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NEW CIRCULAR STRATEGIES TO REDUCE FOOD WASTE*

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Abstract

This study quantifies the economic impact of surplus food donations from companies to the Banco Alimentare of Catania. It examines how these donations reduce operational costs and promote the development of a circular economy model within the agribusiness sector. Food waste generates substantial financial losses for companies. These losses arise from product depreciation, logistical inefficiencies, storage and disposal costs. Implementing integrated recovery systems can effectively mitigate these expenses. Donating surplus food transforms a cost center into an economic opportunity. Companies benefit from fiscal incentives, including tax deductions and credits, which improve the financial sustainability of food donation. The research aims to quantify circular economy indicators according to the UNI/TS 11820:2022 standard applying them to the case of the Banco Alimentare of Eastern Sicily. The analysis is based on a comparative examination of the organization's 2023 and 2024 Social Report with a view to assessing the level of circularity and the socio-economic impact generated in the two financial years. The methodology integrates participant observation, semi-structured interviews with business executives and third-sector operators. Supply chain analysis highlights progressive improvements in logistics but shows also persistent gaps in territorial coordination and the management of unsold fresh produce. In conclusion, the presented model is scalable and adaptable to heterogeneous urban contexts. It generates economic, social, and environmental value by promoting sustainable food systems and circular economy principles.

Keywords: circularity indicators, food donation, food waste reduction, third sector organizations,

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1. Introduction

Food waste represents one of the main economic, environmental, and social challenges of our time (Camoni, 2023). It is estimated that every year more than one third of the food produced for human consumption is wasted, although most of it is still edible, amounting to about 1.05 billion tons according to the Food Waste Index Report (UNEP, 2024). At the same time, nearly 800 million people continue to suffer from food insecurity, and 200 million from micronutrient deficiencies (Sassi and Sassi, 2018). Therefore, food insecurity is not only a problem with the quantity of food produced and available but also an issue of access, which can only be addressed by shifting the focus from global and national levels to the household or individual level (Sassi and Sassi, 2018).

In recent years, there has been a growing need for radical transformation, placing social values of food at the center through the identification of four key concepts: diversity, circular and solidarity economy, co-creation and sharing of knowledge, and responsible and transparent governance. These principles are essential to guide society towards plausible pathways of regeneration for sustainable agriculture and food systems (Wezel et al. 2020). This model involves local and community action, engaging those who live in the territory to build relationships of reciprocity, thus creating a convivial society organized to ensure its members the opportunity to define both the forms and purposes of the socio-economic process (Illich, 1973).

To reverse this trend, it is necessary to adopt an approach centered on human rights and sustainability, promoting investments in small-scale agriculture and drastically reducing greenhouse gas emissions produced by intensive farming practices. Moreover, it is crucial to support family farmers, especially in the most vulnerable countries, in adapting to increasingly extreme climate changes (Biondi, 2025). As with the circular economy, there is no single agreed-upon definition of food waste. In 1981, during a conference at the FAO headquarters focused on preventing food waste among perishable crops, the first definition of “postharvest food losses” was established. This initial definition can be summarized as follows: food waste is “wholesome edible material intended for human consumption, arising at any point in the Food Supply Chain (FSC) that is instead discarded, lost, degraded or consumed by pests” (FAO, 2011).

However, this definition was expanded in a 2011 study commissioned by the FAO and conducted by the Swedish Institute for Food and Biotechnology (SIK), where a distinction was introduced between food losses and food waste (FAO, 2011). Food losses refer to “losses occurring during agricultural production, postharvest, and food processing stages,” while food waste refers to “food discarded during the final stages of the food supply chain (distribution, retail, and final consumption). The first are mainly due to logistical and infrastructural limitations, while the second depends on behavioral factors. In 2013, the FAO introduced a broader definition of food wastage, meaning the sum of food losses and food waste (FAO, 2013). In Italy, the total economic value of food waste exceeds 15 billion euros, with most of this waste originating from households, which make up the largest share (Waste Watcher, 2025).

Food waste has also been classified into three categories: avoidable, possibly avoidable, and unavoidable (Cappelletti et al., 2022). Additionally, there is a distinction between “absolute waste,” referring to products disposed of as waste with no economic value, and “relative waste”. Absolute waste means the disposal of food surplus that generates none of the potential benefits. Relative waste refers to surplus food whose destination allows obtaining at least one of two potential benefits: economic return or use for human consumption (Segrè and Falasconi, 2011).

