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RESEARCH ARTICLE

Cost-Benefit, Energy Sustainability and Technological Assessment of Artificial Intelligence Adoption in Nigeria’s Agricultural and Waste-to-Energy Systems

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Abstract
This study examines the cost-benefit, energy sustainability, and technological implications of artificial intelligence (AI) adoption in Nigeria's agricultural and waste-to-energy (WTE) systems. AI technologies are increasingly transforming agricultural production, renewable energy generation, waste management efficiency, and environmental sustainability across developing economies. Using a quantitative survey design, data were collected from 522 respondents across Nigeria's six geopolitical zones and analysed using descriptive statistics and multiple regression techniques. The findings reveal moderate-to-high AI adoption (Mean = 3.84), significant improvements in operational efficiency (Mean = 4.02), enhanced energy recovery and environmental sustainability (Mean = 3.95), and positive social impacts (Mean = 3.78). Regression results indicate that AI investment significantly improves operational efficiency ($\beta = 0.62$, $p < 0.01$) and sustainability outcomes ($\beta = 0.55$, $p < 0.01$). The study further demonstrates that AI-enabled technologies support smart energy conversion, precision agriculture, renewable energy optimisation, and efficient waste valuation. However, infrastructural deficiencies, unstable electricity supply, limited technical expertise, and high implementation costs remain major barriers. The study concludes that AI adoption provides substantial economic, technological, and energy sustainability benefits that outweigh implementation costs. The results contribute to emerging literature on AI, renewable energy systems, and sustainable technological development in developing economies while offering practical policy recommendations for Nigeria's green transition agenda.

Keywords: Artificial intelligence; Cost–benefit analysis; Energy sustainability; Technology adoption; Waste-to-energy systems

1. Introduction

Artificial intelligence (AI) has emerged as a transformative technology with significant implications for economic productivity, environmental sustainability, and sectoral efficiency across developing economies. Recent studies further indicate that AI-driven agricultural systems can enhance climate resilience, optimise resource utilisation, and improve sustainable food production in developing economies (Dinrifo et al., 2025; Udoinyang, 2024).

In Nigeria, where agriculture contributes approximately 25–30% of GDP and waste management remains a persistent environmental challenge, the integration of AI into agricultural systems and waste-to-energy (WTE) processes offers substantial opportunities for innovation and sustainability (World Bank, 2023; FAO 2022). Recent global studies highlight that AI-driven systems can optimise crop yields, reduce resource inefficiencies, and enhance renewable energy generation through smart waste conversion systems (Vinuesa et al., 2020; Talaviya et al. 2020). Recent evidence suggests that the convergence of artificial intelligence, renewable energy technologies, and sustainable agricultural systems is becoming a major driver of economic transformation worldwide. Studies published in 2025 and 2026 indicate that AI-enabled predictive analytics, intelligent energy management systems, machine learning-based crop monitoring, and automated waste conversion technologies significantly improve energy efficiency, reduce greenhouse gas emissions, and enhance resource productivity (Dinrifo et al., 2025; Ayangbenro et al., 2024; Vinuesa et al., 2020). Furthermore, emerging research demonstrates that AI-supported waste-to-energy systems can increase energy recovery rates while minimising environmental externalities through real-time process optimisation and intelligent monitoring systems (Fang et al., 2023).

Despite these potentials, the adoption of AI in Nigeria faces structural constraints, including high initial investment costs, limited technical expertise, infrastructural deficits, and policy inconsistencies (Ayangbenro et al., Diallo et al., 2024). The cost–benefit dynamics of AI implementation therefore require critical examination, particularly in sectors where financial resources are constrained but sustainability demands are urgent. Furthermore, sustainability analysis is essential to assess whether AI deployment aligns with long-term environmental, economic, and social goals. In agriculture, AI technologies such as precision farming, predictive analytics, and automated irrigation systems have demonstrated the ability to improve productivity while minimising environmental degradation (Li et al., 2021) In Nigeria, where smallholder farmers dominate, AI could enhance decision-making, reduce post-harvest losses, and improve climate resilience. Sustainable agricultural transformation also depends on improved market systems, resource efficiency, and environmentally responsible farming practices across rural communities (Falola et al., 2024). However, the cost implications and scalability challenges remain unclear.

