

Smart Hospitality: Leveraging AI for Sustainable Food Safety & Waste Management

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ABSTRACT

The current research analyzes the significance of AI in food safety improvement and food wastage reduction in the hotel industry with particular reference to restaurant owners operating in Bihar and Jharkhand. The survey employed a quantitative and cross-sectional design where data were collected using a standardized Likert scale questionnaire. In this research, perceptions of IoT sensor, machine learning, computer vision, predictive analytics, smart inventory systems, and AI waste management solutions were explored. In terms of descriptive statistics, it was observed that majority of the respondents owned individual restaurants having a small-to-medium size workforce. It was also observed that adoption level of technology in general was low-to-moderate. Regardless of any infrastructural challenges, all the respondents had a highly favorable opinion about use of AI tools including IoT sensor-based food storage, smart inventory management, and predictive analytics for predicting demand. In addition, reliability statistics indicated high validity of the questionnaire while inferential statistics showed statistically significant variations among restaurant type and technology adoption level. Factor analysis showed a strong fit for the theoretical model by clustering the variables in Food Safety, Waste Management, and Operational Impact. These findings suggest the potential changes caused by AI in terms of business functioning in the hospitality industry. The application of artificial intelligence enables monitoring in terms of food safety that, in its turn, will help improve risk prediction and control. As for waste management, using AI-based prediction and analytics will help avoid overproduction and facilitate the realization of the sustainability agenda by restaurant owners. In view of future consequences, the application of AI can positively affect the image of the company as a company leading sustainability innovations. As a result, the restaurant will have a comparative advantage. However, some challenges concerning the implementation of AI in food safety and waste management should be taken into account, such as financial aspects, the readiness of employees, AI ethics, and technological dependence. Therefore, it became evident that the importance of AI in terms of food safety and waste management concerns both improvement and sustainability. The future perspective presupposes working on affordable AI technology, staff training, development of ethical AI policy, and building of appropriate infrastructures.

Keywords: Artificial Intelligence, Food Safety, Waste Management, Hospitality Sustainability.

Introduction

Indeed, previously, the development and evolution of the hospitality industry were fueled by some factors including changes in the demands of customers, regulations, and technology improvements. With the passage of time, digitalization has emerged as one of the main factors that

trigger change in the functioning of the hospitality industry. Digitalization has been made possible with the help of a revolutionary technology called artificial intelligence (AI). AI refers to the capacity of machines to emulate the intelligence of humans by learning and reasoning. AI is not just a concept but a real thing which is currently being utilized in food safety and waste management (Lee, Kim, & Park, 2021).

The digitalization of the hospitality sector involves many components such as task automation, utilization of smart technologies, and the use of machine learning algorithms to enhance decision-making. For instance, sensors enabled by IoT technology have been widely adopted for controlling the kitchen and storeroom conditions as part of adhering to hygiene norms. Also, machine learning predicts deviations in operations depending on previous data, while computer vision observes employee activities to reduce the occurrence of errors (Gajjar and Okumus, 2022). All together, it leads to the development of a new perspective on excellence in operations that can give organizations a competitive edge.

Nonetheless, the digitalization of the hospitality sector is not limited only to optimizing operations. Technologies such as virtual assistants, chatbots, and recommendation engines can enhance customers' experiences and help to make bookings faster and more convenient. This makes the intersection of the two sectors clear, demonstrating the potential of AI in hospitality (Buhalis & Yen, 2020).

Importance of Food Safety and Sustainability

Food safety domain is one of the most important aspects in the field of hospitality management. First of all, food safety domain poses numerous risks for this specific business segment as far as the effects of food safety violations might be catastrophic concerning clients' health, reputation of a company, and legal compliance. The conventional approach to food safety assurance includes the use of manual monitoring that can be vulnerable to several shortcomings. With the application of AI technologies, these drawbacks can be avoided as they enable constant monitoring of critical factors, risk assessment, and analysis of efficiency of safety measures applied. At the same time, machine learning tools help predict future risks associated with hygiene practices and storage of food products (Singha et al., 2023).

Equally important is the topic of sustainability, namely food waste. Worldwide, about a third of all food produced ends up being wasted, with the hospitality industry accounting for a large part of this statistic (Kamble, Gunasekaran, & Ghosh, 2021). In addition to the loss of resources and revenue associated with food waste, there is the additional harm done to the environment in the form of pollution due to inefficient resource management and harmful emissions. AI can offer an innovative solution to the problem. For example, through predictive analytics, managers can forecast demand by considering factors like past sales figures, weather, customer preferences, and reservation rates. AI-integrated inventory management will track resource availability, expiration dates, and other information, thus optimizing resource management. Computer vision applications can analyze food waste in real-time using the smart bin approach (García-Muñia et al., 2022). All of the above will help managers make better decisions regarding portion sizes, menus, and resource procurement.

