International Journal of Innovative Finance and Economics Research 14(3):145-162, July-Sept, 2026
© SEAHI PUBLICATIONS, 2026 www.seahipublications.org ISSN: 2467-8473

DOI:10.5281/zenodo.21464510

Influence of Green Artificial Intelligence Adoption on Sustainable Innovation: Evidence from Ghana and Nigeria

[1]Obianuju Precious Chekwube-Aziekwe & [2]Lucy Cecilia Mmadubuobi

[1,2]Department of Accountancy, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria
[1]op.aziekwe@unizik.edu.ng
[2]lc.mmadubuobi@unizik.edu.ng

ABSTRACT
The study is set out to accessing the influence of Green Artificial Intelligence Adoption on sustainable Innovation: Evidence from Ghana and Nigeria. Specifically, it assessed the level of awareness and adoption of Green AI, identified key opportunities, and analyzed the major challenges hindering its implementation. A survey research design was adopted, involving a population of 74,324 professional accountants and a sample size of 398 respondents selected through snowball sampling. Data were collected using an electronic questionnaire distributed via Google Forms. One-sample t-test and Structural Equation Modeling were applied to test the hypotheses at a 5% significance level. The findings revealed that: there is a significant level of awareness and adoption of Green AI among professional accountants in Ghana and Nigeria ($t(397) = 14.521$, $p = .000$, $M = 3.52$); adoption of Green AI has a positive and significant effect on sustainable innovation ($\beta = 0.6138035$, $p = 0.000$); challenges facing the implementation of Green AI have a negative and significant effect on sustainable innovation ($\beta = -0.329016$, $p = 0.000$). Hence, promoting Green AI in Ghana and Nigeria can advance sustainable development through informed investment and policy direction. It was recommended that the Financial Reporting Council of Nigeria and the Ghana National Information Technology Agency should establish enabling policies and financial incentives that support the deployment of Green AI infrastructure by providing access to funding, technical support, and favorable regulations to reduce the barriers to implementation.
Keywords: Green Artificial Intelligence, Sustainable Innovations

1.0 INTRODUCTION

In recent years, technological advancement has become one of the most defining forces shaping global development, particularly in the areas of Artificial Intelligence (AI), digital transformation, and sustainability. The use of AI requires enormous computational power, energy consumption, and data processing capabilities, which often lead to a substantial carbon footprint (Mitu & Mitu, 2024). Ahmad, 2024, observed that Green Artificial Intelligence (Green AI) has emerged as an innovative approach that seeks to promote energy-efficient, environmentally responsible, and socially beneficial AI systems. Green AI emphasizes the development and use of AI models and applications that minimize environmental harm while maximizing economic and social benefits. For developing economies, where sustainable development remains a central goal (Oppong, 2022), the adoption of Green AI presents a new frontier for balancing technological advancement with environmental conservation. The global shift toward

sustainability makes it necessary for these nations to explore how emerging technologies like Green AI can help bridge the gap between growth and responsibility.

In today's competitive economy, businesses and governments alike are expected to integrate sustainability into their operations and strategies (Nworie & Orji-Okafor, 2024; Ukoh et al., 2024; Okafor & Nworie, 2025). Green AI contributes to this shift by promoting AI systems that are efficient, less energy-intensive, and capable of addressing environmental issues such as climate change, resource management, and pollution control (Ahmad, 2024).

Sustainable innovation, on the other hand, refers to the process of developing new products, services, and technologies that not only drive economic growth but also reduce negative environmental and social impacts. Together, these concepts align with the global push toward responsible innovation, where progress is achieved without compromising the needs of future generations (El Khirani, 2024).

Developing economies like Ghana and Nigeria, while embracing Green AI and sustainable innovation can open new avenues for economic diversification, technological capacity building, and improved public services. Sectors such as agriculture, energy, healthcare, and transportation can benefit immensely from sustainable Green AI applications that optimize resources while lowering emissions. Moreover, as global investors and trade partners increasingly prioritize sustainability, countries that adopt Green AI stand to gain access to new markets and funding opportunities. Therefore, the integration of Green AI into sustainable innovation strategies is not merely an environmental consideration but also a pathway to economic competitiveness, resilience, and long-term national development (Yigitcanlar, Mehmood, & Corchado (2021). Such a situation would allow developing countries to benefit from innovation while protecting their environment and supporting long-term growth. Through strong policies, investments in research, and collaboration among public and private sectors, developing nations could build technological ecosystems that use AI to drive sustainable innovations across agriculture, energy, healthcare, and education.