Similarly, Nigeria produces more than 32 million tonnes of solid waste each year, a substantial proportion of which is inadequately managed (UNEP, 2022). Waste-to-energy systems, enhanced by AI for optimisation and efficiency, present an opportunity to convert waste into renewable energy while addressing environmental pollution. Recent sustainability literature equally emphasises that integrated technological systems are essential for reducing environmental degradation and improving renewable energy efficiency in emerging economies (Udoinyang et al., 2024). AI can improve sorting efficiency, energy conversion rates, and system maintenance (Fang et al., 2023). However, the economic feasibility and sustainability trade-offs of such systems in Nigeria have not been comprehensively evaluated.

Previous studies have independently examined artificial intelligence adoption in agriculture, renewable energy systems, and waste management, but few have evaluated the economic, technological, energy, and sustainability implications of AI adoption across both agricultural and waste-to-energy sectors in Nigeria. Existing studies primarily concentrate on technical efficiency or adoption determinants, neglecting integrated cost-benefit and sustainability assessments. This study therefore contributes to knowledge by providing a holistic empirical evaluation of AI adoption that combines economic viability, technological effectiveness, operational efficiency, renewable energy sustainability, and environmental outcomes. The innovative aspect of this research lies in its integration of agricultural and waste-to-energy systems within a unified analytical framework, thereby generating evidence that supports sustainable technological transitions in developing economies.

The primary aim of this study is to evaluate the cost–benefit and sustainability implications of AI adoption in Nigeria's agricultural and waste-to-energy systems.
Specific objectives are to: Assess the economic costs and benefits of AI implementation in agriculture and WTE systems, examine the environmental and social sustainability impacts of AI adoption, analyse the relationship between AI investment and operational efficiency, and identify key barriers and enablers of AI adoption in Nigeria.
The study is guided by the following research questions: what are the cost implications of AI adoption in agriculture and WTE systems in Nigeria? what benefits (economic, environmental, and social) are derived from AI implementation? how does AI adoption influence sustainability outcomes? And finally, what factors determine the effectiveness of AI deployment in these sectors?
The study hypotheses are:
H_{01}: AI adoption has no significant effect on operational efficiency in agriculture and WTE systems.
H_{02}: There is no significant relationship between AI investment and sustainability outcomes.
H_{03}: The costs of AI implementation outweigh its benefits in Nigeria's agricultural and WTE sectors.
The remainder of this paper is structured as follows. Section Two presents the theoretical and empirical literature review. Section Three discusses the research methodology, including research design, population, sampling procedures, data collection, and analytical techniques. Section Four presents the results and discussion of findings. Finally, Section Five concludes the study, highlights policy implications, discusses limitations, and suggests directions for future research.

2. Literature Review

This study is anchored on three complementary theories:

Technology Acceptance Model (TAM)

The technology Acceptance Model (TAM) explains that an individual's decision to adopt a technology is largely influenced by how beneficial and user-friendly the technology is perceived to be (Venkatesh et al., 2012). Within the context of this study, TAM explains how farmers and waste management operators perceive AI technologies. Recent digital agriculture studies also demonstrate that perceived usefulness, accessibility, and technical support significantly influence the adoption of AI-enabled agricultural technologies in developing countries (Dinrifo et al., 2025). Recent studies on digital transformation reveal that TAM remains one of the most effective frameworks for understanding AI adoption behaviours in developing economies. Ayangbenro et al., (2024) found that perceived usefulness, technological trust, accessibility, and institutional support significantly influence AI acceptance among agricultural stakeholders in Sub-Saharan Africa. Similarly, Dinrifo et al. (2025) reported that farmers are more likely to adopt AI technologies when they perceive clear economic and operational benefits.

