

ORIGINAL ARTICLE

Prioritizing Circular Agriculture Indicators in Azerbaijan: An AHP-Based Multi-Criteria Evaluation

Saida Khalil^{1*} and Yashar Uysal²

¹ Azerbaijan State University of Economics, Azerbaijan, 6 Istiglaliyyat, AZ1001, Baku, Azerbaijan.
Dokuz Eylul University, Dokuz Eylul University Graduate School of Social Sciences, Central Campus,
35390 Buca/Izmir, Turkey

 <https://orcid.org/0000-0003-3695-7755>

e-mail: saida_khalil@unec.edu.az

² Dokuz Eylul University, Dokuz Eylul University Graduate School of Social Sciences, Central Campus,
35390 Buca/Izmir, Turkey

 <https://orcid.org/0000-0002-3886-8513>

e-mail: yasar.uysal@deu.edu.tr

* Corresponding author



Copyright: © 2026 by the authors

Citation (APA Style):

Khalil, S., & Uysal, Y. (2025). Prioritizing Circular Agriculture Indicators in Azerbaijan: An AHP-Based Multi-Criteria Evaluation. *Economic Insights – Trends and Challenges*, 14(4), 107-123. <https://doi.org/10.51865/EITC.2025.04.07>

Abstract: Circular agriculture holds significant importance in the developing world, just as the concept of circularity holds importance. In this context, the article evaluates and prioritizes the strategic components of circular agriculture in Azerbaijan using the Analytical Hierarchy Process (AHP), a multi-criteria decision-making method designed to transform subjective expert assessments into quantitative data. Using national statistical data from 1990 to 2023, the study identified four key indicators, which were access to irrigation infrastructure, the structural share of livestock production, total agricultural output, and agricultural waste management performance. Pairwise comparisons were conducted using Saaty's 1–9 scale, with the participation of 20 experts from academia, policy and industry ensuring a robust and consistent model ($CR \approx 0.089$). The findings reveal a “hierarchical necessity” within Azerbaijan's agricultural transition. Access to irrigation infrastructure (37.0%) and the share of livestock production (35.9%) emerged as the most critical strategic priorities. These results indicate that modernization of water systems and the development of closed-loop livestock models, such as the feed-manure-biogas cycle, are essential prerequisites for circularity. Conversely, agricultural waste management was given the lowest priority (9.4%), suggesting that stakeholders in transition economies prioritise resource efficiency and input security over waste valorisation. The study concludes that current agricultural capacity in Azerbaijan remains largely theoretical due to structural vulnerabilities such as water scarcity and fragmented land ownership. Consequently, the focus of policy must shift from purely quantitative growth to resource-efficient strategies and integrated institutional governance. This research provides a replicable quantitative framework to guide the sustainable transformation of agriculture in Azerbaijan and other emerging economies.

Keywords: Analytic Hierarchy Process (AHP); Circular Agriculture; Azerbaijan; Sustainable Agriculture.

JEL Classification: Q18; Q15; C44.

1. Introduction

Examining human history reveals radical shifts in production and consumption paradigms, particularly following industrialisation and the proliferation of mass production (Glavić, 2021). While production was historically driven by subsistence needs, the Industrial Revolution established economic profit as the primary motivator for enterprises and national economies alike (Stearns, 2020; Sabel & Zeitlin, 1985). This transformation paved the way for the emergence of the linear economy model. Based on the 'take-make-dispose' logic of sustained demand, this structure converts natural resources into short-lived products and relegates recycling processes to a secondary role (Eghan & Sung, 2025). As a result, countries producing high-tech goods have grown quickly, while resource-dependent developing countries have faced economic decline (Marino & Pariso, 2016; Moraitis, 2022; Shah et al., 2025). Concurrently, public administration reforms, such as privatization, have institutionally entrenched the linear economic model (Farazmand, 2017). The market mechanism has largely supplanted the state's planning role, while growth-oriented development strategies have marginalized social objectives.

This anthropocentric paradigm, which prioritizes human needs while largely disregarding other entities, precipitated increasingly severe economic consequences (Hariram et al., 2023) and environmental degradation (Dijoo & Khurshid, 2022), thereby necessitating the pursuit of alternative models (Blomsma et al., 2023). According to the United Nations Environment Programme, global waste generation, recorded at 2.1 billion tons in 2023, is projected to reach 3.8 billion tons by 2050, and waste management costs are expected to exceed \$640 billion (United Nations Environment Programme, 2024). This data unequivocally demonstrates the unsustainability of the linear economy model. Indeed, rising raw material prices, energy disruptions, and supply chain vulnerabilities are escalating risks within the private sector. Furthermore, the market prevalence of high-cost, low-quality products highlights the model's inherent inefficiencies (Ellen MacArthur Foundation, 2013; Govindan & Hasanagic, 2018). Consequently, the consensus in academic literature regarding the long-term unsustainability of the linear model continues to gain traction.

Since the 1980s, the seminal work by Pearce and Turner (1989) has brought the circular economy approach to the forefront as an alternative to the linear model by proposing a cyclical structure in which resources are reused. Framed by the European Commission's definition, the circular economy is predicated on retaining products and materials within the economic system for as long as possible. This is a principle further substantiated by international policy documents (United Nations, 2015; D'Amato et al., 2017). Emulating natural cycles, the circular economy aims to enhance resource efficiency, transform waste into new production inputs, and promote the utilization of renewable energy (Lacy & Rutqvist, 2015; Antikainen et al., 2018; Barreiro-Gen & Lozano, 2020).

The "3R" strategy, implemented across micro, meso, and macro-levels, is one of the most prevalent instruments of the circular economy (Melo et al., 2022; Khaw-ngern et al., 2021). However, technical limitations in certain sectors can hinder the adoption of circular practices (Jaeger & Upadhyay, 2020). Enterprises often encounter barriers such as technological constraints and organisational inertia (Hopkinson et al., 2018; Hajiyeva et al., 2024). Conversely, the agricultural sector is regarded as one of the most conducive domains to the circular economy, owing to the high potential for reintegrating waste into the production cycle (Gontard et al., 2018).

While existing literature has predominantly examined circular agriculture in developed nations, there is a significant lack of systematic indicators for developing economies that are facing challenges such as water scarcity, fragmented land ownership and financial constraints.

Moreover, there is a dearth of quantitative studies prioritising indicators of circular agriculture in Azerbaijan and the South Caucasus. This study aims to address this issue by applying the Analytic Hierarchy Process (AHP) to national agricultural data. By doing so, it identifies irrigation infrastructure and animal production as critical factors for circular agriculture. It also formulates policy recommendations tailored to Azerbaijan's unique circumstances. Finally, this article contributes not only to conceptual debates on circular agriculture in developing economies but also provides concrete policy prescriptions tailored to Azerbaijan's specific needs.

1.1. Past and Present of Agricultural Activities

Contemporary challenges such as climate change, natural resource depletion, biodiversity loss, and carbon emissions are becoming increasingly critical (Dagevos & Lauwere, 2021; Lu & Wang, 2023). The linear structure, whereby resources are sourced externally, and waste is disposed of without being reintegrated into the system, disrupts the balance of ecosystems in the long term (Velenturf et al., 2019). Linear agriculture is a conventional production model predicated on the 'take-make-dispose' principle (Gupta et al., 2025). In this system, natural resources such as water, soil, fertiliser and energy are converted into waste during production and released into the environment (Knicker et al., 2009; Maji et al., 2020). This model became particularly prevalent as a result of the industrial-based agricultural development policies in the 20th century and was characterized by intensive use of inputs, monoculture production, and mechanization (Giraldo, 2019). However, while providing short-term yield increases, this production model has led to multifaceted long-term problems, including increased soil pollution, declining productivity, waste proliferation, and the depletion of water resources (Altieri, 1995; Sands et al., 2023).

