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RESEARCH ARTICLE **OPEN ACCESS**

Circular Economy Perspective and Implications for Livestock Farming in Albania

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Abstract:

Background: The transition to a circular economy has a principal role in driving sustainability and resilience in food systems. However, the implementation of this approach is complex, and governments should be aware of the challenges of adoption.

Objective: The aim of the study was to identify knowledge gaps and limitations influencing farmers' decisions to implement circularity, emphasizing the importance of policies, education, economic factors, and technology throughout the food chain. This paper highlights the challenges faced by farmers in adopting circular practices in livestock farming.

Methods: Through the multi-actor approach, stakeholders have identified a set of policies, education, economic, and technological factors as critical barriers that impact farmers' decisions and value chain actors to adopt circular practices in their business operations. In this work, the respective variable categories have been tested on a large farmer population through quantitative research instruments.

Results: The results have indicated a significant relationship between variables related to political and regulatory framework categories and farmers' motivation to implement circular practices. The findings have revealed the critical role of relevant policies and regulations, lack of subsidies, and lack of awareness by public institutions in shaping farmers' willingness to adopt circular practices in livestock production. The economic implications associated with the cost of production, investments, and operational costs have been found to impact the feasibility of circular systems.

Conclusion: Providing support to mitigate economic barriers is fundamental in improving sustainability in agri-food systems through a circular economy approach. This comprehensive approach requires establishing dedicated legislation to promote circular practices, providing support for circular economy initiatives, and fostering collaboration among stakeholders along the value chain.

Keywords: Food system, Circularity, Sustainability, Stakeholders, Rural communities, Circular economy.

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1. INTRODUCTION

Even though livestock is defined as a pillar of the agri-food system, in terms of feeding the population, providing nutritional benefits, and supporting the livelihood and vulnerability of communities, its farming activities have significant impacts on food insecurity, depletion of limited resources, and the environment [1]. These issues are derived from the linear structure of the sector, which

requires significant levels of inputs for production, while large amounts of these inputs are not converted into edible products, resulting in product loss and waste within the food chain. Consequently, toxic substances, greenhouse gases, and nutrients are released into the environment.

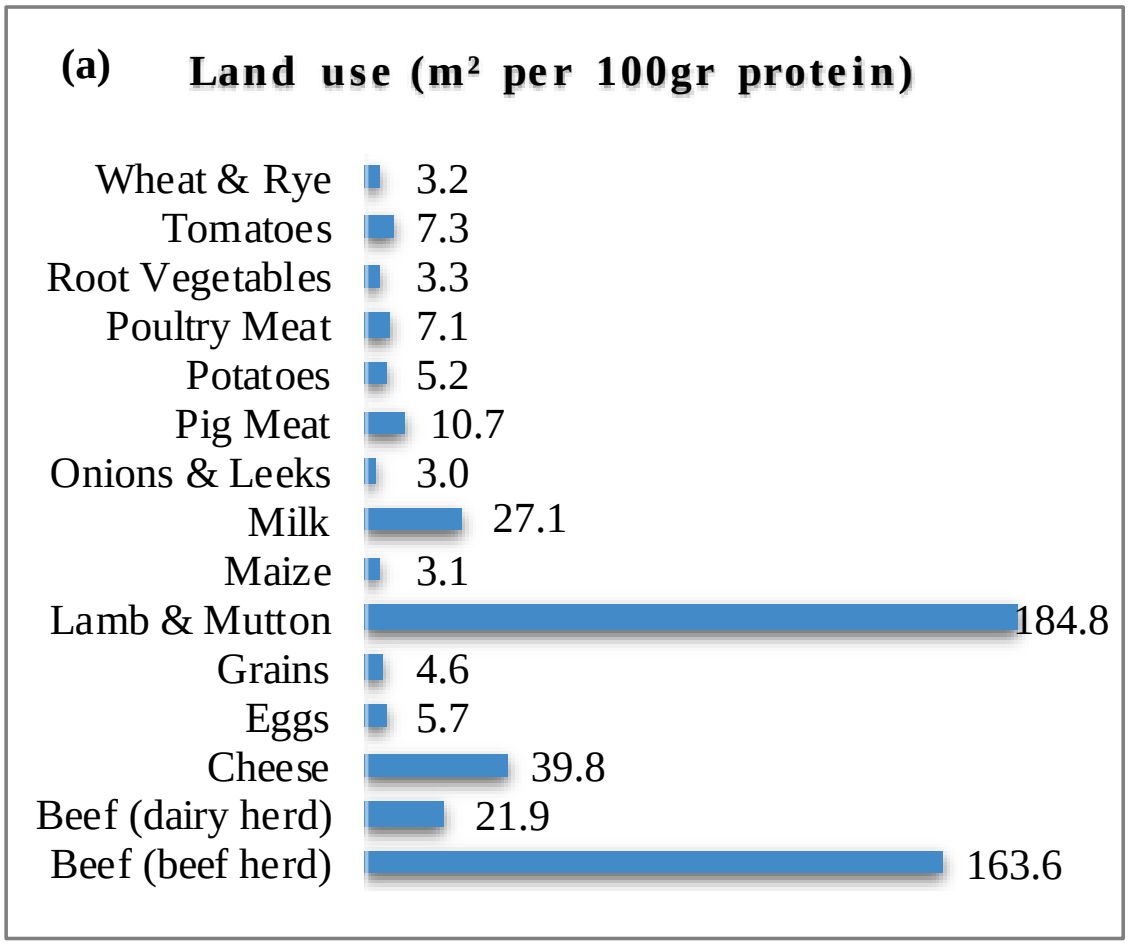
Agriculture and livestock farming are crucial drivers of climate change and have enormous impacts on the environment. This occurrence derives from the fact that they consume 70% of freshwater withdrawals [2], almost 50% of the world's habitable land, while food production is responsible for 26% of global greenhouse gas emissions [3].

The amount of land required to produce food is unequally distributed when crops and livestock products are differentiated for human consumption. If we combine pastures used for grazing with land used to grow crops for animal feed, livestock accounts for 77% of global farming land. While livestock accounts for most of the world's agricultural land, it only produces 18% of the world's calories and 37% of total protein [3].

According to Fig. (**1a**), livestock products have a substantial impact on land per unit of protein compared to permanent and annual crops, while among the meat products, lamb and mutton (184.8 m^2 per 100 g protein) and beef (163.6 m^2 per 100 g protein) have the highest impact on land. Panel (b) presents the greenhouse gas emissions measured in kilograms of carbon dioxide equivalents per kilogram of food, indicating that at a high scale, the absorbed and emitted radiant energy by GHG is derived on the downstream part of the livestock chain, where the initial production occurs.