Cost–Benefit Theory

Cost–benefit theory evaluates whether the benefits of an investment outweigh its costs. Recent applications emphasise sustainability-adjusted cost-benefit frameworks (Boardman et al., 2021). This theory underpins the economic evaluation of AI adoption. Empirical sustainability studies in Nigeria further reveal that investments in modern agricultural and renewable energy technologies can generate long-term economic and environmental benefits despite high initial implementation costs (Udoinyang, 2024). Recent sustainability economics literature argues that cost-benefit analyses of emerging technologies should incorporate environmental and social externalities in addition to direct financial costs and returns. Fang et al. (2023) demonstrate that AI-driven renewable energy systems generate long-term economic benefits through reduced operational inefficiencies, improved resource utilisation, and lower environmental remediation costs.

Sustainable Development Theory

Sustainable Development Theory emphasises balancing economic growth, environmental protection, and social equity (UN, 2021). AI adoption is assessed through this triple-bottom-line lens. Contemporary agricultural sustainability literature equally stresses that environmentally responsible production systems and resource-efficient technologies are essential for achieving sustainable development goals in developing economies (Falola et al., 2024) TAM explains adoption behaviour, cost–benefit theory evaluates economic viability, and sustainable development theory assesses long-term impacts. Recent studies further suggest that artificial intelligence contributes significantly to achieving the Sustainable Development Goals (SDGs) through smart resource management, renewable energy optimisation, climate adaptation, and environmental protection initiatives. Vinuesa et al. (2020) found that AI-supported sustainability interventions improve energy efficiency and environmental performance across multiple sectors in emerging economies. Together, they provide a comprehensive framework for analysing AI in Nigeria's agricultural and WTE sectors.

Empirical Review of AI, Energy and Sustainability Studies

The growing application of AI technologies in agriculture and renewable energy systems has attracted significant scholarly attention. Recent studies reveal that AI-enabled precision agriculture improves crop productivity, reduces resource wastage, and enhances climate resilience. Likewise, intelligent waste-to-energy systems improve renewable energy generation through automated sorting, predictive maintenance, and energy optimisation technologies. However, evidence from developing economies remains fragmented, and comprehensive assessments that integrate economic, environmental, technological, and energy dimensions are scarce.

Recent empirical studies demonstrate the transformative role of AI in agriculture and energy systems. Li et al. (2022) found that AI-driven precision agriculture increased crop yields by 15–25% while reducing fertiliser use.

Similarly, Talaviya et al. (2020) reported improved irrigation efficiency through AI-based monitoring systems. In Africa, studies indicate growing interest in AI adoption but highlight infrastructural and financial challenges. Ayangbenro et al. (2023) observed that farmers in Nigeria encounter several challenges, including inadequate access to digital technologies and the high costs associated with implementation. According to Diallo et al. (2022), they further noted that government policies remain inadequate in supporting AI-driven agricultural innovation, which hinders the potential benefits that AI could bring to the agricultural sector in Nigeria. AI has demonstrated its ability to enhance operational efficiency in waste-to-energy systems. Falola et al. (2023) demonstrated that AI-enhanced sorting systems increased recycling efficiency by 30%. United Nations (2022) reported that AI integration in waste management reduces landfill dependency and greenhouse gas emissions. However, cost concerns remain significant. Similarly, Boardman et al. (2021) emphasise that high upfront investment and maintenance costs can hinder adoption in developing countries. Vinuesa et al. (2020) also highlight the need for long-term cost-benefit evaluations. Sustainability impacts of AI are mixed. While AI enhances efficiency, it may increase energy consumption due to computational requirements (IEA, 2023) which raises concerns about its overall sustainability impact in various sectors.

Nevertheless, when applied in renewable energy systems, AI contributes positively to sustainability outcomes by optimising energy production and consumption, reducing waste, and facilitating the integration of renewable

sources into the energy grid. Most studies focus either on agriculture or waste management independently, with limited integration of both sectors, which hinders a comprehensive understanding of their interdependencies and potential synergies for sustainability.
Additionally, few studies provide a combined cost–benefit and sustainability analysis in the Nigerian context, which is crucial for understanding the overall impact of renewable energy systems on both agriculture and waste management. This study addresses this gap by offering a holistic evaluation.

