemination across age groups of farmers

Familiarity with relevant public policies stands at an average value of 3.01, which indicates a relatively frequent contact with the policy discourse, without however translating into consistent factual knowledge.

Next, we assessed perceptions and attitudes towards the bioeconomy, using a 1-5 Likert scale (higher values indicate higher agreement) for six key statements on sustainability, climate resilience, technological compatibility, complexity, demand and profitability.

Nr. crt.	Statement	Item
1	Circular bioeconomy can improve the sustainability of my farm.	sustainability
2	Circular bioeconomy can increase resilience to climate variability.	climate
3	Circular bioeconomy practices are compatible with the technologies I use.	compatibility
4	Implementation involves high technical complexity.	complexity
5	There is sufficient market demand for products resulting from the circular bioeconomy.	demand
6	Circular bioeconomy can contribute to the profitability of the farm in the medium term.	profit

The assessment of perceptions regarding the usefulness and integration of circular bioeconomy practices highlights a slightly favorable attitude, with an overall average of 3.19 on a scale from 1 to 5. The most credible dimension for farmers remains the environmental dimension, where sustainability is valued at 3.66 and climate resilience at 3.09. In contrast, economic aspects are viewed with more caution, with both market demand (3.24) and profitability (2.92) being assessed more modestly. From a technological perspective, compatibility is slightly below the neutral threshold (2.89), while perceived complexity exceeds the average level (3.32), suggesting that farmers anticipate concrete integration efforts (Figure 5). Overall, the results outline a recognized potential especially in the area of sustainability, but also the need for economic demonstrations and operational simplification to stimulate large-scale adoption.

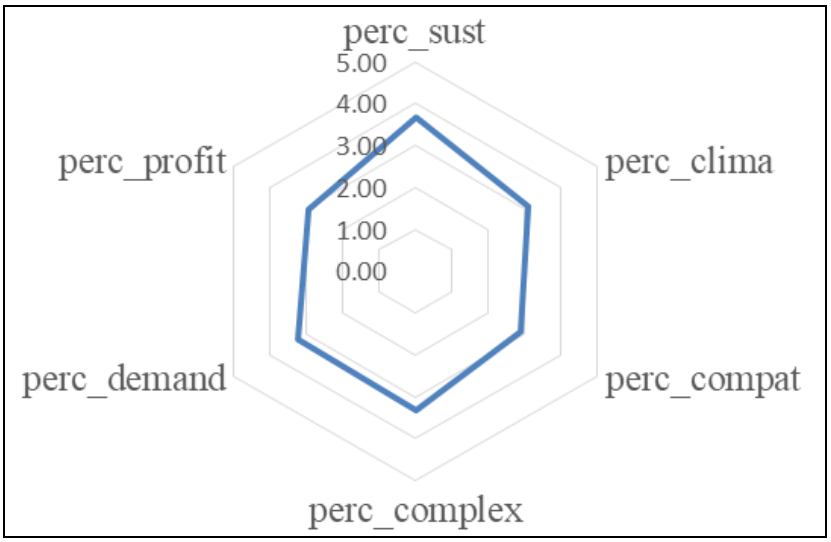


Figure 5. Perception on circular bioeconomy by dimensions

To see if perceptions differ with farm size, we compared average scores across land area classes. Farms <100 ha rate sustainability highly (4.00), but report higher complexity (3.55) and lower levels of compatibility (2.35) and profit (2.35). This is translated to a cautious profile. The farmers 100-499 ha range are the most market-oriented, with the highest perceived demand (3.69) and moderate complexity (3.29), but profitability remains subdued (2.74).