Albania has set up its goals in the context of a circular economy through changes in legislation in the field of waste management and sustainable energy. Most of the changes occur at the private sector level, but their development is very slow. One of the biggest issues in the transition to a circular economy is the waste management system, which requires significant change at the national and regional levels in the field of building infrastructure and closing the loops of materials [4].

The main GHGs emitted by livestock systems are methane (CH4), nitrous oxide (N2O), and carbon dioxide (CO_2); consequently, these three gases have always been priority targets for reduction. World agricultural emissions within the farm gate (at the production stage of crops and livestock) grew by 13% between 2000 and 2020. In addition, approximately 57% have been reported to be derived from livestock-related activities, while the emissions from enteric fermentation generated in the digestive system of ruminant livestock have been reported to be responsible for 39% of agricultural emissions [5].



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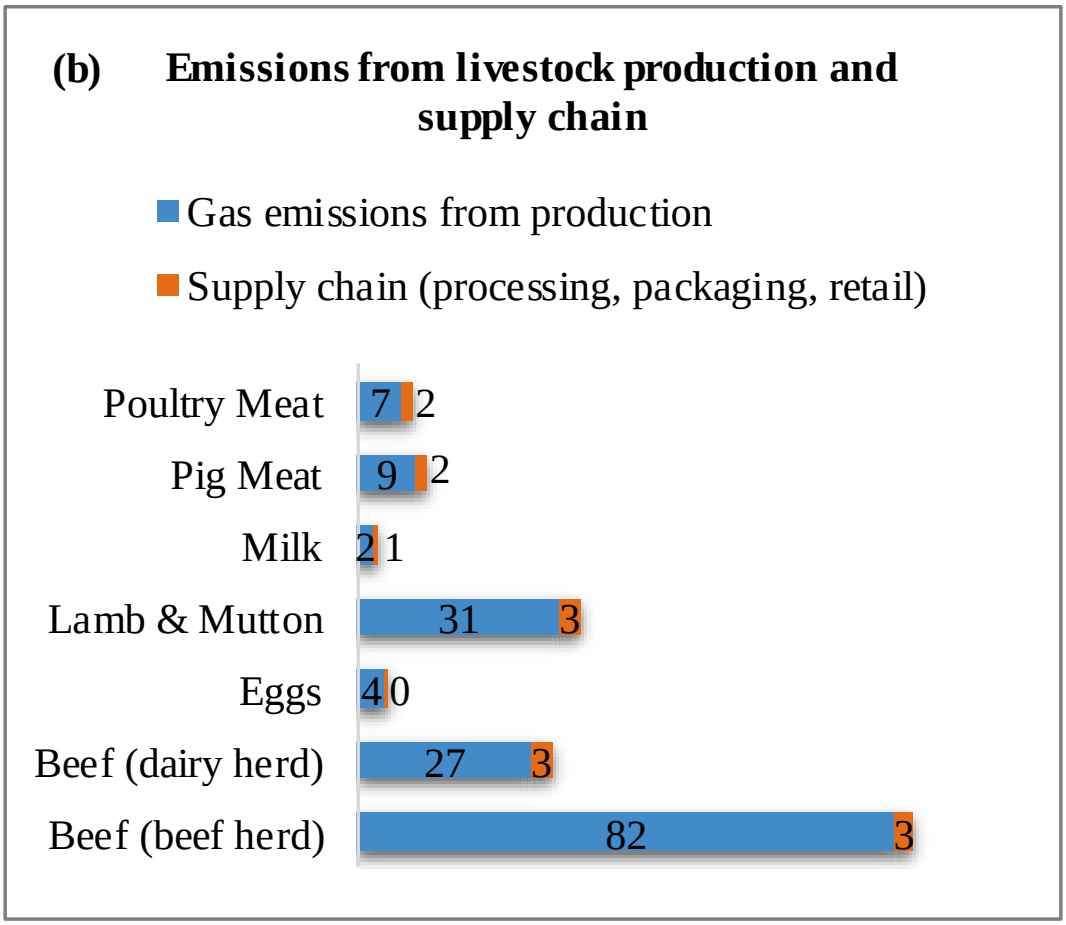


Fig. (1). Land use per 100 grams of protein and gas emissions from livestock system.(**a**) Average land required for producing 100 g of protein. (**b**) Greenhouse gas emissions from livestock production and supply chain measures in kg of carbon dioxide equivalents (CO_2) kg of food (adopted by Our World in Data).

The proportions of CH4, CO2, and N2O to the total greenhouse gas emissions in the food chain are shown in Table **1**. The data from the EDGAR-FOOD database [6] indicate a high predominance of CH4 and N2O emissions at the farm level, whereas the share of CO_2 is higher in the packaging stage, followed by production, transportation, and processing. Globally, from 2014 to 2018, the level of GHG emissions in the food system decreased by 8%. At similar margins, the trend of EU agricultural GHG emissions decreased by 7.7%.

Table **2** shows trends in the global, regional, and local emissions of greenhouse gases from 2014 to 2018. In Albania, the level of GHG emissions in the food system is above the global and European average levels.

Table 1. Share of GHG emissions in the food chain (in %).

Food System Stage	CH_4	CO_2	N_2O
Consumption	0.4	2.1	22.6
End_of_life	306	0.9	46.5
Packaging	88.5	861.2	2.7
Processing	73.7	167.2	12.1
Production	1924.2	315.5	776.4
Retail	14.4	23.1	0
Transport	7.5	182	1.2

Note: (adopted by EDGAR-FOOD database).

Table 2. GHG food system emissions to total GHG emissions (including LULUC).

Food System Stage	2014	2015	2016	2017	2018
World	0.506	0.494	0.470	0.470	0.369
Europe	0.400	0.406	0.372	0.367	0.369
Albania	0.579	0.580	0.547	0.554	0.573

Note: (adopted by EDGAR-FOOD database).

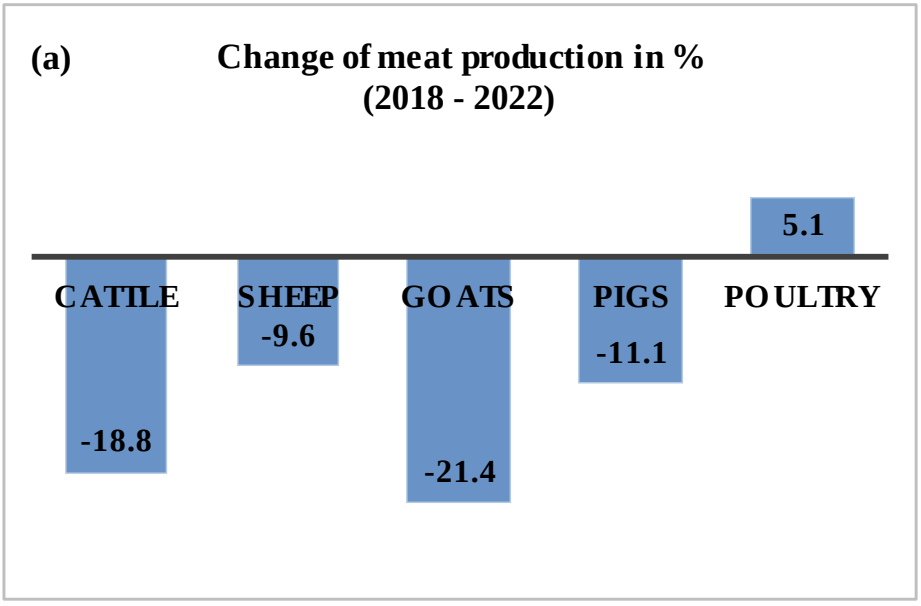
Livestock farming, as part of the agricultural economy, is a significant sector contributing to nearly 50% of the total agricultural output. The share of land used for agriculture is 42.85%, while permanent meadows and pastures cover 17.45% of the land area [7].