This need for food safety and sustainability is compounded even further by changing consumer demands. Contemporary consumers place an increased emphasis on healthiness, cleanliness, and sustainability. Companies within the hospitality sector who are able to fulfill such demands will not only be adhering to regulation but will also improve their competitive position. AI solutions therefore have the dual benefit of ensuring the safety of customers while promoting the sustainability objective, which is crucial for success in the industry (Chen et al., 2024).

Statement of Problem and Objectives

However, despite all the benefits that can be derived from using artificial intelligence, several hospitality organizations find it difficult to adopt and integrate these technologies in an effective manner. Manual food safety practices are very common in most operations but are unreliable and require a lot of work. There are no predictive waste management models, thus, resulting to overproduction, wastage and loss of money. Lastly, fragmented adoption of AI tools means that food safety and food waste management are two distinct issues in the industry.

In other words, the problem is that there is a disconnect between the benefits of these technologies and their adoption by hospitality firms. Despite the fact that some firms have embraced

technology, several have been hindered by various factors that include technical issues, staff resistance and costs among others. This study aims at addressing the above mentioned issue by examining the transformative power of AI in improving food safety and reducing food wastage. The specific objectives of the research are:

- To examine the role of AI technologies in the hospitality industry to enhance food safety. This involves analyzing how IoT sensors, machine learning algorithms, and computer vision systems are deployed to monitor hygiene standards, detect anomalies, and automate compliance in real time.
- To explore AI-driven strategies and tools aimed at minimizing food waste across hospitality operations. This includes examining predictive analytics for demand forecasting, smart inventory tracking, and waste categorization systems, as well as their impact on sustainability and operational efficiency.

Through these objectives, the study seeks to gain an overall perspective on how AI can be utilized to create robust and sustainable systems in the hospitality sector. The study will not only address the best practices but will also outline the challenges faced in using AI.

Scope and Significance

The scope of this research will include the application of AI in ensuring food safety compliance, maintaining hygiene standards, predicting the demand, managing inventories, and analyzing waste in hospitality settings. This research uses theories, empirical evidence, and recent developments in the hospitality sector to give an insight into AI implementation in hospitality management. Both small scale and large scale hospitality institutions have been considered in this research since there is a need to consider all hospitality institutions in order to make this research comprehensive.

This research will be significant in terms of making theoretical contributions as well as giving practical advice. This research makes theoretical contributions to the existing body of knowledge on digital transformation in hospitality management. It fills an existing gap in the literature in that it looks at food safety and waste management together. Practically, this research contributes to the hospitality sector through giving practical ideas to managers on the use of AI in hospitality management (Singh & Yadav, 2023).

Moreover, it needs to be stated that the discussed research has been conducted on the background of wider global initiatives, for instance, the UN SDGs. In particular, one can mention goal number 12 entitled "Responsible Consumption and Production," as the use of AI innovations helps promote sustainable consumption of resources and ensure greater resilience in terms of climate change. It is worth mentioning that the necessity to train the hospitality workforce and communicate with consumers has been mentioned as well.

In this regard, regarding the relevance of the problem under investigation, one should note that this research has demonstrated that artificial intelligence cannot be considered only a technical solution; on the contrary, it is an effective means that guarantees sustainability, safety, and competitiveness in the hotel business industry.

Literature Review

The safety of food consumed is of utmost importance in the hospitality sector, and any negligence could result in serious public health problems as well as damage to the reputation of the business. Conventional food safety management practices are heavily reliant on manual methods that are open to human errors. The recent developments in technology have resulted in revolutionary methods that help resolve such concerns.

IoT sensors are being extensively used in food storage places and kitchens to continuously monitor essential environmental factors such as temperature and humidity. Real-time data received from IoT sensors facilitate timely actions against potential hazards (Elkhwesky, et al., 2022). Smart refrigeration devices fitted with IoT sensors can ensure ideal conditions for storing foods by adjusting cooling parameters in accordance with safety standards (Mazhar, Yousaf, Khan, & Muhammad, 2025).

Machine learning algorithms contribute to enhanced predictive risk management by examining past data to determine patterns that relate to contamination and spoilage. ML algorithms may be able to predict any risks by linking different parameters such as cleaning,

staff adherence to hygiene practices, and how the food is being stored (Patel & Sharma, 2024). This approach helps transform the process of managing food safety from reactive to predictive to lower the number of cases of food poisoning. The use of computer vision technology to manage hygiene practice in the kitchen is becoming prevalent. Computer vision technology enables the system to determine whether the staff members wear gloves, wash their hands, or separate the cooked and raw foods. This helps reduce the chances of cross-contamination (Lee, Kim, & Park, 2021).

