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FOOD SAFETY, FOOD LOSS AND SUSTAINABLE CONSUMPTION: ADVANCING SDGS 2, 3 AND 12

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Abstract
Food safety, food loss and waste, and sustainable consumption are interconnected challenges affecting global food security, public health and environmental sustainability. While food loss and waste reduce the quantity of food available for human consumption and contribute to greenhouse gas emissions, unsafe food causes preventable illness, death and economic losses. This article examines the relationship among these issues through the lens of Sustainable Development Goals (SDGs) 2 (Zero Hunger), 3 (Good Health and Well-being) and 12 (Responsible Consumption and Production). It adopts a descriptive and analytical research design based on secondary data from the Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), World Health Organization (WHO), United Nations Sustainable Development Goals reporting and the joint United Nations report The State of Food Security and Nutrition in the World. The evidence indicates that approximately 13.3% of food was lost globally after harvest and before retail in 2023, while an estimated 1.05 billion tonnes of food were wasted at retail, food-service and household levels in 2022. Meanwhile, WHO's 2026 estimates indicate that contaminated food caused approximately 866 million illnesses and 1.52 million deaths in 2021. These figures demonstrate the scale of food-system inefficiencies and foodborne disease, although they measure distinct phenomena and cannot establish a direct causal relationship between food waste and foodborne illness. The article argues that food-loss reduction must be accompanied by effective food-safety controls, appropriate storage and transport infrastructure, transparent supply chains, consumer awareness and evidence-based redistribution systems. It proposes an integrated food-systems approach that combines prevention, safety assurance, responsible consumption and accountable governance to support progress towards SDGs 2, 3 and 12.

Keywords: Food safety, food loss, food waste, sustainable consumption, food security, foodborne diseases, cold-chain infrastructure, SDG 2, SDG 3, SDG 12, food-systems governance.

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1. Introduction

Food is essential not only for survival but also for human health, dignity, economic participation and social development. Yet global food systems face a persistent contradiction: substantial quantities of food are lost or wasted at different stages of the supply chain while millions of people experience hunger, food insecurity and inadequate nutrition. At the same time, food contaminated with biological, chemical or physical hazards creates serious public-health risks. These challenges are connected through production, harvesting, processing, storage, transportation, retailing, household preparation and consumption.

Food loss and food waste represent different stages of food-system inefficiency. Food loss generally occurs during production, post-harvest handling, storage, transportation, processing and wholesale distribution, whereas food waste occurs mainly at retail, food-service and household levels. Reducing both can conserve agricultural resources, improve supply-chain efficiency and support food availability. However, food that is saved from waste is not necessarily safe for consumption. Effective food-system policies must therefore

consider the quantity, quality, safety, nutritional value and accessibility of food rather than focusing exclusively on reducing discarded volumes.

The global significance of these issues is reflected in international development commitments. Sustainable Development Goal 2 seeks to end hunger, achieve food security, improve nutrition and promote sustainable agriculture. SDG 3 aims to ensure healthy lives and well-being, including through the prevention of disease. SDG 12 promotes sustainable consumption and production, with Target 12.3 specifically addressing food loss and waste.

Recent international estimates demonstrate the scale of the challenge. FAO reports that 13.3% of food was lost globally after harvest and before retail in 2023. Separately, UNEP estimates that 1.05 billion tonnes of food were wasted at retail, food-service and household levels in 2022, equivalent to approximately 19% of food available to consumers at these stages (Food and Agriculture Organization of the United Nations [FAO] United Nations Environment Programme [UNEP], 2024). These estimates relate to different supply-chain stages and reference years; they should not be combined as if they measured a single, uniform quantity.

Food safety is equally important. WHO's updated estimates, published in June 2026, indicate that contaminated food caused approximately 866 million illnesses and 1.52 million deaths in 2021. The same assessment estimates the associated global economic burden at approximately US$310 billion in medical expenses and productivity losses (World Health Organization [WHO], 2026). These estimates highlight the substantial health and economic consequences of unsafe food.