3. Research Method

This study adopts a quantitative research design using survey and econometric analysis. The study covers Nigeria's six geopolitical zones, with selected states including Lagos, Rivers, Kano, Enugu, Plateau, and Borno to ensure regional representation. The questionnaire consisted of five sections measuring AI adoption, technological readiness, operational efficiency, energy sustainability, environmental sustainability, and implementation challenges using a five-point Likert scale. Content validity was established through expert review by specialists in artificial intelligence, agricultural economics, renewable energy systems, and research methodology. A pilot study involving 50 respondents was conducted prior to the main survey, leading to minor modifications that improved clarity and reliability. Multiple diagnostic tests, including multicollinearity assessment, normality testing, and heteroscedasticity analysis, were conducted before regression estimation to ensure robustness of the findings.
The study population comprises agricultural practitioners, waste management operators, policymakers, and AI technology experts. A stratified random sampling technique was employed to select 600 respondents, ensuring proportional representation across sectors and regions. Data were collected using structured questionnaires and supplemented with secondary data from government and international reports. Ethical approval was obtained from a recognised institutional review board, and informed consent was secured from all participants. The reliability of the research instrument was established through Cronbach's alpha, which yielded a coefficient of 0.87, indicating high internal consistency. Data analysis was conducted using descriptive statistics and multiple regression analysis was employed to assess the relationships among AI adoption, operational cost, and sustainability outcomes.

Table 1. Demographic distribution and sampling

Zone	State	Respondents	Occupation	Age Range	Gender	Education	Questionnaire Distribution	Questionnaire Returned
Southern-South	Rivers	100	Farmers/Engineers	25-55	M/F	BSc/MSc	100	90
South-Eastern	Enugu	100	Agric Expert	25-55	M/F	BSc/MSc	100	88
South-Western	Lagos	100	Tech/Policy	25-50	M/F	BSc/PhD	100	85
North-Central	Plateau	100	Mixed	20-50	M/F	BSc	100	87
North-Eastern	Borno	100	Waste Managers	30-60	M/F	Diploma	100	80
North-Western	Kano	100	Farmers	30-60	M/F	Diploma	100	85

Source: Authors Fieldwork, 2026

Table 1 presents a balanced representation across Nigeria's six geopolitical zones to ensure national coverage and reduce regional bias. The states were chosen because of their significant involvement in agricultural production and waste management practices. Lagos represents technological advancement and policy dynamics, while Rivers reflects industrial and waste management relevance. Kano and Borno were selected for their agricultural intensity and waste challenges in northern Nigeria. Enugu and Plateau offer perspectives on mixed agricultural systems. The demographic distribution ensures diversity in occupation, age, gender, and educational background, which is critical for capturing varied perspectives on AI adoption. The high response rate (87%) indicates strong engagement and reliability of the dataset. The inclusion of multiple occupations enhances the robustness of the analysis, as it reflects interdisciplinary insights.

4. Results and Discussion

The integrated analysis of descriptive and regression results will provide evidence of the cost–benefit and sustainability implications of artificial intelligence (AI) adoption in Nigeria's agricultural and waste-to-energy (WTE) systems.

Table 2. Cost and financial implications of AI implementation

Variable	Mean	Std. Deviation	Min	Max
AI Adoption Level	3.84	0.76	1.00	5.00
Cost of Implementation	3.67	0.82	1.00	5.00
Operational Efficiency	4.02	0.71	1.50	5.00
Environmental Sustainability	3.95	0.74	1.20	5.00
Social Impact	3.78	0.80	1.00	5.00
Technical Capacity	3.41	0.88	1.00	5.00

Source: Authors Fieldwork, 2026

The descriptive statistics in Table 2 show moderate-to-high AI adoption in Nigeria's agricultural and waste-to-energy sectors. The mean score for AI adoption (3.84) indicates increased awareness and utilisation of AI technologies among respondents. Operational efficiency recorded the highest mean score (4.02), showing that AI significantly improves productivity and system performance. Environmental sustainability (3.95) and social impact (3.78) also reveal that AI contributes positively to waste reduction, resource optimisation, environmental protection, and improved service delivery. The cost of implementation (3.67) indicates that AI adoption requires considerable financial investment, including infrastructure, maintenance, and training costs. However, respondents still believe that the long-term benefits outweigh the implementation costs. Technical capacity recorded the lowest mean score (3.41), indicating that limited technical expertise and inadequate skills remain major barriers to effective AI adoption and sustainability outcomes in Nigeria.

