Journal scientific and applied research, vol. 29, 2025
International Journal

ISSN 1314-6289 (Print)
ISSN 2815-4622 (Online)

Original Contribution

THE ROLE OF REVERSE LOGISTICS IN SUSTAINABLE AGRICULTURE

Anton Y. Antonov

DEPARTMENT OF ENGINEERING LOGISTICS, FACULTY OF TECHNICAL SCIENCES, KONSTANTIN PRESLAVSKY UNIVERSITY OF SHUMEN, SHUMEN 9712,115, UNIVERSITETSKA STR., E-MAIL: a.antonov@shu.bg

ABSTRACT: *Reverse logistics is emerging as a key mechanism for implementing a circular economy and sustainable agriculture in the face of economic, social, and environmental challenges in the agricultural sector. This report analyzes the conceptual foundations of reverse logistics, its specifics, and its application in sustainable agriculture.*

KEY WORDS: *Circular economy, Reverse logistics, Sustainable agriculture.*

Introduction

The agricultural sector faces serious challenges: soil depletion, losses in the supply chain, surpluses and biodegradable waste, significant greenhouse gas emissions and pressure on resources such as water and energy. (For example: agro-systems contribute to about 22% of global emissions from agriculture, forestry and land use) [2]. At the same time, the concept of sustainable agriculture requires the integration of environmental, social and economic dimensions in resource management. In this context, reverse logistics-which encompasses backflows (return, recycling, reuse of materials, containers, packaging, by-products)-is a tool for resource optimization and closing the loop.

The aim of this report is to explore the role of reverse logistics in sustainable agriculture, to draw theoretical frameworks and practical applications, as well as barriers and prospects for development.

Theoretical overview

Definition and framework of reverse logistics

Reverse logistics refers to the processes associated with the movement of goods, packaging, materials and waste back along the value chain for the purposes of value recovery, recycling, reuse or safe disposal [1]. Authors such as Ilgin & Gupta (2010) define this process as part of a sustainable supply chain,

with a focus on waste minimization and rational use of resources [2]. A bibliometric analysis of the topic shows an otherwise growing academic interest: since 2018, publications in the field of “reverse logistics + sustainability” have increased significantly [2].

Reverse Logistics and the Circular Economy

Reverse logistics is closely related to the concept of a circular economy, where products, materials and by-products are not treated as waste, but as inputs into other cycles [6]. In agriculture, reverse logistics is becoming critical to achieving a circular economy and sustainability.

