

ECONOMIC SOLUTIONS TO GLOBAL FOOD WASTE

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Abstract: Food waste imposes significant financial challenges worldwide, nationally, and at individual levels, due to both the direct loss of income and indirect expenses from squandered resources and environmental consequences. The worldwide economic impact of food waste is estimated to be around \$1 trillion each year. The study was conducted by examining various reports and other publications of specialized international institutions and representatives of the expert community. The purpose of the research was to formulate possible economic solutions for the global reduction of food waste. Economic approaches to global food waste emphasize establishing financial incentives, promoting a circular economy. Economic perspectives on worldwide food waste involve shifting from a linear production model to a circular economy, aiming to enhance resource value and correct market inefficiencies. Important methods include repurposing waste into new items like biofuels or animal feed, enhancing cold storage facilities, and implementing policy measures to decrease food loss throughout the distribution network. Essential strategies comprise financial incentives for food donations, establishing markets for "imperfect" fruits and vegetables. Also of great importance is global food waste reducing utilizing technology for supply chain optimization, enhancing efficiency from production to consumption using data, AI, and better logistics to prevent food loss. Digital tracking technologies are transforming food supply chain management from a reactive to a proactive system, enabling significant reductions in global food waste.

Keywords: food; waste; cost; solution; challenge.

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Introduction

The term *food waste* describes how edible food and inedible components (such as peels or bones) are disposed of in homes, restaurants, and retail establishments. This includes food that is spoiled, discarded due to cosmetic standards, or left unbought, as well as food thrown out by households and restaurants. It ranges from pre-harvest losses on farms to leftovers in consumers' homes.

It signifies a decline in both quantity and quality, frequently brought on by excessive purchases, inadequate storage, or aesthetic standards, leading to resource waste. The massive amount of edible food that is lost, ruined, or thrown away at every stage of the supply chain, from farms to homes, is known as the *food waste problem*.

Food waste generates greenhouse gasses in landfills while millions of people go hungry, making it a serious problem that causes enormous environmental damage, financial losses, and worldwide inequalities. Roughly 30-33% of global food production - amounting to 1.3 billion tons annually - is lost or wasted, equating to over 1 billion meals a day, yet one in nine people remains undernourished. Also, eight to ten percent of the world's annual greenhouse gas emissions come from food loss and waste. (UNEP, 2024), (UNFCCC, 2024). This article aims to present managerial possibilities for solving the global problem of food waste.

Literature Review

The literature dedicated to food waste issues is vast and can be divided into two groups: reports and other publications of official institutions (FAO, Ellen Macarthur Foundation, Geneva Environment Network, UNEP, UNFCCC, WEFORUM, WRI) and articles by various experts in the field addressed. In terms of essence, the presentation of the literature requires grouping the sources. The authors in the first group explain the essence and problems related to food waste (Geneva Environment Network, 2026), (Jangira Lewis, 2022), (Pyle, 2021), (Taste Before You Waste, 2019), (UNEP, 2024), (UNFCCC, 2024), (WEFORUM, 2026), (WFPUSA, 2026).

Other authors have examined a complex of determining interconnected drivers of food waste (Adam, 2015), (Liz Goodwin, 2025), (ReFED, 2026), (Veselá et al., 2023). The experts in the third group focused their research on solutions to global food waste (Aydinli et al., 2023), (Danish, 2025), (Davison, 2026), (European Commission), (Fatorachian et al., 2025), (Foodunfolded, 2023), (Goodwin, 2025), (Mohammad, Mohammad, 2024), (Teixeira, 2025), (The Happy Turtlestraw, 2024). The authors from the fourth group examined the challenges in implementing food waste reduction solutions. (Fatorachian, 2025), (Malhotra, Vos, 2021), (Olabode, 2025), (Sarangi et al., 2024), (Sharma et al., 2023), (Smrtrsolutions, 2024)

Methodology

The research was conducted based on open publications on the Internet. At the initial stage of the research, the systematic research method used to identify relevant literature by examining the reference lists (backward tracking) or citing articles (forward tracking) of foundational papers was used. Then, after selecting the most interesting and eloquent sources, the basic ideas of the topic addressed were grouped, distinguishing: the essence of the global problem of food waste, its multidimensional impact, important contributing factors, the managerial solutions practiced and the existing barriers. For each domain, the material was synthesized, and then compiled into a unique picture.