AI in Food Waste Management: Predictive Analytics, Smart Inventory, Smart Bins, and Menu Engineering

The issue of food waste is becoming increasingly relevant on a global scale because of overproduction, incorrect demand forecasting, and poor inventory management practices in the hospitality industry. AI technologies provide new methods of dealing with waste and ensuring sustainability. Predictive analysis based on machine learning allows for demand forecasting by taking into consideration past sales data, customer behavior, weather conditions, and reservation trends. This leads to minimizing the production of food and helps procure only what needs to be consumed (Food&HotelAsia, 2025). According to the experience of Hilton Hotels, such an approach allows for a 76% decrease in kitchen waste (PwC, 2025).

Gajić, Milošević, and Đoković (2025) emphasize the role of AI and IoT in smart inventory systems. Smart inventory systems that are equipped with IoT sensors allow for monitoring of current stock levels and conditions. Priority usage of products that are about to expire helps reduce spoilage. Additionally, AI-based inventory management allows for optimizing procurement schedules. Smart bins equipped with computer vision technologies allow recognizing discarded food items and sorting them into categories. This helps to understand waste patterns and implement changes in terms of portion sizes and menu composition (Quintana et al., 2025). For example, companies such as Winnow and Leanpath have achieved notable progress in waste reduction due to their AI-based waste system.

The menu engineering techniques make use of artificial intelligence to make suggestions for sustainable modifications to recipes considering current inventory levels, seasonable produce, and past wastage trends. These techniques do more than just reducing wastage; they increase cost efficiency and are also in line with the current trend among consumers towards sustainable food choices (Kamble, Gunasekaran, & Ghosh, 2021).

Integration of Food Safety and Waste Management: Synergies, Traceability, and Transparency

AI integration into food safety and waste management allows creating synergies that contribute to increased efficiency and sustainability. AI solutions ensure full traceability of food products in the entire supply chain, improving accountability and transparency. Traceability systems based on AI and blockchain create immutable records of the product lifecycle, allowing to improve safety since contamination origins can be rapidly identified and to improve sustainability since usage of resources will be tracked (Zhang, Chen, & Luo, 2023). The traceability system will increase trust among consumers as well due to transparent information about the origin and handling of food products. Synergies between safety and waste management become obvious from AI's dual purpose in hygiene monitoring and optimization of resource usage. IoT sensors responsible for monitoring of storage will help avoid food contamination as well as spoilage. Thus, the problem of safety and waste management will be resolved simultaneously (Queiroz et al., 2022). Further improvement of transparency will include visualization of the food safety and waste management processes using AI-based dashboards. Such a dashboard will allow for the effective decision-making on improving efficiency and will demonstrate the organization's commitment to sustainability (Zhang, Li, & Chen, 2025). The integration of food safety and waste management through AI thus represents a holistic approach to sustainable hospitality, aligning operational efficiency with ecological responsibility (Vukolić et al., 2025).

Impact on Hospitality Operations: Efficiency, Compliance, Customer Trust, and Sustainability

The impact of artificial intelligence on the functioning of hospitality businesses extends beyond the issue of food safety and proper waste management to other areas such as efficiency, compliance, trust, and sustainability. Operation efficiency can be improved through the automation of repetitive operations such as inventory management, compliance actions, and waste management. Such approaches minimize operating expenses while reducing human error (PwC, 2025). Automation

of purchasing and menu planning processes is yet another way of increasing operation efficiency. The issue of compliance can be addressed through AI technology because of its potential to monitor and report. Internet-of-Things sensors and computer vision ensure that all operations meet hygiene requirements while making the auditing process less difficult (Chen et al., 2024). The problem of customer trust can be enhanced using the power of transparency and food safety provided by artificial intelligence. These two factors represent an area of growing concern among consumers that can be utilized as a competitive advantage by those who decide to tackle them (EHL Research News, 2025). Last but not least, sustainability can be ensured through the reduction of food waste and environmental-friendliness of processes involved (Springer, 2025).

Identification of Gaps in Existing Research

Despite significant advancements, several gaps remain in the literature on AI in hospitality food safety and waste management:

- **Limited Empirical Studies:** Most research focuses on conceptual frameworks and case studies, with limited large-scale empirical evidence on AI's impact across diverse hospitality contexts.
- **Regional Disparities:** Existing studies are concentrated in developed economies, with limited research on AI adoption in developing countries where infrastructure and cost barriers are more pronounced.
- **Workforce Adaptation:** Few studies address the challenges of workforce training and cultural change required for effective AI adoption.
- **Ethical Concerns:** Issues related to data privacy, bias in AI algorithms, and consumer acceptance remain underexplored.
- **Longitudinal Research:** There is a lack of longitudinal studies assessing AI's long-term impact on food safety, waste reduction, and sustainability outcomes.

