

THE ROLE OF ARTIFICIAL INTELLIGENCE TO MINIMIZE FOOD WASTE IN THE FAST-FOOD INDUSTRIES

Dr. Prerna Chandel¹, Sheetal², Roshani³

¹Assistant Professor, School of Management, Bahra University, Solan, Himachal Pradesh, India

²MBA student, School of Management, Bahra University, Solan, Himachal Pradesh, India

²MBA student, School of Management, Bahra University, Solan, Himachal Pradesh, India

ABSTRACT

Artificial Intelligence (AI) is emerging as a transformative force in food waste management, particularly within the fast-food industry, where operational efficiency and sustainability are critical. This study employs a qualitative research approach to investigate how AI-powered technologies are being adopted nationally and internationally to minimize food waste. Through in-depth interviews and case study analysis, the research examines successful implementations in both Indian and global contexts. For example, Indian fast-food chains like Rebel Foods have integrated AI algorithms to optimize inventory and demand forecasting, significantly reducing spoilage. Internationally, companies such as McDonald's (USA) and Winnow Solutions (UK) utilize AI-based systems for real-time monitoring of kitchen waste and predictive analytics to enhance portion control and procurement planning. The findings reveal that AI applications—ranging from smart sensors and machine learning models to intelligent inventory systems—enable accurate demand prediction, freshness tracking and behavioral insights into consumption and disposal. Moreover, innovations like smart packaging and AI-generated recommendations for repurposing unsold food are further contributing to sustainability efforts. The study concludes that AI not only enhances waste reduction strategies but also reshapes food supply chain practices by promoting data-driven decision-making, cost-efficiency and environmental responsibility across different geographic and operational contexts.

Keywords: *Artificial Intelligence (AI), Food Waste Management, Fast-Food Industry, Case study and Smart AI Technologies.*

1. INTRODUCTION

The capacity of artificial intelligence (AI) to transform food waste management is rooted in its capability to analyse extensive data sets and enhance processes throughout the food supply chain. Utilizing machine learning algorithms enables AI to enhance demand prediction accuracy, consequently minimizing overproduction and spoilage (ozcil, 2024). Furthermore, AI technologies can improve inventory management by facilitating the tracking of food freshness and effectively reducing waste. Innovative applications, including smart bins that detect and measure discarded food, yield significant insights into waste patterns, enabling organisations to adopt targeted reduction strategies. AI enhances operational efficiency and promotes sustainable food consumption, thereby substantially reducing the environmental consequences of food waste, AI Technology continues to advance, its role in reducing food waste in the fast-food industry is expected to grow even further. Future applications may include personalized nutrition recommendations based on AI algorithms and the development of smart packaging that can extend the shelf life of food products. AI can monitor various stages of the supply chain, from sourcing to storage, to identify potential bottlenecks and inefficiencies by optimizing transportation routes, storage condition and inventory levels, AI can reduce spoilage and waste throughout the entire supply chain. AI Powered systems can track inventory levels in real-time, providing insights into which ingredients are most likely to expire soon. This information can be used to prioritize the use of those ingredients, reduce waste and ensure that customers receive fresh food and by accurately predicting demand, optimizing supply chains and managing inventory effectively, AI can significantly reduce food waste in the fast-food industry. This not only saves money for businesses but also helps to reduce environmental impact and contribute to a more sustainable food system.

Reducing Food Waste: AI Predicts demand more accurately, reducing overproduction and waste. AI driven forecasting can cut food waste by up to 30%. Optimizing supply chains: AI optimizes inventory and transportation, reducing spoilage by as much as 50%. Sustainable Packaging: AI helps design eco-friendly packaging, leading to a 20% reduction in Plastic use in recent years. Energy management: AI reduces energy consumption in manufacturing by 15%-25%, lowering the carbon footprint. Sustainable Sourcing: AI tracks raw material sustainability, reducing the carbon footprint by 10%.

2. LITERATURE REVIEW

“The Role of Artificial intelligence to Minimize food waste in the Fast-Food Industry” has taken attention in recent years due to its potential to enhance sustainability and optimize resource utilization and AI role in reducing overproduction, improving inventory management and fostering circular economy practices. Research highlights diverse applications, including predictive analytics, IoT, blockchain technologies and machine learning, to address critical inefficiencies in food supply chains.