Fundamentally, the linear agricultural system is characterized by high input intensity and a unidirectional production flow. Production relies mostly on external inputs, as chemical fertilisers, pesticides and intensive irrigation. This input-based structure forces farmers to depend on artificial resources rather than natural ones, thereby increasing production costs. In this model, the production process proceeds as an unidirectional flow, converting natural resources into products and discharging the resulting waste outside the system (FAO, 2017). Processes like recovery, reuse and circular transformations are not part of this structure. As a result, agricultural waste is often released directly into the environment instead of being treated through composting, biogas production or other recycling methods. This exacerbates environmental pollution and impedes the valorisation of agricultural waste as a potential resource (MacArthur, 2013).

Another key feature of the linear agricultural system is its heavy reliance on fossil fuel-derived energy. Many essential farming activities, such as operating machinery, running irrigation systems and supporting production processes, depend heavily on energy sources that are not sustainable in the long term. This dependence significantly increases the carbon footprint of agricultural production, making it more challenging to address climate change (Franco & Borrás, 2021).

Additionally, the linear agricultural model tends to prioritise maximising short-term yields. Farmers and producers often base their decisions mainly on immediate market demand and annual production targets. While this approach may increase output in the short term, important factors such as soil health, sustainable resource use and the balance of surrounding ecosystems are often overlooked. Over time, these neglected aspects can reduce the land's productivity, making agricultural systems more fragile and vulnerable to environmental pressures (Rockström et al., 2009).

Deteriorating soil quality reduces productivity, forcing farmers to rely more on external inputs. This increases costs and reduces incomes, exacerbating rural poverty (Bhagat et al., 2024).

Uncontrolled agricultural waste also contributes to climate change by increasing carbon dioxide and methane emissions (Elbasiouny et al., 2019). The finite nature of natural resources highlights the need for more sustainable production and consumption patterns. This challenge is recognised globally in the United Nations' Sustainable Development Goals, with Goal 12 on Responsible Consumption and Production promoting a more sustainable economic framework (UN, 2015).

1.2. Structural Trends in Azerbaijani Agriculture: Constraints of the Linear Model and Emerging Local Practices

Azerbaijan's economy relies on oil and gas exports, but agriculture is also important for rural development and diversification (Suleymanov et al., 2013; Aliyev, 2023). In 2023, the sector accounted for about 6% of the GDP and 36% of employment (State Statistical Committee of the Republic of Azerbaijan, 2023). Of the nation's 4.8 million hectares of agricultural land, around 45% is arable (State Statistical Committee of the Republic of Azerbaijan, 2024).

Since the 1990s, Azerbaijan's agricultural sector has undergone significant transformation. After gaining independence in 1991, structural reforms and government subsidies drove long-term growth. Total agricultural production rose from 102 million manats in 1990 to 12.995 billion manats in 2024, an increase of roughly USD 7.58 billion. This growth reflects a shift in Azerbaijan's agricultural structure, as well as higher output. Crop production fell from 63% in 1990 to 48.5% in 2023, while livestock production increased from 36.3% to 51.4%. This shows that the sector is now more balanced and diversified (State Statistical Committee of the Republic of Azerbaijan, 2024).

Meanwhile, agricultural waste surged from 2.7 thousand tonnes in 2010 to 40.8 thousand tonnes in 2023. This represents a 15-fold increase compared to a threefold increase in production. While waste accounts for only around 0.33% of the total production value, much of it remains unprocessed, exacerbating its environmental impact.

Consequently, the current landscape clearly underscores the necessity of expanding waste minimization, organic recycling, and circular utilization practices within the agricultural sector.

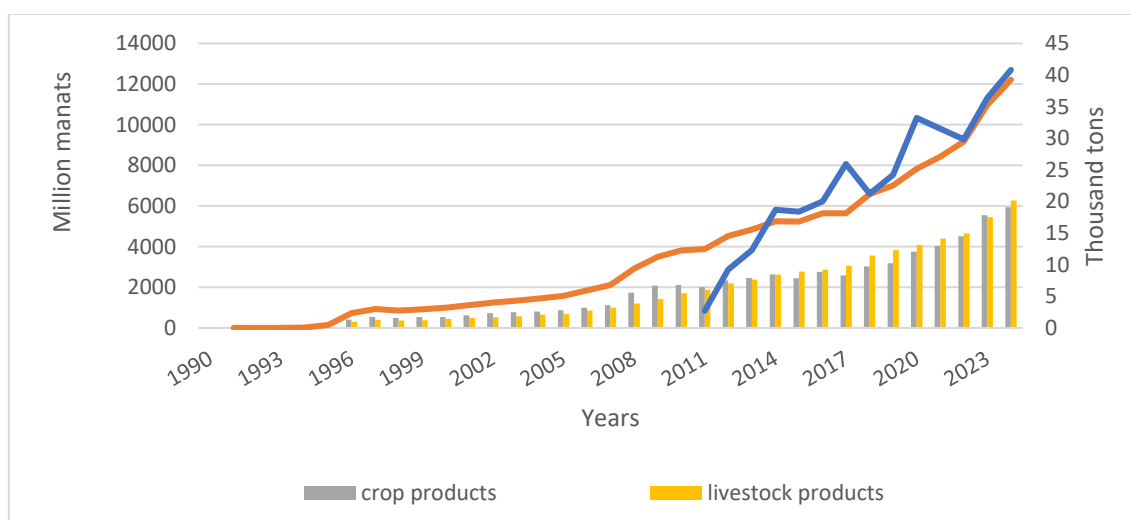


Fig. 1. Agricultural Production Volume in Azerbaijan, 1990–2024

Source: State Statistical Committee of the Republic of Azerbaijan, 2024.

Since 2005, the Azerbaijani government has prioritised strengthening irrigation infrastructure. They have supported technological modernisation in order to advance the agricultural sector (Ismayilova & Hajiyeva, 2024). Investment in agroparks like the Azersun Shamakhi Agropark

(established in 2021) has supported industrial-scale agricultural production. The Agrarian Credit and Development Agency (AKIA) was founded in 2015. It offers financial and technical support to boost the production capacity of SMEs in rural areas. AKIA also provides digital tools like the e-agriculture platform (EKTIS) to support data-driven decision-making processes. Platforms like AgroDiary help farmers plan crops and analyse efficiency using digital monitoring and modern agricultural techniques. This promotes more effective use of resources. Similarly, Azersun's Shamakhi Agropark supports both domestic and export markets through its production, which focuses on fruits, vegetables, and livestock.

In the academic sphere, initiatives as the Agricultural and Food System Management Certificate Programme at ADA University and the "Towards 2050: The Future of Agricultural and Food Sciences in Azerbaijan" play a key role in building knowledge and capacity for sustainable agriculture. Collaborations with Italian universities further support this by facilitating the exchange of international expertise. At an institutional level, the Baku Dialogues publication "Applying the Sustainable Cities Implementation Framework in Azerbaijan" highlights the need to incorporate sustainability policies into both urban and agricultural planning (Valiyev & Namazova, 2024).