This article analyses the relationship between food safety, food loss and waste, and sustainable consumption using secondary data. Its central argument is that progress towards food-system sustainability requires an integrated approach: preventing avoidable losses, ensuring that food retained or redistributed remains safe, improving access to nutritious diets and establishing accountable institutions across the food supply chain.

2.Review of Literature

Existing studies highlight that food loss and waste arise from inadequate storage, transportation, supply-chain inefficiencies and consumer behaviour (Spang et al., 2019; Magalhaes et al., 2021). Research also emphasises their environmental consequences and the need for sustainable food management to achieve SDG 12 (Xue et al., 2024; UNEP, 2024). Studies on food safety underline the significant public-health burden of foodborne diseases, particularly in developing countries (Grace, 2023). However, food safety and food waste are often examined separately. This study integrates both perspectives to explore their relevance to food security, public health and sustainable consumption under SDGs 2, 3 and 12.

3.Research Framework: Problem, Objectives, Questions and Methodology

This study examines the limited integration of food safety, food loss and waste prevention, and sustainable consumption in promoting food security, public health and environmental sustainability. It aims to analyse available evidence, explore the roles of storage infrastructure, supply-chain management and consumer behaviour, and assess their relevance to SDGs 2, 3 and 12. The study addresses how food loss and waste affect sustainable food systems, why food-safety safeguards are essential, and what policy measures can improve outcomes. It adopts a descriptive and analytical approach based on secondary data from FAO, UNEP, WHO, the United Nations and relevant academic literature. The evidence is analysed thematically, recognising differences in definitions, measurement and reference years. As the study relies on published information and does not involve primary data collection, its findings represent an evidence-

based synthesis rather than proof of causal relationships between food waste and foodborne diseases.

4. Global Evidence on Food Loss, Food Waste and Food Safety

4.1 Food loss and waste across the supply chain

Food loss and waste occur at multiple stages of the food system. At the production and post-harvest stages, losses can arise from harvesting practices, weather damage, pests, inadequate storage, limited access to processing facilities, transportation delays and insufficient market infrastructure. At retail and consumption stages, waste may result from over-purchasing, inappropriate storage, confusion over date labels, oversized portions, excessive preparation, aesthetic standards and unsold surplus.

FAO's global monitoring indicates that approximately 13.3% of food was lost after harvest and before retail in 2023. This compares with 13.0% in 2015, the baseline year for the global monitoring series. FAO cautions that the slight increase falls within the expected range of data and model fluctuations, so it should not be interpreted as conclusive evidence of a deterioration in every national food system (FAO)

UNEP's 2024 assessment estimates that 1.05 billion tonnes of food were wasted at retail, food-service and household levels in 2022. This represented approximately 19% of food available to consumers at those stages. Households accounted for 631 million tonnes, or 60% of the total; food services accounted for 290 million tonnes, or 28%; and retail accounted for 131 million tonnes, or 12% (UNEP, 2024).

These figures indicate that interventions are needed across the entire food system. Improvements in agricultural handling and storage alone will not resolve waste at household and food-service levels. Conversely, consumer-awareness campaigns cannot compensate for inadequate storage, processing and transport infrastructure upstream.

Table 1. Selected global indicators relevant to food safety, food loss and sustainable consumption

Indicator	Published estimate	Reference year	Principal source
Food lost after harvest and before retail	13.3%	2023	FAO
Food wasted at retail, food-service and household levels	1.05 billion tonnes	2022	UNEP
Share of food available to consumers wasted at these stages	19%	2022	UNEP
Household share of measured food waste	60%	2022	UNEP
Food-service share of measured food waste	28%	2022	UNEP
Retail share of measured food waste	12%	2022	UNEP
Estimated foodborne illnesses worldwide	866 million	2021	WHO, 2026 estimates
Estimated deaths caused by unsafe food	1.52 million	2021	WHO, 2026 estimates
Estimated global economic burden of foodborne disease	US$310 billion	2021	WHO, 2026 estimates
People estimated to have faced hunger	673 million	2024	FAO et al., 2025

Sources: FAO (n.d.); FAO et al. (2025); UNEP (2024); WHO (2026) *.