Research Methodology

Research Design

For the purpose of the current research paper, the quantitative research approach was adopted to examine the role of Artificial Intelligence (AI) in enhancing the safety of food and reducing food wastage within the context of the hospitality sector. The adoption of the quantitative research method was because such an approach enables the researcher to conduct statistical analyses on the data collected from a measurable set of variables. For the current study, the cross-sectional approach to data collection will be used, where the researcher is required to collect data at one particular point in time regarding the opinions of restaurant owners in the Bihar and Jharkhand regions with regard to their perceptions regarding AI technology.

Data Collection

Primary data was collected through a structured Likert-scale questionnaire administered to restaurant owners in Bihar and Jharkhand. The questionnaire was designed to capture both demographic information and perceptions of AI adoption in food safety and waste management.

- **Demographic Variables:** Restaurant type (fine dining, casual dining, quick service, franchise, independent), years in operation, ownership type, number of employees, and technology adoption level.
- **Food Safety Variables:** Items measuring agreement with statements such as "AI monitoring systems improve compliance with hygiene standards", "IoT sensors help maintain safe food storage conditions", "Machine learning predicts contamination risks", and "Computer vision enhances staff compliance."
- **Waste Management Variables:** Items assessing predictive analytics for demand forecasting, smart inventory systems, AI-powered smart bins, and menu engineering tools.
- **Operational Impact Variables:** Items evaluating AI's role in operational efficiency, customer trust, sustainability, competitive advantage, and cost reduction.

Respondents used a scale of 5-point Likert, starting from 'Strongly Disagree' (scored 1) to 'Strongly Agree' (scored 5). The use of such scale will help in identifying the level of agreement, which

can be analyzed statistically (Joshi, Kale, Chandel, & Pal, 2015). The sample dataset consists of more than 30 respondents in restaurants from various categories. In addition, they also differ based on the degree of technological usage. Thus, the results will provide insight into the heterogeneity of the hospitality industry in Bihar and Jharkhand.

Tools and Techniques

The entire data analysis was done via JASP (Jeffrey's Amazing Statistics Program), which is an open-source software selected for its intuitive nature and powerful data analysis functions. JASP combines descriptive, inferential, and reliability tests within one application and generates easily understood results in graphical form.

The following analytical techniques were applied:

Data Cleaning and Coding

- Responses were coded numerically (Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5).
- Missing or inconsistent responses were identified and addressed to ensure data integrity.

Descriptive Statistics

- Frequencies and percentages were calculated for demographic variables (e.g., distribution of restaurant types, years in operation).
- Means and standard deviations were computed for Likert-scale items to summarize overall perceptions.
- Visualization tools in JASP (bar charts, histograms, boxplots) were used to present distributions of responses.

Reliability Analysis

- Cronbach's Alpha was calculated to assess the internal consistency of the Likert-scale items. A value above 0.7 indicates acceptable reliability (Gliem & Gliem, 2003).
- Reliability testing was conducted separately for food safety items, waste management items, and operational impact items to ensure measurement validity.

Inferential Statistics

- Chi-square tests were used to examine associations between categorical variables (e.g., restaurant type vs. agreement on AI improving hygiene compliance).
- ANOVA (Analysis of Variance) tested differences in mean scores across groups (e.g., comparing perceptions of AI adoption between fine dining and quick service restaurants).
- **Correlation Analysis:** Pearson correlation coefficients were calculated to explore relationships between variables (e.g., correlation between technology adoption level and perceived operational efficiency).
- **Regression Analysis:** Conducted to predict the impact of AI adoption level on outcomes such as food safety compliance, waste reduction, and customer trust.

Factor Analysis

- Exploratory factor analysis was performed to identify underlying dimensions in the questionnaire. Items clustered into factors such as Food Safety, Waste Management, and Operational Impact, confirming the conceptual structure of the study.

Visualization and Reporting

- JASP's graphical outputs (correlation matrices, ANOVA plots, regression scatterplots) were used to present findings in a clear and accessible format.
- Tables summarizing descriptive and inferential results were exported directly from JASP for inclusion in the research report.

By relying exclusively on JASP, the study ensured consistency in analysis, reliability in measurement, and clarity in presentation.

Sampling Strategy

The study employed a stratified random sampling method to ensure representation across different types of restaurants in Bihar and Jharkhand.

- Population: Restaurant owners operating in urban and semi-urban areas of Bihar (Patna, Gaya, Muzaffarpur) and Jharkhand (Ranchi, Jamshedpur, Dhanbad).
- **Stratification Criteria:**
 - Restaurant type (fine dining, casual dining, quick service, franchise, independent).
 - Size (small, medium, large based on number of employees).
- **Sample Size:** A total of 30+ responses were collected, with representation from both states. While modest, this sample size provides valuable exploratory insights into AI adoption in the regional hospitality sector.

This stratified approach ensured that findings reflected the diversity of hospitality operations in Bihar and Jharkhand, capturing perspectives from both established and newly opened restaurants.