However, despite growing interest in Artificial Intelligence, the concept of Green Artificial Intelligence appears to be relatively new and underexplored in many developing economies (Aderibigbe, Ohenhen, Nwaobia, Gidiagba & Ani (2023). There is limited awareness among policymakers, industry leaders, and technology practitioners about the environmental implications of AI systems (Ahmad, 2024). Many organizations continue to adopt artificial Intelligence solutions that require high computational power without considering their environmental cost. As a result, the current pattern of AI development risks widening the gap between technological advancement and sustainable development in Ghana and Nigeria. The continued reliance on high-energy AI systems could increase energy demand, contribute to carbon emissions, and place pressure on already limited resources. Without deliberate efforts to promote Green AI, the promise of sustainable innovation may not be fully realized (Ahmad, 2024). This could hinder progress toward achieving national and global sustainability goals, limit the competitiveness of local industries, and increase dependence on environmentally harmful technologies. In the long term, failure to address these challenges may prevent Ghana and Nigeria from taking advantage of AI-driven opportunities that could foster inclusive growth and environmental protection. Both countries host Universities, research labs, and innovation hubs (e.g Ghana NLP, Data science Nigeria) contributing to AI development. However, this study examines the current level awareness of Green AI technologies, opportunities of adoption of Green AI, and challenges facing the adoption of Green AI in developing countries using Ghana and Nigeria as a case study.

The main objective of the study is to examine the Influence of Green Artificial intelligence Adoption on Sustainable Innovation: Evidence from Ghana and Nigeria. The specific objectives are to:

1. Assess the current level of awareness and adoption of Green AI technologies for sustainable innovations in Ghana and Nigeria.
2. Identify the key opportunities that Green AI presents for sustainable innovation in Ghana and Nigeria.

3. Analyze the major challenges hindering the implementation of Green AI for sustainable innovation in Ghana and Nigeria

1.1 **Null Hypotheses**

H_{01}: There is no significant level of awareness and adoption of Green AI for Sustainable innovation in Ghana and Nigeria.

H_{02}: Green AI does not significantly contribute to sustainable development in Ghana and Nigeria.

H_{03}: The challenges faced in implementing Green AI have no significant effect on its adoption in Ghana and Nigeria.

2.0 LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Adoption of Green Artificial Intelligence (Green AI)

Green Artificial Intelligence refers to the development and use of artificial intelligence systems that are designed to reduce environmental harm and promote energy efficiency (Ahmad, 2024). It involves creating algorithms, data centers, and computational processes that consume less energy while maintaining high levels of performance. The focus is on making AI technology environmentally responsible by limiting the carbon footprint that results from data processing, machine learning training, and deployment (El Khirani, 2024). This approach encourages researchers, industries, and governments to consider how the creation and use of AI can align with sustainability goals and contribute to environmental protection. Green AI promotes a balance between technological advancement and ecological responsibility. It recognizes that traditional AI systems often require massive computing resources, leading to increased power consumption and higher greenhouse gas emissions. Green AI seeks to counter this trend by encouraging the use of energy-efficient hardware, renewable energy sources, and improved algorithmic design that reduces computational demands (Bhive, 2025), Green AI seeks to mitigate this through: model compression, low-Power chips, Edge AI systems, and renewable-energy-powered data centers Through such efforts, it becomes possible to make AI systems not only intelligent and powerful but also conscious of environmental limits. This aligns with global calls for sustainable development, particularly in addressing challenges such as climate change, pollution, and resource depletion.