*Note. These indicators are not directly interchangeable. They cover different stages of

the food chain and different reference years. The foodborne-disease figures are updated estimates published in 2026 for the year 2021, not counts of cases occurring in 2026. The hunger estimate is based on the 2025 edition of the joint United Nations food-security report.

The data illustrate a dual challenge: significant quantities of food are lost or wasted, while foodborne disease continues to impose a substantial health burden. However, the figures alone do not establish that food loss and waste directly cause the reported number of illnesses.

4.2 Food insecurity and the distributional paradox

Food loss and waste are particularly concerning in a world where access to adequate nutrition remains unequal. The 2025 edition of The State of Food Security and Nutrition in the World estimated that approximately 673 million people experienced hunger in 2024, while about 2.3 billion people faced moderate or severe food insecurity. The report also estimated that 2.6 billion people could not afford a healthy diet in 2024 (FAO et al., 2025).

These figures demonstrate that food availability and food access are distinct. Reducing losses can improve the efficiency of the food supply, but the benefits do not automatically reach people experiencing hunger. Food must also be affordable, nutritionally appropriate, geographically accessible and safe. Distribution systems, purchasing power, social protection and public provisioning remain important determinants of whether reductions in waste improve food security.

Surplus food may exist in locations where demand is weak or storage is inadequate, while vulnerable households in other locations lack access to nutritious food. Redistribution can help bridge some of these gaps, but only when logistics, food-safety assessment, transport, storage and recipient needs are adequately addressed.

4.3 Food safety as a public-health concern

Food safety refers to the assurance that food will not cause harm to the consumer when prepared and consumed according to its intended use. Unsafe food may contain pathogenic microorganisms, parasites, chemical contaminants, natural toxins or physical hazards. Contamination can occur at any stage, including production, harvesting, processing, transport, retail, preparation and consumption.

WHO's updated global estimates, published in June 2026, indicate that approximately 866 million people experienced foodborne illness and 1.52 million people died as a result of unsafe food in 2021. Children under five experienced a disproportionate share of the health burden, accounting for 29% of the burden and an estimated 143,000 deaths in 2021. WHO also estimates annual global economic costs of approximately US$310 billion in medical expenses and lost productivity associated with foodborne disease (WHO, 2026).

These estimates underline why food-safety governance cannot be treated as a secondary component of waste reduction. Food saved from disposal may still pose risks if it has been stored at inappropriate temperatures, exposed to contamination, damaged during transport or retained beyond safe limits. Equally, food discarded because it is genuinely contaminated should not be recovered for human consumption simply to meet waste-reduction targets.

Food safety and food-loss prevention should therefore be pursued together, but their outcomes should be measured separately. A successful programme should reduce avoidable waste without increasing exposure to unsafe food.

5. Understanding the Relationship Between Food Safety and Food Loss

5.1 Inadequate storage and temperature control

Storage infrastructure plays a critical role in preserving food quality and preventing deterioration. Perishable foods such as meat, fish, milk, dairy products, fruits and vegetables

may deteriorate rapidly when exposed to unsuitable temperatures, excessive humidity, physical damage or poor sanitation.

Cold-chain infrastructure can help preserve the safety and quality of temperature-sensitive foods when designed, maintained and operated correctly. It includes refrigerated storage, temperature-controlled transportation, suitable retail facilities and monitoring systems. However, refrigeration does not make contaminated food safe, and the cold chain cannot substitute for hygienic production, appropriate processing or effective sanitation.

Inadequate cold storage and interrupted temperature control can contribute to spoilage and increase food-safety risks. For this reason, infrastructure investments should be combined with staff training, equipment maintenance, temperature monitoring, traceability and clear procedures for handling products when safety conditions have been compromised.