Due to the importance of livestock production in local economies, rural communities are highly dependent on the jobs derived from it. Apart from its economic importance and production premises, this sector is strategic in harmonizing the development of rural regions. However, the general trend indicates a steady decline in the number of livestock farms, animal units, meat, and dairy production. In the last five years, meat production from cattle has undergone a negative growth of 18.8%, whereas meat production from goats has incurred a decrease to 21.4% [8]. The trend in milk production is at similar levels. During 2018-2022, a 15% decline was observed in cow's milk, whereas the milk produced from goats and sheep incurred a decrease ranging from 11% to 19% (Fig. **2b**).

Competitiveness of the livestock sector and production trends have been reported to be largely driven by the small size of farms, property ownership issues, labor shortage, low number of farmers' cooperatives and producer associations, low level of technological advancement, high costs, and low compliance with environmental, food safety, and animal welfare standards. All of these issues have been reported to lead to a low intensity of capital return on farm operations, inducing difficulties in achieving sustainability goals [9].

The livestock sector is a key driver of humanity's transgression of several planetary boundaries, with ruminant meat production being particularly impactful [10]. A transition toward a circular food system where the agricultural food chain changes from a linear production with a beginning, ending at leaks, to a circular food chain with minimal unnecessary losses, could be the answer to some of these challenges [11]. However, shaping a sustainable future for agriculture and livestock may depend on understanding the motivations and challenges that stakeholders in the supply chain face in periods of transformative change.

The transition toward a circular economy offers opportunities for both industrialized and developing countries. The European Commission emphasizes that developing and emerging countries face the same challenges as more developed economies in improving the environmental and social sustainability of their economies and mitigating the economic and social costs of further environmental degradation [12]. However, these countries face greater challenges due to the lack of human, financial, and institutional resources. In Albania, although the implementation of circular practices in the food chain is part of the discussions of policymakers, there is little evidence and research on how policies should be updated for sustainable supply chains. Moreover, the concept of a circular economy is not clear to all actors involved in livestock production, and the implementation of circular practices in the food chain is in the early stages. To successfully implement circular practices in the food chain, barriers that influence the application of circularity in livestock farming must be addressed.



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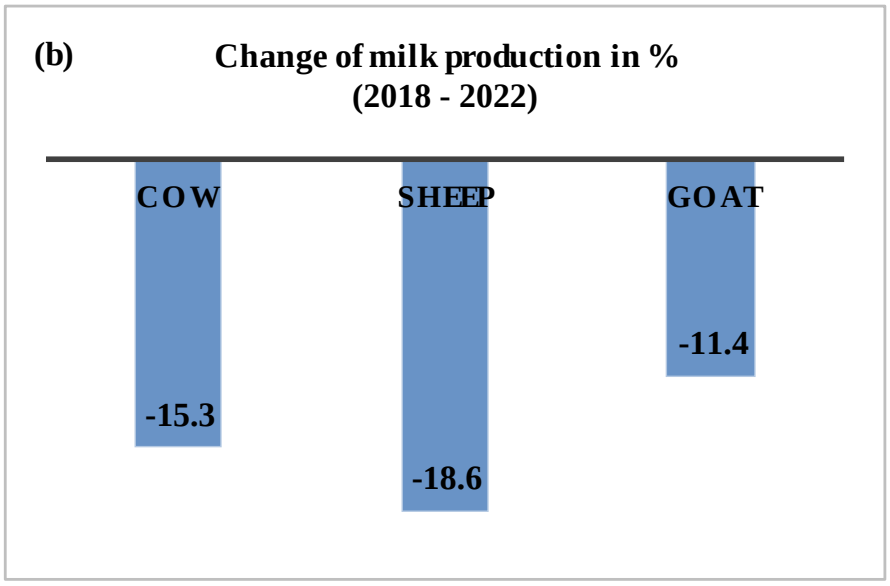

Fig. (2). Development trend of livestock production in Albania (2018–2022).(**a**) Change of meat production in %. (**b**) Change of milk production in % (data source: Albanian Institute of Statistics, 2023).

This study aimed to focus on the factors that motivate farmers to think about circular practices and the role of stakeholders in switching from a linear to a circular approach. It can prove to be an important contribution to the scarce literature related to the aforementioned issues.

1.1. Toward the Circular Economy Approach

To match the goals of sustainable development, a conversion of the agri-food system that targets the deployment of technology and know-how and new business models with new value-sharing principles as well as supportive policies and legislation are required [13].

The circular economy has become one of the main pillars of the European Green Deal; therefore, various countries have accelerated toward the adaptive approach of this concept, with particular attention to agriculture and livestock farming, considering the set of impacts described in the previous sections of this paper. Albania, as part of the Western Balkan countries aiming to become a member state of the European Union, has defined the goals for the implementation of the circularity approach in legislation related to waste management and sustainable energy. The document of strategic policies and the national plan on integrated waste management defines the mechanism and actors involved in the transition from linear to circular economy to prevent and reduce the negative impacts on human health, the environment, and adaptation to climate change [14].

In general, livestock farming systems are linear, and therefore considered as a “take, make, dispose” model of production, utilizing high levels of input, a large proportion of which is not converted into edible products, and therefore is wasted and damaging environmental outputs [15]. In line with the principles of circular economy, Imke and Martin [16] pointed out that moving toward a circular food system requires new practices and technologies that minimize the input of finite resources, encourage the use of regenerative resources, prevent the leakage of natural resources (*e.g.*, carbon (C), nitrogen (N), phosphorus (P), and water), and stimulate the reuse and recycling of inevitable resource losses, in order to add value to the food system. Similarly, Jurgilevich *et al*. [17], after defining the concept of circular economy and explaining how the loop of nutrients in the food system can be closed to minimize food losses and waste, inferred that measures must be assigned both at the producer and consumer levels, while Gustavson *et al*. [18] argued that food losses in developing regions are more predominant near the production level.

