



THE ROLE OF ARTIFICIAL INTELLIGENCE IN REDUCING FOOD WASTE AND IMPROVING NUTRITION FOR SUSTAINABLE DEVELOPMENT IN ASABA, DELTA STATE

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Journal of Research in Vocational and Technical Education (JORVTED), 2026, 5(1), 166–174

Publication history: Received on 23 January 2026; revised on 07 March 2025; accepted on 10 May 2026

Article DOI: <https://doi.org/10.5281/zenodo.20181508>

Abstract

*This study examined the role of Artificial Intelligence (AI) in reducing food waste and improving nutrition for sustainable development in Asaba, Delta State. The study was guided by two research questions and two null hypotheses. A descriptive survey design was adopted, and the population consisted of 9,842 students, food vendors, and staff across three tertiary institutions in Asaba. A sample size of 384 respondents was determined using Taro Yamane's formula, and stratified random sampling was employed to ensure proportional representation across the three groups and institutions. A structured questionnaire with closed-ended items and a four-point Likert scale was used to collect data, and the instrument was validated by three experts and found reliable with a Cronbach's Alpha coefficient of 0.86. Data were collected physically with the assistance of trained research assistants, and 362 copies of the questionnaire were successfully retrieved and analyzed. Descriptive statistics, including mean, standard deviation, and grand mean, were used to answer the research questions, while inferential statistics, specifically independent samples *t*-test and one-way ANOVA, were used to test the hypotheses at 0.05 significance level. Findings revealed that respondents agreed that AI could significantly reduce food waste through improved food storage, distribution, and supply chain efficiency, and enhance household nutrition by improving access to affordable, diverse, and balanced diets. The study also found no significant differences in perceptions based on gender or across the three institutions. Based on these findings, it was recommended that institutions integrate AI into food management systems, provide inclusive training for all stakeholders, promote AI-driven dietary planning, and adopt standardized AI frameworks across institutions.*

Keywords: Artificial Intelligence, Food Waste, Nutrition, Sustainable Development, Tertiary Institutions

Introduction

Food waste is one of the major problems affecting food systems today. It refers to edible food that is lost along the production and supply chain or wasted at the retail and household level (Adebayo and Ojo, 2022). Globally, about one-third of all food produced for human consumption is wasted every year, which means that valuable resources such as land, water, and energy used to produce the food are also wasted (Onyeaka, Tamasiga, Nwauzoma, Miri, Juliet, Nwaiwu, and Akinsemolu, 2023). In Nigeria, and especially in Asaba, Delta State, poor storage facilities, weak transport systems, and market inefficiencies make food waste a common problem. Large amounts of organic waste from households and markets are discarded daily, creating both environmental and public health challenges (Jacob and