Relative waste can follow three different routes: products disposed of as waste (without economic value, not intended for human consumption); products destined for animal feed, biogas production, or composting (having economic value but not for human consumption); products recovered and donated for human consumption (Pesenti and Rovati, 2015). The latter contribute to reducing the social and environmental impacts of food waste, even though they do not produce a direct economic return.

2. The economic cost of food waste

Food waste and the related waste management generate a significant economic impact for the businesses involved, affecting operational costs and company resources allocated to treatment and disposal (Costantino, 2024). Companies face costs not only from product loss but also from logistical inefficiencies and waste management. Waste in production and trade accounts for about 41.5% of the total supply chain waste cost, equivalent to 5.85 billion euros (Il Pais, 2025). This share includes losses due to logistical inefficiencies, damage during transport, storage, and commercialization.

Losses are common and can happen at any stage: production, distribution, or consumption. Causes include accidental damage, incidents, miscalculations, unexpected events and conditions. To prevent food losses, it is important to distinguish between reuse and recovery: reuse involves immediate use of a still-usable product for its original purpose, while recovery implies transforming waste material to give it a new life in the form of new products or objects (Waste Watcher, 2025).

These principles shape the foundation of strategies implemented by many food banks, which play a crucial role in recovering and redistributing surplus food. Recovery and donation of these surpluses to third-sector organizations represent an efficient and sustainable approach, turning waste into a valuable resource and generating economic, social, and environmental benefits (Rizzi, 2024). According to the Council for Agricultural Research and Economics (CREA, 2024), in 2022 large, medium, and small companies donated 138,678 tons of food, excluding beverages and animal feed. The Italian legal framework for food surplus donation is mainly defined by Law No. 166/2016, also known as the Gadda Law (Parlamento Italiano, 2016). Surplus food benefits from tax incentives for both businesses and individuals (Maino et al., 2020; Maino, 2021). Businesses enjoy VAT exemption and deductibility of purchase costs, while individuals can deduct or deduct donations in cash or in kind. This context encourages collaboration between businesses and nonprofit organizations, creating a circular economy model based on solidarity and resource optimization (Pirolo, 2023),Ombuen, 2023).

However, challenges remain in managing food donations, particularly regarding fragmented information flows, limited territorial integration, and a lack of shared digital tools to facilitate coordination among the many actors involved in the supply chain (Berti and Fidolini, 2023; Lizzi, 2022). This operational complexity highlights the urgent need for more effective solutions to improve communication and collaboration. The global relevance of the issue is confirmed by the examination of United Nations Sustainable Development Goal 12, which aims to “ensure sustainable consumption and production patterns.” Specifically, the goal is to “halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains by 2030” (United Nations, 2015).

Sustainable Development Goal 2 aims to “end hunger, achieve food security and improved nutrition, and promote sustainable agriculture,” targeting the eradication of world hunger by 2030. However, global data show a concerning trend: since 2015, food insecurity has significantly increased, driven by factors such as the COVID-19 pandemic, armed conflicts, climate change, and worsening socio-economic inequalities (FAO, 2023). This scenario

underscores the urgent need to act on both food production and distribution as well as surplus recovery and redistribution (European Commission, 2015).

Though distinct, these two goals are closely linked: reducing food waste not only supports more sustainable resource management but also represents a concrete opportunity to increase food availability for the most vulnerable populations. Integrated policies that promote supply chain efficiency, surplus recovery, and consumer awareness can offer a synergistic approach to tackling both environmental and social issues related to hunger (Heydari, 2024; Quaglia and Bartezzaghi, 2025). Integration of these goals is therefore essential for achieving sustainable development globally.

The paper aims to assess the financial effects of surplus food donations made by companies to the Banco Alimentare of Catania. It explores how these donations lower operational expenses and encourages the growth of a circular economy framework within the agribusiness sector. The research seeks to apply circular economy metrics based on the UNI/TS 11820 (2022) standard to evaluate the social, economic, and environmental outcomes of food donation activities. Additionally, the study emphasizes the importance of integrated recovery systems and partnerships among businesses, nonprofits, and institutions to build sustainable food networks and effectively curb food waste. It also discusses the potential benefits of digital platforms and sophisticated measurement tools for improving surplus food management and sustainability practices.