Results and Discussion

Food waste has become a major global problem that threatens sustainable development through its significant impact on the environment, economy and society.

Key environmental impacts can be formulated as follows (Geneva Environment Network, 2026), (Jangira Lewis, 2022):

- *Climate Change*: Methane, a greenhouse gas far more powerful than carbon dioxide, is produced when food waste decomposes in landfills. Every year, food waste causes about 3.3 billion tons of CO₂ equivalent emissions worldwide.
- *Water Waste*: Seventy percent of the freshwater used worldwide is used for agriculture. Water used for crop spraying, irrigation, and raising livestock is wasted when food is wasted.
- *Land Use & Biodiversity Loss*: Food waste accounts for over 28% of the world's agricultural land (1.4 billion hectares), which directly contributes to habitat destruction and decreased biodiversity.

- *Deforestation & Pollution:* Deforestation frequently results from the expansion of agricultural land. Furthermore, using pesticides and fertilizers needlessly contributes to the development of food waste.

The global economic impact of food waste can be examined in three dimensions:

- *Global and Local Financial Loss:* An estimated USD 1 trillion in economic losses are caused by food waste worldwide each year. Food that is never consumed is grown on 28% of the world's arable land. (UNEP, 2026) Food waste reduction is a crucial issue for both environmental and economic gain, with a \$14 return for every \$1 invested (WRI, 2017).
- *Business and Operational Losses:* Businesses, including restaurants and retailers, lose between \$780 billion and \$1 trillion annually due to unsold, uneaten, or spoiled food. (Galactic, 2025) Recent findings indicate that the expenses related to food waste throughout the supply chain account for 33% of total revenue. This global figure is projected to reach \$540 billion by 2026. Food waste is indeed a dual setback. Retailers face rising costs for inputs, labor, and logistics, while simultaneously discarding inventory that could have been sold. They incur higher expenses to stock food items, only to lose their complete value when those items remain unsold. According to some estimates the worldwide cost of food waste could soar to \$3.4 trillion by 2030. The shortcomings are especially apparent in high-value perishable goods. Projections for 2026 indicate that wasted meat could result in \$94 billion in lost value, while fresh produce and baked goods are expected to account for \$88 billion and \$67 billion in losses, respectively (WEFORUM, 2026).
- *Household and Retail Waste:* According to the 2024 UNEP Food Waste Index Report, roughly 1.05 billion tonnes of food were wasted in 2022, with 60% coming from households, 28% from food service, and 12% from retail. At the same time, 783 million people were affected by hunger and a third of humanity faced food insecurity (UNEP, 2024).

Food waste also has multiple **social influences** (Pyle, 2021), (Taste Before You Waste, 2019), (WFPUSA, 2026):

- **Food Insecurity and Hunger:** While millions struggle with hunger, vast amounts of food go to waste. Saving just a quarter of the food currently discarded could feed 870 million people.
- **Ethical Concerns and Resource Waste:** Throwing away food also means squandering the labor, water, energy, and land invested in its production.
- **Economic Strain on Households:** For consumers, this waste translates into substantial financial losses – Canadian households, on average, lose more than \$1,100 annually.
- **Health and Social Exclusion:** Limited access to healthy food contributes to poor health, and food insecurity often brings emotional distress, including shame and social isolation.
- **Environmental Injustice:** When food decomposes in landfills, it emits methane, a potent greenhouse gas that accelerates climate change - impacting especially vulnerable populations such as low-income communities and farm workers in developing countries.

- **Over-exploitation of Resources:** The demand for higher yields puts growing pressure on agriculture, contributing to water shortages and the decline of biodiversity.