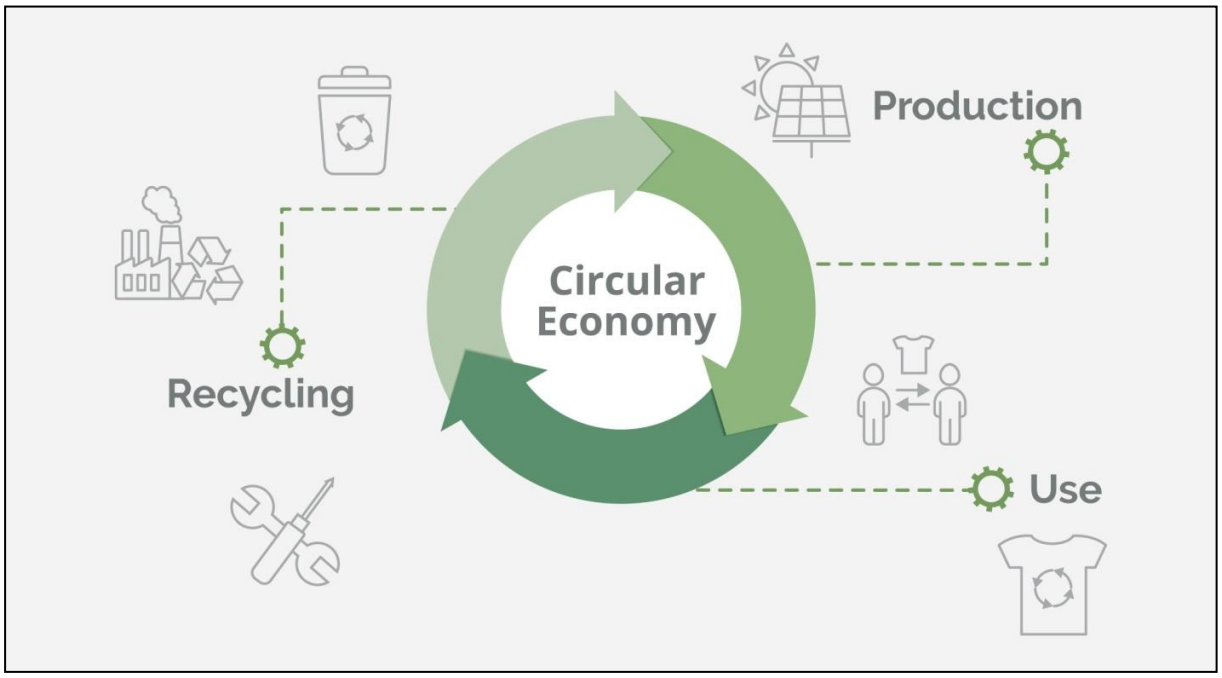

Fig. 1. Circular Economy [8, 9]

Agriculture generates significant amounts of crop residues, animal manure, by-products from crop processing, pesticide and fertilizer packaging, as well as the reuse of packaging, collection and recycling of plastic foils, pallets, cassettes, etc. The management of these flows is the basis of reverse logistics in the agricultural sector.

Characteristics of the agri-food chain

Reverse logistics in agri-food chains is characterized by the following features:

• High level of perishable products, which requires rapid processing, optimal transport conditions and good infrastructure [2].

• A significant amount of food is lost or turned into waste along the chain: during collection, storage, transport and processing.

• Need for coordination between multiple actors: producers, traders, logistics companies, waste operators, regulatory authorities.

• Additional barriers – lack of infrastructure for reverse flow, high logistics costs, quality and suitability of returned products, lack of traceability [2].

Applications in Sustainable Agriculture

Waste Reduction and Resource Optimization

A key function of reverse logistics in agriculture is the reduction of food losses. This occurs by returning unsold or defective produce for processing or secondary markets. This practice, according to Jovanović et al. (2023), reduces GHG emissions and improves the efficiency of the chains. In addition, the repeated use of packaging (pallets, boxes, containers) limits the consumption of new materials, which brings economic and environmental benefits [2].

Supporting circular models and renewable resources

Reverse logistics supports the implementation of models such as:

• Composting plant residues and animal waste and returning them to the soil as organic fertilizer - which improves fertility and reduces the need for synthetic fertilizers.

• Using biomass from residues to produce energy (biogas) and returning the residual material to the circular cycle.

• Introducing logistical and technological solutions to monitor and manage reverse flows through digital technologies, which increases transparency and efficiency (e.g. IoT, blockchain) [1].

Economic and social aspects

From an economic perspective, reverse logistics can lead to:

• Reducing the cost of new materials and packaging through reuse.

• Generating additional revenue through recycling or selling recovered raw materials.

• Increasing the competitiveness of farmers who integrate sustainable practices - this can also improve their image in the market.

Socially, sustainable practices strengthen the relationship between producers and consumers, stimulate “green” jobs and support the inclusion of smaller farms in sustainable chains.

Strengths and Weaknesses of Reverse Logistics in Sustainable Agriculture

Strengths

1. Waste and pollution reduction

- Limiting the disposal of hazardous materials.
- Improving the ecological balance in agricultural systems.

2. Economic benefits

- Reducing costs through the reuse of materials.
- Possibility of generating additional income from secondary raw materials (biogas, compost).

3. Improving the image of agricultural enterprises

- Consumer confidence in sustainable practices increases.
- Facilitates access to subsidies and green funds.

4. Resource optimization

- Better management of material, water and energy flows.
- Reducing carbon footprint and energy consumption.

5. Compliance with EU regulations and policies

- Supports the implementation of the principles of the circular economy and the Green Deal.