The concept of circular economy in livestock farming is linked to the role of farm animals in the food system. Studies have shown that farm animals reared under a circular approach can play a crucial role in feeding humanity [19-21]. These farm animals would not consume edible human biomass, such as grains, but convert by-products from the food system, which are inedible to humans, and biomass from grasslands into valuable food, manure, and other ecosystem services. Food systems analysis indicates that the use of natural resources and emissions associated with modern food systems can be substantially reduced by shifting to a circular food system [22].

Another important issue to be considered when addressing the importance of the transition to circular practices consists of the challenges related to the antibiotic crisis in the livestock industry. Xi C *et al*. [23] defined antibiotic residues, antibiotic-resistant bacteria, and resistance genes as important environmental pollutants, and therefore responsible for the public health crisis throughout the globe. Related to this, Founou and Essack [24] pointed out that since the farm environment is composed of environmental sites (manure, wastewater,

soils, effluent, and sewage) that serve as hotspots for antibiotic resistance pollution, farm animals are exposed to a high degree to their environment and, as a consequence, can be easily infected with bacteria harboring problematic genetic material. Masebo *et al*. [25], after assessing the welfare and health status of bulls imported from France and fattened in Italy in a commercial fattening unit, defined that clinical investigations can help to evidence critical points in management and housing system that could threaten health and welfare of animals. However, the choice of antibiotics and antimicrobial consumption patterns vary across continents due to geographical differences. In the study by Van Boeckel *et al*., antimicrobial use has been reported to be influenced by food animal species, regional production patterns, types of production systems, and lack of legislative framework [26].

Despite the various initiatives undertaken by the Albanian government in the last few years to sustain the circular economy initiative as one of the building blocks of the European Green Deal, there is still no act or dedicated legislation on the transition to the circular economy; also, there exists a lack of subsidies for business initiatives that reduce, reuse, or recycle waste [4], and very limited awareness campaigns are ongoing that encourage a circular economy, especially in agriculture and livestock farming. This fact has been emphasized by other researchers when analyzing the factors that influence the efficiency of food chains in emerging economies [27].

1.2. The Divergent Framing of the Circular Approach and the Albanian Context

Even though 3R's principles "reduction, reduce, and recycle" constitute the basis for circular business models [28], most of them are focused on recycling and product-as-a-service system. The adaptive approach of circular business models refers to introducing circularity as a fundamental way to produce goods and services, but its implementation in practice is assorted [29]. Introducing or adapting the concept of circularity in rural economies depends on how this approach is framed in the current environment. Various authors [30-32] have concluded that the primary impediment to this transition is the growing need for innovation, which includes not only research on new technologies, but also clear guidance on their use, policy support for establishing appropriate regulatory frameworks, and appropriate incentives for technology adoption.

Julian *et al*. [33], after analyzing 114 conceptualizations of a circular economy, argued that a circular economy is not considered a systematic shift in the sustainable development of the economy, concluding that it must be understood as a fundamental systemic change in order to ensure its impact.

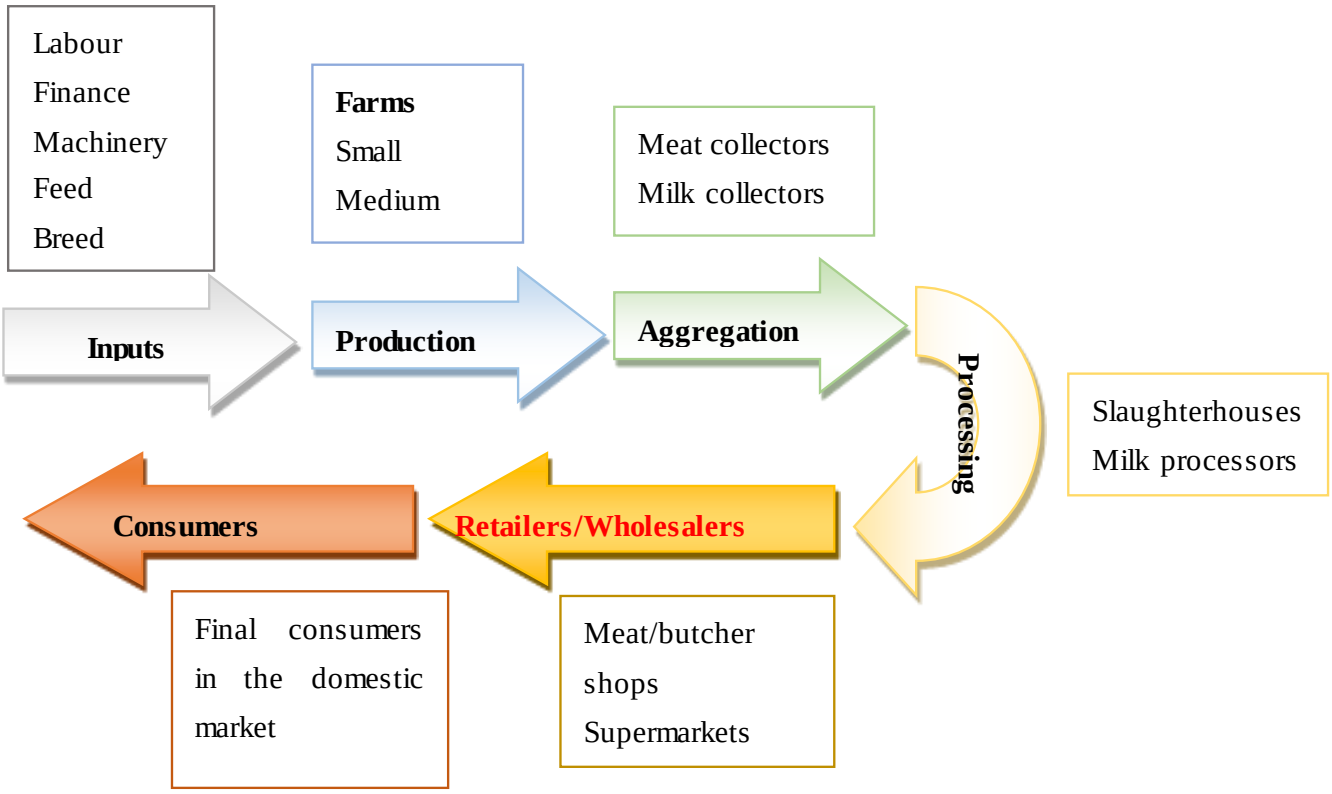

Fig. (3). The linear structure of the meat and dairy value chain in Albania.