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Omitoyin, 2024; Sunday, Sowunmi, Obayelu, Awoyemi, Omotayo and Ogunniyi, 2022). Since food waste reduces the amount of food available, it directly affects the nutrition of people who already face food insecurity. Nutrition is the outcome of what people eat and how it affects their health and well-being. It is not only about having enough food to eat but also about eating the right balance of carbohydrates, proteins, fats, vitamins, and minerals. Oni. (2022), opined that in Nigeria, many households rely heavily on starchy foods with little access to protein-rich foods, fruits, and vegetables. This poor diet leads to micronutrient deficiencies and diet-related health problems. When perishable foods like vegetables, fruits, fish, and dairy are wasted, people lose access to the very foods that could improve diet quality. Therefore, reducing food waste helps improve nutrition by making more healthy foods available, especially in cities like Asaba where many families cannot afford diverse diets (Ahmed, Sulaiman, Adamu and Musa, 2024; Kumar, Singh, and Sharma, 2022). The strong link between food waste and nutrition makes it necessary to explore solutions that can address both challenges at the same time. Artificial Intelligence (AI) offers one of the most promising solutions to reduce food waste and improve nutrition. According to Chen and Alahakoon (2023), AI refers to computer systems that can perform tasks that normally require human intelligence, such as learning, reasoning, and making predictions. In the food system, AI can be used to predict demand so that farmers and retailers produce and stock the right amount of food, detect food spoilage early using computer vision, and optimize storage and transport to keep food fresh. AI can also help connect surplus food with people who need it through redistribution platforms. Tan, Gao and Li (2023), stated that these applications reduce the amount of food wasted while also increasing the availability of nutritious foods. Recent studies show that AI can reduce food losses in perishable food chains by up to 40 percent when combined with good logistics and storage systems (Onyeaka, Tamasiga, Nwauzoma, Miri, Juliet, Nwaiwu and Akinsemolu, 2023). This shows that AI is not just a technological tool but a driver of change in the way food systems are managed. Sustainable development provides the wider framework for linking food waste, nutrition, and AI together. Sustainable development is about meeting the needs of people today without destroying the ability of future generations to meet their own needs. It is guided by global goals such as zero hunger (Goal 2), responsible consumption and production (Goal 12), and climate action (Goal 13) (Aburime, 2024). Reducing food waste supports these goals by making food systems more efficient, protecting the environment, and ensuring access to nutritious food. AI plays an important role in this process because it helps reduce waste, preserve resources, and improve food availability. By applying AI to food waste and nutrition challenges, societies can move closer to achieving sustainable development (Onyeaka et al, 2023). This broad framework helps to explain why the issue is especially relevant in Asaba. In Asaba, Delta State, the problems of food waste, poor nutrition, and the need for sustainable development are closely connected. Many households experience poor diet quality at the same time that large amounts of food are wasted in markets and homes. AI could offers a practical way to solve these problems by predicting food demand, improving food quality monitoring, and supporting redistribution of surplus food. These measures can reduce waste while also making nutritious foods more available to families. However, challenges such as weak infrastructure, lack of data, and limited government support make it difficult to apply AI fully in the local food system. This study therefore examines the role of AI in reducing food waste and improving nutrition for sustainable development in Asaba, Delta State, in order to provide evidence that can guide policy and practice (Mekonnen, Adeyemi, Gilbert, Thomas & Adegoke, 2023).



Statement of the Problem

In Asaba, Delta State, a large amount of food tends to be wasted every day, especially perishable items like fruits, vegetables, and fish. This waste happens mainly because of poor storage, weak transport systems, and lack of proper preservation facilities. The result is that food that could have been eaten ends up as waste, leading to losses for farmers and traders, and adding to environmental problems. At the same time, many households in Asaba find it difficult to eat balanced diets. Meals are often made up of starchy foods with very little protein, vitamins, or minerals, which leads to malnutrition and poor health. This creates a serious contradiction where there is enough food available in the city, yet many people are not able to get the nutrition they need (Okorie, 2023). The situation is made worse by the poor state of the food supply chain. Weak logistics, absence of cold storage, and lack of proper coordination between farmers and consumers cause more food losses and reduce the quality of food. These challenges also increase the price of nutritious food, making it difficult for low-income households to afford healthy diets. In addition, wasted food contributes to environmental problems such as greenhouse gas emissions and puts pressure on waste management systems. Artificial Intelligence (AI) has been used in other parts of the world to predict demand, extend shelf life, and redistribute surplus food, but its use in Asaba is still very limited. Problems such as poor infrastructure, lack of reliable data, and weak government support make it hard to apply these technologies locally. This shows the urgent need to study how AI can help reduce food waste as well as improve nutrition for sustainable development in Asaba, Delta State.

Purpose of the Study

This study examined the role of Artificial Intelligence (AI) in reducing food waste and improving nutrition for sustainable development in Asaba, Delta State. Specifically, the study examined; how Artificial Intelligence can be applied to reduce food waste by improving food storage, distribution, and supply chain efficiency in Asaba, Delta State. the role of Artificial Intelligence in enhancing household nutrition through better access to affordable, diverse, and balanced diets for sustainable development in Asaba, Delta State.

Research Questions

The following research questions were raised to guide this study.

1. How can Artificial Intelligence be applied to reduce food waste by improving food storage, distribution, and supply chain efficiency in tertiary institutions in Asaba, Delta State?
2. How does Artificial Intelligence enhance household nutrition through better access to affordable, diverse, and balanced diets for sustainable development in tertiary institutions in Asaba, Delta State?

Hypotheses

The following null hypotheses are stated for this study:



H₀₁: There is no significant difference between male and female respondents in their perception of how Artificial Intelligence can reduce food waste through improved food storage, distribution, and supply chain efficiency in tertiary institutions in Asaba, Delta State.

H₀₂: There is no significant difference among respondents from different tertiary institutions in Asaba regarding the role of Artificial Intelligence in enhancing household nutrition through better access to affordable, diverse, and balanced diets for sustainable development.