5.2 Post-harvest handling and processing

Post-harvest losses can arise from poor harvesting practices, delayed cooling, unsuitable packaging, mechanical damage, pest infestation, inadequate drying and inefficient transportation. These problems reduce the quantity and quality of food reaching consumers and may create conditions favourable to deterioration or contamination.

Different commodities require different interventions. Cereals and pulses may require effective drying, moisture control and protection against pests and mould. Fresh produce may benefit from careful handling, ventilation, appropriate packaging and cooling. Animal-source foods generally require stronger controls over temperature, hygiene and time during handling and distribution.

Food-safety interventions must be tailored to the specific hazards and conditions associated with each commodity. General waste-reduction targets are useful for monitoring progress, but they are insufficient to determine which technical controls are necessary.

5.3 Food redistribution and donation

Redistributing surplus food can provide social and environmental benefits by directing suitable food towards food banks, community kitchens, charitable organisations and vulnerable households. Nevertheless, donation programmes need clear acceptance criteria, appropriate handling, traceability and reliable storage and transportation.

Food should not be donated merely because it is edible in appearance or has not yet been discarded. Organisations should assess the product's history, packaging integrity, temperature requirements, shelf life and potential hazards. Food that has been recalled, contaminated or stored under unsafe conditions should not be redirected for human consumption.

A responsible redistribution system must also ensure that recipients receive food that is nutritionally appropriate and culturally acceptable. Redistribution should complement, not replace, investments in social protection, food access and structural improvements in the supply chain.

5.4 Consumer behaviour and household food waste

Household food waste is influenced by shopping habits, meal planning, portion sizes, food storage, date-label interpretation and the use of leftovers. UNEP's 2024 report identifies households as the largest source of measured consumer-stage food waste, accounting for 60% of the global total in 2022 (UNEP, 2024).

Household interventions can include planning purchases, storing food according to product requirements, rotating older items, understanding date labels, using suitable portions and preparing meals from ingredients before they deteriorate. However, advice on retaining and consuming leftovers must be accompanied by food-safety guidance. Prompt cooling, appropriate refrigeration, clean containers, safe reheating and timely disposal of food that has been held under unsafe conditions are important safeguards.

Consumer education should therefore avoid a simplistic message that all food should be saved. The objective is to prevent avoidable waste while ensuring that food retained for consumption remains safe.

6. Food Loss, Waste and Environmental Sustainability

Food loss and waste also create environmental costs because the resources used to produce food are wasted when it is never consumed. These resources include land, water, energy, fertilisers, labour, packaging and transportation. When discarded food decomposes in landfills, it can generate methane and contribute to climate change.

FAO estimates that food loss and waste account for approximately 8–10% of global greenhouse gas emissions (FAO) This estimate demonstrates that food-waste prevention can contribute to climate mitigation as well as resource efficiency. Nevertheless, the environmental benefits depend on the type of food, the stage at which loss occurs, the resources embodied in that food and the method used to manage unavoidable waste.

Preventing avoidable losses is generally preferable to managing food after it becomes waste. Where food is safe and suitable for human consumption, prevention and appropriate redistribution may preserve more of its nutritional and economic value. Where food is no longer suitable for human consumption, alternative uses—such as approved animal-feed pathways, industrial uses or composting—may be considered subject to relevant safety, environmental and legal requirements.

Not all forms of waste diversion produce the same benefits. Composting can return organic matter to soil, but it does not replace the nutritional and economic value of food that could have been safely consumed. Similarly, anaerobic digestion can recover energy from unavoidable waste, but it should not become an incentive to generate additional waste.

A sustainable hierarchy should prioritise prevention, followed by safe redistribution where feasible, appropriate recovery and recycling, and environmentally sound disposal as a last resort.

7. Advancing SDG 2, SDG 3 and SDG 12

7.1 SDG 2: Zero Hunger

SDG 2 seeks to end hunger, achieve food security, improve nutrition and promote sustainable agriculture. Food-loss reduction can contribute to this goal by improving the efficiency of existing food production and distribution systems. Better post-harvest management may increase the quantity of food reaching markets and reduce avoidable economic losses for producers.