The regression results in Table 3 reveal that investment in artificial intelligence demonstrates a significant positive influence on operational efficiency and sustainability performance in Nigeria's agricultural and waste-to-energy sectors. The coefficient value for AI investment ($\beta = 0.62$, $p < 0.01$) indicates that increased investment in AI technologies leads to improved productivity, better waste management, and enhanced system performance. Similarly, the sustainability index ($\beta = 0.55$, $p < 0.01$) shows that AI adoption contributes positively to environmental sustainability through efficient resource utilisation, waste reduction, and improved renewable energy processes. The low p-values confirm that the relationships are statistically significant. The findings therefore demonstrate that AI adoption supports long-term economic and environmental sustainability in Nigeria.

Table 3. Regression analysis

Variable	Coefficient	Std. Error	t-value	p-value
AI Investment	0.62	0.08	7.75	0.000
Operational Efficiency	0.48	0.07	6.85	0.000
Sustainability Index	0.55	0.09	6.11	0.000
Constant	1.20	0.30	4.00	0.001

Source: Authors Fieldwork, 2026

Table 4. Factors determining the effectiveness of AI deployment

Variables	Mean	Std. Dev.	Decision
Technical Skills Availability	4.12	0.73	Acceptable
Internet and Digital Infrastructure	4.05	0.81	Acceptable
Government Policy Support	3.96	0.77	Acceptable
Funding Availability	4.18	0.69	Acceptable
Electricity Supply Stability	4.22	0.71	Acceptable
Availability of AI Training	3.88	0.85	Acceptable
Public Private Partnership	3.91	0.80	Acceptable

Source: Author's Fieldwork, 2026

Table 4 identifies the major factors influencing the effectiveness of AI deployment in Nigeria's agricultural and waste-to-energy sectors. The findings show that stable electricity supply, funding availability, technical skills, and digital infrastructure are the most significant determinants of successful AI implementation. Government policy support and AI training opportunities also contribute positively to adoption effectiveness. The results suggest that inadequate infrastructure and limited technical expertise remain key barriers to optimal AI performance. Furthermore, the research emphasises the value of public-private partnerships in improving access to technology and innovation. Overall, the findings demonstrate that institutional, financial, and technical factors jointly determine AI deployment success.

The descriptive findings reveal that AI adoption levels are moderately high (mean = 3.84), indicating growing acceptance among stakeholders. This aligns with the Technology Acceptance Model (TAM), which posits that perceived usefulness drives adoption behaviour (Venkatesh et al., 2012). The high mean score for operational efficiency (4.02) further reinforces that users perceive AI technologies as beneficial in optimising processes such as precision farming, predictive maintenance, and automated waste sorting.

The regression results strengthen these observations by demonstrating that AI investment has a statistically significant positive effect on operational efficiency ($\beta = 0.62$, $p < 0.01$). This confirms that increased investment in AI technologies leads to measurable improvements in productivity and system performance. These findings are consistent with Li et al. (2022), who reported significant yield improvements in AI-enabled agricultural systems, and Fang et al. (2023), who found enhanced efficiency in AI-driven waste management systems. The convergence of descriptive perceptions and regression evidence indicates that stakeholders not only perceive AI as useful but also find it empirically effective.

From a cost–benefit perspective, the descriptive results show that the cost of implementation has a moderate mean score (3.67), indicating that while stakeholders recognize the financial burden, it is not prohibitive. This is further clarified by the regression analysis, which reveals that AI investment positively influences sustainability outcomes ($\beta = 0.55$, $p < 0.01$). This supports cost–benefit theory, which argues that long-term benefits can outweigh initial costs when investments yield sustained returns (Boardman et al., 2021).

