



INNOVATION-BASED CIRCULAR AGRI-FOOD CHAINS: OPTIMIZING AGRICULTURAL SYSTEMS AND REDUCING LOSSES

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Abstract: The shift toward sustainable agri-food systems requires improved resource efficiency and reduced losses across the value chain. Traditional models remain characterized by significant inefficiencies, particularly in food waste and input utilization. This study explores the role of innovation-driven circular agri-food chains in enhancing system performance and minimizing environmental impact. The findings highlight that innovation-based circular models are essential for resilient agri-food systems, but their implementation depends on supportive policies, investment, and stakeholder engagement.

• Introduction

In the context of increasing pressures on natural resources and the need to ensure the sustainability of agri-food systems, optimizing resource flows and reducing food losses are becoming strategic priorities. Traditional production and consumption models are characterized by significant inefficiencies, reflected in resource waste and negative environmental impacts. In this context, the transition to circular agri-food chains based on innovation represents an essential direction for the development of sustainable and resilient agriculture. The study aims to analyze the role of emerging technologies and innovative solutions in optimizing agricultural systems and reducing losses along the agri-food chain, from production to consumption.

• Material and method

Methodologically, the research adopts a mixed approach. The quantitative analysis is based on performance indicators regarding resource efficiency and food loss levels, using relevant statistical data. In addition, an analysis is applied to assess the environmental impact of different agri-food chain models, as well as a comparative analysis between traditional systems and systems based on innovation (digital technologies, waste recovery solutions, smart management systems). Resource flow modeling methods are also used to highlight systemic efficiency.

• Results and discussions

The research results highlight that the integration of digital technologies, intelligent management systems and waste recovery solutions significantly contribute to increasing the efficiency of agri-food systems. Circular economy-based models allow for a more efficient use of inputs (water, energy, raw materials), simultaneously reducing food losses and environmental impact.

The comparative analysis between traditional and innovative systems shows that the implementation of technologies such as digital monitoring, advanced traceability and by-product reuse leads to significant improvements in economic and environmental performance.

Table 1. Comparison between Traditional System and Innovation-Based Circular System

Indicator	Traditional System	Circular System (Innovation-Based)
Food losses (%)	30–40%	10-20%
Resource use efficiency	Low	High
Level of digitalization	Low	High
Traceability	Limited	Advanced
Environmental impact	High	Low
Operational costs	High	Optimized

Resource flow modeling also indicates an optimization of material and energy circuits, highlighting the reduction of losses in critical stages of the agri-food chain. From an economic perspective, these transformations lead to increased added value and more efficient operational costs, while from an ecological perspective, they contribute to reducing emissions and conserving resources. However, the adoption of these solutions is influenced by factors such as the level of digitalization, access to financing and the institutional framework.

• Conclusions

The study confirms that innovation is a key factor in the transition to efficient and sustainable circular agri-food chains. The integration of emerging technologies and circular economy solutions allows for the reduction of losses, the optimization of resource use and the improvement of the overall performance of agricultural systems. However, fully realizing these benefits requires the adoption of integrated strategies, supported by coherent public policies, investment in innovation and the development of technological skills.

In conclusion, promoting circular agri-food chains based on innovation not only responds to current sustainability challenges, but also contributes to creating more resilient, competitive agri-food systems adapted to the demands of the economy of the future.

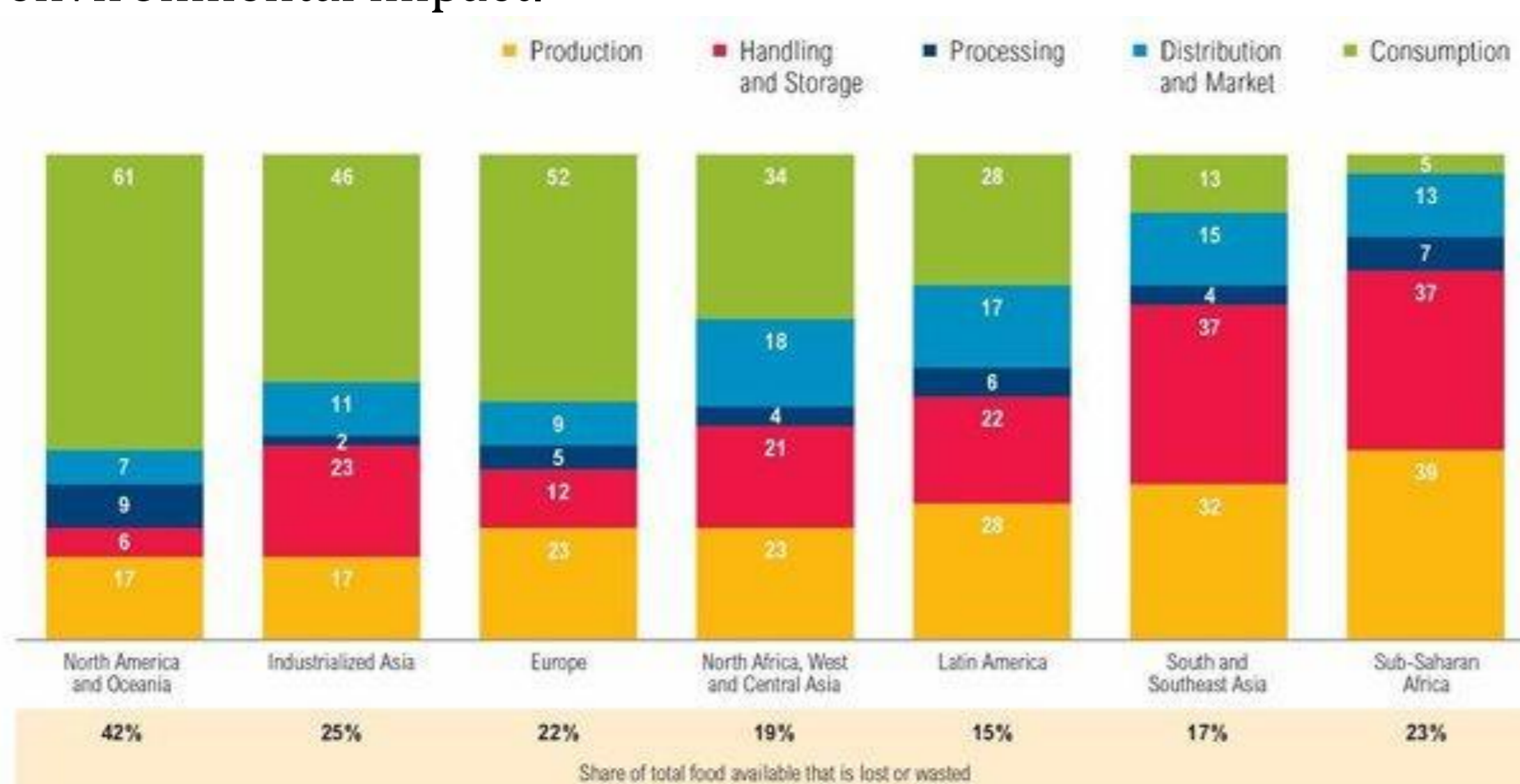


Figure 1. Share of total food available that is lost or wasted