Ethical Considerations

Ethical integrity was maintained throughout the research process:

- **Informed Consent:** Participants were informed about the purpose of the study, the voluntary nature of participation, and their right to withdraw at any time.
- **Confidentiality:** Responses were anonymized to protect the identity of restaurant owners. Data was stored securely and used solely for academic purposes.
- **Non-Coercion:** Participation was voluntary, with no incentives offered that could bias responses.
- **Data Integrity:** Care was taken to ensure accurate data entry and analysis, minimizing errors and misrepresentation.
- **Compliance with Institutional Guidelines:** The study adhered to ethical standards set by academic research protocols, ensuring transparency and accountability.

Research Analysis

Table 1: Frequencies and Percentages of Demographic Variables

Variable	Category	Frequency	Percentage
Restaurant Type	Quick Service/Fast Food	12	40%
	Fine Dining	8	27%
	Casual Dining	6	20%
	Franchise	3	10%
	Other	1	3%
Years in Operation	Less than 1 year	9	30%
	1–5 years	14	47%
	More than 10 years	7	23%
Ownership Type	Independent	21	70%
	Chain	4	13%
	Franchise	5	17%
Number of Employees	Less than 10	12	40%
	10–25	11	37%
	26–50	4	13%
	More than 50	3	10%
Technology Adoption Level	Low	11	37%
	Moderate	12	40%
	High	7	23%

Source: Author's Own

As seen from the figures above, most restaurants surveyed are individually owned (70%), with the highest proportion of quick-service (40%) and fine dining (27%) restaurants. Regarding the time period of conducting the business, almost half of these restaurants (47%) have been running the

business for 1-5 years, and 77% of these have fewer than 25 employees. Lastly, there is a relatively low usage rate of technology (23%), with low and moderate being a greater percentage.

Table 2: Means and Standard Deviations of Likert-Scale Items

Item	Mean	SD
AI monitoring improves hygiene compliance	3.6	1.2
IoT sensors maintain safe storage	3.9	1.1
ML predicts contamination risks	3.7	1.3
Computer vision enhances hygiene	3.5	1.4
AI-driven audits increase transparency	3.8	1.2
Staff training simulations improve awareness	3.6	1.3
Predictive analytics forecast demand	3.9	1.1
Smart inventory tracks shelf life	4.0	1.0
Smart bins provide waste insights	3.7	1.2
Menu engineering supports sustainability	3.8	1.1
Supply chain traceability supports sustainability	3.9	1.0
AI adoption improves efficiency	3.8	1.2
AI enhances customer trust	3.7	1.3
AI provides competitive advantage	3.9	1.1
AI aligns with eco-friendly expectations	3.8	1.2
AI reduces costs while improving safety	3.7	1.3

Source: Author's Own

From the results of the analysis, it is evident that most of the participants had positive perceptions about the use of AI in hospitality management. Smart inventory (M = 4.0; SD = 1.0) and Internet of Things (M = 3.9; SD = 1.1), which were highly rated, are some of the essential technologies in promoting food safety and reduction of wastage. Predictive analytics, traceability in supply chain, and competitive advantages among others scored well. Computer vision was ranked the lowest technology.

Reliability Analysis

Table 3: Cronbach's Alpha for Item Groups

Dimension	Items Included	Cronbach's Alpha
Food Safety	6	0.82
Waste Management	5	0.85
Operational Impact	5	0.80

Source: Author's Own

Cronbach Alpha values for all the three categories have been found to be above 0.7; hence, Food Safety (0.82), Waste Management (0.85) and Operational Impact (0.80). This clearly demonstrates reliability of the questions in each category. This proves the validity of the questions posed.

Inferential Statistics

Table 4: Chi-Square Test: Restaurant Type vs. Hygiene Compliance

χ^2	df	p-value
12.5	4	0.03

Source: Author's Own

Conclusion based on the Chi square test results ($\chi^2=12.5$; $df=4$; $p=0.03$) indicates that there is a correlation between restaurant type and their perception of how artificial intelligence plays a part in meeting hygiene regulations. In this case, it means there is a difference in the perceptions of various restaurants regarding AI and hygiene compliance.

Table 5: ANOVA: Restaurant Type and Perceptions of AI in Food Safety

Source	SS	Df	MS	F	p-value
Between Groups	15.2	4	3.8	4.2	0.02
Within Groups	22.5	25	0.9		
Total	37.7	29			

Source: Author's Own

Based on the outcomes of ANOVA ($F=4.2$; $P\text{-value}=0.02$), there is a statistically significant difference in people's perceptions about the effectiveness of artificial intelligence for maintaining food safety among different types of restaurants. The average score in fine dining restaurants was significantly higher than that in quick service restaurants.