Due to the inefficiencies of biological feed conversion and the higher energy demand required by the animals, livestock production in Albania fits more into the linear production system. Fig. (**3**) shows a linear model of the meat (cattle, sheep, and goats) and dairy value chains in Albania. However, unlike other industrialized economies, few efforts have been made to close the loop with the circular production model.

Shane *et al*. [15] defined the importance of the virtual trade of resources linked to the impact of circularization through space and time. In this context, considering the drivers of the competitiveness of livestock farming in Albania and the poor governance of the value chain, the efficiency of circular economy activities may be compromised, and critical natural resources may not return to the point of production. In line with these misgivings, in the research workshop organized by the European Commission [34], it was argued that even though the transition to a circular economy brings economic, social, and environmental benefits, the "circularization" could cause economic and social stress if not properly analyzed before implementation.

The livestock value chain differs from other chains and consequently requires a different form of transition to a circular economy. This is because of product attributes, life cycle, durability, and function. Thus, it is important that before defining transitional goals and setting up effective strategies and attempts toward circularity, the factors that impact adaptability within the value chain must be analyzed. In the following sections, evidence is generated on the factors that influence decision-making in implementing circular initiatives in the downstream part of the livestock value chain, considering a multi-actor approach.

2. MATERIALS AND METHODS

2.1. Study Area and Size

The areas chosen for conducting the research were the Korça and Dibra regions. These regions were selected based on the economic importance that livestock farming represents for their rural territories and communities and the similarity in terms of the characteristics of livestock production.

Emilio *et al*. [35] defined the transition from a linear to a circular economy model as a process that requires the development and application of new knowledge, leading to innovative, technological, and sustainable processes, products, and services. Considering that the circular approach in agriculture is correlated with the application of new technologies and innovation, large-scale farms are more likely to adopt agricultural machinery because of the economies of scale associated with larger operations [36]. Therefore, after an initial screening of the farms in the defined regions, the typology of the livestock farms that would be part of the survey was determined. According to Engjell and Drini [37], the minimum threshold for cattle farms to be considered potentially market-oriented is more than 20 heads, while for sheep and goats, it is over 200. In conclusion, only livestock farms that were financially viable and had a strong market orientation were considered in this study (Table **3**).

Table 3. Population of farms and size.

Region	Dairy and Cattle		Sheep and Goats	
	Farm Size	Number of Farms	Farm Size	Number of Farms
Korçë	Over 20	132	Over 200	135
Dibër		13		73

Note: (source: Ministry of Agriculture and Rural Development, GIZ; Milk and Meat Sector Study Report 2021).

From the population of farms represented in Table **3**, the representation basis was defined using probability sampling, focusing on randomized selection. In addition, 149 questionnaires were considered valuable (dairy, beef, cattle, sheep, and goat farms) and distributed in the regions of Korça and Dibra.

2.2. Research Method

The research method applied in this study was based on the identified research problem, the type of collected data, and the purpose of their use. Therefore, a combination of qualitative and quantitative research was identified as the most appropriate method for this study.

Initially, the factor categories that influenced the implementation of circular techniques in the downstream part of the value chain were defined through a literature review and multiple sessions with various stakeholders. After selecting the factors according to each category, the structure of the questionnaire was created and distributed to a wider population, focusing on farmers involved in livestock farming (dairy and beef cattle and sheep/goats) in the target regions.

The qualitative technique relied on interpretive techniques seeking to explore and describe a particular concept, such as "circular economy" that is considered new for Albanian farmers and other chain stakeholders. In addition, a multi-actor approach has emerged through the application of various focus groups. Donald and Pamela [38] explained the role of applying the focus group technique and the output it produces to enrich all levels of research questions or hypotheses. The main objective of the focus group technique was to collect a vast number of ideas and behavioral observations from stakeholders (farmers, value chain actors, academics, public institutions, and NGO representatives) regarding the concept of circular economy and the importance of implementing circular practices in the livestock value chain. After this process, the observations received from the stakeholders were used for quantitative testing, focusing on the main obstacles preventing Albanian farmers in the target regions from implementing circular practices.

Pearson's chi-square test was used to assess the relationship between two categorical variables [39-41]. In this case, the defined variables were livestock farms (cattle/beef, sheep, and goats), and a set of factors was

divided into four categories (policies and governance, education and skills, economics and technology, and logistics). In addition, the hypotheses for the test of independence were defined, which are stated as follows:

H_0: There is no significant association between the adoption of circular practices and specific barriers in each category.

H_1: There is a significant association between the adoption of circular practices and specific barriers in each category.

The chi-square test was used to assess whether there was a relationship between the identified barriers and the decision to adopt circular practices. Therefore, the chi-square test formula for independence was used to measure the discrepancy between the observed (f_o) and expected (f_e) frequencies, where χ^2 represents the symbol for the chi-square statistic [42] (Eq **1**).

$$[\chi^2 = \Sigma \frac{(f_o - f_e)^2}{f_e}] \quad \textbf{(1)}$$

The chi-square test for independence (correlation coefficient) indicates whether the association between the observed variables is significant, but does not show the contingency level. Similarly, Raspa F *et al*. [43] used bivariate analysis to investigate the effect of stocking density on behavioral activity frequencies, analyzing the relationship by using the Pearson correlation coefficient.

To measure the strength of the relationship between variables, and because the applied chi-square test involved a matrix larger than 2 × 2, Cramer's V formula was used to measure the effect size of the identified barriers on the farmers' decision to adopt circular practices on their farms, where df_* is the degree of freedom for the chi-square test of independence (Eq **2**).

$$[V = \sqrt{\frac{\chi^2}{n(df*)}}] \quad \textbf{(2)}$$

To interpret the effect size of the respective barriers that influence farmers' motivation to implement circular practices on their farms, the standards for interpreting Cramer's V, as proposed by Jacob [44], were taken as a reference (Table **4**).

Table 4. Standards for interpretation of cramer's V coefficients.

Degree of Freedom	Small Effect	Medium Effect	Large Effect
Df* = 1	0.10	0.30	0.50
Df* = 2	0.07	0.21	0.35
Df* = 3	0.06	0.17	0.29

Note: [source: Jacob, C (1988)].

2.3. Strategy for Stakeholder Engagement

The issues derived from the actual linear model of agriculture and livestock farming, inducing climate change, biodiversity loss, economic fluctuations, and social issues, have called for the attention of the actors of the agri-food chain, consumers, academic institutions, NGOs, and policymakers, as well as the need to implement circularity strategies within the production chain. Indeed, such important issues related to the sustainability of the food value chain, which are part of a complex interaction between the actors in the food chain, require the involvement of a multi-actor perspective. Moreover, transformative changes (from a linear structure to a circular one) require the involvement of all value chain actors, starting with input providers, farmers, downstream enterprises, and finally, consumers [45].

