IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 11, November 2025

DOI: 10.17148/IARJSET.2025.121149

Smart And Sustainable Food Systems Through Technology and Waste Reduction

Harshith Y A[1], Harshitha Umashankar[2], Priya Chandrika R[3], Sai Kiran R D[4], Shrishail[5], Roopa K Murthy[6]

Student, Computer Science and Design, K. S. Institute of Technology, Bengaluru, India[1-5]

Assistant Professor, Computer Science and Design, K. S. Institute of Technology, Bengaluru, India[6]

Abstract : The global food system faces a growing challenge on how to meet rising demand without exhausting natural resources or worsening environmental impacts. This paper explores on how smart technologies and effective waste reduction strategies can make food systems more sustainable and resilient. It looks at the potential of tools such as Artificial Intelligence (AI), the Internet of Things (IoT), and data-driven decision-making to improve efficiency for exporting food. By integrating these technologies with circular economy principles, it is possible to minimize food loss, reduce carbon emissions, and promote more responsible production and consumption patterns. Real-world examples illustrate how innovations like precision farming, smart sensors, and digital supply chains can cut waste, enhance food quality, and strengthen food security. This study states that combining technology with sustainability practices can help build a more inclusive, efficient, and environmentally friendly food system. These insights offer practical guidance for policymakers, researchers, and industry leaders working towards smarter and more sustainable approaches to food production and distribution.

Keywords : Smart food systems, Sustainability, Food waste reduction, Technology, Circular economy.

I. INTRODUCTION

The global food sector is undergoing a period of intense transformation as it confronts the dual challenge of feeding a growing population and protecting the planet's limited resources. Current food production and distribution systems are often inefficient, resource-intensive, and responsible for a significant share of greenhouse gas emissions. At the same time, nearly one-third of all food produced worldwide is lost or wasted each year, highlighting deep inefficiencies on how food is grown, processed, and consumed. These issues underscore the emergence of smarter and more sustainable food systems that balance productivity with environmental and social responsibility.

Emerging technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), blockchain, and precision agriculture offer promising tools for addressing these challenges. By enabling real-time monitoring, data-driven decision-making, and improved resource management, these innovations can help reduce waste, enhance food security, and support more sustainable supply chains. Integrating such technologies with circular economy principles encourages the reuse and recovery of resources, fostering a system that not only minimizes waste but also adds value at every stage of the food chain.

This Paper explores how digital innovation and waste reduction strategies can jointly drive the transition toward smart and sustainable food systems. It examines the roles of technology, policy, and stakeholder collaboration in creating resilient, efficient, and environmentally sound approaches to food production and consumption. Ultimately, the study seeks to contribute to a deeper understanding of how technology can be leveraged to support a more sustainable and equitable global food future.

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II. LITERATURE REVIEW

SL NO.	YEAR OF PUBLICATION	PROJECT TITLE	DESCRIPTION
1.	2025 [1]	Prudent: A Hotel Food Safety and Hygiene Checking Smartphone Application with Hotel Search, Problem Report, Inquiry Assistance	Food safety and hygiene have become critical issues in the hospitality industry due to the increasing number of foodborne illnesses and contamination incidents. Several studies have explored different technologies such as blockchain, Machine Learning, and IoT to enhance food traceability, contamination detection, and monitoring of hygiene standards. For instance, research has used microwave sensing and Deep Learning to identify adulteration and ensure food quality, while others focused on blockchain-based systems to improve transparency in food supply chains. However, most existing solutions lack user-friendly tools that allow real-time hotel inspection, customer feedback, or problem reporting. The Prudent mobile application addresses these gaps by combining hotel search, food safety assessment, and reporting functions into one system. It also includes features like seminar information, hygiene tips, fake blogger detection, and crime reporting to ensure consumer trust. This integrated approach demonstrates how digital tools can enhance public awareness, accountability, and food safety practices in the hospitality sector [1].
2.	2024 [2]	Examining Food Literacy and Anti-Food Waste Behaviour to Support Food Smart City Initiative9	Many studies have shown that food waste is becoming a serious problem, especially in cities where household habits play a big role. This research highlights that being food literate knowing how to plan meals, shop wisely, store food properly, and use leftovers can greatly reduce the amount of food people throw away. When individuals apply this knowledge in their daily routines, such as checking expiry dates, cooking suitable portions, and reusing ingredients, food waste naturally decreases. The study conducted in Indonesia found that food literacy not only improves awareness but also helps shape better household routines, which then encourage more mindful food use. By combining education on smart food practices with technology based tools like food tracking and donation apps, cities can move closer to becoming truly sustainable and waste-conscious communities.[2]
3.	2024[3]	Food Insecurity and the Global Environment: The Role of Food Loss and Waste	Food insecurity is a major global challenge linked closely to food loss, waste, and spoilage. This study explains how a safe and sufficient food supply is vital for human health and sustainability. Despite advances in food science, a large portion of food produced worldwide is lost due to poor handling, microbial spoilage, and