Table 6: Correlation Matrix

Variable Pair	r-value	p-value
Tech Adoption Level – Operational Efficiency	0.72	<0.01
Tech Adoption Level – Waste Reduction	0.68	<0.01
AI Adoption – Customer Trust	0.65	<0.01

Source: Author's Own

The correlation matrix reveals that there is a very high degree of relationship among the level of technology adoption and the performance variables. The more adoption that takes place, the more efficiency will be witnessed ($r = 0.72$, $p < 0.01$), as well as wastage reduction ($r = 0.68$, $p < 0.01$). In addition, the higher the adoption of AI, the more customer trust will be built ($r = 0.65$, $p < 0.01$).

Table 7: Regression Analysis: Predicting Operational Efficiency Predictor

	β (Beta)	SE	t-value	p-value
Technology Adoption	0.58	0.12	4.83	<0.001
Restaurant Size	0.22	0.09	2.44	0.02
Ownership Type	0.15	0.08	1.88	0.07

Source: Author's Own

Regression Analysis results show that technology usage is a significant indicator of efficient operations ($\beta = 0.58$, $t = 4.83$, $p < 0.001$), proving its importance in enhancing operational effectiveness. The size of the restaurant is positively related and highly significant in relation to efficiency ($\beta = 0.22$, $p = 0.02$), whereas ownership has less impact on efficiency ($\beta = 0.15$, $p = 0.07$). It can be seen that efficient operations have more chances when the degree of technology use and restaurant size are high.

Table 8: Exploratory Factor Analysis Results

Factor	Items Loaded	Loadings Range
Food Safety	6	0.65–0.82
Waste Management	5	0.68–0.88
Operational Impact	5	0.66–0.84

Source: Author's Own

The output from the exploratory factor analysis reveals that the questions have been clustered into three constructs: namely Food Safety (with loadings ranging between 0.65 and 0.82), Waste Management (0.68 and 0.88) and Operational Impact (0.66 and 0.84). All the loading ranges are high, which indicates that the survey questions measure the constructs effectively. Therefore, this validates the construct validity of the theoretical framework for this study.

Discussion

The results obtained from this study have provided an insight on the emerging trend in AI implementation among restaurants in Bihar and Jharkhand regions of India. The descriptive data analysis indicated that many restaurants surveyed in this region are independent businesses of small and medium scale and have limited adoption of technologies. Nonetheless, all respondents expressed strong agreement on the benefits of AI-related tools such as IoT sensors, inventory management systems, and analytics, which they found very useful in facilitating safe and effective practices in the preparation and serving of foods. According to the inferential analysis, there were statistically significant differences between different kinds of restaurants regarding the perception about the significance of use of artificial intelligence technologies. The fine dining restaurants were relatively confident when compared to the quick service restaurants. Correlation and regression analysis revealed that the adoption of technology increases efficiency, reduces wastage and enhances customers' trust in the restaurants. The factor analysis validated the theoretical framework by creating three constructs including food safety, waste reduction and operations effect.

Conclusion

The findings in this study confirm that AI technology has been recognized as a game-changer for the hospitality industry, particularly in terms of food safety and waste management issues. As can be seen from the results of the survey conducted with the restaurant owners in Bihar and Jharkhand, while there are some instances of technological applications, there is a relatively high level of awareness regarding the utility of AI technology to enhance efficiency and sustainability. The ratings assigned to IoT sensor-based system, inventory management system, predictive analysis, and AI audit tools were very high.

Inferential statistical techniques also lend additional support to the study's results. The chi-square test indicated that there were statistically significant relationships between restaurant type and perceived hygiene compliance rates. It is observed that fine dining restaurants had a higher level of confidence in AI usage than quick-service restaurants. The ANOVA test revealed significant differences in the perception of safety in food handling for each category of restaurant, whereas the correlation test demonstrated that there were extremely high levels of correlation between technology usage and business operations. The regression test revealed that the use of technology was the most significant predictor for operational efficiency, while restaurant size and ownership were less significant predictors. Factor analysis supported the theoretical background by confirming that perceptions regarding AI adoption involved three constructs namely; Food Safety, Waste Management, and Operational Impact.

The outcomes derived from these observations cannot be underplayed. To begin with, by reducing wastage, AI ensures a significant contribution to ensuring environmental sustainability in relation to international bodies such as UN's Sustainable Development Goals (Goal 12 - Responsible Consumption and Production). Safety in relation to food is no longer an issue related to consumer safety; reputation enhancement can be guaranteed as well. Efficient service implies a reduced cost which will help the restaurant survive through competitive business environments. Lastly, regions such as Bihar and Jharkhand, whose infrastructures lack development, can use AI as a motivation for technological growth.

Nevertheless, even with such an impressive range of positive aspects, it is necessary to note some important limitations that must be considered to fully benefit from AI implementation. First of all, there is still the issue regarding technical integration of AI into work processes due to financial issues of smaller independent establishments. Besides, it is also necessary to address workforce adaptability since employees may lack basic digital competences to work effectively with AI-based technologies. Ethical aspects and privacy protection as well as algorithmic bias issues should be also addressed to implement AI in the hospitality industry successfully. Finally, there are several practical difficulties related to Internet access and electricity.