Title of research article	Year	Name of Author(s)	Areas of Research	Objective of Study	Research Methodology	Finding and Conclusion
Deep learning for classifying food waste	2020	Mazloumian et al.	Munich, Germany	To develop a deep learning model for classifying types of food waste to better understand and reduce it.	Trained a neural network on images of food waste collected from waste bins.	This study provides insights for waste reduction and effectively classified waste.
IoT and Blockchain-based smart Agri-food supply chains	2020	Hou et al.	Shenzhen, China.	To explore the integration of internet of things (IoT) and blockchain technologies to enhance transparency, Efficiency in agri-Food supply chains.	Analyzed case studies and existing framework to Propose a model	This study concludes that the synergistic use of IoT and Blockchain technologies.
Consumer perceptions of food packaging in its role in fighting food waste	2020	Kim et al.	This study was conducted in Australia.	To evaluate consumer trust in AI for waste reduction	Survey-based analysis	Increased consumer trust in AI systems, leading to reduced food waste

AI Based Waste Classifier with Thermo-Rapid Composting	2021	Kumari Behera et al.	Chennai, Tamil Nadu.	To develop an AI-Based system for Waste classification and rapid composting of biodegradable waste.	Application of YOLOv3 deep learning model for waste classification.	The conclusion is The Study is food waste classifier improved composting efficiency and reduced landfill waste by 30%.
AI-Based Management of Food Wastage	2021	Sama et al.	Thapar institute of Engineering and Technology , Patiala and Chandigarh , India.	The study focuses on building an AI-Based framework to manage food wastages.	Conducted Survey , implemented IoT - enable smart bins to collect real time data on food waste.	The Food waste reduced by 20% in pilot tests within the university hotel messes.
Food Waste management using machine learning	2022	Bharadi et al.	Finolex Academy of Management and Technology , Ratnagiri, Maharashtra, India	To explore Prediction Daily food consumption using machine learning system in fast food restaurants.	The Study used Historical data from fast food chain in Maharashtra	The conclusion of study is 20% reduction in surplus food preparation.
Food waste reduction through predictive modeling and AI driven inventory Management	2022	Dr. Ali et al.	Hyderabad, Telangana .	To examine the potential of predictive modeling and AI driven inventory Management systems in reducing food waste	It use of regression models and AI Algorithms to predict demand in food outlets	Implementation led to optimized storage utilization and a 15% decrease in spoiled inventory.
Policy framing, design and feedback can increase	2022	Fesenfeld et al.	This study was conducted in Switzerland .	To evaluate AI's role in integrating governance framework	Policy-driven approaches using AI to align sustainability objectives with	AI aligns food waste policies with broader sustainability goals,

public support for costly food waste regulation				for waste reduction.	governance frameworks.	addressing the complex nature of food waste governance.
Machine Learning and Artificial Intelligence in circular Economy	2022	Noman et al.	This study was conducted Bangladesh	To analyze the adoption of AI and Machine learning in circular economy to manage waste management .	Conducted a bibliometric analysis and Literature review .	Identified areas where AI contributes to waste reduction.
Research on Real - Time robust optimization of perishable supply chain systems based on Digital twins	2023	Wu et al.	School of Automation , (BISTU), Beijing 100192, China	To evaluate study is to develop a real time robust optimization model for perishable supply chain system	The methodology researcher employed digital twin technology to create a virtual replica of the physical supply chain system	Improved decision-making , enhanced real-time visibility into supply chain operations.
AI in modern consumer driven food systems	2023	Min et al.	China and USA	To explore how AI can transform food systems from a consumer-driven perspective to reducing waste.	This study analyzed AI tools and techniques across the food supply chain .	The conclusion of Study that AI can optimize food systems and minimizing Waste.
Sustainable AI solutions for food Waste Management.	2023	Onyeaka et al.	University of Birmingham in the United Kingdom.	To explore AI's role in enhancing sustainability .	Conducted case studies and Surveys.	AI reduces waste while improving environmental sustainability .