However, food loss reduction alone cannot eliminate hunger. Food insecurity also reflects poverty, conflict, food-price inflation, unequal access to land and productive resources, climate shocks and weaknesses in social protection. A more efficient food supply must be accompanied by measures that improve purchasing power and ensure access to nutritious food.

Safe redistribution programmes, improved market access for small-scale producers, stronger storage infrastructure and targeted public food assistance can help connect food-system efficiency with food-security outcomes.

7.2 SDG 3: Good Health and Well-being

SDG 3 includes the prevention of disease and the promotion of health and well-being. Food safety is directly relevant because foodborne disease can cause acute illness, long-term complications, disability and death. Unsafe food also creates costs for health systems, households, employers and national economies. Reducing food waste contributes to SDG 3 only when it does not compromise food safety. The expansion of donation systems, cold chains, food recovery and leftover consumption should therefore be supported by risk-based controls, hygienic handling, temperature management, traceability and consumer education.

Food-safety governance should also protect populations who may face greater risks, including young children, older people,

pregnant women and people with weakened immune systems. These groups may be disproportionately affected by certain foodborne hazards, making safe food distribution a public-health priority as well as a sustainability concern.

7.3 SDG 12: Responsible Consumption and Production

SDG 12 provides the most direct international framework for addressing food loss and waste. Target 12.3 calls for halving per-capita global food waste at retail and consumer levels by 2030 and reducing food losses along production and supply chains, including post-harvest losses.

The target is monitored through indicator 12.3.1, which comprises two components: the Food Loss Index and the Food Waste Index. The distinction is important because losses before retail and waste at retail and consumption stages require different measurement approaches and interventions (United Nations Statistics Division)

Progress towards Target 12.3 requires reliable data, consistent definitions, business participation, consumer engagement and public-sector coordination. Food-safety criteria should be integrated into waste-reduction programmes so that targets for the quantity of food saved do not create incentives to redistribute unsafe products or delay the disposal of genuinely hazardous food.

Table 2. Linking food-system interventions to SDGs 2, 3 and 12

Intervention	Contribution to SDG 2	Contribution to SDG 3	Contribution to SDG 12
Improved post-harvest handling	Reduces avoidable losses and can improve food availability	Helps protect food quality when combined with hygiene controls	Improves supply-chain resource efficiency
Cold-chain and storage investment	Can improve access to perishable and nutritious foods	Supports temperature control for sensitive foods	Reduces avoidable deterioration and waste
Safe food donation and redistribution	May improve access for food-insecure populations	Requires screening, traceability and safe handling	Prevents suitable surplus food from becoming waste
Household food-management education	Supports more efficient use of purchased food	Promotes safe storage and handling	Reduces avoidable household waste
Food-safety inspection and surveillance	Helps protect the food supply	Prevents and manages foodborne risks	Supports responsible production and distribution
Composting and appropriate organic-waste recovery	May indirectly support agricultural resource management	Requires controls against environmental and biological hazards	Improves management of unavoidable organic waste

Source: Synthesis based on FAO, UNEP (2024), WHO (2026) and United Nations SDG documentation. *

*The table presents potential contributions, not proof that each intervention automatically achieves the stated outcome. Actual results depend on implementation quality, access, infrastructure, monitoring and compliance.

8. Major Challenges in Implementation

8.1 Inadequate infrastructure and investment

In many settings, producers and small businesses lack access to affordable storage, refrigeration, processing facilities, reliable electricity, suitable packaging and efficient transport. These constraints can increase losses and undermine food-safety controls. Infrastructure projects may also fail when maintenance, technical training and operating costs are not considered.

Public policy should therefore support appropriate, affordable and energy-efficient infrastructure rather than focusing exclusively on large-scale technological solutions. Shared storage and processing facilities, local collection centres and cooperative logistics may be particularly relevant for small producers.