In addition to improving energy efficiency, Green AI also encourages ethical and responsible innovation. It involves rethinking how data is collected, processed, and stored, ensuring that AI systems are developed in ways that respect environmental and social well-being (Yigitcanlar et al., 2021). For developing countries, Green AI provides an opportunity to use technology in ways that promote economic growth without sacrificing environmental integrity. By investing in sustainable AI research, training, and infrastructure, nations can ensure that technological progress contributes to a cleaner, more sustainable future (Ahmad, 2024). Green AI therefore represents a pathway toward responsible technological transformation that supports both human advancement and environmental preservation. The proxies for Green AI in this study are: Energy-Efficient AI, Carbon-Aware AI, Sustainable AI Lifecycle Management, and Green Cloud AI. Energy-Efficient AI reduces the power consumption of artificial intelligence systems by optimizing algorithms and hardware for lower energy use (Zhu et al., 2022). Carbon-Aware AI minimizes emissions by scheduling computations in regions or times where renewable energy is available (Vergallo & Mainetti, 2024). Sustainable AI Lifecycle Management ensures environmental responsibility throughout every stage of AI development, from data creation to hardware disposal (Dua & Patel, 2024). Green Cloud AI operates within cloud environments powered by renewable energy, reducing emissions from large-scale data processing (Yang et al., 2018).

2.1.2 Opportunities for Green AI Adoption in Ghana and Nigeria

Green Artificial Intelligence offers an important pathway for addressing development needs while minimizing environmental impact. In developing countries, Green AI can support innovation across renewable energy, agriculture, transportation, urban management, and public services. Both Ghana and

Nigeria face dual challenge of rising electricity demand and the need to decarbonize their power sectors. Green AI contributes to this through: Smart Grid Optimization, Renewable Energy forecasting :,Agyeman, quansah,Ntiamoah, Mensah, & Ramde, (2021),Climate Smart Agriculture:,Quanshie, abdulai & Fraser(2023), Smart Cities and Urban services, Environment monitoring and climate resilience, Digital Innovation startup and Talent Development, Alignment with Policy& Global Sustainability goals. Adoption of Green AI can improve greater opportunities for developing countries under study. As global attention shifts toward sustainable digital development, Ghana and Nigeria stands at a critical juncture where adoption of Green AI can help them leapfrog traditional, carbon-heavy pathways and a more sustainable digital future

2.1.3 Challenges Facing Green AI in Ghana and Nigeria

Despite the significant potential of Green AI, a combination of infrastructural, economic, policy, and socio-technical barriers limits its adoption in Ghana and Nigeria. Infrastructural constraints i.e. Inadequate digital and energy infrastructure, Limited access to high performance computing, unstable electricity supply, High computational cost & carbon footprint; Stubell, Ganesh, & McCallum, (2019), Policy & Regulatory Gaps, Data scarcity & Digital Inequality, Skill Gap, Brain Drain & Ethical Challenges. All this challenges continue to constrain adoption.

2.1.4 Sustainable Innovation

Sustainable innovation refers to the creation and improvement of products, services, or processes that promote economic development while reducing environmental harm and fostering social well-being (Oksanen & Hautamäki, 2015). It involves finding new ways of producing and delivering goods and services that use fewer natural resources, generate less waste, and create long-term value for both society and the environment (Bhive, 2025). Unlike traditional forms of innovation that focus mainly on profitability or efficiency, sustainable innovation integrates environmental and social considerations into every stage of development, from design to implementation. This approach encourages organizations and governments to pursue progress without compromising the ability of future generations to meet their own needs. It recognizes that true advancement must consider not only financial gains but also the protection of ecosystems, community welfare, and equitable resource distribution. Sustainable innovation therefore represents a shift in how societies think about growth and competitiveness, emphasizing responsibility and long-term impact over short-term success (Ahmad, 2024). It often involves adopting cleaner technologies, renewable energy, and circular economic practices that allow materials and products to be reused or repurposed rather than discarded.

In developing economies, Yousaf et al. (2021) averred that sustainable innovation has the potential to drive inclusive growth by addressing environmental and social challenges while promoting industrial and technological development. For instance, innovations in agriculture can improve productivity while conserving soil and water, and advancements in energy can expand access to power while reducing emissions. When businesses and institutions commit to sustainable innovation, they contribute to a system where economic prosperity, social progress, and environmental preservation move forward together (Saxena et al., 2024). In this way, sustainable innovation serves as a foundation for building resilient economies that are capable of sustaining both people and the planet over the long term.