Despite these advances, Azerbaijan's agricultural sector still faces several structural challenges. Issues such as water scarcity, limited mechanisation, inadequate farmer training and low capacity to adapt to climate change continue to hinder the sector's efficiency and productivity. Additionally, the ownership structure, divided into small parcels and characterized by small-scale production, limits agricultural planning and export capacity (Gulaliyev et al., 2019).

When these dynamics are considered, the agricultural sector in Azerbaijan requires both structural transformation and policies aligned with circular-economy principles. Circular practices involving agricultural waste, water reuse and strengthened local production chains can enhance environmental sustainability and economic resilience. Within this framework, given the structural limitations of linear agriculture, circular agriculture appears not only to be an alternative but also a strategic necessity for Azerbaijan. Such a transformation will both protect natural resources and provide long-term economic resilience.

1.3. The Future of Agricultural Activity: Circular Agriculture

In recent years, the concepts of circularity and the circular economy have increasingly featured on the strategic agendas of academia, the media, policymakers, and other decision-makers (Geissdoerfer et al., 2020). A key reason for this growing interest is the challenge of producing healthy and affordable food for a growing global population while using limited natural resources. This requires a more efficient use of resources, like a reduction in waste and the adoption of sustainable land management practices. This is a fundamental shift in how production and consumption systems currently operate. The agricultural sector is central to this transformation: it must increase its use of renewable energy, reduce its greenhouse gas emissions and implement environmentally friendly practices to help combat climate change (Rodino et al., 2023). Currently, one of the most comprehensive approaches proposed to achieve these objectives is the circular economy, which aims to foster economic growth without compromising ecological integrity (European Commission, 2020).

Circular agriculture is the adaptation of this approach to agricultural practices and is grounded in several core principles. These principles focus on protecting soil, water and air, avoiding unnecessary production and waste. They are directing limited resources towards essential human needs, without overloading the natural capacity of ecosystems. They also emphasise reintegrating agricultural residues and by-products into the production system, while reducing energy use and moving towards renewable sources. As well as promoting environmental sustainability, these principles provide a practical framework for strengthening the long-term resilience of agricultural production and improving the efficiency of resource management

(Silvius et al., 2023). The success of circular agricultural systems cannot be determined solely by theory. It must be measured using indicators that reflect sustainability, efficiency and economic performance at the farm level. Micro-level indicators are therefore essential for monitoring and understanding how individual farms contribute to a more circular and sustainable agricultural system.

Micro-level indicators (Figure 2), which enable evaluation of circular agricultural systems at the farm or enterprise-scale, allow holistic analysis of the environmental, economic, and functional dimensions of agricultural activities. These indicators are typically grouped into five main categories as nutrient management, waste management, energy and emissions, water management, and economic viability. Nutrient management indicators evaluate the effectiveness with soil nutrients. They are recycled without loss, using measures like nutrient cycling efficiency and nutrient balance. In the context of waste management, the composting rate and the reuse of crop residues indicate the degree of circularity implemented (Gang, 2023). Energy and emissions indicators are crucial for reducing the environmental impact of agricultural production. They are measured by factors such as the use of renewable energy, greenhouse gas emission levels, and the system's carbon sequestration capacity (Maraveas et al., 2023; Cherubini et al., 2009). Water management indicators reveal the extent to which practices such as water-use efficiency and rainwater harvesting support the water cycle within the system (Stroosnijder, 2009). Ultimately, the financial sustainability of the system can be assessed using economic indicators like farm profitability, return on investment, income diversification and the reduction of production costs through circular practices (Tisdell, 1996).

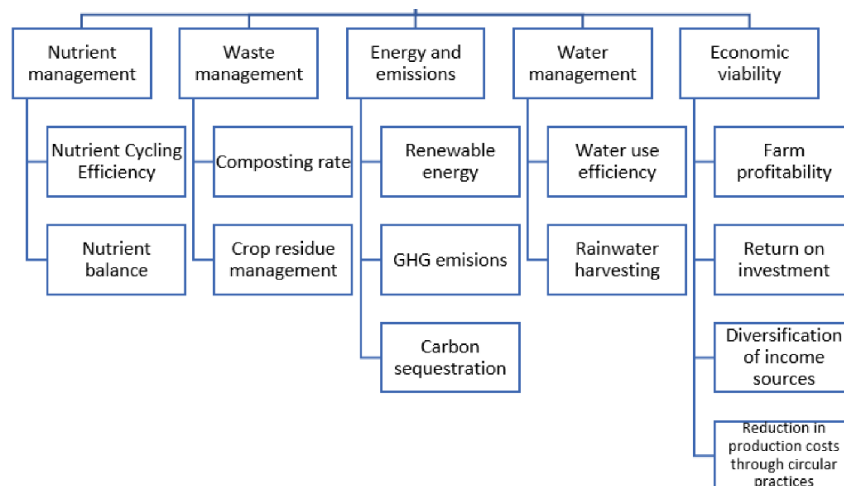


Fig. 2. Micro Level Indicators

Source: Rodino et al., 2023

Although the concept of circular agriculture is still relatively new, different countries implement it in ways that reflect their agricultural systems, environmental priorities and policy contexts. The Netherlands, for example, is often considered a pioneer in this field, particularly for its efforts to reuse agricultural by-products as livestock feed. In its vision document, 'Circular Agriculture in 2030', the country outlines a strategy to treat waste as a valuable resource, reduce reliance on external inputs and minimise environmental impact (OECD, 2023).

Germany, on the other hand, places a strong emphasis on the circular bioeconomy. In this approach, agricultural waste is used to produce biogas and compost, generating renewable energy and improving soil fertility (Cossel, 2019). Denmark supports circular agriculture through practices such as organic waste recovery and agroecological farming, alongside national policies aimed at reducing food waste (Halloran, 2014). In developing countries, circular agriculture is more frequently associated with local knowledge, low-cost solutions, and rural development policies. For example, in India, organic cycles are supported by traditional

composting methods. These variations demonstrate that, although circular agriculture is based on universal principles, each country develops its own unique solutions tailored to its specific circumstances (Rao, 2024).

2. Methodology

This study used the Analytic Hierarchy Process (AHP) to identify and prioritise the most important policies for advancing circular agriculture. The AHP is one of the most widely used multi-criteria decision-making methods because it enables researchers to convert subjective judgements into measurable numerical values. It is particularly useful in complex situations where different factors, such as economic, environmental and structural considerations, need to be evaluated together. Circular agriculture involves balancing multiple interconnected dimensions. Therefore, the AHP provides a clear, structured approach for comparing these factors and determining their relative importance (Saaty & Wind, 1980).

Circular agriculture is not just about increasing production volumes. It also encompasses important issues such as waste management, the efficient use of resources and water, and maintaining balance within the agricultural sector. In other words, improving agricultural sustainability requires considering multiple factors simultaneously. The Analytic Hierarchy Process (AHP) was chosen for this study because circular agriculture is based on many interconnected, multidimensional criteria. Efficient water use, recycling agricultural waste, energy efficiency, environmental impact and economic feasibility all need to be evaluated alongside production levels.