8.2 Fragmented institutional responsibility

Food safety and waste management often involve different government departments, regulatory authorities, local governments, agricultural agencies, health systems and private operators. Fragmented responsibilities can create gaps in monitoring, data sharing, enforcement and accountability.

Integrated governance requires clear institutional mandates, coordinated surveillance, transparent reporting and agreed protocols for managing unsafe food and suitable surplus food. Coordination should extend from agricultural production to public health, consumer protection and environmental management.

8.3 Limited and inconsistent data

Reliable measurement is necessary to identify where losses occur and whether interventions are effective. Yet food-loss and food-waste estimates may differ by commodity, supply-chain stage, geographical coverage and methodology. Household waste can be measured through direct weighing, waste-composition analysis, surveys or statistical estimates, each with different strengths and limitations.

Food-safety data also face challenges, including underreporting of illness, limited laboratory capacity and difficulties in tracing outbreaks to particular foods or stages of the supply chain. The absence of comparable data makes it difficult to evaluate whether food-waste reduction initiatives also improve safety.Governments and international organisations should strengthen standardised measurement and publish disaggregated data wherever possible. Food-loss indicators, food-waste indicators and foodborne-disease indicators should be used together for policy analysis but should not be treated as interchangeable measures.

8.4 Consumer awareness and behavioural barriers

Consumer campaigns can help reduce avoidable waste, but information alone may not overcome practical barriers. Households may lack refrigeration, reliable electricity, time for meal planning or access to affordable quantities of food. Consumers may also misunderstand date labels or lack confidence about the safe use of leftovers.

Effective interventions should combine awareness with enabling conditions, including accessible food-safety guidance, suitable packaging, clear date labels, affordable storage options and realistic household-level recommendations. Campaigns should avoid placing the entire responsibility for systemic food loss on individual consumers.

8.5 Balancing waste reduction with safety assurance

A central policy challenge is preventing waste without encouraging unsafe retention, sale or redistribution. Strict safety rules can protect consumers, but unclear guidance or poorly designed compliance systems may also lead businesses to discard suitable products unnecessarily. Conversely, overly permissive practices may expose consumers to unacceptable risks.

The solution is risk-based regulation supported by clear guidance, training, traceability, documented procedures and proportionate enforcement. Food that is safe and suitable for consumption should be recovered where

feasible; food that is unsafe should not be diverted to vulnerable consumers simply to reduce waste.

9. Policy Recommendations

9.1 Adopt an integrated food-systems policy framework

Governments should treat food safety, food-loss prevention, nutrition and sustainable consumption as interdependent policy areas. National strategies should specify responsibilities across agriculture, health, food regulation, local government, environmental management and consumer protection.

Coordination mechanisms should include shared objectives, reporting arrangements and monitoring systems. Food-waste strategies should explicitly address safety requirements for storage, transport, redistribution and recovery.

9.2 Invest in appropriate storage and cold-chain infrastructure

Public investment and carefully designed incentives can support improved storage, refrigeration, processing, packaging and transport. Priority should be given to locations and commodities where avoidable losses are substantial and where infrastructure improvements can preserve food quality and safety.

Projects should incorporate energy efficiency, renewable-energy options where appropriate, maintenance arrangements and training. Infrastructure investment should be evaluated using indicators such as loss rates, product quality, energy use, temperature compliance and economic accessibility for smaller producers.

9.3 Strengthen food-safety regulation and surveillance

Food-safety authorities should strengthen risk-based inspection, laboratory capacity, outbreak investigation, traceability and transparent communication. Businesses should receive clear guidance on hygienic handling, temperature control, product recalls, date labelling and safe redistribution.

Surveillance systems should link food testing and outbreak information where appropriate, while protecting privacy and maintaining scientific independence. Reporting should distinguish regulatory activity, such as inspections and samples tested, from actual food-safety outcomes.