2.2 Theoretical Framework

2.1 Innovation Diffusion Theory

The Innovation Diffusion Theory was developed by Everett Rogers in 1962 to explain how new ideas, technologies, and practices spread within a society or organization over time (Ikwuo et al., 2024). Rogers drew from research in sociology, communication, and rural development to understand why some innovations are quickly adopted while others face resistance. The main postulations of the Innovation Diffusion Theory are that the adoption of a new technology depends on several factors, including the perceived advantage of the innovation, its compatibility with existing values and practices, its complexity, the possibility of trying it out before full use, and the visibility of its results (Patnaik & Bakkar, 2024). The theory also categorizes adopters into groups such as innovators, early adopters, early majority, late

majority, and laggards, depending on how quickly they embrace new ideas. Communication channels, social systems, and the time factor play major roles in determining how fast and widely an innovation spreads. Essentially, the theory suggests that adoption is not a uniform process but rather one influenced by social structure, perception, and access to information (Pinho et al., 2021).

This theory is relevant to the study of Green Artificial Intelligence in developing economies like Ghana and Nigeria because it helps explain how new and sustainable technologies can be accepted or resisted in different contexts. The adoption of Green AI depends not only on its technical benefits but also on awareness, institutional readiness, and perceived usefulness among stakeholders (El Khirani, 2024). Using this framework, the study can explore how factors such as knowledge dissemination, cultural compatibility, and resource availability affect the acceptance of environmentally friendly AI solutions.

2.3 Empirical Review

Song and Deng (2025) explored how Artificial Intelligence (AI) influences Green Economic Efficiency (GEE) using panel data from 30 provinces in China between 2011 and 2020. Their findings reveal that AI significantly improves GEE, though its effects differ across regions and governance structures. The impact is stronger in provinces that are economically advanced and technologically developed. Regarding governance, excessive reliance on market-based environmental regulations tends to weaken the positive impact of AI on GEE, while administrative-command and informal environmental regulations enhance it. Substantive green technological innovation appears to reduce AI's effectiveness due to high investment requirements, whereas symbolic green innovations strengthen it. The study also found that both administrative and judicial intellectual property protections could lessen AI's marginal effect, with administrative protection showing a stronger threshold effect.

Al Halbusi, Al-Sulaiti, Alalwan, & Al-Busaidi,(2025) analyzed how AI capabilities influence green innovation and, in turn, affect sustainable performance and circular economy outcomes. Their study also introduced big data analytics and knowledge management systems as moderating factors linking AI capabilities to green innovation. Using data from multiple industrial sectors in Qatar, they employed structural equation modeling (SEM) and artificial neural networks (ANN) for analysis. The study found that AI capabilities have a significant positive impact on green innovation, which in turn strengthens sustainable performance and circular economy objectives. Moreover, big data analytics and knowledge management systems amplify this relationship, suggesting that their integration enhances AI-driven sustainability outcomes.

Mijit, Xu, & Ma, (2025) examined the influence of Artificial Intelligence Innovation and Development Pilot Zones (AIIDPZ) on green innovation in China. Using data from listed firms, they applied a heterogeneity-robust difference-in-differences approach to evaluate how the AIIDPZ policy affected firms' green innovation outcomes. The findings show that the policy significantly increased both the quantity and quality of green innovations, with varying effects across industries. Low-polluting firms tended to expand the quantity of innovations, while capital- and labor-intensive sectors focused more on improving innovation quality. Mechanism analysis revealed that AI adoption improved operational efficiency, which in turn promoted advanced green innovation.

Chen, Khan, & Chen, (2024) investigated the relationship between big data analytics–artificial intelligence (BDA-AI), supply chain ambidexterity, and sustainable innovation performance. The study explored how these elements influence sustainable supply chain management (SSCM), innovation ambidexterity, and environmental outcomes. Using data from manufacturing sector employees, the results demonstrated that BDA-AI and supply chain ambidexterity significantly enhance SSCM, which subsequently improves sustainable innovation and environmental performance. The analysis also revealed that SSCM serves as a mediating factor linking BDA-AI and supply chain ambidexterity to innovation and environmental performance.

Raman, Pattnaik, Lathabai, Kumar, Govindan, & Nedungadi, (2024) reviewed literature on Green AI and Sustainable AI using thematic analysis combined with BERT opic modeling to identify both broad and emerging themes. The analysis revealed three major thematic clusters: responsible AI for sustainable

development, advancements in energy-efficient AI, and big data-driven computational progress. Five emerging research themes were also identified, including ethical eco-intelligence, sustainable neural computing, and cognitive AI innovation. The study highlights a growing convergence between ethical AI, sustainability, and green computing, suggesting that future AI development should balance technological advancement with environmental and ethical responsibility. This aligns with global sustainability goals that promote ecological preservation and responsible technological progress.