The paper is divided into three main sections. The first part introduces the challenge of food waste, emphasizing its economic, social, and environmental impacts, and the relevance of circular economy principles. The second section details the methodology, with a focus on quantifying circularity indicators using the UNI/TS 11820:2022 standard (Amicarelli and Bux, 2023; Matarazzo et al., 2024). This includes collecting and analyzing data on various indicators categorized as core, specific, and optional, which together provide a comprehensive assessment of the organization's circularity level. The third section presents a case study on the Banco Alimentare of Catania, examining the economic benefits of surplus food donations, operational logistics, and the overall sustainability impact. The paper concludes by discussing the scalability of the model and future technological enhancements for better surplus management.

4. Materials and methods

The methodology is based on quantifying circularity indicators defined by the UNI/TS 11820 (2022) standard. This standard was published by the Italian Standards Body (UNI) on November 30, 2022. It was then updated in 2024. The indicators are applied to the activities of Banco Alimentare. The 2024 revision of UNI/TS 11820 retains the evaluation method and expands the indicator system from 71 to 81, improving alignment with the international ISO 59004 standard (Consorzio Carpi, 2024; ISO 59004, 2024; UNI/TS 11820, 2024). This update makes circularity measurement more flexible and adaptable to different business contexts, facilitating clearer communication through structured reports. However, this increased flexibility introduces complexity in selecting indicators and managing exclusions, requiring companies to have strong interpretative skills to ensure consistency and reliability in evaluation (Fantin et al., 2024). For these reasons, this study uses the 2022 version parameters, considered appropriate for its objectives. UNI/TS 11820 provides a structured method and a set of indicators to assess the circularity level of an organization or group of organizations, regardless of sector, size, or products/services offered. It enables monitoring progress, identifying improvement areas, and communicating results.

Relevant indicators are selected and measured for recovery, managing, and redistributing food surpluses. These cover categories such as material resources, energy and water, waste and emissions, logistics, products and services, human resources, and sustainability policies.

Necessary data are collected through internal monitoring and management records, ensuring quality, completeness, and traceability. Each indicator is calculated using standard formulas that normalize values on a scale from 0 to 1, classified as core (mandatory), specific (partially mandatory), and rewarding (optional) indicators. Complete evaluation of core indicators and at least half of the specific indicators is ensured, integrating rewarding indicators where applicable.

The overall circularity level is expressed as a percentage, obtained through weighted aggregation of the selected indicator scores. This allows a balanced assessment of Banco Alimentare's environmental, economic, and social performance. A disaggregated analysis by category is performed to identify strengths and areas for possible improvement. The adopted approach is systemic, considering multiple circularity aspects: efficient resource use, responsible waste management, innovation in business models, and collaboration along the value chain. This enables an objective evaluation of the system's effectiveness. Collaboration among businesses, third sector, and institutions is a strategic lever. Through territorial synergy, it is possible to build fairer, more sustainable, and efficient food systems (Maino, 2021).

5. Case study

This study aims to analyze the economic dynamics related to the donation of surpluses by companies to the Banco Alimentare of Catania. This organization operates not only in the province of Catania but covers the entire eastern Sicily region. The focus is on the positive effects in terms of cost reduction for companies and the development of sustainable practices. In 2024, the organization managed a total volume of approximately 7.922.763 kg of food. This represents a 25.1% decrease compared to 2023. The decline was due to changes in the operational context but did not compromise the effectiveness and quality of recovery and distribution activities. Supply channels come from various sources, with a predominance of FEAD and national funds. These provided 4.211.339 kg of food in 2024, marking a 44% decrease compared to the previous year (Garrone et al., 2023).

Agro-food companies contributed 1.335.510 kg of surpluses, down 14.85%, attributable to more accurate production planning and changes in donation policies. Collaboration with the Large-Scale Retail Trade (GDO) through the Siticibo Program recovered 820.712 kg of fresh and cooked food, focusing on nutritionally valuable products. Significant growth was reported in donations of fruit and vegetable products, which reached 401.185 kg in 2024, a 39.58% increase thanks to strengthened partnerships with the Agro Food Market of Sicily (MAAS) in Catania, where the organization is based, as well as with individual producers.