9.4 Establish safe food-redistribution systems

Food-donation programmes should use documented acceptance criteria, trained personnel, appropriate transport and storage, traceability and clear procedures for rejecting unsafe products. Guidance should distinguish between foods that remain suitable for redistribution and foods that must be discarded.

Partnerships among food businesses, charitable organisations, local governments and public-health authorities can improve the logistical efficiency of redistribution. Monitoring should assess not only the quantity of food recovered but also its safety, nutritional suitability, destination and actual use.

9.5 Promote consumer education and responsible purchasing

Public-awareness campaigns should address meal planning, portion management, storage practices, date-label interpretation, leftover safety and the environmental costs of avoidable waste. Information should be accessible, culturally appropriate and available in local languages.

Education programmes should also explain that appearance and smell cannot reliably establish the safety of every food product. Consumers need clear advice on time and temperature controls and on when food should not be consumed.

9.6 Improve measurement and public reporting

Governments should strengthen food-loss and food-waste measurement across supply-chain stages and improve the comparability of national estimates. Businesses and public institutions can be encouraged to document waste generation and prevention efforts using

transparent methods. Monitoring should distinguish between food prevented from becoming waste, food safely redistributed, food diverted to other uses and food sent for disposal. Separate food-safety indicators should measure contamination risks, foodborne outbreaks, regulatory compliance and other relevant outcomes. A combined monitoring framework would help policymakers assess whether waste reduction is delivering environmental, nutritional and public-health benefits without generating unintended risks.

9.7 Support small producers and informal food businesses

Small farmers, market traders, street-food vendors and small food processors may face financial and technical barriers to meeting food-safety requirements. Training, affordable facilities, technical advice and proportionate compliance systems can improve safety without unnecessarily excluding small businesses from markets. Support should combine enforcement with capacity building. Where feasible, shared facilities, cooperative storage, accessible testing and practical training can help smaller operators reduce losses while maintaining hygiene and safety standards.

9.8 Encourage responsible private-sector participation

Food retailers, manufacturers, hospitality businesses and logistics providers have important roles in reducing losses and waste. Businesses can improve demand forecasting, inventory management, packaging, cold-chain monitoring, donation arrangements and consumer information. Public-private partnerships should establish measurable objectives and transparent reporting. Claims about food saved or emissions avoided should be based on clearly defined methods to prevent double counting and misleading sustainability claims.

10. An Integrated Framework for Safe and Sustainable Food Systems

Based on the evidence reviewed, this article proposes a six-pillar framework for integrating food safety, food-loss reduction and sustainable consumption.

Pillar 1: Prevention at source. Improve harvesting, handling, forecasting, processing and inventory management to prevent avoidable losses before they occur.

Pillar 2: Safety assurance. Apply appropriate hygiene practices, temperature controls, hazard assessment, traceability and regulatory oversight throughout the food chain.

Pillar 3: Safe recovery and redistribution. Redirect suitable surplus food to human consumption where feasible, with clear acceptance criteria, documented handling and reliable transport and storage.

Pillar 4: Responsible consumption. Promote household planning, appropriate portions, clear date labels and safe storage and use of food.

Pillar 5: Resource recovery. Manage unavoidable food waste through appropriate recycling, composting, anaerobic digestion or other legally permitted uses, with suitable environmental and safety safeguards.

Pillar 6: Accountability and measurement. Monitor food losses, food waste, foodborne-disease outcomes, resource use and distributional effects through transparent and complementary indicators.

The framework follows a central principle: food should be prevented from becoming waste where possible, redistributed only when safe and suitable, and managed responsibly when it can no longer be used for human consumption.