In such a complex decision-making environment, traditional methods that focus on a single criterion are often insufficient. However, AHP offers a systematic way to evaluate multiple factors simultaneously. It also enables the opinions and judgements of decision-makers to be translated into numerical values, facilitating the clear and structured comparison of criteria and determination of priorities. The indicator set used in the AHP analysis was established through a three-stage process. First, a systematic literature review was conducted in the Scopus, Web of Science, and ScienceDirect databases for the period 2010-2024 using the keywords 'circular agriculture indicators,' 'sustainable agriculture metrics' and 'resource-efficient farming systems'. Additionally, 12 international policy documents were examined, including the Farm-to-Fork strategy and documents from the FAO, UNEP, OECD, and the European Union. As a result of this screening, 22 indicators were identified; after removing redundancies, a final list of seven indicators was produced. Subsequently, four core indicators reflecting the priorities of circular agriculture in Azerbaijan were selected: total agricultural production, agricultural waste management performance, access to irrigation infrastructure, and the share of livestock production in total agricultural production. These indicators represent dimensions such as resource efficiency, integration of circular flows, and sustainability of the production structure.

All data used in the research are primary and were generated using structured questionnaires for AHP assessments. Experts were selected via purposive sampling based on the following criteria: at least 10 years of professional experience; expertise in sustainable agriculture, water management, waste management, agro-ecology, or agricultural economics; and representation of policy, academic, and practical dimensions. A total of 20 experts participated in the study. These individuals were classified as academic experts (8 individuals from Azerbaijan State Agricultural University and the Institute of Economics of the Azerbaijan National Academy of Sciences), sector experts (7 individuals from agro-holdings, aquaculture administrations, and agricultural cooperatives), and policymakers (5 individuals from the Ministry of Agriculture, the Ministry of Ecology and Natural Resources, and the FAO Azerbaijan office). This profile represents the technical, economic, and environmental aspects of circular agriculture in Azerbaijan.

The AHP survey was designed based on the evaluation of indicators within their categories using the pairwise comparison method. All experts rated the indicators using Saaty's 1–9 scale of importance. Expert evaluations were collected individually and then combined using the geometric mean within a group decision-making framework to construct the final pairwise comparison matrices. To ensure reliability, a Consistency Ratio (CR) of 0.10 or lower was required for all matrices. Any matrices exceeding this threshold were re-evaluated, and only those that met the consistency requirement were included in the final analysis. Thus, the methodological validity of the data was ensured.

Data obtained from experts were analysed using AHP to calculate weight coefficients for each indicator. The analysis was performed using the Super Decisions and Expert Choice software packages. The resulting indicators were ranked to reveal the strategic priority areas of circular agriculture in Azerbaijan, and category-based weights were compared. Furthermore, a sensitivity analysis was conducted to test the robustness of the results. Throughout the study, the anonymity of all participants was carefully protected. The collected data was used exclusively for research purposes, and all experts participated voluntarily with their informed consent. Ethical principles were strictly followed at every stage of the research process.

This process contributed to the design of circular agricultural policies in a more data-driven, rational manner, demonstrating that the AHP method is a viable tool not only for theoretical but also for practical decision-making.

2.1. Determining the Indicators

The indicators used in this study were selected to capture the structural transformation of agricultural policies and the development of circular agricultural practices in Azerbaijan. Initially, seven key indicators were evaluated to provide a comprehensive overview. Next, indicators with overlapping functions were combined to create a more concise, coherent analytical model. All financial values are denominated in Azerbaijani Manats (AZN). To mitigate the impact of exchange-rate volatility on the analysis results, stemming from the transition to a fixed exchange-rate regime in 2015, the study used an exchange rate of 1 AZN $\approx$ 0.58 USD, the rate adopted by the Central Bank. This approach enabled consistent evaluation of the financial indicators and made them comparable to international values. Data were derived from the State Statistical Committee and the Ministry of Agriculture of the Republic of Azerbaijan, as well as from the authors' calculations. The indicators ultimately selected are in Figure 3.

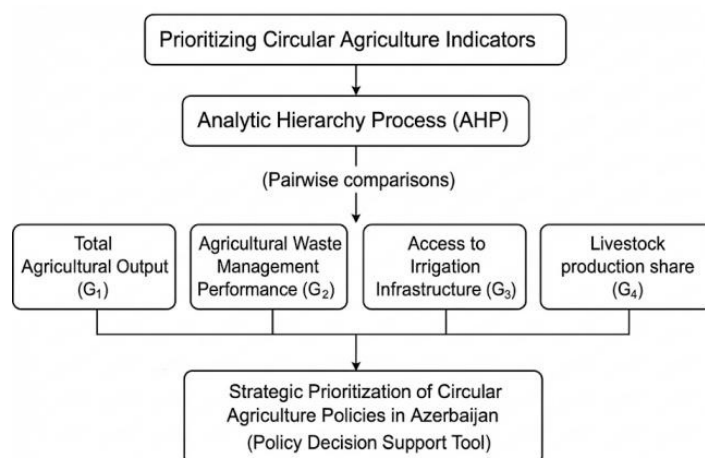


Fig. 3. AHP-Based Framework for Prioritizing Circular Agriculture Indicators in Azerbaijan

Source: Based on calculation.

Figure 3 illustrates the structure of the multi-criteria decision-making model applied in the study. Total agricultural production, waste management performance, access to irrigation infrastructure, and the share of livestock production in total agricultural production are hierarchically evaluated using AHP to support strategic agricultural planning.

2.2. AHP Method and Decision Matrix Development

Using the AHP method, pairwise comparisons were initially conducted among indicators, and the relative importance of each criterion with respect to the others was determined using Saaty's 1–9 scale. The scale employed is presented in Table 1.

Table 1. The AHP scale

Degree	Description
1	Equally important
3	Moderately important
5	Strongly important
7	Very strongly important
9	Extremely important
2,4,6,8	Intermediate values

Source: Saaty & Wind, 1980

The intensity of the significance scale for pairwise comparisons (Saaty & Wind, 1980) is presented. The pairwise comparison matrix, constructed based on the authors' expert evaluations, is presented in equation (1).

$$A = \begin{bmatrix} 1 & 2 & 0.5 & 0.33 \\ 0.5 & 1 & 0.33 & 0.25 \\ 2 & 3 & 1 & 2 \\ 3 & 4 & 0.5 & 1 \end{bmatrix} \quad (1)$$

Source: based on the authors' expert evaluations

The indicator weights (w), obtained by normalizing this matrix, are presented in the Fig.4.

Figure 4 illustrates the weights of circular agricultural indicators derived from AHP analysis. Findings were collected from an AHP survey that included 20 experts in Azerbaijan. A Consistency Ratio (CR) threshold of 0.10 was met for the obtained pairwise comparison matrices; matrices exceeding this threshold were re-evaluated. The analysis was performed using Super Decisions and Expert Choice software, which calculated the weight coefficients for each indicator.

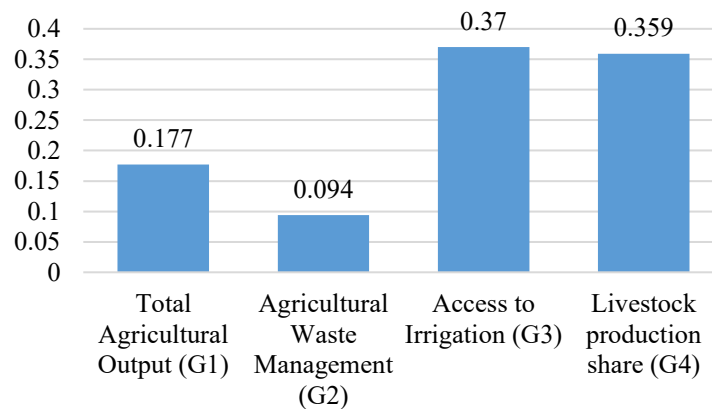


Fig. 4. Prioritization of Indicators via AHP Results (% Weights)

Source: Based on calculation.