Food waste has *a complex of determining interconnected drivers* (Adam, 2015), (Liz Goodwin, 2025), (ReFED, 2026), (Veselá et al., 2023):

1. **Household and Consumer Behavior.** This is the largest source, driven by over-buying, improper storage, excessive meal preparation, and throwing away leftovers. Poor planning and impulse buying by consumers are among the causes. Buying food without a plan or buying in bulk because of promotions leads to over-buying. Another cause is misunderstanding expiration date labels. Confusion between “best before” (safety) and “best before” (quality) dates lead to throwing away safe food. Some of the problems are related to storage and handling. Improper storage (e.g., improper refrigerator temperatures) leads to premature spoilage. Some problems are related to serving behavior. This includes serving large portions and not using leftovers.
2. **Retail and Food Service Sector.** Grocery stores often overstock their display cases to create an illusion of abundance, while strict cosmetic standards (based on appearance) result in perfectly edible fruits and vegetables being thrown away. That is, retailers reject products that do not meet rigid cosmetic standards (shape, size, color), even if they are nutritious. Also, worth mentioning are overstocking and display. Keeping shelves fully stocked to create an impression of “fullness,” which leads to spoilage of unsold products. Similarly, some problems are related to hospitality practices. Buffets, large menus, and in some cases, excess food prepared for tourists contribute greatly to waste.
3. **Supply Chain and Production.** Lack of cold chain infrastructure, inadequate storage technology and poor transportation lead to high spoilage rates, particularly in developing economies. In these regions, poor roads, limited cold storage (refrigeration) and inefficient transportation lead to significant losses before reaching the market. Some of the problems are related to harvesting challenges. Lack of labor, unfavorable market prices or inadequate harvesting technology can lead to crops being left in the field. Other problems are related to inadequate packaging, which can cause food to spoil more quickly, although excessive and rigid packaging can sometimes create various waste problems. Also, low retail prices of food can reduce its perceived value, making it cheaper for businesses to waste it than to manage it, while fluctuations in market prices can cause farmers to leave crops unharvested.

Economic solutions to global food waste include (European Commission), (Goodwin, 2025), (The Happy Turtlestraw, 2024):

- **Economic incentives for food donation:** Economic incentives for food donation include enhanced tax deductions, corporate tax credits, and government grants designed to encourage businesses to donate surplus food rather than disposing of it. These mechanisms reduce disposal costs and provide significant tax savings, with some regions offering deductions covering a percentage of the net book value of donated food. Many jurisdictions provide enhanced deductions, where businesses can deduct the cost of the food plus a portion of the potential profit. For instance, France and Spain allow 60% and 35% respectively of the net book value of donated food to be claimed as a corporate tax credit. (European Commission) Donating food allows businesses to avoid hefty landfill or waste-disposal fees. Financial grants are available for organizations investing in food, supporting the logistics and infrastructure of food recovery programs. While a legal

mechanism, safe food donation laws (e.g., the Emerson Act in the US) act as an economic incentive by removing the risk of litigation for donors, thus reducing the "risk cost" of donation. (The Network for Public Health Law)