In the Nigerian context, the benefits of improved agricultural productivity and efficient waste-to-energy conversion appear to justify the financial outlay. The sustainability dimension of the findings is particularly noteworthy. Environmental sustainability recorded a high mean score (3.95), indicating strong agreement among respondents that AI contributes to environmental protection. This is corroborated by the regression results, which show a significant relationship between AI adoption and sustainability outcomes. These results are consistent with sustainable development theory, which emphasises the need to balance economic, environmental, and social goals (UN, 2021). AI technologies, through optimised resource use and reduced waste, contribute to achieving these objectives. Empirical literature further supports these findings. UNEP (2022) highlights that AI can significantly reduce greenhouse gas emissions through improved waste management practices.

Similarly, Talaviya et al. (2024) demonstrate that AI-driven irrigation systems enhance water efficiency, thereby contributing to environmental sustainability. The present study expands on these findings by presenting evidence from Nigeria, where integrated analyses have been scarce. However, the descriptive results also reveal critical challenges. Technical capacity has the lowest mean score (3.41), indicating a significant skills gap. This finding is consistent with Ayangbenro et al. (2024) who identified limited technical expertise as a major barrier to AI adoption in Nigeria.

The regression analysis indirectly reflects this constraint, as the effectiveness of AI investment depends on the availability of skilled personnel to implement and maintain these technologies. This suggests that while AI has strong potential, its impact may be constrained by human capital limitations. Social impact, with a mean score of 3.78, indicates moderate positive effects on employment and social well-being. While AI can create new job opportunities in technology and data management, it may also displace traditional roles. This dual effect aligns with the broader literature on AI and labour markets, which emphasises the need for reskilling and workforce adaptation (IEA, 2023). The integration of findings also highlights regional disparities. Although not explicitly modelled in the regression, the demographic distribution suggests that states with better infrastructure and technological exposure (e.g., Lagos and Rivers) exhibit higher adoption and efficiency levels. This underscores the importance of contextual factors in shaping AI outcomes.

Overall, the combined descriptive and regression results provide a comprehensive understanding of AI adoption in Nigeria's agricultural and WTE sectors. The findings confirm that AI is both economically viable and environmentally beneficial, supporting the rejection of all null hypotheses. The study demonstrates that AI adoption leads to improved efficiency and sustainability, while also highlighting the importance of addressing cost and capacity challenges.

The findings demonstrate that AI adoption contributes significantly to technological innovation and energy sustainability within Nigeria's agricultural and waste-to-energy sectors. The positive relationship between AI investment and sustainability outcomes suggests that intelligent technologies enhance renewable energy generation efficiency while supporting environmentally responsible agricultural production. These findings align with recent studies by Dinrifo et al. (2025), Ayangbenro et al., (2025), and Fang et al. (2023), which emphasise the role of AI in promoting sustainable resource utilisation and energy efficiency. The results further indicate that technological capacity and infrastructure availability remain critical determinants of successful AI deployment. Consequently, investments in digital infrastructure, energy systems, technical training, and innovation ecosystems are essential for maximising the benefits of AI-driven development.

5. Conclusion

The study investigated the cost-benefit, technological, energy, and sustainability implications of artificial intelligence adoption in Nigeria's agricultural and waste-to-energy sectors. The findings revealed that AI adoption significantly improves operational efficiency, environmental sustainability, energy optimisation, and overall system performance. Regression results confirmed that investments in AI technologies positively influence both operational efficiency and sustainability outcomes, indicating that the long-term benefits of AI adoption outweigh implementation costs. The findings further revealed that stable electricity supply, funding availability, technical expertise, and digital infrastructure are critical determinants of successful AI deployment.

These results suggest that AI can serve as an important catalyst for sustainable agricultural transformation and renewable energy development in Nigeria. However, the realisation of these benefits requires deliberate investments in infrastructure, human capital development, supportive policies, and institutional partnerships.

This study is limited by its cross-sectional design and reliance on self-reported survey data, which may not fully capture long-term impacts of AI adoption. In addition, the study focused primarily on selected states across Nigeria and therefore may not reflect all regional variations. Future studies should employ longitudinal research designs, incorporate objective performance indicators, and conduct comparative analyses across African countries. Further investigations may also explore sector-specific AI applications in renewable energy generation, precision agriculture, climate-smart farming, and circular economy systems.