The results show that access to irrigation infrastructure (G3) is the top priority, with a weight of 37.0%, followed closely by the share of livestock in agricultural production (G4) at 35.9%. In contrast, agricultural waste management (G2) ranks lowest, with only 9.4%. The consistency analysis supports the reliability of these results, with $\lambda_{\max} \approx 4.24$, $CI \approx 0.08$, and $CR \approx 0.089$. Because $CR < 0.10$, the decision matrix was deemed consistent. This indicates that the experts adopted a systematic and logical approach when prioritizing the circular agriculture indicators.

These findings indicate that infrastructure and production structure are the most critical elements in Azerbaijan's transition to circular agriculture. Although waste management is a significant component, the current priority is the development of irrigation systems and the adaptation of livestock management to an integrated cycle. The obtained weights suggest that policymakers should prioritize investments in water infrastructure, organic fertilizer production systems, and integrated agricultural models. Consequently, the results rely not only on weight percentages but also on data foundation based on expert opinion, which is methodologically verified and validated by the consistency ratio.

These findings reveal that infrastructure and production structure are the most critical elements in the transition to circular agriculture in Azerbaijan. While waste management remains important, the current focus is on developing irrigation systems and integrating livestock into farming cycles. The results suggest that policymakers should prioritise investment in water infrastructure and systems for producing organic fertilisers, as well as the adoption of integrated agricultural models. Consequently, the results rely not only on weight percentages but also on a data foundation rooted in expert opinion, methodologically validated, and secured by the Consistency Ratio.

2.3. Consistency Ratio Calculation

One of the most important stages of the AHP method is measuring the consistency of the comparisons made by the decision-maker. For this purpose, the Consistency Ratio (CR) is calculated. First, the maximum eigenvalue ($\lambda_{\max}$) of the matrix is calculated.

$$A * w = \text{Weighted Sum Vector} \quad (2)$$

$$\text{then:} \quad A * w / w \quad (3)$$

These values are then averaged to determine the maximum eigenvalue ($\lambda_{\max}$).

$$\lambda_{\max} = \frac{\sum (\frac{A * w}{w})}{n} \quad (4)$$

Next, after determining the Consistency Index (CI) and the Random Consistency Index (RI ≈ 0.9 for $n = 4$), the Consistency Ratio (CR) is calculated using the following formula:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (5)$$

$$CR = \frac{CI}{RI} \quad (6)$$

The results obtained within this framework are as follows:

$$\lambda_{\max} \approx 4.24$$

$$CI = \frac{4.24 - 4}{4 - 1} = \frac{0.24}{3} \approx 0.08$$

$$CR = \frac{0.08}{0.90} \approx 0.089$$

The obtained weights indicate that access to irrigation infrastructure (G3) and the share of livestock in agricultural production (G4) are the highest-priority indicators. This result indicates

that policies for circular agriculture should focus not only on production volume but also on developing sustainable systems that integrate water management and production diversification. By contrast, the waste management indicator was given relatively low priority, reflecting the fact that recycling practices in Azerbaijan are still underdeveloped.

3. Results

For many years, Azerbaijan's agricultural sector has mainly been assessed in terms of price fluctuations, rural employment, subsidy policies and political debates. Meanwhile, issues of sustainability, circularity and structural transformation have largely been overlooked. Current conditions demonstrate that minimal progress has been made in implementing circular economy principles or addressing fundamental challenges such as water management, waste recovery, and modernising livestock production. This highlights the urgent need for comprehensive agricultural policy reform.

The Analytic Hierarchy Process (AHP) is a quantitative method for identifying the priority areas for the transition to circular agriculture in Azerbaijan. According to the results, the most important factor is access to irrigation infrastructure (G3) emerges as the most critical element, accounting for 37.0% and thus necessitating the widespread adoption of modern technologies to enhance water efficiency. With a share of 35.9% (G4) in overall agricultural output, livestock production emphasises the need to implement closed-loop systems in livestock farming that connect feed, manure, and biogas. Awareness of agricultural waste management comes in third at 9.4% (G2), showing that it is still a relatively low priority among stakeholders.

These findings show that, for the successfully expand of circular agriculture, infrastructure must be strengthened, water resources must be managed effectively, and livestock production processes must be integrated into the circular model. Consequently, the AHP results reveal the three fundamental axes upon which Azerbaijan must focus during the transition process: irrigation infrastructure, structural transformation of the livestock sector, and awareness of waste management.

4. Strategic Roadmap for Transitioning to Circular Agriculture

These findings align with the problem areas identified in the Circular Agriculture Policy Roadmap. Resource inefficiencies, low waste recovery rates and traditional irrigation methods resulting in water loss, and structural inefficiencies in livestock farming coincide with the priorities identified by the AHP analysis. Therefore, investments in infrastructure and the redesign of the production structure constitute key focal points in the policy development process.

The Circular Economy Policy Roadmap in Figure 5 has been designed in alignment with the AHP analysis results. State subsidies for composting and biogas investments are critical for strengthening the G2 indicator, which measures waste recovery. Training programs for farmers on closed-loop agricultural practices are fundamental to implementing the G4 indicator, which assesses the circular contribution of livestock production. Investment incentives to modernize irrigation infrastructure directly support the G3 indicator, which measures water-use efficiency.

The roadmap outlines a phased approach to transitioning to circular agriculture. In the short term, it recommends raising awareness, running pilot projects in circular agriculture and developing training programmes for farmers. In the medium term, efforts should focus on modernising irrigation infrastructure, expanding biogas and composting facilities, and implementing closed-loop systems on a larger scale in livestock farming. In the long term, the full integration of circular agriculture into the institutional framework will be achieved; national

standards for circular agriculture will be established; policy updates will be informed by indicator-driven sustainability metrics.

Detailed agricultural maps prepared at the district, provincial, and regional levels will facilitate the identification of regional comparative advantages. This mapping will clarify which production types should be developed in specific regions, what quantities are required, the optimal locations for biogas facilities, and which areas require protection. Although the identification of waste types, quantities, and environmental impacts appears to be a low priority (G2), it will lay the groundwork for enhancing recovery potential in the medium term.

