FOOD WASTE REDUCTION AND PROVISION: THE CURRENT SPECTRUM OF SOLUTIONS - A REVIEW

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Abstract— *Food waste is a constantly rising global issue, with one-third of food produced globally going to waste every year. This waste contributes to food insecurity, environmental damage, and economic losses, while hunger persists, especially in developing nations. Recent reports, including India's low ranking in the 2023 Global Hunger Index, highlight the urgency of addressing food waste and improving food redistribution. Various technological solutions such as the Internet of Things (IoT), big data, blockchain, grassroots initiatives, and policy frameworks have been proposed to reduce food waste. However, challenges related to cost, scalability, and coordination between stakeholders persist. This review explores these solutions, identifies their limitations, and presents a comprehensive strategy for improving food waste management. Flow diagrams illustrating the food waste process and possible interventions are also included.*

Keywords: *food waste, reduction, provision, social network, environmental, hunger*

I. INTRODUCTION

Food waste and hunger coexist in today's global food system, with both reaching unprecedented levels. The Global Hunger Index 2023 ranked India 111th out of 125 countries, signaling a worrying trend in food insecurity despite the country being one of the world's largest food producers. Globally, the United Nations Food and Agriculture Organization (FAO) estimates that 1.3 billion tons of food is wasted every year, equivalent to about one-third of the total food produced [1]. This paradox where food waste is rampant while millions go hungry demands innovative solutions at both the global and local levels.

Food waste occurs across all stages of the food supply chain, from production and harvesting to consumer waste. This review assesses existing technological, grassroots, and policy solutions to address food waste, highlights their challenges, and presents a roadmap for enhancing food waste management systems and also paves the path to unravelling a social network to rule out hunger.

II. CURRENT SCENARIO: HUNGER AND FOOD WASTE

A. Global Hunger and Food Security

Hunger remains a significant issue despite global advances in food production. According to the 2021 State of Food Security and Nutrition in the World report, more than 820 million people are undernourished globally [1]. The Global Hunger Index (GHI) 2023, which ranks countries based on levels of hunger and undernutrition, further underscores the gravity of the situation, especially in regions such as South Asia and Sub-Saharan Africa.

In India, which houses a considerable proportion of the world's hungry population, the Global Hunger Index (GHI) 2023 revealed persistent issues with malnutrition and undernourishment. India's GHI score of 29.1, considered "serious," is particularly concerning given the country's significant food production

capacity [1]. This highlights a stark imbalance between food availability and distribution, exacerbated by food wastage across the supply chain.

B. *Food Waste Distribution Across the Supply Chain*

Food waste occurs at various points, contributing significantly to the global hunger problem:

- Production Stage: During farming and harvesting, crops are lost due to poor harvesting techniques, pests, and diseases.
- Post-Harvest Handling and Storage: In developing nations, inefficiencies in transportation and storage lead to large amounts of food spoilage.
- Processing and Packaging: During food processing, substantial amounts of food are discarded due to imperfections, which further increases waste.
- Retail and Consumer Stages: In developed countries, food waste peaks at the retail and consumer levels. Supermarkets and households often discard edible food due to expiration labels, excess stock, and uneaten leftovers.
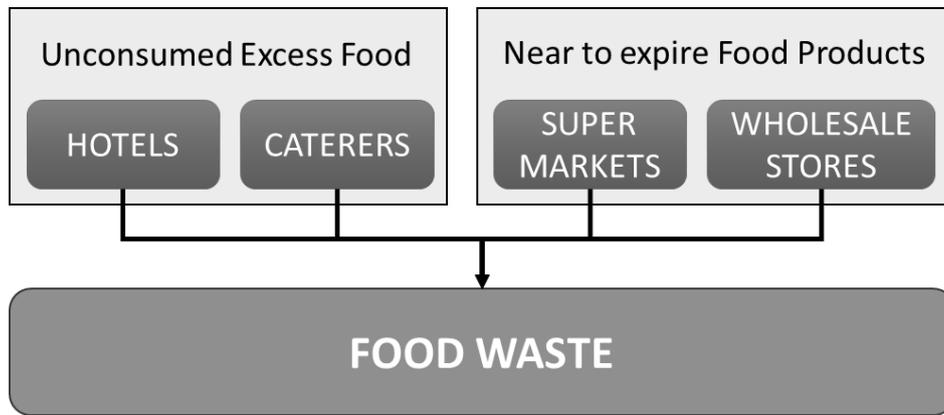