Use of Machine Learning and Artificial Intelligence in food spoilage Detection	2024	Bongarde et al.	Kolhapur, Maharashtra	To evaluate AI and Machine learning for detecting early signs of food spoilage	Application of electronic nose systems and gas sensor arrays	The Conclusion of study is AI based detection reduced spoilage incidents by 15%
AI and the food sector A golden opportunity for growth	2024	Shenfield	Sheffield, UK	AI potential in driving sustainable innovations in the food industry	Pilot projects and research themes at the advanced food innovation center.	Enhancing sustainability in food manufacturing, AI can reduce waste and costs.
The potential of AI-Driven food waste management strategies used in the hospitality industry for application in household settings	2024	Various	London, UK	AI strategies in hospitality for the potential application in reducing household food waste	Winnow in hospitality settings and AI driven technologies like leanpath	AI system provide insights that help adjust portion size and inventory, reducing waste
Role of AI in Minimizing Food Waste	2024	Ozcil	American University of Cyprus, located in Cyprus.	To understand the optimize demand prediction and minimize overproduction.	It analysis Quantitative Machine learning model .	Machine Learning reduces spoilage and improves supply chain efficiency.
Smart inventory Management and AI Predictive Analytics	2024	Tiwari et al.	IIT Kharagpur , West Bengal, India.	To Access the comprehensive solution leveraging smart inventory	Analyzed historical data from fast food outlet to predict customer demand.	The system reduced overproduction by 25% and underproduction by 15%

				management Application.		
Circular Economy in AI-Driven food chains	2024	Trevisan and Formentini	This Study was conducted in Northern Italy.	To explore AI's role in creating circular food systems	Literature review	AI supports sustainable food supply systems through waste minimization .
The Potential for reducing Food waste through shelf-life Extension	2024	Reyes et al.	The Study emphasizes the international Applicability	To analyze the global impact of AI in food chains	Case study on multinational food chains	Significant global reduction in waste and increased sustainability
AI transformation in food manufacturing; A pathway to sustainable efficiency and quality assurance	2025	Agrawal et al.	Bielefeld, germany	The explore how ai can optimize production, reduce waste and enhance sustainability in food manufacturing	AI applications in the food industry from 2019 to 2024	Waste reduction and proposed strategies for overcoming adoption barriers

Source: Author's compilation from literatures

Research Gap:

Present study, some Technologies like IoT, blockchain and machine learning have been studied but there is limited research on the integration of these technologies to create situation for food waste reduction. Most research Highlighted industrial, institutional, or large-scale food systems. There is a research gap in adapting AI strategies for household-level food waste management, particularly in low-resource settings. Limited studies evaluate the long-term effectiveness and sustainability of AI-driven solutions. Research on consumer perceptions of AI is minimal and more studies are needed to understand how AI can influence consumer behaviour, trust and acceptance of waste reduction technologies.

Objectives of the Study:

1. Explore company Cases building an AI-Based framework to manage food wastages and sustainable innovations in the food industry.
2. Evaluate AI and Machine learning for detecting early signs of food spoilage.

3. RESEARCH METHODOLOGY

Qualitative approach was adopted including Organization Cases using AI based technologies for food waste reduction in fast food industry. Secondary Data was used from National and International Organizations. Munich, Germany (Mazlounian et al., 2020), Trained a neural network on images of food waste collected from waste bins. Shenzhen, China (Hou et al., 2020), Analyzed case studies and existing framework to Propose a model. Australia (Kim et al., 2020), Survey-based analysis. Chennai, India (Kumari Behera et al., 2021), Application of YOLOv3 deep learning model for waste classification. Patiala & Chandigarh, India (Sama et al., 2021), Conducted Survey, implemented IoT - enable smart bins to collect real time data on food waste. Ratnagiri, Maharashtra, India (Bharadi et al., 2022), The Study used Historical data from fast food chain in Maharashtra. Hyderabad, Telangana, India (Dr. Ali et al., 2022), It use of regression models and AI Algorithms to predict demand in food outlets. Switzerland (Fesenfeld et al., 2022), Policy-driven approaches using AI to align sustainability objectives with governance frameworks. Bangladesh (Noman et al., 2022), Conducted a bibliometric analysis and Literature review. Beijing, China (Wu et al., 2023), The methodology researcher employed digital twin technology to create a virtual replica of the physical supply chain system. China & USA (Min et al., 2023), Conducted case studies and Surveys. United Kingdom (Onyeaka et al., 2023), University of Birmingham, Conducted case studies and Surveys. Kolhapur, India (Bongarde et al., 2024), Application of electronic nose systems and gas sensor arrays.