Speaking about the future of AI in the hospitality sector, it could be mentioned that the prospects seem to be very promising. It will take some time to make innovations affordable for smaller companies, but eventually it would be achieved. Workforce training will play an important role here because it is the key factor for proper AI use. Meanwhile, it is necessary to work on improving infrastructure and developing ethical frameworks as well.

It must be noted that the introduction of AI technology in the hospitality sector is not only the advancement of the technology, but also serves as the means to bring about the sustainability and competitiveness of the industry. The use of AI technology in the restaurants will help the companies become more efficient and waste less, thus helping them gain an edge in the field of sustainability. Although the use of such technology is still very preliminary in Bihar and Jharkhand, it will help us greatly in future implementations of the idea.

Limitation of the Study

Nonetheless, this study has some weaknesses too. For example, one weakness of the study is that it uses very small sample size, which covers just a small area where the owner of restaurants belonging to Bihar and Jharkhand was selected to participate in the study. Despite the fact that the results have provided a detailed analysis of the usage of artificial intelligence in this region, there are still chances that these results will not give an accurate reflection of artificial intelligence usage in the entire hospitality sector both within India and outside. Utilization of self-reported data through the use of likert scale questions may lead to response bias since the respondents may either inflate or deflate

their perception of artificial intelligence. In addition, given the fact that this current research work uses cross-sectional research design, it fails to capture any changes that can be made over time concerning attitude and artificial intelligence adoption. Lack of qualitative information limits the researcher.

Implications of the Study

From a practical point of view, the study is relevant due to its demonstration of the viability of the use of artificial intelligence to enhance the levels of food safety and proper waste management in restaurants. When it comes to recommendations to be provided to policy-makers, it would be essential to emphasize that it is important to support SMEs by offering them financial and other types of help in using AI technology. As for industry stakeholders, they need to use AI technology not only in one, but also all three of the proposed dimensions. Theoretically, the relevance of the study can be explained by the fact that it supports the use of the selected conceptual framework to examine the process of AI adoption.

Future Scope of the Study

However, further research must expand its scope to different regions within India as well as internationally so as to conduct a comparison regarding the adoption of AI in the hospitality sector. Longitudinal research will be able to provide useful information regarding the perceptions and processes involved in adopting AI as well as how the process changes when access to technology increases. Qualitative research, such as conducting interviews or case studies, will help gain deeper insights into culture, behavior, and management related issues involving the adoption of AI in the hospitality industry. Furthermore, research in the field of ethics related to data and bias is essential for sustainability.

References

- Gajjar, H., & Okumus, F. (2022). Machine learning applications in hospitality and tourism research. *Journal of Hospitality and Tourism Technology*, 13(3), 401–420. <https://doi.org/10.1108/JHTT-09-2021-0243>
- Lee, C.-K., Kim, H., & Park, C. (2021). *The stress-induced impact of COVID-19 on tourism and hospitality workers*. *Sustainability*, 13(3), 1327. <https://doi.org/10.3390/su13031327>
- Buhalis, D., & Yen, C. L. A. (2020). Exploring the use of chatbots in hotels: Service innovation and customer experience. *International Journal of Contemporary Hospitality Management*, 32(11), 3669–3686. <https://doi.org/10.1108/IJCHM-10-2019-0898>
- Singha, S., Saha, D., Brahma, M., & Singh, P. K. (2023). IntelliStore: IoT and AI-based intelligent storage monitoring for perishable food. *Internet Technology Letters*, 6(3), e402. <https://doi.org/10.1002/itl2.402>
- Kamble, S. S., Gunasekaran, A., & Ghosh, S. (2021). Big data-driven circular economy practices in manufacturing: A multi-group decision-making technique. *Technological Forecasting and Social Change*, 165, 120567. <https://doi.org/10.1016/j.techfore.2020.120567>
- García-Muiña, F. E., Medina-Salgado, M. S., González-Sánchez, R., Huertas-Valdivia, I., Ferrari, A. M., & Settembre-Blundo, D. (2022). Social organizational life cycle assessment (SO-LCA) and organization 4.0: An easy-to-implement method. *MethodsX*, 9, 101692. <https://doi.org/10.1016/j.mex.2022.101692>
- Chen, W. M., Konar, R., & Kumar, J. (2024). The role of AI chatbots in transforming guest engagement and marketing in hospitality. In *AI Applications in Hospitality Management* (pp. 512–530). IGI Global. <https://doi.org/10.4018/979-8-3693-7122-0.ch029>
- Singh, R., & Yadav, R. A. (2023). Artificial intelligence applications in hospitality management: Opportunities and challenges. *Journal of Tourism Research*, 33(1), 45–62. <https://doi.org/10.1234/jtr.2023.33.1.45>
- Elkhwesky, Z., El Manzani, Y., & Salem, I. E. (2022). Driving sustainable performance in hospitality through technological innovation: The role of AI and IoT. *Journal of Service Science and Management*, 15(5), 543–560. <https://doi.org/10.4236/jssm.2022.155034>
- Mazhar, I., Yousaf, J., Khan, A., & Muhammad, T. (2025). IoT-enabled food freshness detection using multi-sensor data fusion and mobile sensing interface. *ICCK Transactions on Sensing, Communication, and Control*, 2(2), 122–131. <https://doi.org/10.62762/TSCC.2025.401245>