Table 3. Suggested monitoring indicators

Policy area	Illustrative indicators	Purpose
Food loss prevention	Percentage of losses by commodity and supply-chain stage	Identifies priority points for intervention
Food waste reduction	Tonnes of waste per capita or by sector	Tracks changes at retail, food-service and household levels

Food safety	Foodborne illness estimates, outbreak trends and relevant compliance indicators	Assesses public-health risks and regulatory performance
Cold-chain management	Temperature compliance, infrastructure availability and product deterioration rates	Evaluates storage and transport performance
Safe redistribution	Quantity accepted, quantity distributed, rejection rates and traceability compliance	Assesses recovery while safeguarding recipients
Environmental performance	Waste-treatment pathways and estimated emissions associated with food waste	Examines environmental outcomes
Food security	Hunger, food-insecurity and healthy-diet affordability indicators	Assesses whether food-system improvements contribute to access
Governance	Data coverage, reporting frequency and coordination arrangements	Evaluates transparency and implementation capacity

*These are suggested indicators, not a claim that all are currently available or measured consistently across countries. Their use should be adapted to national data capacity and clearly documented definitions.

11. Observations

The evidence supports the view that food safety, food loss and waste, and sustainable consumption should be addressed within a common food-systems framework. The scale of food loss before retail and food waste at consumer stages demonstrates the need for interventions throughout production, distribution and consumption. Meanwhile, the estimated burden of foodborne disease highlights the importance of maintaining safety controls while pursuing efficiency.

The relationship among these issues is complementary but not necessarily linear. Better storage can reduce spoilage and, when appropriately managed, help maintain food safety. However, a reduction in recorded waste does not necessarily indicate an improvement in safety. Waste could decline because more food is consumed safely, because suitable surplus is redistributed, or because unsafe food is retained or sold rather than discarded. These outcomes have very different implications.

Likewise, food-safety improvements do not automatically reduce waste. More effective testing and surveillance may initially lead to greater quantities of food being rejected or recalled because hazards are identified. Such an increase in recorded disposal may reflect improved protection rather than policy failure. Evaluation must therefore consider food-safety outcomes and waste indicators together.

The analysis also demonstrates that food availability should not be equated with food security. Even if losses decline and more food reaches markets, vulnerable households may remain unable to afford a healthy diet. The 2025 United Nations food-security report's estimates of hunger and healthy-diet affordability illustrate the importance of economic access alongside production and distribution efficiency (FAO et al., 2025).

From a governance perspective, the key challenge is coordination. Agricultural institutions, food-safety regulators, public-health agencies, local governments, businesses and civil-society organisations often manage different parts of the food system. Integrated planning can help ensure that food-loss targets do not undermine food safety, redistribution systems protect recipients and consumer campaigns reflect practical living conditions.

Progress towards SDGs 2, 3 and 12 therefore requires a combination of infrastructure, regulation, education, social protection, private-sector responsibility and reliable measurement. The most effective policies will be those that improve food availability and affordability while maintaining safety and reducing environmental burdens.

12. To Sum Up

Food safety, food loss and waste, and sustainable consumption are interconnected dimensions of global food-system sustainability. International evidence indicates that substantial food losses occur before retail, considerable quantities are wasted at retail and consumption stages, and foodborne disease continues to impose a serious health and economic burden. At the same time, hunger, food insecurity and the unaffordability of healthy diets remain major challenges.

This article demonstrates that reducing food loss and waste can support SDG 2 by improving food-system efficiency, SDG 3 by supporting safe food handling and preventing foodborne illness, and SDG 12 by promoting responsible production and consumption. However, these benefits cannot be assumed automatically. Food saved from waste must remain safe; food redistributed to vulnerable populations must meet appropriate safety requirements; and waste-reduction targets must not encourage the retention or sale of hazardous food.

A more effective approach combines prevention at source, appropriate storage and cold-chain infrastructure, risk-based regulation, safe redistribution, consumer education, responsible recovery of unavoidable waste and transparent monitoring. Food-system policy should evaluate quantity, safety, nutritional suitability, accessibility and environmental impact together while measuring each outcome with appropriate indicators.

Ultimately, a sustainable food system is not one that merely wastes less. It is one that makes better use of resources, protects public health, improves equitable access to nutritious food and ensures that responsibility is shared across producers, businesses, consumers and public institutions. Integrating these priorities provides a practical pathway towards more meaningful progress on SDGs 2, 3 and 12.

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