Weaknesses

1. High initial investments

- Need for infrastructure (collection points, logistics centers, transport).
- High costs for technologies for sorting, processing and monitoring flows.

2. Complexity of the logistics network

- Coordination between farmers, processors, traders and institutions.
- Difficulties in transporting small quantities to remote agricultural areas.

3. Insufficient information and motivation

- Many farmers are not aware of the benefits or procedures for return and recycling.
- Lack of trained personnel in the field of reverse logistics.

4. Regulatory and administrative obstacles

- Difficult bureaucracy in obtaining permits, certification and reporting.
- Differences between national and European standards.

5. Limited market for secondary raw materials

- Insufficient development of markets for compost, biogas, recycled materials.
- Low return on investment in some regions.

Summary

Aspect	Strengths	Weaknesses
Environmental	Reduces waste, conserves natural resources	Uneven implementation by region
Economic	Reduces costs, creates new revenue streams	High initial costs
Social	Improves image and sustainability	Insufficient awareness
Technical/logistical	Traceability and optimization capabilities	Complexity of logistics processes

Conclusion

Reverse logistics is an essential element for achieving sustainability in agriculture, as it reduces waste and optimizes resource cycles. However, its integration requires significant investments in infrastructure, technology and coordination. Success in this area leads to better environmental performance, higher economic efficiency and social sustainability for rural regions. Future work should focus on developing models, measuring effects and removing barriers.

The greatest strength of reverse logistics is its ability to transform waste from a liability into an asset, thus directly contributing to economic and environmental sustainability.

The greatest weakness is the cost and complexity of implementation, especially when dealing with perishable goods, which requires impeccable coordination and significant investments.

Acknowledgments

This scientific article under project number RD-08-123/07.02.2025 „Research on the application of ergonomics in activities related to engineering logistics“ is funded.

References:

[1] Salas-Navarro, K., Castro-García, L., Assan-Barrios, K., Vergara-Bujato, K., & Zamora-Musa, R.. Reverse Logistics and Sustainability: A Bibliometric Analysis. Sustainability, 16 (13), 5279. (2024) https://doi.org/10.3390/su16135279 MDPI.

[2] Jovanović, S., Campisi, B., Gallenti, G., & Troiano, S.. Reverse logistics in agri-food supply chains: A systematic literature review. (2025) e-ISBN 978-88-5511-632-9 https://www.openstarts.units.it/handle/10077/37446.

[3] Ummi, N., Marimin, Noor E., Romli M.. Risk Management in Reverse Supply Chain for Sustainable Agri-food Industry: A Systematic Literature Review and Future Research Agenda. Operations and supply chain management, Vol. 16, No. 3, 2023, pp. 323 – 339 ISSN 1979-3561 | EISSN 2759-9363.

[4] S Tavakkoli Moghaddam et al. (2019). A reverse logistics chain mathematical model for perishable goods logistics. link.springer.com

[5] Peña-Montoya, C. C. (2020). Assessment of maturity of reverse logistics as a strategy to sustainable development. journals.sagepub.com

[6] Iasmim Taísle Gomes Vanderlei de Almeida, Ana Regina Bezerra Ribeiro, Leila Lopes Ramalho, Leandro de Sousa Floriano, Ruan Samuel Chaves de Araújo. Circular Economy And Reverse Logistics: A Systematic Review. RGSA – Revista de Gestão Social e Ambiental, ISSN: 1981-982X, 2023.

[7] Samsun Nahar, Mala Sian, Ryan Larder, Fiona L. Hatton and Elliot Woolley, "Challenges Associated with Cleaning Plastic Food Packaging for Reuse" (MDPI, 2022) https://doi.org/10.3390/waste1010003.
[8] https://bulgaria.representation.ec.europa.eu/novini-i-sbitiya/novini-0/konsultaciya-za-zakonodatelniya-akt-za-krgovata-ikonomika-2025-08-01_bg.
[9] https://economiagt.com/en/economics-and-sustainability/from-waste-to-resources-virtuous-circles-in-ethanol-production/.