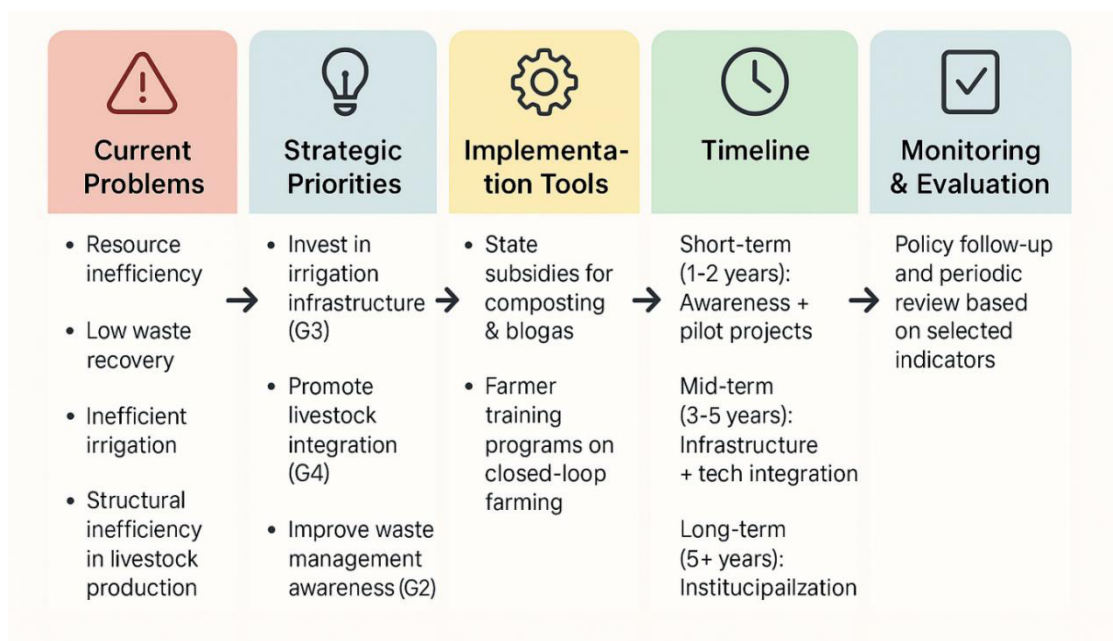


Fig. 5. Circular Agriculture Policy Roadmap

Source: Based on calculation.

First regional disparities are clarified, long-term product and region-based support mechanisms must be established. Crucially, these mechanisms should be differentiated according to the producers' ecological impact scores. This approach will promote circular economy practices and ensure a reduction in production models that are associated with significant environmental harm.

Clarifying the definition of 'producer' within rural-urban relations, certifying active producers, and mandating technical training must constitute the central elements of this transformation. Circular agriculture, clean production techniques, water efficiency, and valorization of organic waste should be included as fundamental topics in training curricula.

The implementation of new-generation integrated cooperative models should aim to increase resource efficiency by promoting shared use of machinery and equipment and rendering the production-supply-marketing chain more sustainable. These cooperatives would be well-placed to serve as coordination centres for both data collection and circular-economy applications.

In order to minimise ecological damage, fertilisers and pesticides should only be applied after a thorough soil analysis. Packaging waste should also be managed through a deposit-return system. To protect water resources, open irrigation methods should be phased out, and the transition to modern irrigation systems should be supported through financial incentives. Furthermore, the establishment of biogas systems in livestock regions should be regarded as a pivotal element in the transformation of waste management.

5. Conclusions

This study has revealed that Azerbaijan's capacity to transition to a circular agricultural model remains largely at a discursive level and that the existing institutional and technical infrastructure is insufficiently prepared to support this transformation. The fact that irrigation infrastructure (G3) and the structural transformation of livestock production (G4) emerged as the highest priorities in the AHP analysis indicates that the agricultural system's fundamental vulnerabilities, which have remained insurmountable for many years, persist. Of all the evaluated criteria, agricultural waste management received the lowest priority. While this may seem to contradict the principles of a circular economy, it reflects the practical approach of stakeholders in transition economies such as Azerbaijan. The findings suggest a kind of 'hierarchical necessity', whereby attention is first given to key inputs and structural frameworks, particularly irrigation systems and livestock management, before turning to outputs as waste. This demonstrates that circularity in Azerbaijan is currently interpreted primarily in terms of resource efficiency rather than waste valorisation. Modernising fundamental production assets is essential to ensure the technical and economic feasibility of advanced waste recycling for local farmers. On the other hand, the low emphasis on waste recovery awareness (G2) suggests that environmental sustainability is not yet a key consideration in policy planning. This suggests that the modernisation of agriculture in the country is largely viewed through a technical lens, with important structural aspects such as managing ecological cycles, adopting closed-loop production systems and encouraging behavioural changes receiving insufficient attention.

Although the policy roadmap presented in this study outlines the necessary governance, infrastructure, and educational mechanisms for the transition to circular agriculture. Efforts must address the potential challenges of weak institutional coordination, limited data and regional disparities. Key obstacles that could reduce the roadmap's effectiveness include the absence of a national agricultural inventory, subsidies that reward production volume rather than ecosystem services, imprecise producer profiles, and inadequate inspection systems. Overcoming these issues is essential to ensure that interventions have a meaningful and lasting impact.

Thus, the study shows that while the roadmap provides a guiding framework, achieving a complete transformation is difficult without redesigning the existing institutional structure and establishing a robust monitoring and evaluation system.

The findings suggest that Azerbaijan should strengthen its strategic governance before implementing technical solutions for the transition to circular agriculture. Interventions in water management, livestock production structures and waste recovery will only produce lasting benefits when supported by transparent institutions, data-driven planning, producer education policies and ecology-based support mechanisms. Otherwise, circular agriculture will run the risk of remaining mere policy rhetoric, confined to short-term projects that fail to generate structural transformation.

These assessments demonstrate that circular agriculture is not merely an environmental preference for Azerbaijan but a strategic imperative for agricultural productivity, rural development, and national food security. However, this transformation will remain limited unless the imperative is supported by political determination, governance reform, and long-term planning.

Strengths and Limitations

Strengths: The primary strength of this study is its originality. To the best of the authors' knowledge, this is the first article to explore this specific subject matter in depth, filling a significant gap in the existing literature.

Limitations: The main limitation of this study was the scarcity of literature and secondary data on this topic. The lack of prior research limited the ability to conduct an extensive comparative analysis and necessitated adopting a more exploratory approach.

Authors' Contributions

Saida Khalil: Conceptualization, Methodology, Data Curation, Formal Analysis, and Writing – Original Draft.

Yashar Uysal: Writing – Review & Editing, Validation, and Conclusion.

Acknowledgements:

This article is derived from the author's doctoral dissertation research at Dokuz Eylul University under the supervision of Prof. Dr. Yashar Uysal.

Funding:

The authors received no financial support for the research, authorship, or publication of this article.

References

1. Agrarian Credit and Development Agency. (AKIA). (2015). *Agrarian Credit and Development Agency – Main page*. <https://www.akia.gov.az/en/main/>
2. Aliyev, S., Babayev, F., Galandarova, U., Gafarli, G., & Balajayeva, T. (2023). Economic security of regions: A prerequisite for diversifying the Azerbaijan economy. *Journal of Eastern European and Central Asian Research (JEECAR)*, 10(5), 827-840. <https://doi.org/10.15549/jeecar.v10i5.1480>
3. Altieri, M.A. (1996). *Agroecology: The Science of Sustainable Agriculture*, Second Edition (2nd ed.). CRC Press. <https://doi.org/10.1201/9780429495465>
4. Antikainen, R., Lazarevic, D., Seppälä, J. (2018). Circular Economy: Origins and Future Orientations. In: Lehmann, H. (eds.) *Factor X. Eco-Efficiency in Industry and Science*, vol 32. Springer, Cham. https://doi.org/10.1007/978-3-319-50079-9_7
5. Azersun Holding. (2021). *Azersun Shamakhi Agropark*. Azersun Holding. <https://azersun.com/en/activity-fields/azersun-samaxi-aqropark>
6. Barreiro-Gen, M., & Lozano, R. (2020). How circular is the circular economy? Analysing the implementation of circular economy in organisations. *Business Strategy and the Environment*, 29(8), 3484-3494. <https://doi.org/10.1002/bse.2590>
7. Bhagat, R., Walia, S. S., Sharma, K., Singh, R., Singh, G., & Hossain, A. (2024). The integrated farming system is an environmentally friendly and cost-effective approach to the sustainability of agri-food systems in the modern era of the changing climate: A comprehensive review. *Food and Energy Security*, 13(1), e534. <https://doi.org/10.1002/fes3.534>
8. Blomsma, F., Bauwens, T., Weissbrod, I., & Kirchherr, J. (2023). The 'need for speed': Towards circular disruption - What it is, how to make it happen and how to know it's happening. *Business Strategy and the Environment*, 32(3), 1010-1031. <https://doi.org/10.1002/bse.3106>
9. Sabel, C., & Zeitlin, J. (1985). Historical Alternatives to Mass Production: Politics, Markets and Technology in Nineteen-Thcentury Industrialization, *Past & Present*, Volume 108, Issue 1, August 1985, Pages 133–176, <https://doi.org/10.1093/past/108.1.133>
10. Cherubini, F., Bird, N. D., Cowie, A., Jungmeier, G., Schlamadinger, B., & Woess-Gallasch, S. (2009). Energy-and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations. *Resources, conservation and recycling*, 53(8), 434-447. <https://doi.org/10.1016/j.resconrec.2009.03.013>
11. Dagevos, H., & Lauwere, C. D. (2021). Circular business models and circular agriculture: Perceptions and practices of Dutch farmers. *Sustainability*, 13(3), 1282. <https://doi.org/10.3390/su13031282>
12. D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B.D., Toppinen, A. (2017). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of cleaner production*, 168, 716-734. <https://doi.org/10.1016/j.jclepro.2017.09.053>