- **Investment in Cold Chain and Infrastructure:** Investing in enhanced storage, transportation, and processing facilities (such as solar-powered dryers) greatly minimizes post-harvest losses, especially in developing areas. Investing in sustainable cold chain infrastructure – refrigerated storage, transportation, and monitoring - is essential for decreasing the nearly 40% of food wasted in developing regions. With the sustainable cooling market projected to reach \$600 billion by 2050, investments are directed towards minimizing post-harvest losses, boosting small-scale farmer income, and strengthening food security, particularly in Africa and India. (Davison, 2026), (FAO) These investments are essential not only for minimizing food waste but also for promoting environmental sustainability and aiding the livelihoods of small-scale farmers in developing areas.
- **"Imperfect" Produce Markets:** Farm-level waste is decreased by establishing markets and encouraging the sale of fruits and vegetables that are safe, wholesome, and visually flawed. "Imperfect" produce markets, also known as the "ugly produce movement," offer nutritious and safe fruits and vegetables that are turned down by regular supermarkets because of aesthetic flaws (size, shape, color). By sourcing directly from farmers, these markets cut down on food waste. They also serve customers who care about the environment by providing convenient, sustainable home delivery at lower prices. (Aydinli et al., 2023), (Foodunfolded, 2023) The use of these "quirky-looking" ingredients in processed foods, drinks, and spirits is also becoming more common in these markets, normalizing the consumption of non-uniform food.
- **Digital Supply Chain Optimization:** By using IoT sensors and digital twins, retailers can better manage inventory, track transportation, and keep an eye on food freshness, all of which reduce spoilage. In order to change the food supply chain from a reactive, linear process to a proactive, transparent, and responsive ecosystem, Digital Supply Chain Optimization (DSCO) makes use of cutting-edge technology, particularly the Internet of Things (IoT), artificial intelligence (AI), and blockchain. DSCO helps stakeholders reduce food waste, increase logistics efficiency, and improve food safety from farm to consumer by improving data visibility and predictive capabilities. (COM4, 2023), (Fatorachian et al., 2025), GEP (2023)
- **Circular Economy Models:** Food waste can be turned from a disposal expense into a source of income by being converted into value-added products like animal feed, biogas, fertilizer, or energy. By reducing, reusing, and recycling waste, circular economy models for food waste aim to close the nutrient loop and turn waste into resources. Important tactics that help achieve SDG 12 (Responsible Consumption and Production) by reducing waste include designing out waste, redistributing excess food, valorizing by-products, and composting. (Danish, 2025), (Ellen Macarthur Foundation, 2019), (Mohammad, Mohammad, 2024), (Teixeira, 2025), (UTS)

The main circular economy models for solving the problem of food waste are:

- *Circular Food Design:* utilizing by-products in new food products or optimizing packaging to increase shelf life as examples of designing food systems to reduce waste.

- *Redistribution and Sharing Economy*: selling extra food, giving it away, or sharing it (e. A g. platforms that link eateries with extra food to customers) to cut down on waste at the retail and consumer levels.
- *Valorization of By-products*: repurposing food waste by converting industrial food leftovers into high-value nutrients, animal feed, or bioenergy.
- *Organic Waste Recycling*: by replenishing the soil with nutrients through composting, ecosystems are restored and the food chain is closed.
- *Industrial Symbiosis*: a system that reduces waste and resource consumption by using waste from one food process as an input for another.

These models aim to transition from a linear "take-make-dispose" system to a regenerative one that minimizes environmental impact.

- ***Vertical Farming and Local Sourcing***: Putting hydroponic vertical farms right in stores cuts down on how far food travels and how much spoils, so it gets from being picked to your plate super-fast. When you grow food vertically and get it from local sources, it's a smart, high-tech way to really cut down on wasted food. This is because you get rid of those long shipping routes, make growing conditions just right, and make sure food gets from the farm to you almost immediately. By growing food inside in cities, this approach tackles the big problem that about a third of all the food we make goes to waste before it even gets to people, especially the stuff that goes bad quickly (Shypple, 2022).
- ***Data-Driven Waste Management***: Using digital tools and platforms to monitor food waste enables both businesses and households to measure, manage, and minimize losses more effectively. By leveraging AI, IoT sensors, and predictive analytics, data-driven approaches can reduce food waste by 20-45%, enhancing supply chain performance and streamlining inventory control. Companies analyze factors like sales trends, weather patterns, and consumer habits to fine-tune production, while smart kitchens use AI-powered visual recognition systems to automatically monitor and reduce waste – often lowering expenses by 3-5%. Compared to conventional methods, these data-based strategies not only cut waste significantly but also boost recycling precision above 90% and deliver annual cost savings of 15-25%. For instance, retailers apply AI to adjust prices dynamically, offering discounts on items nearing expiration to prevent spoilage. Smart sensors connected via IoT capture real-time environmental conditions, helping extend product shelf life and reduce waste by up to 10%. Machine learning models assess past sales, seasonal events, and weather to forecast demand more accurately, minimizing excess in both retail and kitchen operations. Mobile AI applications allow users to photograph leftovers and log waste, offering recipe suggestions based on existing ingredients to help reduce household food loss. Additionally, AI and sensor technologies assist in sorting waste streams, determining optimal reuse pathways such as composting, animal feed, or biogas production. (Arman et al., 2024), (Clark et al., 2025), (Eitfood, 2025), (Fatorachian, 2025), (Kayikci, 2022), (The climate drive), (Wu et al., 2025).