The applied methodological approach used in this study was the multi-actor approach. This methodology approach is related to the fact that the collaborative process aims to connect the actors of the bottom-up agri-food chain with experts in the field and the scientific network, increasing knowledge of the concept of circular economy, and using scientific results for innovative solutions. Accordingly, Gianluca *et al*. [46] defined the interaction between actors, activities, and outcomes as key elements for a transdisciplinary approach that can address future challenges in agri-food systems. Similarly, UNDP [47] proclaims that the ease of adopting technology, the empowerment of farmers' communities, and the enforcement of the link between farmers, researchers, and experts are the main strengths of participatory research. The steps followed for stakeholder engagement consist of three phases, as conceptualized in Fig. (**4**). According to this approach, the strategies comprise a desktop study, participatory monitoring (focus groups/workshops), and a survey, aiming to facilitate the incorporation of farmers' knowledge and other stakeholders in the food chain.

Table 5. Barriers to livestock farming (stakeholders' overview).

Policies and Governance	Education and Skills	Economic	Technology and Logistic
Not adequate policies, legislation and regulations	Level of education	High costs of livestock production	Low level of technology
Lack of preferential policies	Limited knowledge and professional skills	High investment costs	Poor agricultural infrastructure
Lack of support and insufficient subsidies	Lack of knowledge transfer through extension services	High operational costs	Poor digital and logistic infrastructure
Lack of promotion and awareness from public institutions	Lack of knowledge on using digital technologies	Size of livestock farms	-
Lack of cooperation between farmers and chain actors	Lack of information on circular economy and benefits	-	-

Note: (source: authors).

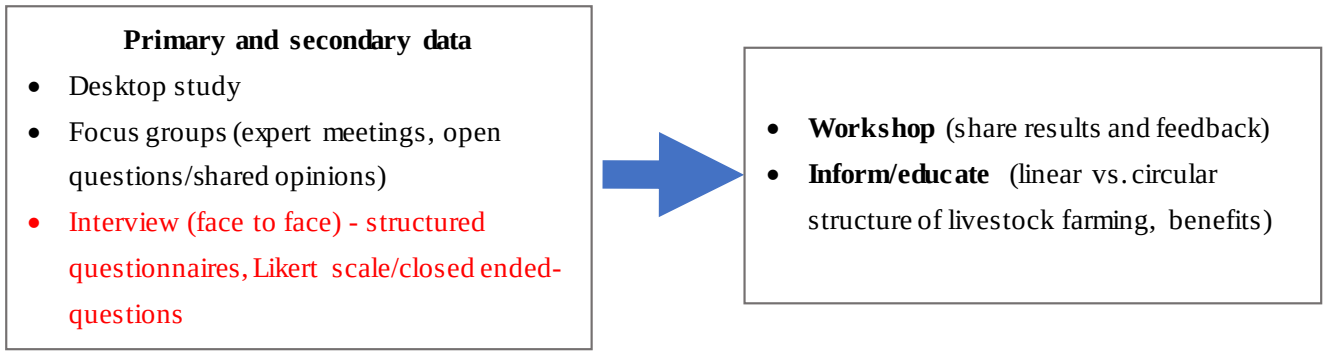

Fig. (4). Stakeholder's participatory approach (source: authors).

Table 6. Chi-square test and effect size for policy and governance barriers.

Policies and Governance	Pearson Chi-square Test			Cramer's V		Valid Cases
	Value	Df	Asymptotic Significance (2-sided)	Value	Approximate Significance	
Not adequate policies/legislation	11.381 [a]	2	.003	.285	.003	140
Lack of preferential policies	3.810 [a]	2	.149	.166	.149	138
Insufficient subsidies	9.595 [a]	2	.008	.259	.008	143
Lack of promotion	13.763 [a]	2	.001	.318	.001	136
Lack of cooperation between chain actors	6.625 [a]	2	.036	.219	.036	138

Note: (source: authors).

The reason for using this approach was to enhance the knowledge of farmers, value chain actors, and other participants related to the issues of circularity, which could anticipate a positive impact on the depletion of resources, food security, and biodiversity, and provide benefits for the livestock farming system. In this context, focus group meetings with 9–12 participants, including farmers, value chain actors, academics, representatives from public institutions (Regional Agency of Agriculture Extension and Center of Agriculture Technology Transfer), and workshops, were organized in the targeted regions. Through this process, a set of significant factor categories (Table **5**) that mainly influence the implementation of circular techniques in the downstream part of the value chain were defined. Based on the feedback received from the group meetings, a structured questionnaire with specific variables and questions was prepared and distributed to farmers involved in livestock production to measure their behavior, knowledge, and opinions on the barriers that prevent them from implementing circular practices. The information was gathered during the period September-December 2023 by conducting in-person interviews with livestock farmers in the defined regions of the research. Two sections made up the format of the questionnaire. The purpose of the first section's questions was to gather descriptive data regarding the size, location, age, gender, workforce, farm size, and data regarding experience and educational background of farmers. The second section of the questionnaire comprised closed-ended questions with a five-point Likert rating scale. The questions enabled respondents to share their insights through specific statements to get their opinions on the main obstacles that prevent them from adopting circular practices and examine farmers' understanding of the circular economy's principles. The questionnaire was tested by stakeholders before it was finalized.

3. RESULTS

3.1. Identification of Barrier Categories in Livestock Farming

Adopting circular economy solutions is crucial for achieving food security and agricultural sustainability [48]. Prior to their application, there are predominant challenges that need to be addressed by chain actors and policymakers before exposing these practices to the farm level and further on the food chain. Therefore, it is essential to identify, understand, and apply measures that can provide economic, environmental, and social benefits. In this study, through a multi-actor approach, stakeholders (livestock farmers, food chain actors, academics, representatives of public institutions, and NGOs) joined forces and identified the barrier categories (variables) that prohibit the adoption of circular economic practices (Table **5**).

3.2. Policy and Governance Barriers

This section presents an analysis of the political and

regulatory factors that stipulate the implementation of circular practices in livestock farms. In most cases, the results have shown a significant relationship between the variables belonging to the political and regulatory framework categories (Table **6**) and farmers' motivation to implement circular practices. The null hypothesis has been validated for only one variable, stating that farmers' willingness to adopt circular practices and the lack of preferential policies are independent; therefore, there has been found no relationship between them.

Considering the values of the chi-square test ($p < 0.05$) and the standards for interpreting the coefficients that define the size effect (Cramer's V), it has been observed that an effect size medium to large may provide evidence that farmers' decisions to adopt circular practices are highly influenced by the relevance of policies and regulations (V = 0.285), lack of subsidies (V = 0.259), lack of promotion and awareness by public institutions (0.318), and lack of cooperation between chain actors (V = 0.219). These findings have also been testified in other studies [49, 50], manifesting that the transition toward "circularity" derives from multiple drivers, where policy and governance can significantly influence the implementation of circular practices.