Ridwan, Bala, Shiam, Akhter, Asrafuzzaman, Shochona, & Shoha, (2024) analyzed the role of AI in promoting environmental sustainability in the United States between 1990 and 2019. The study also assessed how financial development, ICT usage, and economic growth affect the Load Capacity Factor (LCF). Using an Autoregressive Distributed Lag (ARDL) model, the researchers found long-term relationships among variables and validated the Load Capacity Curve hypothesis. The results indicated that AI and ICT contribute positively to environmental capacity, while financial development and population growth negatively affect it. Robustness tests supported these findings, confirming the reliability of the model. The study emphasizes the importance of AI and digital technologies in enhancing environmental resilience while managing the ecological impact of population and financial activities.

Rashid A., Baloch N., Rasheed R., and Ngah, A. H, (2025) examined the role of big data analytics (BDA) powered by artificial intelligence (AI) in improving sustainable performance (SP) through green supply chain collaboration (GSCC), sustainable manufacturing (SM) and environmental process integration (EPI). Data was collected from 249 supply chain professionals working at various manufacturing firms, and hypotheses were tested through a quantitative method using PLS-SEM with the help of SmartPLS version 4 to validate the measurement model. The study identified that BDA-AI significantly and positively affects GSCC, SM and EPI. Similarly, the results showed that GSCC significantly and positively affects SP. At the same time, SM and EPI have an insignificant effect on SP. The GSCC found a significant relationship between BDA-AI and SP for mediation. However, SM and environmental performance integration did not mediate the relationship between BDA and AI Adebola, F., Kehinde,O., Temitope,A., and Bunmi, S. (2024) examined A policy framework on AI usage in Developing Countries and it's impact. The policy tailored to developing countries, emphasizing the need for robust infrastructure, capacity building, ethical governance, and economic incentives. Key elements include the development of digital infrastructure, education and training programs to enhance AI literacy, and ethical guidelines to ensure fairness and transparency in AI applications. Data governance and privacy protections are critical, particularly in countries where regulatory frameworks are underdeveloped. Furthermore, international cooperation is highlighted as a necessity for aligning local policies with global AI standards, facilitating cross-border data sharing, and ensuring equitable access to AI innovations. The potential impact of AI on economic growth, job creation, healthcare, education, and public service delivery is profound, yet challenges such as workforce displacement, increased inequality, and the digital divide must be carefully managed. The proposed framework addresses these challenges, providing strategies to overcome barriers to AI adoption, including financial constraints, governance issues, and unequal access to technology. Moreover, it stresses the importance of fostering public-private partnerships and ensuring that AI development is inclusive, benefiting all segments of society. By implementing a comprehensive AI policy framework, developing countries can harness AI's transformative power to drive sustainable development, improve social outcomes, and strengthen their economic standing in the global landscape. This review concludes by recommending continuous policy evaluation and adaptation to keep pace with AI's rapid evolution.

Melguizo, Katz, and Jung, (2025) carried out a research on the novel empirical evidence on AI development and its environmental implications in 23 middle and high-income countries, confirming that, initially, in the majority of countries AI increases energy consumption and CO2 emissions. However, the study showed that these relationships are not linear, since, for high spending levels, AI has a positive impact on the environment in terms of emission reduction and higher reliance on renewable energies, a kind of g*reen AI Kuznets curve*. This reversal in the trend is achieved from $220-$580 AI market per

capita, and therefore, as of today, only AI leading countries, such as Singapore and the US, are benefitting from this technological dividend. These results have clear policy implications, calling for a less fragmented global AI and energy governance given environmental externalities, national AI strategies with a solid energy pillar, and innovations in financing towards greener AI adoption, while achieving more transparency and standards for measuring and reporting its energy use.