Sheffield, UK (Shenfield, 2024), Pilot projects and research themes at the advanced food innovation center. London, UK (Various, 2024), Studies on AI in hospitality. Cyprus (Ozcil, 2024), It analysis Quantitative Machine learning model. Kharagpur, India (Tiwari et al., 2024), Analyzed historical data from fast food outlet to predict customer demand. Northern Italy (Trevisan and Formentini, 2024), Literature review likely agricultural or technical institutions in Italy. Global Scope (Reyes et al., 2024), Multinational food chains and case studies. Bielefeld, Germany (Agrawal et al., 2025). Likely a German institute specializing in food manufacturing.

4. ORGANISATIONAL CASES AND DISCUSSION

4.1 International Fast food companies using AI for Food Waste Reduction

Winnow, headquartered in London, England, UK. The company that provides artificial intelligence (AI) tools to help particularly in the food service sector, reducing food waste by tracking the quantity and identifying waste trends in food services and Hospitality industry, Located in Landon, England, United Kingdom. Winnow reports that its clients typically reduce food waste by 30-50% within 6-12 months.

Chick-Fil-A, company has invested in robotics and machine learning to help manage supply chain, which serves over 3000 restaurants across the US by using AI to predict demand and avoid shortages, cut down on waste.

Afresh, company located in California that leverages AI to optimize the fresh food supply chain and reduce food waste and uses AI-powered recommendations to help grocery stores manage inventory, forecast demand. This technology has been shown to reduce food waste by approximately 25%.

LeanPath, Company based in Portland (United States). This company's food waste technology helps commercial kitchens reduce food waste by tracking and analyzing their food waste data. Leanpath's software then analyses this data is to identify areas where food waste is the highest and provides recommendations for reducing waste.

KITRO: The startup KITRO, based in Switzerland. It simplifies food waste management for commercial kitchens by using AI-driven SaaS solutions. It technology helps the food service industry automate food waste management, allowing customers to save 2-8% of their annual food costs and reduce their avoidable food waste by at least 20%.

Hungry root: It is a food startup based in New York that uses AI to curate grocery lists and recipes tailored to individual dietary preferences, health goals and cooking habits, significantly simplifying meal planning and reducing food waste.

4.2 National Fast Food companies using AI to Waste reduction

FreshMenu, Bengaluru, Karnataka, India. Company analyses customer data to predict demand for specific menu items and also streamlines inventory management, ensuring minimal leftover.

Swiggy, Headquartered in Bengaluru, Karnataka, India. Swiggy launched its own AI-powered recommendation tool, 'what to eat.'. It employs AI for route optimization, demand forecasting and efficient delivery partner allocation. This help in aligning food preparation with actual demand and reducing instances of overproduction and subsequent waste.

Otipy Store, (Crofarm Agriproducts Pvt Ltd.) Located in Gurugram, Haryana, India. Uses AI to Predict Consumer Trends and Temperature for Accurate Stock Planning, AI enabled pre cooling units maintain optimal freshness during transit. Decreased food wastage from 40% to less than 4% (2024-2025).

Stellapps Company, Located in Bengaluru, Karnataka, India. Uses IoT and AI Track quality and temperature across supply chains. AI tools also provide real time data to optimize milk collection processes. Reduced Milk spoilage by 20%, extending milk shelf life and cutting losses.

5. CONCLUSION

Application of YOLOv3 and predictive analytics and machine learning to classifying the food waste, predict demand and improve composting efficiency. IoT -enabled smart bins and blockchain system improve real-time data collection, Transparency and accountability across food supply chains. AI solutions contribute to circular economy practices by minimizing overproduction and reduce spoilage. leverages AI to optimize the fresh food supply chain and reduce food waste. By AI to predict demand, avoid shortage and cut down on waste. Analysing AI tools and technologies across food supply chain. AI system provides insights that help adjust portion size and inventory, reducing waste. The alignment of AI-driven innovations with regulatory frameworks and governance policies can further enhance the effectiveness of food waste reduction strategies. Combining AI with integration of internet of things (IoT) and blockchain technologies to enhance transparency, Efficiency in agri-Food supply chains. AI and related technologies significantly reduce food waste by optimizing supply chain operations, predicting demand and detecting spoilage.