13. de Melo, T. A., de Oliveira, M. A., de Sousa, S. R., Vieira, R. K., & Amaral, T. S. (2022). Circular economy public policies: A systematic literature review. *Procedia Computer Science*, 204, 652-662. <https://doi.org/10.1016/j.procs.2022.08.079>
14. Dijoo, Z. K., & Khurshid, R. (2022). Environmental degradation as a multifaceted consequence of human development. In *Environmental Biotechnology* (pp. 39-56). Apple Academic Press. <https://doi.org/10.1201/9781003277279-2>
15. Eghan, B., & Sung, K. (2025). Upcycling and Recycling Revolution: Techniques for Textile Waste Management Towards Sustainability. In *Advances in Textile Materials and Processing Techniques for Sustainability* (pp. 377-412). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-95-0469-5_13
16. Elbasiouny, H., Elbanna, B. A., Al-Najoli, E., Alsherief, A., Negm, S., Abou El-Nour, E., Nofal, A., Sharabash, S. (2019). Agricultural Waste Management for Climate Change Mitigation: Some Implications to Egypt. In: Negm, A., Shareef, N. (eds) *Waste Management in MENA Regions*. Springer Water. Springer, Cham. https://doi.org/10.1007/978-3-030-18350-9_8
17. Ellen MacArthur Foundation. (2013). *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*. <https://ellenmacarthurfoundation.org>
18. European Commission. (2020). A new circular economy action plan for a cleaner and more competitive Europe. *European Commission: Brussels, Belgium*, 1-20.
19. FAO. Food and Agriculture Organization of the United Nations. (2017). *The future of food and agriculture: Trends and challenges*- Rome <https://digitallibrary.un.org/record/1311693?v=pdf>
20. Farazmand, A. (2017). Public sector reforms and transformation: Implications for development administration. In *International development governance* (pp. 545-559). Routledge. <https://doi.org/10.4324/9781315092577-30>
21. Franco, J. C., & Borras Jr, S. M. (2021). The global climate of land politics. *Globalizations*, 18(7), 1277-1297. <https://doi.org/10.1080/14747731.2021.1979717>
22. Geissdoerfer, M., Pieroni, M. P., Pigosso, D. C., & Soufani, K. (2020). Circular business models: A review. *Journal of cleaner production*, 277, 123741. <https://doi.org/10.1016/j.jclepro.2020.123741>
23. Giraldo, O. F. (2019). Political ecology of agriculture. *Page Political Ecology of Agriculture*. <https://doi.org/10.1007/978-3-030-11824-2>
24. Glavič, P. (2021). Evolution and current challenges of sustainable consumption and production. *Sustainability*, 13(16), 9379. <https://doi.org/10.3390/su13169379>
25. Gontard, N., Sonesson, U., Birkved, M., Majone, M., Bolzonella, D., Celli, A., ..., & Sebok, A. (2018). A research challenge vision regarding management of agricultural waste in a circular bio-based economy. *Critical Reviews in Environmental Science and Technology*, 48(6), 614-654. <https://doi.org/10.1080/10643389.2018.1471957>
26. 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>
27. Gulaliyev, M. G., Abasova, S. T., Samedova, E. R., Hamidova, L. A., Valiyeva, S. I., & Sertash, L. R. (2019). Assessment of agricultural sustainability (Azerbaijan case). *Bulgarian Journal of Agricultural Science*, 25, 2.
28. Gupta, D., Sharma, P., Gupta, T.K. (2025). Circular Economy Principles. In: Esquivel Escalante, K., Feregrino Pérez, A.A., Rosales Pérez, A., Prasad, R. (eds,) *Green Nanomaterials. Nanotechnology in the Life Sciences*. Springer, Cham. https://doi.org/10.1007/978-3-032-04492-1_14
29. Hajiyeva, N., Burkadze, Z., & Khalil, S. (2024). Fostering Green Entrepreneurship Education and the Socioeconomic Inclusion of Women in the South Caucasus Region. In J. Andrei, M. Vasić, L. Chivu, & B. Kuzman (Eds.), *Marketing and Resource Management for Green Transitions in Economies* (pp. 154-183). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-3439-3.ch007>
30. Halloran, A., Clement, J., Kornum, N., Bucatariu, C., & Magid, J. (2014). Addressing food waste reduction in Denmark. *Food policy*, 49, 294-301. <https://doi.org/10.1016/j.foodpol.2014.09.005>
31. Hariram, N. P., Mekha, K. B., Suganthan, V., & Sudhakar, K. (2023). Sustainalism: An integrated socio-economic-environmental model to address sustainable development and sustainability. *Sustainability*, 15(13), 10682. <https://doi.org/10.3390/su151310682>
32. Hopkinson, P., Zils, M., Hawkins, P., & Roper, S. (2018). Managing a complex global circular economy business model: Opportunities and challenges. *California Management Review*, 60(3), 71-94. <https://doi.org/10.1177/0008125618764692>