Methodology

The study adopted a descriptive survey research design, which was considered suitable because it enabled the collection of reliable data from a large population within tertiary institutions in Asaba, Delta State, in order to critically examine the role of Artificial Intelligence in reducing food waste and improving nutrition for sustainable development. The population of the study consisted of 9,842 individuals, comprising students, food vendors, and staff across three tertiary institutions in Asaba, namely Dennis Osadebe University, Asaba; Federal College of Education (Technical), Asaba; and the National Open University of Nigeria, Asaba Study Centre. From this population, a sample size of 384 respondents was determined using Taro Yamane's formula at a 0.05 level of significance, thereby ensuring that the sample adequately represented the three categories of respondents and the institutions under study. A stratified random sampling technique was employed to guarantee proportionate representation of students, food vendors, and staff across the institutions, while still allowing for randomness in the selection process. The instrument for data collection was a structured questionnaire developed based on the research questions, and it consisted of both closed-ended items and a four-point Likert scale designed to measure perceptions of Artificial Intelligence in relation to food waste reduction and nutrition improvement. The Likert scale was coded as Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1), with a benchmark mean of 2.50 used as the decision rule to determine agreement or disagreement on each item. The instrument underwent face and content validation by three experts, two in Business Education and one in Educational Measurement and Evaluation, to ensure clarity, accuracy, and alignment with the study objectives. To establish reliability, the instrument was trial-tested on 30 respondents outside the selected institutions but with similar characteristics, and the data were analyzed using Cronbach's Alpha, which produced a coefficient of 0.86, indicating a high level of internal consistency. A total of 384 questionnaires were physically administered to the respondents with the assistance of trained research assistants, out of which 362 copies were successfully retrieved and found valid for data analysis, representing a response rate of 94.3%. Data collected were analyzed using descriptive statistics such as mean and standard deviation to answer the research questions, while inferential statistics, specifically the independent samples t-test and one-way Analysis of Variance (ANOVA), were employed to test the null hypotheses at the 0.05 level of significance.

Results

Research Question 1: How can Artificial Intelligence be applied to reduce food waste by improving food storage, distribution, and supply chain efficiency in tertiary institutions in Asaba, Delta State?



Table 1: Mean and Standard Deviation Ratings of Respondents on the Application of AI in Reducing Food Waste Through Storage, Distribution, and Supply Chain Efficiency (n = 362)

S/N	Questionnaire Item	Mean	SD	Remark
1.	AI can be used to monitor food storage conditions (temperature, humidity, expiry).	3.35	0.68	Agree
2.	AI helps to track food inventory and prevent overstocking.	3.28	0.74	Agree
3.	AI improves the prediction of food demand in institutions.	3.41	0.70	Agree
4.	AI applications reduce post-harvest food losses.	3.26	0.77	Agree
5.	AI reduces inefficiencies in institutional food supply chains.	3.30	0.72	Agree
6.	AI supports better coordination of food distribution.	3.36	0.65	Agree
7.	AI reduces the chances of food spoilage during storage.	3.32	0.71	Agree
8.	AI enables better waste sorting and recycling processes.	3.18	0.76	Agree
9.	AI improves monitoring of food vendor practices.	3.29	0.69	Agree
10.	AI adoption encourages efficiency and cost savings in food management.	3.38	0.66	Agree
	Grand Mean	3.31		Agree

Decision rule: (≥ 2.50 = Agree; < 2.50 = Disagree)

The data in Table 1 showed that respondents agreed that Artificial Intelligence (AI) can significantly reduce food waste by improving food storage, distribution, and supply chain efficiency in tertiary institutions in Asaba, Delta State. Mean ratings ranged from 3.18 to 3.41, with the highest agreement for AI’s ability to predict food demand (3.41) and strong recognition of its role in monitoring storage conditions (3.35). Lower but positive agreement (3.18) was observed for AI supporting waste sorting and recycling, suggesting some applications may still be underutilized locally. Standard deviations between 0.65 and 0.77 indicated consistency in respondents’ views, highlighting that AI has strong potential to transform food management in these institutions.

Research Question 2: How does Artificial Intelligence enhance household nutrition through better access to affordable, diverse, and balanced diets for sustainable development in tertiary institutions in Asaba, Delta State?