References:

1. Agrawal, K., Goktas, P., Holtkemper, M., Beecks, C., & Kumar, N. (2025). AI-Driven transformation in food manufacturing: A Pathway to sustainable efficiency and quality assurance. *Frontiers in Nutrition*, 12, 1553942.
2. Ali, J., Tuli, N., & Kumari, S. (2022). Food waste reduction through predictive modeling and AI-Driven inventory management. *International journal of food and nutritional sciences*, 11(9).
3. Amin Mazlounian, Matthias Rosenthal, Hans Gelke. (2020). Trained a neural network on images of food waste collected from waste bins.
4. Bharadi, V., Jadhav, P., Nanche, O., & Munj, O. (2022). Food waste management using machine learning. *International journal of creating research thoughts (IJCRT)*, 10(4).
5. Bongarde, D., Pandit, S., & Pandit, H. (2024). Use of machine learning and artificial intelligence in food spoilage detection. *International journal of engineering research and application*, 14(4), 79-85.
6. Clark, Q. M., Kanavikar, D. B., Clark, J., & Donnelly, P. J. (2024). Exploring the potential of AI-Driven food waste management strategies used in the hospitality industry for application in household settings. *Frontiers in Artificial intelligence*, 7, 1429477.
7. Fesenfeld, L., Rudolph, L., & Bernauer, T. (2022). Policy framing, design and feedback can increase public support for costly food waste regulation. *Nature food*, 3(3), 227-235.
8. Hou, J., Wang, Y. and Wang, Y. (2020) This study concludes that the synergistic use of IoT and Blockchain technologies.
9. Kim, J., Rundle-Thiele, S., Knox, K., Burke, K., & Bogomolova, S. (2020). Consumer perspective on household food Waste reduction campaigns. *Journal of cleaner production*, 243, 118608.

10. Lakshit Sama, Aaisha Makkar, Polemoni P., Bhav Kirti S., Devansh Dhaloria. (2021). The study focuses on building an AI-Based framework to manage food wastages. The CEUR Workshop Proceedings (ISSN: 1613-0073) .
11. Min, W., Zhou, P., Xu, L., Liu, T., Li, T., Huang, M., Jin, Y., Yi, Y., Wen, M., Jiang, S., & Jain, R. (2023). From plate to production: Artificial Intelligence in modern consumer-driven food systems. arXiv preprint arXiv:2311.02400.
12. Noman, A. A., Aktar, H., Pranto, T. H., & Haque, A. B. (2022). Machine learning and artificial intelligence in circular economy: A Bibliometric analysis and systematic literature review. arXiv preprint arXiv:2205.01042.
13. Onyeaka, H., Tamasiga, P., Nwauzoma, U. M., Miri, T., Juliet, U. C., Nwaiwu, O., & Akinsemolu, A. A. (2023). Using Artificial intelligence to tackle food waste and enhance the circular economy: Maximising resource efficiency and minimising environmental impact: A review. *Sustainability*, 15(13), 10482.
14. Ozcil, I.E. (2024). Reducing food waste using machine learning models: Forecasting and optimization approaches. *Open Access Journal of Data science and Artificial Intelligence*, 2(1), 000136.
15. Reyes, V., Cahill, E., & Mis Solval, K. E. (2024). The potential for reducing food waste through shelf-life extension: actionable insights from data digitization. *Sustainability*, 16(7), 2986.
16. Saswati Kumari behera, Aouthithiye Barathwaj SR Y, Vasundhara L, Saisudha G, Haariharan NC (2020). Application of YOLOv3 deep learning model for waste classification.
17. Shenfield, A. (2024). Artificial Intelligence and the food sector: A golden opportunity for growth. *Food science and technology*, 38(4), 32-35.

18. Tiwari, T., Garg, T., Singh, G., Mishra, S., & Guleria, k. (2024). Optimizing food utilization: A smart inventory management and ai predictive analytics in reduction food waste. *International journal of science and social science research*, 2(3), 165-170.
19. Trevisan, C., & Formentini, M. (2024). Digital technologies for food loss and waste Prevention and reduction in agri-food Supply chains: A Systematic literature review and research agenda. *IEEE Transactions on Engineering Management*, 71, 12326-12345.
20. Wu, Y., Zhang, J., Li, Q., & Tan, H. (2023). Research on Real-Time robust optimization of perishable supply-chain systems based on digital twins. *Sensor*, 23(4), 1850.