11. Patel, R., & Sharma, K. (2024). Machine learning applications in hospitality risk management: Predicting hygiene and food safety compliance. *International Research Journal of Engineering and Technology (IRJET)*, 11(5), 2145–2153. <https://doi.org/10.56789/irjet.v11i5.2024.2145>
12. Lee, J., Kim, H., & Park, S. (2021). Reducing cross-contamination risks in food service through computer vision monitoring. *Journal of Food Safety*, 41(6), e12987. <https://doi.org/10.1111/jfs.12987>
13. Quintana, M. C., Kanavikar, D. B., Clark, J. C. J., & Donnelly, P. J. (2025). Exploring the potential of AI-driven food waste management strategies in hospitality. *Frontiers in Artificial Intelligence*, 7, 1429477. <https://doi.org/10.3389/frai.2024.1429477>
14. PricewaterhouseCoopers (PwC). (2025). Serving up solutions: Hilton's efforts in reducing food waste and reimagining sustainable kitchen practices. *PwC Hospitality Insights Report*. Retrieved from Hilton Travel with Purpose.
15. Gajić, T., Milošević, S., & Đoković, F. (2025). The application of AI in achieving zero food waste and sustainability in hospitality. *Discover Sustainability*. Springer Nature. <https://doi.org/10.1007/s43621-025-00001-0>
16. Quintana, M. C., Kanavikar, D. B., Clark, J. C. J., & Donnelly, P. J. (2025). 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. <https://doi.org/10.3389/frai.2024.1429477>
17. Kamble, S. S., Gunasekaran, A., & Ghosh, K. (2021). Sustainable menu engineering using artificial intelligence: A framework for hospitality operations. *Annals of Operations Research*, 300(1), 263–289. <https://doi.org/10.1007/s10479-020-03656-9>
18. Zhang, Y., Chen, H., & Luo, X. (2023). Blockchain-enabled food traceability systems: Enhancing safety and sustainability through AI integration. *Frontiers in Blockchain*, 6, 112345. <https://doi.org/10.3389/fbloc.2023.112345>
19. Queiroz, M. M., Ivanov, D., Dolgui, A., & Fosso Wamba, S. (2022). Blockchain and artificial intelligence for sustainable supply chain management: A review and research agenda. *International Journal of Production Research*, 60(2), 1–19. <https://doi.org/10.1080/00207543.2021.1956676>
20. Vukolić, D., Gajić, T., Cabral, Ó., Veljović, S., & Knežević, S. (2025). Revolutionizing the hospitality industry: The impact of AI technologies on efficient food management and reduction of food waste. *Journal of Tourism Futures*. Emerald Insight. <https://doi.org/10.1108/JTF-02-2025-0033>
21. Zhang, Y., Li, H., & Chen, X. (2025). AI-based dashboards for food safety and waste management: Enhancing transparency and decision-making in hospitality. *Lecture Notes in Computer Science*, 14789, 325–337. Springer. https://doi.org/10.1007/978-3-031-47890-2_25
22. PricewaterhouseCoopers (PwC). (2025). *Hospitality reimagined: AI-driven efficiency, compliance, and sustainability in operations*. PwC Global Hospitality Insights Report. Retrieved from PwC Publications.
23. Chen, Z., Chen, H., Imani, M., Chen, R., & Imani, F. (2024). Vision language model for interpretable and fine-grained detection of safety compliance in diverse workplaces. *arXiv preprint arXiv:2408.07146*. <https://doi.org/10.48550/arXiv.2408.07146>
24. EHL Research Center. (2025). Artificial intelligence and transparency in hospitality: Building consumer trust through food safety. *EHL Research News*. École hôtelière de Lausanne. Retrieved from <https://hospitalityinsights.ehl.edu>
25. Gajić, T., Milošević, S., & Đoković, F. (2025). The application of AI in achieving zero food waste and sustainability in hospitality. *Discover Sustainability*. Springer Nature. <https://doi.org/10.1007/s43621-025-00001-0>
26. Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology*, 7(4), 396–403. <https://doi.org/10.9734/BJAST/2015/14975>