Recovery activities are supported by an advanced information system based on SAP ERP. This system ensures full traceability of incoming and outgoing food flows, monitoring expiration dates, quality, and food integrity. Operating procedures maintain the cold chain for fresh and frozen products, following HACCP food safety regulations. Food items with expired "Best Before Dates" are also handled in accordance with Gadda Law 166/2016 (Parlamento Italiano, 2016). This practice expands the quantity of food available for distribution, as foods past Best Before Dates are still safe for consumption if packaging remains intact and storage conditions are adequate. The volume of food recovered corresponds to estimated savings in the millions of euros, considering the commercial value and costs associated with production,

transport, and disposal of unused food. Only in 2023, Banco Alimentare Sicilia Orientale ODV reduced CO_2 emissions by about 7.300 tons, with similar or improved figures expected for 2024. The logistical activities emitted only 512.5 kg of CO_2. Donation and redistribution activities are supported by well-established territorial networks involving over 350 partner organizations, including canteens, communities, and volunteer associations.

In summary, Banco Alimentare confirmed its ability to effectively manage food surpluses in 2024. It integrates technical, logistical, and relational skills. Careful monitoring of economic and environmental data, combined with an organizational approach based on transparency and partnerships, constitutes a replicable social circular economy model. This model generates sustainable value for both the community and the environment (Caglioti 2022).

6. Results and discussion

Banco Alimentare has developed a specific indicator to systematically assess the social, economic, and environmental impact of its activities. This indicator integrates parameters such as the quantity of food recovered, the economic value of corporate volunteering and the reduction of greenhouse gas emissions. Although the model does not formally follow international circularity standards like UNI/TS 11820 or ISO 59004 (2024), it reflects the principles of the circular economy, aiming to maximize resource efficiency and minimize waste. This tool enables transparent, multidimensional impact assessment, supporting strategic planning and communication with various stakeholders.

In 2024, the economic value of corporate volunteering linked to Banco's activities was estimated at around € 30.030 euros. This derives from being over 1.155 working hours contributed by company employees engaged in essential operational tasks related to sorting and distribution. Cost-benefit analysis showed a positive ratio of 1.22 between economic benefits and costs incurred by companies, confirming the social and economic sustainability of the implemented model. The data collected from the questionnaire given to "Banco Alimentare of Eastern Sicily" confirm the effectiveness of their model in reducing food waste and improving environmental impact. In 2024, they distributed over 10 million kilograms of food and saved more than 1,000 tons of CO_2 by recovering surplus food. The strong partnership with more than 50 agri-food companies and over 75 GDO stores supports their circular economic approach. Local projects like "Cuore Generoso" help recover fresh produce close to expiration at zero kilometers inside the MAAS center. The organization is also working on sustainability by installing a solar panel system, developed with ERG Italia and Crédit Agricole, and using electric vehicles to cut emissions. On the social side, the "Orange Day" education program raises awareness in schools about food waste and solidarity. Nearly 25 tons of seized fish were recovered in 2024 by following strict protocols to ensure food quality and safety. Despite these positive results, challenges remain around coordination, logistics and energy costs, and managing food expiration dates. The organization continues to address these through integrated sustainability strategies.

The Italian technical specification UNI/TS 11820:2022 introduces 71 key Environmental, Social and Governance (ESG) scalable indicators for evaluating the degree of circularity of individual businesses or clusters of organizations. These indicators are grouped into six categories: material resources and components, energy and water resources, waste and emissions, logistics, product and service, and human resources, assets, policies and sustainability. The formulation includes quantitative data, qualitative information and semi-quantitative data. Finally, UNI/TS provides a final formulation to calculate the overall Level of Circularity (LC) of an organization (Eq. 1):

$$LC = \frac{\sum P_c + \sum P_s + 0.5 \sum P_r}{n\,P_c + nP_s} \quad (1)$$

Table 1. Indicators results and description from UNI/TS 11820:2022 (Authors' elaboration)