At the same time, the application of management technologies to reduce food waste faces certain challenges, the main ones of which include (Fatorachian, 2025), (Malhotra, Vos, 2021), (Olabode, 2025), (Sarangi et al., 2024), (Sharma et al., 2023), (Smrtrsolutions, 2024):

1. ***Economic and Financial Barriers***. The study identified three categories of economic and financial barriers. First, there is the need to bear high initial investment costs.

Implementing IoT sensors, AI-based management systems and advanced packaging is expensive, creating a high barrier to entry, especially for small and medium-sized enterprises (SMEs). Second, there is the low perception of return on investment. Many companies hesitate to invest due to uncertainty about the long-term amortization of these technologies. Third, there are significant operational costs. Maintaining smart systems, including software updates and staff training, imposes ongoing financial burdens.

2. ***Technological and Infrastructure Gaps.*** These can be divided into three groups. The first consists of data silos and integration issues. The lack of standardized data protocols means that the different technologies used within the supply chain often do not interact well, preventing perfect end-to-end traceability. The second group is linked to inadequate physical infrastructure. In developing regions, the absence of basic infrastructure - such as reliable cold chains, electricity or internet connectivity - limits the ability to adopt sophisticated technologies. And the third group are barriers formed by the variability of waste composition. Artificial intelligence systems designed to sort or process waste often struggle with the inconsistent and diverse nature of food waste, causing operational inefficiencies in automated systems.
3. ***Managerial and Organizational Challenges.*** These are diverse, starting with resistance to change. Company culture can be a significant barrier, with skepticism about the reliability of new technologies and a lack of skills to manage digital tools (e.g., IoT data analysis). Similarly, there is a lack of qualified personnel. There is currently a lack of expertise to design, implement and maintain digital food management systems. There is also limited cooperation. It is important to note that reducing food waste requires cooperation across the entire supply chain. However, low motivation for information sharing between actors - driven by the fear of a competitive disadvantage - restricts data sharing.
4. ***Regulatory and Policy Limitations.*** Serious obstacles to reducing food waste have become inconsistent or outdated waste management regulations that can slow the adoption of new and sustainable technologies, especially in the efficient recycling and reuse of food waste. Similarly, it is worth noting that strict regulations, often reluctant to enforce expiration dates, can hinder the adoption of smart technologies that could safely extend the shelf life of food, causing avoidable waste.

Conclusions

Food waste pertains to consumable food products that are thrown away, spoiled, or left uneaten at the retail or consumer stages (including households, restaurants, and shops). This phenomenon constitutes a significant sustainability challenge, as nutritious food is discarded rather than consumed, frequently as a result of overproduction, inadequate storage, or surpassing expiration dates. Solving the problem of food waste globally can allow for a substantial reduction in the problem of hunger and malnutrition. Minimizing food waste presents an essential chance to lower carbon emissions, save precious resources, and enhance food security. Tackling this challenge necessitates improving logistics, altering consumer habits, and increasing the redistribution of food to those who require it.

International practice has developed multiple solutions for reducing food waste. These include the implementation of the circular economy, economic incentives for food donation, vertical farming and local sourcing, investment in cold chain and infrastructure, overcoming

food market imperfections, digital supply chain optimization. Similarly, in the information age, data-driven waste management technologies can be of great help. The managerial activity of reducing food waste faces a series of obstacles of an economic, financial, managerial, organizational nature, technological and infrastructure gaps, as well as regulatory and policy limitations. Overcoming them is an important and complex task.

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