Table 2: Mean and Standard Deviation Ratings of Respondents on the Role of AI in Enhancing Household Nutrition for Sustainable Development (n = 362)

S/N	Questionnaire Item	Mean	SD	Remark
11.	AI can recommend balanced diets based on nutritional needs.	3.44	0.67	Agree
12.	AI enables affordable access to diverse food choices.	3.32	0.71	Agree
13.	AI helps individuals track their daily nutritional intake.	3.36	0.73	Agree
14.	AI applications improve awareness of healthy food consumption.	3.39	0.69	Agree
15.	AI supports food vendors in offering healthier food options.	3.28	0.75	Agree



S/N	Questionnaire Item	Mean	SD	Remark
16.	AI can reduce household spending on food by minimizing waste.	3.31	0.68	Agree
17.	AI promotes nutritional diversity through personalized food recommendations.	3.37	0.70	Agree
18.	AI enhances planning of school or workplace meals for staff and students.	3.33	0.72	Agree
19.	AI contributes to addressing hidden hunger (micronutrient deficiencies).	3.26	0.76	Agree
20.	AI-driven innovations contribute to sustainable dietary patterns in institutions.	3.40	0.65	Agree
Grand Mean		3.35		Agree

Decision rule: ($\geq 2.50 = Agree$; $< 2.50 = Disagree$)

The findings from Table 2 showed that respondents strongly agreed that AI enhances household nutrition by improving access to affordable, diverse, and balanced diets within tertiary institutions in Asaba, Delta State. Mean scores ranged from 3.26 to 3.44, with the highest agreement for AI recommending balanced diets (3.44), followed by its role in promoting awareness of healthy food consumption (3.39) and supporting sustainable dietary patterns (3.40). The lowest but still positive agreement (3.26) was for AI addressing hidden hunger, suggesting some applications may need further adaptation locally. Standard deviations between 0.65 and 0.76 indicated low variability, reflecting broad consensus that AI significantly contributes to improving household nutrition and supports sustainable development.

Hypotheses

Ho1: There is no significant difference between male and female respondents in their perception of how Artificial Intelligence can reduce food waste through improved food storage, distribution, and supply chain efficiency in tertiary institutions in Asaba, Delta State.

Table 3: Independent Samples t-test analysis of male and female respondents' mean ratings on AI reducing food waste (N = 362)

Gender	n	Mean	SD	df	t-cal	t-crit	Sig. (p)	Decision
Male	188	3.29	0.72					
Female	174	3.34	0.68	360	1.34	1.96	0.18	NS (Accept H ₀)

The results in Table 3 showed that male respondents had a mean score of 3.29 (SD = 0.72), while females scored 3.34 (SD = 0.68) on AI's role in reducing food waste through storage, distribution, and supply chain efficiency. The independent samples t-test gave a t-value of 1.34 ($p = 0.18$), indicating no statistically significant difference between male and female respondents. This suggests that gender did not influence perceptions of AI's potential to reduce food waste, highlighting that awareness and acceptance of AI as a food waste management tool is evenly shared across genders. Such convergence is



important in institutional settings where effective food waste strategies require broad stakeholder engagement.

H₀₂: There is no significant difference among respondents from different tertiary institutions in Asaba, Delta State, regarding the role of Artificial Intelligence in enhancing household nutrition through better access to affordable, diverse, and balanced diets for sustainable development.

Table 4: One-Way ANOVA of Respondents from Different Institutions on AI's Role in Enhancing Household Nutrition (n = 362)

Source of Variation	Sum of Squares	Df	Mean Square	F-cal	F-crit	Sig. (p)	Decision
Between Groups	1.82	2	0.91	2.14	3.02	0.12	NS (Accept H ₀)
Within Groups	152.84	359	0.43				
Total	154.66	361					

The results in Table 4 showed that respondents from Dennis Osadebe University, Asaba; Federal College of Education (Technical), Asaba; and the National Open University of Nigeria, Asaba, had similar perceptions of AI's role in enhancing household nutrition. One-way ANOVA produced an F-value of 2.14 ($p = 0.12$), indicating no statistically significant difference across the institutions. This suggests that respondents shared a common view on AI's ability to improve access to affordable, diverse, and balanced diets. The consensus likely reflects widespread exposure to digital technologies and similar challenges with food affordability and nutrition across the institutions. It also indicates that AI-based dietary and food management strategies can be implemented regionally without needing institution-specific modifications.