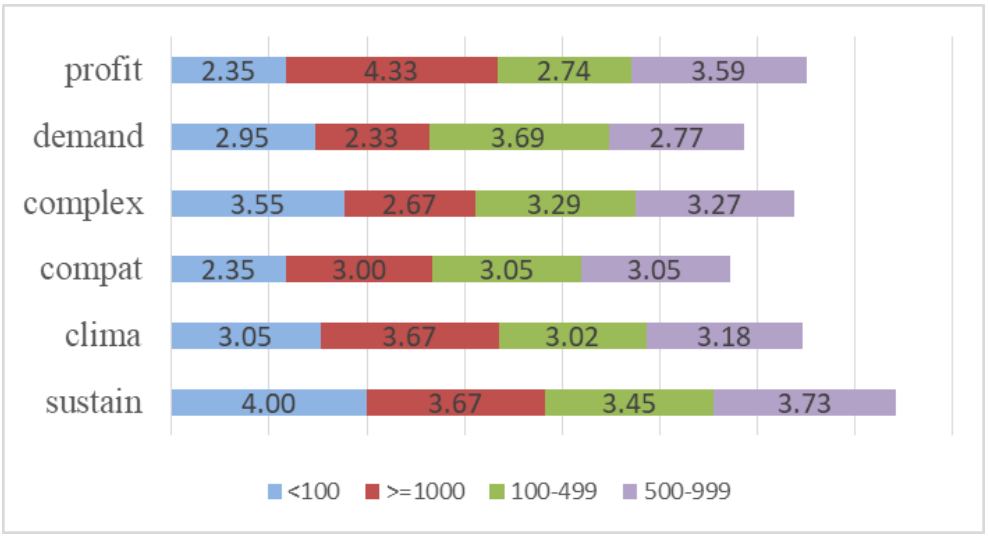


Figure 6. Relationship between farm size and perceptions of circular bioeconomy

At 500-999 ha, sustainability (3.73) and profit (3.59) increase, although demand decreases (2.77). At ≥1000 ha, the lowest complexity (2.67), highest climate resilience (3.67), and peak profit (4.33) are observed, but also the lowest perceived demand (2.33). Overall, as farm size increases, perceptions reconfigure from low technological fit/high complexity to better economic feasibility.

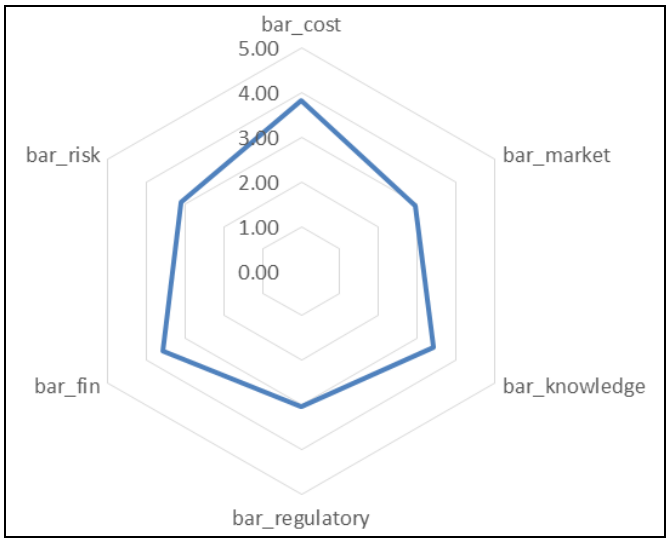


Figure 7. Barriers on circular bioeconomy by dimensions

The composite average index of the barriers identified by the selected farmers was equal to 3.32, outlining a profile in which economic impediments prevail over strictly technical ones, suggesting that financial packages (grants/guarantees/subsidized loans) and applied training would have the best impact-effort ratio.

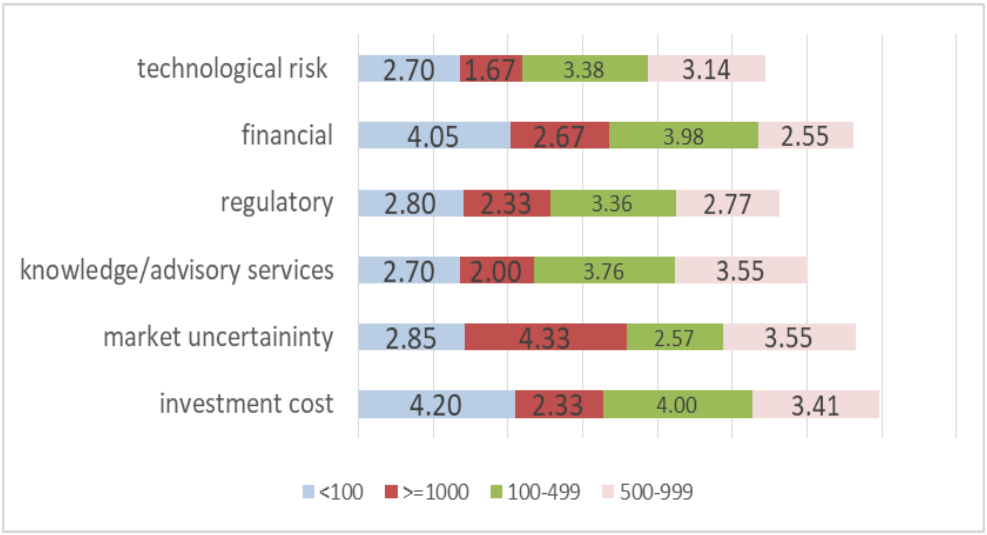


Figure 8. Relationship between farm size and barriers of the circular bioeconomy

In terms of barriers, capital constraints stand out as the most pressing: initial costs (3.84) and difficulties in accessing finance (3.59) are the main challenges reported by farmers. These are followed by the lack of knowledge and specialized advisory services (3.40), which confirms the need for better-adapted training and technical support programs. Technological risks (3.10) and regulatory or bureaucratic pressure (3.05) appear at an intermediate level, but are not negligible. In contrast, market uncertainty emerges as the least pronounced barrier (2.94), which suggests that farmers'

perception is focused more on financial and knowledge aspects than on market ones.