3.3. Educational and Skill Barriers

The transition to a circular economy in livestock farming requires a set of necessary skills and knowledge to implement circular practices and improve value chain management. The role of individual engagement with this transformation and the gaps in existing knowledge highlight the need to adopt a new way of thinking and develop new competencies and skills [51]. This can be challenging for Albania, considering the education level of farmers and a gap in 'deep skills', which can be a barrier to the implementation of the circular approach. According to the descriptive statistics, the data of the survey indicated that of the 149 farmers, 70% had primary and secondary education, 18.9% had vocational education, and only 6.1% had a university degree (Fig. **5**).

Furthermore, the relationship between the adoption of circular practices and educational barriers was analyzed (Table **7**).

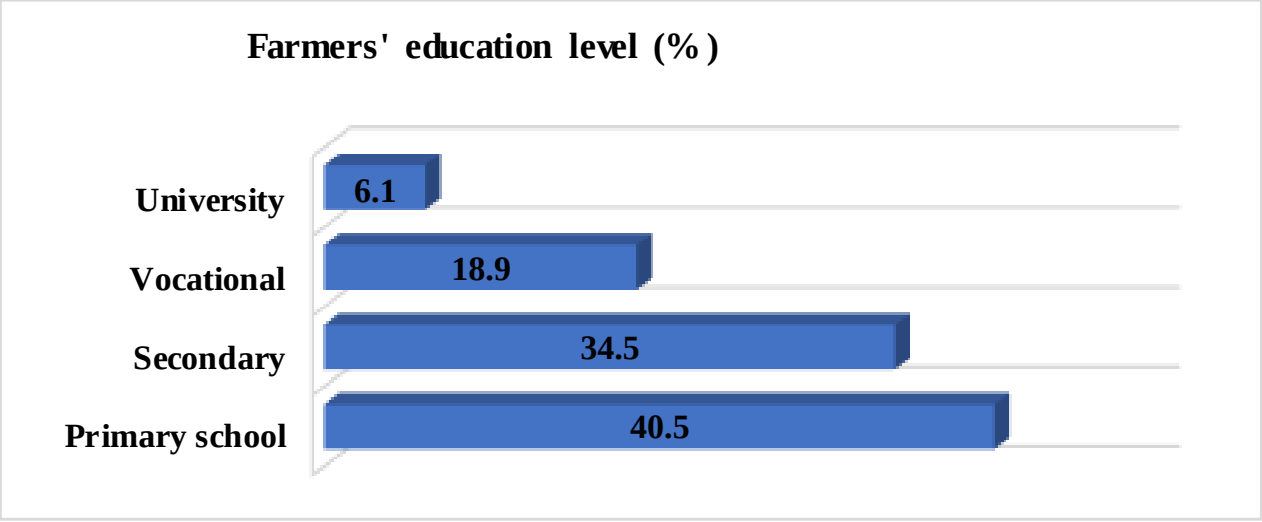

Fig. (5). Education level of farmer population (source: authors).

Table 7. Chi-square test and effect size for educational and skill barriers.

Education and Skills	Pearson Chi-square Test			Cramer's V		Valid Cases
	Value	Df	Asymptotic Significance (2-sided)	Value	Approximate Significance	
Level of education	2.989[a]	2	.224	.147	.224	138
Limited qualification and skills	1.043[a]	2	.594	.087	.594	139
Lack of knowledge transfer through extension services	2.818[a]	2	.244	.143	.244	138
Lack of knowledge on using digital technologies	1.715[a]	2	.424	.111	.424	138
Lack of information and awareness on the circular economy benefits	.327[a]	2	.849	.049	.849	138

Note: (source: authors).

Table 8. Chi-square test and effect size for economic barriers.

Economic	Pearson Chi-square Test			Cramer's V		Valid Cases
	Value	Df	Asymptotic Significance (2-sided)	Value	Approximate Significance	
High production cost	9.596[a]	2	.008	.262	.008	140
High investment cost	9.131[a]	2	.010	.254	.010	142
High operational cost	10.641[a]	2	.005	.279	.005	137
Size of livestock farms	3.860[a]	2	.145	.167	.145	139

Note: (source: authors).

Through the application of the chi-square test of independence for all categories of variables, no consistency was noted, indicated by the values of $p > 0.05$. Accordingly, it can be determined that farmers' decisions to implement circular practices in livestock farming are not influenced by their level of education, limited qualification, and lack of information and knowledge. Although several studies highlight the role of farmers' education in the adoption and implementation of new sustainable methods as part of the circular economy approach, in our study, farmers perceived that they can apply circular practices even without possessing appropriate education and qualification. As farmers' and other stakeholders' activities affect to a great extent many sectors, such as the environmental, economic, and food sectors, they deserve proper information about the current environmental situation and specific training in the agricultural circular economy [52].

3.4. Economic Barriers

The economic factors that affect farmers' adoption of circular practices were analyzed. In their pursuit of increasing agricultural sustainability and closing resource loops through circularity, many governments find that farmers are often unable or unwilling to invest their own resources in farm improvements, and research is being undertaken to examine the drivers of adoption [53]. The results in Table **8** reveal a frequency distribution determining the significant relationship between the economic variables (production cost, investment cost, and operational cost) and farmers' willingness to apply a circular approach. This was confirmed by the chi-square test values lower than 0.05 ($p < 0.05$) for all these variables.

According to Jacob's standard (1988), Cramer's-V coefficients for the economic variables ("high production cost" a = 0.262, "high investment cost" a = 0.254, "high operational cost" a = 0.279) denote a large correlation effect ($V > 0.21$). The evidence provided points out the lack of a clear subsidy framework and adequate support that fosters farmers' initiatives toward circularity. Regarding the farm size variable, Ibtissem *et al*. [54] stated that farm size is a positive predictor over time, but conversely, the survey results have indicated that despite being selected from the stakeholder's engagement as a significant factor that may influence farmers' decisions to adopt circular practices, when tested in a large sample, the values of the chi-square test for independence ($p = 0.145$) have inferred the two measured variables to be independent, showing that farm size does not influence Albanian farmers' decision to implement circular actions in farm activities. Probably compared to the other variables, this factor has not been considered significant.

3.5. Technological and Logistic Barriers

Various studies have claimed that the transition to circular food supply chains aims to prevent food loss and waste, improve resource utilization, and regenerate natural systems [55, 56]. The implementation of modern technologies and digitization can create more efficient production systems and enhance the efficiency of resources in livestock farming. Using the sample data of the distributed questionnaires, the chi-square test for goodness of fit was used to test the relationship between the technology and logistic variables category and farmers' willingness to adopt circular practices. The observed frequencies ($p = 0.041$ and $V = 0.21$) determined that the level of agricultural infrastructure has a medium effect on farmers' decisions to implement circular practices.