Fig.1 Food Supply and Waste Points

III. CURRENT SOLUTIONS

A. *Technological Interventions*

a. Internet of Things (IoT)

IoT has become an essential tool in monitoring and managing food across the supply chain. IoT devices, such as smart sensors, track environmental conditions like temperature and humidity in food storage and transport environments, helping to prevent spoilage. Rao et al. (2020) detail how IoT-based systems can predict when food is at risk of spoiling, triggering alerts for timely action. In addition, IoT can be used to optimize inventory management by monitoring food usage patterns and automating stock replenishment in retail and food service operations [3].

b. Big Data Analytics

Big data analytics provides valuable insights into consumer behaviour, supply chain inefficiencies, and market demand patterns. By analysing vast datasets, companies can forecast demand more accurately, preventing overproduction. Gupta et al. (2021) highlights how supermarkets and food distributors can use big data to adjust procurement decisions based on historical data trends, preventing unsold food from being wasted [4]. Additionally, machine learning algorithms can predict spoilage rates and optimize stock rotation practices.

c. Blockchain for Food Redistribution

Blockchain technology, while still emerging, is proving to be a promising solution for food redistribution by providing transparent and secure tracking of food donations. Singh et al. (2022) demonstrates how blockchain systems can enhance the efficiency of food redistribution networks by tracking surplus food from donors to recipients, ensuring accountability and trust [5]. Blockchain creates a reliable system that records every step of food donations, from collection to delivery, reducing fraud and mismanagement in food donation processes.

B. Grassroots Initiatives

Grassroots movements are crucial in bridging the gap between food waste and food insecurity, particularly in developing countries. In India, organizations like the Robin Hood Army collect surplus food from restaurants and redistribute it to underserved communities. Sharma (2019) highlights how such initiatives not only reduce waste but also address food insecurity in urban centres [6]. These initiatives rely heavily on volunteers and local partnerships, making them more agile and community-focused.

C. Policy Interventions

Policy frameworks aimed at reducing food waste and promoting food redistribution are essential for scaling solutions. Countries like France have passed laws requiring supermarkets to donate unsold food, while in the United States, tax incentives for food donations encourage businesses to contribute surplus food to food banks [1]. In India, the Ministry of Consumer Affairs (2021) has promoted public-private partnerships to combat food waste [7]. However, such policies often lack enforcement mechanisms or clear guidelines, reducing their overall impact.

IV. LIMITATIONS AND CHALLENGES

A. Technological Barriers

While IoT, big data, and blockchain have shown promise in reducing food waste, their adoption faces significant challenges:

- High Costs: The cost of implementing IoT sensors, blockchain networks, and big data systems is often prohibitive for small-scale farmers, businesses, and grassroots organizations, particularly in developing nations.
- Infrastructure Issues: In many parts of the world, digital infrastructure is either absent or unreliable, limiting the effectiveness of these technologies in rural and remote regions.
- Technical Expertise: Adoption of these technologies requires technical expertise, which many organizations, especially small businesses and NGOs, lack.

B. Grassroots Initiative Constraints

Grassroots food redistribution initiatives, while effective at the local level, face challenges related to scalability, coordination, and sustainability. These initiatives often depend on volunteer labour and inconsistent donations, which can result in operational inefficiencies. Additionally, the lack of formal oversight or government support can limit the reach of these programs, particularly in rural or remote areas [6].

C. Policy and Regulatory Gaps

Policy frameworks aimed at reducing food waste are often underdeveloped, lack enforcement, or fail to provide sufficient incentives for businesses to participate. In some cases, food donation regulations are unclear, leading to legal concerns over liability for donated food. For example, while laws in the United States provide tax incentives and liability protection for food donors, many countries lack such legal protections, dissuading businesses from donating food [1]. Stronger enforcement and clearer regulations are needed to foster greater participation from businesses and ensure more widespread redistribution efforts.

V. CONCLUSION

Food waste reduction requires a multifaceted approach, integrating technological innovations, grassroots initiatives, and robust policy frameworks. While IoT, big data, and blockchain present cutting-edge solutions, their implementation remains constrained by cost, scalability, and infrastructure limitations. Grassroots initiatives play a crucial role in redistributing surplus food, but they need greater formal support to scale effectively. Stronger policy frameworks, particularly those providing incentives for food donation and waste reduction, are essential to creating more sustainable food systems. Addressing global food waste will require collective efforts from governments, businesses, NGOs, and communities. A combination of technological innovations, grassroots action, and international collaboration is key to solving the dual crises of food waste and hunger.

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