Similar to our results, other authors have reported that the adoption of bioeconomy/ circular farming practices is conditioned by economic and organizational factors (profitability, risk, access to finance), but also by awareness and knowledge - with notable regional variations in the EU (Dieken et al., 2021; Herrera et al., 2023; Papadopoulou et al., 2023; Pink et al., 2025).

Along with pressure related to climatic changes, sustainability relies on increasing added value (processing, frozen products), organic farming, diversification of varieties and association of producers, directions that converge with the logic of the bioeconomy and are relevant for diversification strategies at the farm level (Atkociuniene and Balkibayeva, 2019; Lucasenco, 2024).

The circular bioeconomy has gained increasing visibility in the last decade and is frequently presented as a response to multiple societal challenges; however, the sustainability and scale of this trajectory depend on broad social acceptance, which requires a careful understanding of the perspectives of the actors involved.

A scoping analysis synthesized 105 academic articles on the acceptance of the bioeconomy, revealing a pronounced geographical bias towards the USA, Germany and China and a modest representation of Eastern Europe. Previous studies predominantly treat acceptance, focused on attitudes and perceptions, often towards abstract concept, indicating the need for participatory methodologies and a reorientation towards active acceptance, namely towards how bioeconomic innovations are effectively adopted and used in everyday life (Sadeghzadeh, 2025).

Comparative assessments of sustainable agriculture in EU candidate and neighbouring countries such as Georgia, Moldova, Ukraine, Poland and Romania have indicated the efficient functioning of the systems analysed, with Romania among the cases highlighted for its performance. This positioning creates a favourable ground for the expansion of the bioeconomy: if macro-level efficiency is coupled with investments in bio-based value chains, training and infrastructure, the transition to a socio-ecological model becomes plausible (Stratan et al., 2024). More recently, a systematic review of the EU literature on the circular economy highlighted the focus on regulatory frameworks and opens the opportunity for econometric analyses and research focused on stakeholder awareness, in support of bio-circular diversification at farm level (Vovk et al., 2025).

An exploratory study among agricultural actors in Argentina (n=534) shows that there is a shared vision of the circular economy as a more sustainable model of production-consumption, but the transition is perceived as in its early stages; respondents emphasize recycling/reuse and the integration of productive units, and the barriers cited concern political-economic literacy and technological skills. The authors recommend investments in education and research, with citizens as the central agent of transformation, to structure progressive steps (indicators, programs, policies) - a direction that also supports in our case the need for applied training and involvement of actors in the operationalization of the bioeconomy (Rotolo et al., 2022).

A study conducted in Austria highlights that the bioeconomy is associated by respondents with diverse themes, ranging from sustainability and responsible consumption to criticisms related to the practical feasibility of the concept. The analysis shows the existence of two main visions: one oriented towards technological and industrial developments, and another focused on regionalism and environmental protection. Differences between social groups are significant, with farmers expressing a higher degree of skepticism, especially in relation to potential economic inequities and the risks associated with change. These findings highlight the importance of including a variety of social perspectives in the process of formulating and implementing bioeconomy strategies (Stern, 2018).

CONCLUSIONS

The results of this study confirm that the transition towards a circular bioeconomy in Romanian agriculture is at an early but

promising stage. Farmers show moderate levels of familiarity with the concept, with environmental benefits perceived more positively than economic ones, while barriers remain concentrated around capital constraints and limited access to specialized knowledge. At the same time, differentiated information channels across age groups highlight the need for tailored dissemination and training strategies. Taken together, these findings suggest that policies aiming to foster circular bioeconomy should combine financial instruments with applied training and participatory approaches, thereby addressing both the economic and social dimensions of adoption. Strengthening awareness and building trust at the farm level can create the conditions for a more inclusive and resilient transition to the bio-based economy in Eastern Europe.

A limitation of the study is that the sample structure does not fully reflect the agricultural reality of Romania, where most farms are under 5 ha. Instead, the sample is better representative of medium and large commercial farms, which, although numerically minority, hold a significant share of the utilized agricultural area and play an essential role in the transition to circular bioeconomy. Thus, the results should be interpreted in the light of this specific profile of respondents, focusing on the segment with the greatest economic relevance and innovation potential.