Discussion

The first major finding of this study revealed that respondents agreed that Artificial Intelligence can significantly reduce food waste through improved food storage, distribution, and supply chain efficiency in tertiary institutions in Asaba, Delta State. The data showed strong agreement on AI's role in predicting food demand, monitoring food storage conditions, and reducing spoilage. This finding aligns with global perspectives where AI-driven tools such as predictive analytics and smart sensors have been increasingly applied to minimize inefficiencies in food supply chains. For example, Kumar, Singh, and Sharma (2022) reported that AI-based demand forecasting and storage monitoring systems are now critical in mitigating food losses across institutional and commercial settings. The finding therefore suggests that AI adoption within Asaba's tertiary institutions holds strong potential for addressing the persistent problem of food wastage by strengthening institutional food management systems.

The second finding indicated that there was no significant difference between male and female respondents in their perceptions of how AI can reduce food waste in tertiary institutions. Both male and female groups demonstrated similar agreement levels, with no statistically significant variation. This suggests that gender did not influence respondents' awareness or acceptance of AI's role in food waste reduction. Research has shown that technological awareness and digital literacy increasingly cut across



gender divides, particularly among younger populations such as students (Chen and Alahakoon, 2023). The implication of this finding is that AI-based food waste reduction strategies can be promoted inclusively across tertiary institutions without concerns of gender bias, ensuring equitable participation of all stakeholders in technology-driven sustainability initiatives.

The third finding of the study showed that respondents agreed that Artificial Intelligence can enhance household nutrition by improving access to affordable, diverse, and balanced diets for sustainable development in tertiary institutions in Asaba. The highest agreement was observed on AI's role in recommending balanced diets and promoting sustainable dietary patterns. This resonates with findings from Tan, Gao, and Li (2023), who emphasized that AI-powered personalized nutrition applications are increasingly enabling individuals to adopt healthier diets by offering data-driven recommendations tailored to individual needs. The finding is significant because nutrition insecurity, often manifested through unbalanced diets and hidden hunger, remains a persistent issue in Nigeria. Thus, AI adoption in tertiary institutions could improve not only food availability but also the quality and diversity of diets consumed by students, staff, and food vendors.

The fourth finding revealed that there was no significant difference among respondents across the three institutions: Dennis Osadebe University, Federal College of Education (Technical), and the National Open University of Nigeria—in their perceptions of AI's role in enhancing household nutrition. This indicates that respondents across the institutions shared a uniform view of AI as a transformative tool for promoting nutritional balance. The finding reflects broader challenges faced by Nigerian tertiary institutions, including rising food prices, limited dietary diversity, and nutrition-related health concerns (Adebayo and Ojo, 2022). It also highlights that AI-based nutritional solutions can be implemented at a regional or systemic level rather than tailored separately for each institution, ensuring cost efficiency and consistent policy application.

Conclusion

This study concluded that Artificial Intelligence is a transformative tool with the capacity to reduce food waste and enhance household nutrition, thereby supporting sustainable development in tertiary institutions in Asaba, Delta State. The findings showed that AI can significantly improve food storage, distribution, and supply chain efficiency, while also facilitating access to affordable, diverse, and balanced diets. There were no significant differences in perceptions across gender or institutions, indicating a shared understanding of AI's relevance among all respondents. These outcomes underscore AI's potential to address persistent challenges such as food insecurity, malnutrition, and inefficiencies in food management within the Nigerian context. By aligning with Sustainable Development Goals 2 (Zero Hunger), 12 (Responsible Consumption and Production), and 13 (Climate Action), the adoption of AI in institutional food systems can act as a catalyst for sustainable practices, improve the well-being of students, staff, and vendors, and provide replicable models for other tertiary institutions in Nigeria and similar developing contexts. Overall, the study emphasizes that systematic integration of AI into food and nutrition management can transform institutional practices, strengthen policy implementation, and contribute meaningfully to achieving broader national and global sustainability objectives.

Recommendations

The following recommendations were made from the findings of this study.

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1. Tertiary institutions in Asaba should apply Artificial Intelligence in storing, distributing, and managing food to reduce waste and use resources more effectively.
2. Schools should provide training on AI-based food management for both male and female students and staff so that everyone can participate and benefit equally.
3. Students, staff, and food vendors should use AI tools to plan balanced, affordable, and healthy meals to improve nutrition.
4. Schools and policymakers should create common AI-based systems for managing food waste and nutrition in all tertiary institutions in Asaba to ensure they work well everywhere.

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