According to the responses received from the farmer population (Table **9**), it has been inferred that there is no relationship between the variables "low level of technology", "level of digitalization, and circularity, determined by the values of $p > 0.05$. The obtained results have been found to "clash" with the conclusions that have emerged from the focus groups organized with stakeholders. Nevertheless, several studies indicate that

Table 9. Chi-square test and effect size for technology and logistic barriers.

Technology and Logistics	Pearson Chi-square Test			Cramer's V		Valid Cases
	Value	Df	Asymptotic Significance (2-sided)	Value	Approximate Significance	
Low level of technology	.699[a]	2	.705	.071	.705	138
Poor agricultural infrastructure	6.393[a]	2	.041	.214	.041	140
Poor digital and logistic infrastructure	2.077[a]	2	.354	.122	.354	139

Note: (source: authors).

the adoption of innovative technologies is related to multiple constraints faced by various socioeconomic groups in different regions [57], initial technology investment, expected benefits, maintenance costs, farmers' socioeconomic characteristics, and preferences toward alternative sustainable actions [58].

4. DISCUSSION

The analysis provided in this study has highlighted various barriers that hamper farmers from progressing toward the implementation of circular practices. The need to enhance the efficient use of resources, reduce food loss, and improve sustainability in livestock farming has led to new scenarios focusing on the implementation of circular practices at the farm level and throughout the value chain. However, adoption depends on certain factors that influence their decision-making process [50]. Understanding barriers to adoption can lead to improved resource efficiency, nutrient reuse, reduced environmental impact, and economic gain.

For potential market-oriented farms, the implementation of a circular approach at the farm level represents a great challenge, given the lack of adequate policies, insufficient subsidies, economic costs, and lack of promotion from public institutions. These challenges stress the complexity of the transition toward a circular economy and highlight the need for coordinated efforts from policymakers, value chain actors, and society as a whole, in order to overcome the defined barriers. Even though the circular economy concept is becoming more familiar to farmers in livestock production in developing countries, still the implementation of circular practices has limited margins of adoption.

The transition to circular farming can generate significant costs, particularly initial investments for the deployment of new technologies, processes, and infrastructure. These costs are a major obstacle for farmers, especially in developing countries, considering the farm size and the limited financial resources. Even though the initial investment costs can be significant, the associated economic benefits are multi-dimensional. Ramirez *et al*. [59], in their work, have described the economic benefits of implementing circular practices in the livestock industry, such as the recovery of energy and nutrients from waste (converting the organic content of waste into methane biogas for generating electricity) and the production of nutritionally advanced feeds (treating wastes and producing fertiliser products). From the economic perspective, the total economic value of agricultural economies will be increased due to lower cost of inputs and new revenue streams, deriving from the increased price of low-value products. In this context, government intervention for providing incentives that encourage investments in technology modernisation, infrastructure, and innovation can help to compensate for the initial investment costs and foster the implementation of circularity in livestock farming.

Limited awareness appears to be a significant barrier to circularity with a large number of farmers pointing to the lack of information on the advantages of CE implementation. The awareness of the value chain stakeholders is the first step for this approach to thrive. Social media platforms can have a significant role in facilitating collaboration and disseminating information to a wider audience about circular economy practices in livestock farming. For example, the usage of Instagram as a social media platform for teaching has provided encouraging outcomes in increasing the knowledge of the general public and educating people on the subject of dairy cow nutrition and management [60]. The importance of raising awareness among farmers about the benefits of implementing circular agriculture at both economic (in terms of improving efficiency) and environmental levels should be well documented in order to provide solutions for implementation issues. The role of governments and educational institutions in providing education and training for enhancing the knowledge and skills of farmers, technicians, and future veterinarians related to circular practices in livestock farming can be beneficial, as reported by Muca E *et al*. [61]. Besides, the adoption of the "circular approach" in livestock farming is important not only for sustainable rural development, but also for a necessary transition towards improvement for every farm and farmer.

CONCLUSION

As one of the main subsectors of agriculture, sustainable livestock farming can promote the long-term availability of the agri-food system, protect natural resources, enhance economic resilience, and contribute to poverty reduction, food security, and agricultural development. This study has emphasized the importance of addressing the barriers to circular farming and implementing policies that aim to ensure environmental sustainability within the circular economy framework. Moreover, the results have indicated that "circularity" is not a new concept for many livestock farmers, but rather something they have always been doing. Through the multi-actor approach, stakeholders have identified the set of policies, education, economic, and technological factors as critical barriers that impact farmers' decisions and value chain actors to adopt circular practices in their business operations. Additionally, the surveyed livestock farmers' population has stated the barriers to be the lack of adequate policies, insufficient subsidies, economic costs, and lack of promotion and cooperation between actors and chain actors. The findings have highlighted the high costs of production, investment, and farm operations as major deterrents for livestock farmers, implying that the lack of farmers' willingness to invest in circular practices is more evident in developing countries where the "circular" approach is not as familiar as it is in industrialized regions.

The results of this study support the argument that implementing measures at the farm level is crucial for circular farming adoption. This is because a circular economy consists of a set of practices that can be adopted for different farm styles, addressing the concerns related

to soil destruction, loss of biodiversity, depletion of natural resources, and food loss and waste.

The evidence provided implies that the "road" to circular farming is not simple. Overall, the results support the argument that policymakers can play a crucial role in incentivizing and supporting the adoption of circular practices to drive sustainable and efficient livestock production.

The study has various limitations as it has focused mostly on the barriers to implementing circular practices at the farm level. The barriers may differ for other value chain actors. Future research may focus on the limitations that influence other actors in the food chain. The next limitation is related to the fact that the study has been carried out only on livestock farms, without including agriculture farms. Since circular agriculture is considered an important component of the rural development strategy, the inclusion of agriculture farms could have provided more comprehensive results. Future studies can be carried out by creating simulations of CAP policy implementation and the scenarios for circular economy adoption in the agriculture sector.

AUTHORS' CONTRIBUTION

It is hereby acknowledged that all authors have accepted responsibility for the manuscript's content and consented to itssubmission. They have meticulously reviewed all results and unanimously approved the final version of the manuscript.

LIST OF ABBREVIATIONS

GHG	=	Greenhouse gases
NGO	=	Nongovernmental organization

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The approval for the implementation of this study has been signed by the Rector of the University, and the ethics for project implementation has been part of the university regulation.

HUMAN AND ANIMAL RIGHTS

All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee, and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Only human subjects have been included in the study. Prior to their participation in the survey, informed consent was obtained from the respondents.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available in the [Zenodo] at [https://zenodo.org/uploads/11658141], reference number [10.2174/01187433153121322406110746 25].

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CONFLICT OF INTEREST

All authors declare no conflicts of interest related to this work.

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