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			inefficient preservation. Such losses affect the economy, environment, and public health by increasing hunger and greenhouse gas emissions. Microorganisms are among the main causes of food spoilage, responsible for nearly one-fourth of global food loss. To combat this, various preservation methods physical, chemical, and biological are emphasized to maintain food safety, extend shelf life, and reduce waste. The paper concludes that tackling food spoilage and waste is essential for achieving global food security and meeting the United Nations's Zero Hunger goal.[3]
4.	2023 [4]	Sustainable Paths to Food Security from the Perspective of Food Loss and Waste Management	This paper explores how reducing Food Loss and Waste (FLW) can significantly strengthen global food security and sustainability. It highlights that nearly one-third of global food production is wasted annually, worsening hunger, resource scarcity, and environmental issues. By reviewing existing literature and policies, the authors identify key strategies such as efficient supply chains, reprocessing surplus food, adopting smart agricultural technologies, and raising consumer awareness. The research also emphasizes education, innovative food distribution models, and supportive government policies as essential for sustainable food systems. Overall, the review suggests that minimizing FLW through technological, behavioural, and policy interventions is a practical path toward achieving long-term food security and environmental balance.[4]
5.	2022 [5]	Sharing Food with FoodLifeSavr Smartphone App	This paper explores on how Geographic Information Systems (GIS) can enhance global food safety amid rapid population growth and resource limitations. The authors review how GIS supports monitoring food production, transportation, and storage to ensure safety and traceability from farm to consumer. They discuss global trends in food production, genetic modification, and cold-chain logistics, emphasizing the importance of digital tracking for preventing contamination and ensuring compliance with standards. The paper highlights about Turkey's progress on GIS for mapping agricultural areas, tracking livestock, and verifying food origins through barcode systems. Overall, the review demonstrates that GIS technology is a powerful tool for improving food security, enhancing transparency, and supporting sustainable food management systems worldwide.[5]
6.	2021 [6]	Online Food Delivery Platforms and Plastic Ban	This paper examines on the growing environmental challenges caused by single-use plastics in Online Food Delivery (OFD) services. It highlights on how the rapid expansion of OFD platforms has intensified plastic pollution due to disposable packaging. Reviewing existing

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			research, the authors note that while prior studies have focused on the environmental impacts and consumer attitudes toward sustainable packaging, few have explored the behavioural interactions between restaurants and delivery platforms. Using evolutionary game theory, the study analyses these stakeholders' response to government bans and incentives promoting degradable packaging. The literature reveals that collaborative governance where platforms monitor restaurant compliance and governments provide subsidies or penalties is essential for achieving sustainable outcomes. Overall, the behavioural change and coordinated policy enforcement are key to reduce plastic waste in the OFD industry.[6]
7.	2019 [7]	Microstructural Analysis in Plant-Based Foods	The main objective of this research was to evaluate the feasibility of using a Convolutional Neural Network (CNN) for discriminating structures in foods of vegetal origin. Specifically, the study processed micrographs of pumpkin tissue to enhance the detection of cells and intercellular spaces. The elements were classified into two sets manually by a trained operator. The implementation utilized transfer learning with a pre-trained AlexNet CNN. The methodology involved cross-validation and one hundred repetitions to randomize the training and validation data. The performance was evaluated using classification statistics, namely Accuracy (EXC) and F-measure (MEF). The results showed potential for the discrimination of structures, with mean values of EXC=0.858\pm0.012 and MEF=0.873\pm0.011$.[7]
8.	2018 [8]	Consumers' Behavior of Restaurant Selection	Consumer behaviour in restaurant selection is shaped by multiple factors such as food quality, price, atmosphere, service speed, and location. Studies consistently identify food quality as the most influential determinant, reflecting growing consumer demand for fresh, locally sourced, and authentic ingredients. Research by Lewis and Auty highlights that restaurant choice may vary depending on the dining occasion, while Clark and Wood emphasize the role of service efficiency and ambiance in shaping preferences. Recent findings also reveal that social influence, online reviews, and past experiences significantly affect consumer decisions. Moreover, the rise of environmental awareness and local food movements has encouraged customers to favour restaurants that collaborate with local farmers and promote sustainability. Overall, understanding these behavioural trends helps restaurants develop effective marketing strategies and improve customer satisfaction by considering their offerings with evolving consumer expectations.