ACKNOWLEDGEMENTS

This work has benefited from support through the ADER 2023-2026 Sectoral Projects financing contract ADER 22.1.4/2023.

REFERENCES

Atkociuniene, V., and Balkibayeva, A., 2019. *The role of cooperation for the needs of bioeconomy development*. Research for Rural Development, 2: 87-94.

Cristache, N., Florea, N.V., Năstase, M., Croitoru, G., Fortea, C., Tureatca, M.V., 2025. *The Influence of Political, Social and Economic Factors on the Acceptance of Technology in the Workplace in the Context of Industrial Revolution 4.0*. Amfiteatru Economic, 27(68): 76-92.

Dieken, S., Dallendörfer, M., Henseleit, M., Siekmann, F., Venghaus, S., 2021. *The multitudes of bioeconomies: A systematic review of stakeholders' bioeconomy perceptions*. Sustainable Production and Consumption, 27: 1703-1717.

Herrera, S.I.O., Kallas, Z., Serebrennikov, D., Thorne, F., McCarthy, S.N., 2023. *Towards circular farming: factors affecting EU farmers' decision to adopt emission-reducing innovations*. International Journal of Agricultural Sustainability, 21(1), 2270149.

Lucasenco, E., 2024. *Sustainable development of the vegetable sector in the context of ensuring food security in the Republic of Moldova*. Agrarian Economy and Rural Development - Trends and Challenges. International Symposium. 15th Edition: 48-56.

Nastić, L., Jeločnik, M., Subić, J., 2024. *Processing of medicinal herbs: Economic analysis*. Agrarian Economy and Rural Development - Trends and Challenges. International Symposium. 15th Edition: 15-23.

Oltenacu, N., Oltenacu, C.V., Buzatu, C.S., Gâdea, M., 2024. *Comparative research regarding the energy efficiency of wheat crop, in ecological and conventional cultivation systems*. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(4): 621-630.

Paltaki, A., Loizou, E., Chatzitheodoridis, F., Partalidou, M., Nastis, S., Papadopoulou, C.I., Michailidis, A., 2024. *Farmers' training needs in bioeconomy: evidence from Greece*. International Journal of Sustainable Agricultural Management and Informatics, 10(2): 143-161.

Papadopoulou, C.I., Loizou, E., Chatzitheodoridis, F., Michailidis, A., Karelakis, C., Fallas, Y., Paltaki, A., 2023. *What makes farmers aware in adopting circular bioeconomy practices? Evidence from a Greek rural region*. Land, 12(4), 809.

Pink, M., Kiełbasa, B., Niewiadomski, M., Piecuch, K., 2025. *Barriers and Challenges Faced in the Deployment of Principles of the Circular Bioeconomy: Awareness, Knowledge and Practices Based on the Example of Polish Agriculture*. Sustainability, 17(10), 4729.

Rodino, S., Butu, A., Butu, M., 2019. *Analysis of the perception on Bioeconomy and environmental economics concept*. International Multidisciplinary Scientific GeoConference: SGEM, 19(5.3): 61-68.

Rotolo, G.C., Vassillo, C., Rodriguez, A.A., Magnano, L., Vaccaro, M.M., Civit, B.M., Ulgiati, S., 2022. *Perception and awareness of circular economy options within sectors related to agriculture in Argentina*. Journal of Cleaner Production, 373, 133805.

Sadeghzadeh, M., Henchion, M., O'Neill, E., 2025. *Exploring Social Acceptance in the Bioeconomy: A Scoping Review and Future Research Directions*. Cleaner and Circular Bioeconomy, 100157.

Stern, T., Ploll, U., Spies, R., Schwarzbauer, P., Hesser, F., Ranacher, L., 2018. *Understanding perceptions of the bioeconomy in Austria - An explorative case study*. Sustainability, 10(11), 4142.

Stratan, A., Lopotenco, V., Lucasenco, E., Staver, L., 2024. *Transition to sustainability: A DEA evaluation of agricultural systems in EU candidate and neighboring countries*. International Conference on Management Science and Engineering Management, Singapore: Springer Nature Singapore: 365-377.

Todirică, I.C., Petcu, V., Ciornei, L., Popa, M., Simion, P.S., Grădilă, M., Zaharia, T.A., 2024. *Regenerative Agriculture Key Traits-Bibliometric Analysis and Quantitative Review*. Romanian Agricultural Research, 41: 353-361. https://doi.org/10.59665/rar4133

Vovk, V., Taşdöken, Ö., Bölük, G., Stratan, A., Polcyn, J., 2025. *Circular Economy in the European Union: A Prisma-Based Systematic Review and Meta-Synthesis*. Sustainability, 17(3), 1282.