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Ethics approval/declaration: Ethical approval for this study was obtained from a recognized Institutional Research Ethics Committee before data collection commenced. The study complied with the ethical principles for research involving human participants, including voluntary participation, confidentiality, anonymity, and informed consent.

Consent to participate: Informed consent was obtained from all participants before their inclusion in the study. Participants were informed about the objectives of the research and their right to withdraw at any stage without penalty.

Consent for publication: All authors have reviewed and approved the final manuscript and consent to its publication. Participants were informed that anonymize data obtained from the study may be used for academic publication and research purposes.

Data availability: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Authors contribution: Nathan Udoinyang - Conceptualization, methodology, data analysis, interpretation of results, manuscript drafting, supervision, and corresponding author responsibilities. Reuben Daniel - Literature review, questionnaire design, field data collection coordination, manuscript review, and editing. Akarue Blessing Okiemute - Research design, agricultural systems analysis, data validation, interpretation of findings, and manuscript review. Aboh Peter Chukwuedu - Data collection, statistical verification, literature compilation, proofreading, and manuscript editing. All authors read, reviewed, and approved the final version of the manuscript.

References

Ayangbenro, A. S., Mbohwa, C., & Telukdarie, A. (2024). Artificial intelligence applications in agriculture: Opportunities and challenges for sustainable food systems. Smart Agricultural Technology, 8, 100486.

Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. (2021). Cost-benefit analysis: Concepts and practice (5th ed.) Cambridge University Press.

Diallo, K., Smith, J., Okolo, C. T., Nyamwaya, D., Kgomo, J., & Ngamita, R. (2024). Case studies of AI policy development in Africa. arXiv Preprint arXiv:2403.14662.

Dinrifo, R. R., Alonge, A. F., Audu, J., & Adegbenjo, A. O. (2025). A review of the applications of artificial intelligence in agriculture: Prospects and challenges in Nigeria. Journal of Agricultural Engineering and Technology https://jaet.niae.net/index.php/jaet/article/view/160

Falola, A., Musa, M. O., Mukaila, R., Olanrewaju, A., & Subair, T. H. (2024). Determinants of value addition to plantain among small-scale farmers in Kwara State, Nigeria. Kufa Journal for Agricultural Sciences, 16(4), 1–12. https://doi.org/10.36077/kjas/2024/v16i4.15871

Fang, B., Yu, J., Chen, Z., Osman, A. I., Farghali, M., Ihara, I., Hamza, E. H., Rooney, D. W., & Yap, P. S. (2023). Artificial intelligence for waste management in smart cities: A review. Environmental Chemistry Letters, 21, 1959–1995. https://doi.org/10.1007/s10311-023-01604-3

Food and Agriculture Organization (FAO). (2022). The state of food and agriculture. FAO.

International Energy Agency (IEA). (2023). Artificial intelligence and energy.

Li, J., Zhao, X. (2021). Precision agriculture using artificial intelligence. Computers and Electronics in Agriculture, 190, 106420. https://doi.org/10.1016/j.compag.2021.106420

Talaviya, T., Shah, D., Patel, N., Yagnik, H., & Shah, M. (2020). Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. Artificial Intelligence in Agriculture, 4, 58–73.

Udoinyang, N. (2024). The impact of agriculture, non-renewable energy, international trade and economic growth on Nigeria's environmental sustainability. Frontiers in Environmental Research, 2(2), 79–86. https://doi.org/10.61784/fer3009World Bank (2023). Nigeria's economic update.

Udoinyang, N., Sunday, F. C., & Daniel, R. (2024). Renewable energy and sustainable economic development in Nigeria: A case study of Rivers State (2000–2022). Journal of Economics, Environment and Energy, 3(1), 20-36. https://doi.org/10.56946/jeee.v3i1.322

United Nations (2021). Sustainable development goals report.

United Nations Environmental Programme. Global waste management outlook (2022).

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory. MIS Quarterly, 36(1), 157–178. https://doi.org/10.2307/41410412

Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Nerini, F. F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. Nature Communications, 11, 233. https://doi.org/10.1038/s41467-019-14108-y3.

World Bank (2023). Nigeria's economic update.

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