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9.	2015 [9]	GIS Applications in Food Safety	Food safety has become a global concern due to rapid population growth, limited resources, and the increasing complexity of food production and distribution systems. Geographic Information Systems (GIS) have emerged as a crucial tool in addressing these challenges by enabling real-time monitoring and management of food production, transportation, and storage. Studies emphasize that GIS supports efficient resource allocation, ensures the traceability of food from production to consumption, and helps maintain quality standards. It also assists in identifying risks such as contamination, environmental pollution, and supply chain inefficiencies. The integration of GIS with agricultural and logistic data provides governments and industries with valuable insights for decision-making and policy formulation. Ultimately, GIS applications contribute to building a safer, more sustainable food system capable of meeting the needs of an expanding global population while maintaining high standards of safety and reliability.[9]
10.	2015[10]	Food Nanotechnology and Safety	Nanotechnology has become a promising innovation in the food industry, offering ways to enhance food quality, safety, and nutritional value. It enables the manipulation of materials at the nanoscale to create products with improved texture, flavour, and shelf life. Applications include nano-based food packaging that prevents spoilage, nano sensors for detecting contaminants, and nano-filtration systems that purify food ingredients. However, despite these advancements, concerns remain about the potential health and environmental risks of nanoparticles. Research indicates that some nanomaterials may penetrate human cells or cross biological barriers, posing unknown long-term effects. As a result, international organizations like WHO and FAO have called for strict evaluation standards and transparent labelling of nano-foods. While nanotechnology holds great potential to transform the global food industry, ensuring consumer safety through proper regulation, risk assessment, and ethical practices.[10]

III. CONCLUSION

Building smart and sustainable food systems through technology and waste reduction is vital for ensuring global food security and environmental balance. The integration of digital tools such as Artificial Intelligence, IoT, and Data Analytics helps farmers optimize resources, improve crop yields, and monitor supply chains more efficiently. These innovations not only enhance productivity but also minimize losses caused by overproduction, inefficient distribution, or spoilage. At the same time, embracing sustainable practices like recycling organic waste, promoting circular food economies, and encouraging responsible consumption can significantly reduce the environmental footprint of food production. By combining technological advancements with conscious human behaviour and policy support, societies can create resilient food systems that benefit both people and the planet. Ultimately, achieving sustainability in the food systems is not just about innovation it is about collaboration, awareness, and a shared commitment to reducing waste while ensuring that every individual has access to nutritious and affordable food.

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SUSTAINABLE DEVELOPMENT GOALS

SDG Goals	Goal Description	Justification
SDG 2: Zero Hunger	Achieve food security, improved nutrition & sustainable agriculture	Technology (AI, IoT, GIS, sensors) improves production efficiency, reduces losses, and ensures nutritious, safe food reaches consumers. Waste reduction increases available food supply.
SDG 3: Good Health and Well-being	Promote healthy lives for all.	Smart food systems ensure food safety, detect contamination using technology, and reduce foodborne diseases. Waste reduction leads to safer, fresher food.
SDG 11: Sustainable Cities and Communities	Make cities inclusive, resilient & sustainable	Smart city initiatives for food waste management, food donation apps, and optimized food distribution reduce urban waste and improve sustainability.
SDG 13: Climate Action	Combat climate change.	Food waste reduction lowers methane emissions. Smart agriculture reduces carbon footprint through optimized inputs and reduced spoilage.

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