Category	***Type***	***Indicator (UNI/TS 11820:2022)***	***Estimate for Banco Alimentare (2024)***	***Value***
1. Materials	specific	% of reclaimed material (vs. disposed)	100% (all managed flow is reclaimed and redistributed)	1
	specific	kg of reclaimed material vs. total managed	7,922,763 kg / 7,922,763 kg = 100%	1
2. Energy & Water	specific	% of energy from renewable sources	Solar panel system installed — estimated 5-10% of energy needs	0.1
3. Waste & Emissions	core	CO_2 reduction (t) from baseline (t/year)	~7,300 t of CO2 saved (2023, stable trend in 2024)	1
	core	CO**2** emissions from logistics (kg)	512.5 kg of CO2	1
4. Logistics	specific	% of electric vehicles out of total operational vehicles	Electric vehicles introduced — plausible estimate: 10%	0.1
	specific	Digital traceability (e.g., SAP ERP)	100% present on flows, expiration dates, and quality	1
5. Final Products/Services	rewarding	Average time food remains in distribution (days)	1	1
	specific	kg of fruit and vegetables reclaimed	401,185 kg (+39.6%)	0.396
6. Human Resources, Assets, & Policies	core	Corporate volunteering (hours and value)	1,155 hours → €30,030 (€26/hour)	1
	core	Number of partners involved	50+ agri-food companies, 75 large-scale retail points, 350 beneficiary organizations	1
	core	Control systems (HACCP, SAP ERP, Gadda Law)	100% in full use	1
	specific	Education/sustainability actions	"Orange Day" program active in schools	1
	specific	Local projects (inclusion, zero-km reclamation)	"Cuore Generoso" (at MAAS); 25 t of reclaimed fish	1
	rewarding	Replicable/transparent model (governance)	Replicable social circular economy model (Caglioti 2022)	1

Table 1 quantifies the value for each single indicator, specifying category, type (core, specific or rewarding), identifying number and unit.

The implementation of UNI/TS 11820:2022 provides that the Banco Alimentare Circularity Level in 2024 (LC) is 70.31%. More precisely, the circularity levels per indicator group correspond to the following values:

(a) 100.00% for material resources and components.
(b) 10.00% for energy and water resources.
(c) 100.00% for waste and emissions.
(d) 55.00% for logistics.
(e) 89.60% for products and/or services
(f) 100.00% for human resources, assets, policy, and sustainability.

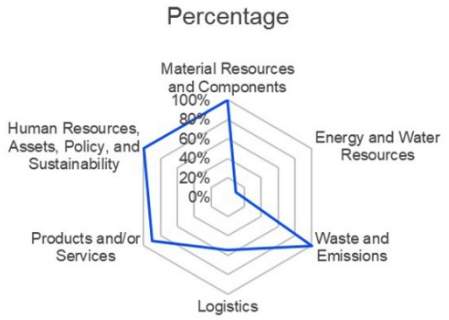

Fig. 1. Radar chart for each indicators' category from UNI/TS 11820:2022 (Authors' elaboration)

7. Concluding remarks

The study on the circularity level of Banco Alimentare, measured according to the UNI/TS 11820:2022 framework, reveals important insights into the operational and strategic role of third sector companies within the circular economy. Achieving a circularity level of 70.31% in 2024 is noteworthy, especially given that the UNI/TS 11820:2022 standard is new and not yet widely used as a benchmark in the sector. This high level of circularity demonstrates the company's deep commitment to sustainable practices and enhances its standing in a market that increasingly prioritizes environmental protection.

The analysis confirms the organization's crucial role in managing food surpluses sustainably, with significant social, economic, and environmental impacts. However, operational complexities and growing territorial coordination highlight the necessity for innovative management approaches. A key opportunity is the design of a territorial digital platform to monitor and manage surpluses, enhancing supply-demand matching and improving collaboration among businesses, nonprofits, and institutions. Such a modular and scalable platform could optimize logistics and ensure more transparent monitoring of food resources, reducing waste and strengthening Banco Alimentare as a cornerstone of the local solidarity economy.

The systematic adoption of the carbon footprint as a sustainability indicator allows quantification of the climate impact avoided through recovery and redistribution activities. Assimilated into a digital reporting system, this metric supports informed management aimed at emission reduction and promotes transparency and accountability. Integrating this digital platform with carbon footprint monitoring and UNI/TS 11820 (2024) regulatory indicators

offers a standardized framework for measuring and improving circularity, enhancing the rigor of environmental and social impact assessments.

Technological innovation in surplus management and the use of advanced environmental indicators are strategic levers to boost Banco Alimentare's effectiveness and sustainability. Recent evidence shows that reducing food waste requires an integrated approach combining actions across the supply chain, supportive policies, and strengthened recovery networks like food banks that turn surpluses into valuable social and environmental resources.

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