33. Ismayilova, H., & Hajiyeva, S. (2024). Agro-Economic Synergy: Enhancing Food Security through Innovative Agricultural Practices in Azerbaijan. *Agora International Journal of Economical Sciences*, 18(2), 134-147. <https://doi.org/10.15837/ajies.v18i2.6947>
34. Jaeger, B., & Upadhyay, A. (2020). Understanding barriers to circular economy: cases from the manufacturing industry. *Journal of Enterprise Information Management*, 33(4), 729-745. <https://doi.org/10.1108/JEIM-02-2019-0047>
35. Khaw-ngern, K., Peuchthonglang, P., Klomkul, L., & Khaw-ngern, C. (2021). The 9Rs strategies for the circular economy 3.0. *Psychol. Educ. J*, 58, 1440-1446. <https://doi.org/10.17762/pae.v58i1.926>
36. Knickel, K., Brunori, G., Rand, S., & Proost, J. (2009). Towards a better conceptual framework for innovation processes in agriculture and rural development: from linear models to systemic approaches. *Journal of agricultural education and extension*, 15(2), 131-146. <https://doi.org/10.1080/13892240902909064>
37. Lacy, P., & Rutqvist, J. (2015). *Waste to wealth: The circular economy advantage* (Vol. 91). London: Palgrave Macmillan. <https://doi.org/10.1057/9781137530707>
38. Lu, C., & Wang, K. (2023). Natural resource conservation outpaces and climate change: Roles of reforestation, mineral extraction, and natural resources depletion. *Resources Policy*, 86, 104159. <https://doi.org/10.1016/j.resourpol.2023.104159>
39. MacArthur, E. (2013). Towards the circular economy. *Journal of industrial ecology*, 2(1), 23-44.
40. Maji, S., Dwivedi, D.H., Singh, N., Kishor, S., Gond, M. (2020). Agricultural Waste: Its Impact on Environment and Management Approaches. In: Bharagava, R. (eds.) *Emerging Eco-friendly Green Technologies for Wastewater Treatment. Microorganisms for Sustainability*, vol 18. Springer, Singapore. https://doi.org/10.1007/978-981-15-1390-9_15
41. Maraveas, C., Karavas, C. S., Loukatos, D., Bartzanas, T., Arvanitis, K. G., & Symeonaki, E. (2023). Agricultural greenhouses: Resource management technologies and perspectives for zero greenhouse gas emissions. *Agriculture*, 13(7), 1464. <https://doi.org/10.3390/agriculture13071464>
42. Marino, A., & Pariso, P. (2016). From linear economy to circular economy: research agenda. *International Journal of Research in Economics and Social Sciences*, 6225(6), 2249-7382.
43. Ministry of Agriculture of the Republic of Azerbaijan. (n.d.). *E-agriculture platform (EKTİS)*. <https://eagro.az/>
44. Moraitis, A. (2022). From the post-industrial prophecy to the de-industrial nightmare: Stagnation, the manufacturing fetish and the limits of capitalist wealth. *Competition & change*, 26(5), 513-532. <https://doi.org/10.1177/10245294211044314>
45. OECD. (2023). Policies for the Future of Farming and Food in the Netherlands, OECD Agriculture and Food Policy Reviews, OECD Publishing, Paris, <https://doi.org/10.1787/bb16dea4-en>.
46. Pearce, D. W., & Turner, R. K. (1989). *Economics of natural resources and the environment*. Johns Hopkins University Press. <https://doi.org/10.56021/9780801839863>
47. Rao, M. M., Botsa, S. M., Rao, T. P., Goddu, S. R., & Vijayasanthi, C. (2024). A comprehensive review on agricultural waste production and onsite management with circular economy opportunities. *Discover Sustainability*, 5(1), 288. <https://doi.org/10.1007/s43621-024-00492-z>
48. Rockström, J., Steffen, W., Noone, K., ...& Foley, J.A. (2009). A safe operating space for humanity. *Nature* 461, 472–475. <https://doi.org/10.1038/461472a>
49. Rodino, S., Pop, R., Sterie, C., Giuca, A., & Dumitru, E. (2023). Developing an evaluation framework for circular agriculture: a pathway to sustainable farming. *Agriculture*, 13(11), 2047. <https://doi.org/10.3390/agriculture13112047>
50. Saaty, T. L., & Wind, Y. (1980). Marketing applications of the analytic hierarchy process. *Management science*, 26(7), 641-658. <https://doi.org/10.1287/mnsc.26.7.641>
51. Sands, B., Machado, M. R., White, A., Zent, E., & Gould, R. (2023). Moving towards an anti-colonial definition for regenerative agriculture. *Agriculture and Human Values*, 40(4), 1697-1716. <https://doi.org/10.1007/s10460-023-10429-3>
52. Shah, K., Tiwari, C., & Sunny, A. (2025). Unveiling the Circularity: Challenges and Barriers in Transitioning to the Circular Practices. *Circular Economy and Sustainable Innovation: Pathways and Applications for a Greener Future, Volume 2*, 273-303. https://doi.org/10.1007/978-3-032-00437-6_13
53. Silvius, J., Hoogstra, A. G., Candel, J. J., de Olde, E. M., de Boer, I. J., & Termeer, C. J. (2023). Determining the transformative potential of circular agriculture initiatives. *Ambio*, 52(12), 1968-1980. <https://doi.org/10.1007/s13280-023-01894-5>

54. State Statistical Committee of the Republic of Azerbaijan. (2023, December 20). *Azerbaijan's gross domestic product in January–November 2023*.
<https://www.stat.gov.az/news/index.php?lang=az&id=6340>
55. State Statistical Committee of the Republic of Azerbaijan. (2024). *Agricultural land resources: Agricultural land by categories*. <https://www.stat.gov.az/source/agriculture/>
56. Stearns, P. N. (2020). *The industrial revolution in world history*. Routledge.
<https://doi.org/10.4324/9780203808405>
57. Stroosnijder, L. (2009). Modifying land management in order to improve efficiency of rainwater use in the African highlands. *Soil and Tillage Research*, 103(2), 247-256.
<https://doi.org/10.1016/j.still.2008.05.019>
58. Suleymanov, E., Nuri Aras, O., & Huseynov, R. (2013). The Importance of Azerbaijan's Energy Revenues in its Exports Volume and the Effects on the National Economy.
<https://dx.doi.org/10.2139/ssrn.2370896>
59. Ting-lu FAN, Shang-zhong LI, Gang ZHAO, Shu-ying WANG, Jian-jun Zhang, Lei Wang, Yi Dang, & Wan-Li Cheng. (2023). Response of dryland crops to climate change and drought-resistant and water-suitable planting technology: A case of spring maize. *Journal of Integrative Agriculture*, 22(7), 2067-2079. <https://doi.org/10.1016/j.jia.2022.08.044>
60. Tisdell, C. (1996). Economic indicators to assess the sustainability of conservation farming projects: An evaluation. *Agriculture, ecosystems & environment*, 57(2-3), 117-131.
[https://doi.org/10.1016/0167-8809\(96\)01017-1](https://doi.org/10.1016/0167-8809(96)01017-1)
61. United Nations Environment Programme (2024). *Global Waste Management Outlook 2024: Beyond an age of waste – Turning rubbish into a resource*. Nairobi.
<https://doi.org/10.59117/20.500.11822/44939>
62. United Nations. (2015). *Goal 12: Responsible Consumption and Production*, United Nations Sustainable Development. <https://sdgs.un.org/goals/goal12>.
63. United Nations. (2015). *The Paris Agreement* | United Nations. <https://unfccc.int/process-and-meetings/the-paris-agreement>
64. Valiyev, A., & Namazova, F. (2024). *Long way ahead: Applying the sustainable cities implementation framework in Azerbaijan* (Vol. 8, No. 1, Fall 2024). *Baku Dialogues*. Institute for Development and Diplomacy, ADA University. https://bakudialogues.idd.az/media/2024/12/12/bd-v8-n1-fall-2024_valiyev-namazova_1.pdf
65. Velenturf, A. P., Archer, S. A., Gomes, H. I., Christgen, B., Lag-Brotons, A. J., & Purnell, P. (2019). Circular economy and the matter of integrated resources. *Science of the Total Environment*, 689, 963-969. <https://doi.org/10.1016/j.scitotenv.2019.06.449>
66. Von Cossel, M., Wagner, M., Lask, J., Magenau, E., Bauerle, A., Von Cossel, V., ... & Winkler, B. (2019). Prospects of bioenergy cropping systems for a more social-ecologically sound bioeconomy. *Agronomy*, 9(10), 605. <https://doi.org/10.3390/agronomy9100605>