Yin, Cai, and Hung (2023), investigated on "How does Artificial Intelligence development affect Green technology Innovation in China? Evidence from dynamic panel data analysis" Based on China's inter-provincial panel data from 2006 to 2019, the system GMM, dynamic panel threshold model, and quantile regression model were constructed to examine various influences of AI development on GTI under different environmental regulation intensity, research and development (R&D) investment, and institutional environmental threshold conditions. The findings presented that AI development significantly contributes to GTI and GTFP, with an impact coefficient of 0.0122 and 0.0084, and this influence is mainly reflected in the western region of China and is more obvious in the 2006–2012 period. AI development mainly enhances green technological efficiency, and it has dampening effects on green technological progress during the period 2013–2019. Additionally, there are non-linear threshold effects in the relationship between the level of AI development and GTI when environmental regulatory intensity, R&D investment, and institutional environment are in different level intervals. AI development will boost GTI only when the intensity of environmental regulation and institutional environment is above a certain threshold value.

Umoudo, John, & Augustine, (2024) investigated how green technologies contribute to sustainable economic development in Nigeria, focusing on sectors such as energy, agriculture, and waste management. Their research highlighted that renewable energy, energy-efficient systems, and sustainable farming practices can mitigate environmental challenges while driving economic progress. Using a descriptive research design and a stratified random sampling method, data were gathered from 385 participants across sectors actively using green technologies. Structured questionnaires ensured content validity and reliability testing. The findings showed a strong positive relationship between the adoption of green technologies and sustainable economic outcomes, particularly in energy efficiency and resource management. However, challenges such as high costs and limited technical expertise persist. The study advocates for stronger governmental support, infrastructure investment, education to maximize the benefits of green technology.

Ali and (2023) explored how Green AI can advance sustainability by integrating machine learning to support a circular economy. The study emphasizes that while AI technologies currently consume significant energy, they can also be repurposed to reduce emissions and resource waste. Green AI focuses on embedding environmental efficiency into AI systems, encouraging reuse, recycling, and remanufacturing to create closed-loop supply chains. This approach moves industries away from the traditional linear economy model toward one that maximizes resource efficiency. The paper proposes AI-driven optimization frameworks as key to achieving economically viable and environmentally sound industrial systems.

Varshney et al. (2023) examined how AI-driven green technologies can enhance sustainable practices across renewable energy, waste management, agriculture, and eco-friendly materials. Their interdisciplinary analysis showed how innovation in these areas can transform industries while minimizing environmental harm. The research also discussed challenges such as economic barriers, policy constraints, and low public awareness that hinder widespread adoption. Case studies demonstrated tangible environmental and economic benefits of implementing green technologies, confirming their practical feasibility. The authors emphasized that innovation and collaboration among governments, industries, and communities are essential for achieving a sustainable future where technological progress aligns with environmental preservation.

3.0 METHODOLOGY

This study adopted a survey research design to obtain quantitative data from members of professional accounting bodies in Ghana and Nigeria. The design was considered appropriate because it allows for the collection of data from a large population within a relatively short time and helps capture opinions, perceptions, and experiences related to the awareness, adoption, opportunities, and challenges of Green Artificial Intelligence (Green AI). The survey approach enabled the researcher to gather primary information through structured questions, providing empirical evidence on the state of Green AI implementation and its relationship with sustainable innovation in developing economies.

The population of the study consisted of professional accountants who are members of recognized accounting institutes in both Ghana and Nigeria. Specifically, the study targeted 67,887 members of the Institute of Chartered Accountants of Nigeria (ICAN) (ICAN, 2025) and 6,437 members of the Institute of Chartered Accountants (Ghana) (ICAG) (Boso & Essuman, 2021). The combined population was therefore 74,324 members. These groups were selected because accountants are increasingly involved in sustainability reporting, corporate governance, and innovation-driven decision-making, which aligns with the objectives of Green AI and sustainable development.

The sample size for the study was determined using the Taro Yamane (1967) formula, which is stated as:

Sample Size = $= \frac{N}{1+N\,(e)^2}$

Where:

n = sample size

N = population size

e = level of significance (0.05)

Substituting for the total population of 74,324:

Sample size = $\frac{74,324}{1+74,324\ (0.05)^2}$

Sample size = 397.8

Thus, the sample size is approximately 398 respondents. A snowball sampling technique was used to select participants for the study. The approach began with a few ICAN and ICAG members who were knowledgeable about technological and sustainability issues. These initial respondents then referred other qualified members within their professional networks to participate in the survey. This method was chosen because it allowed the researcher to reach a wider group of professionals who possess relevant understanding of Green AI and sustainable innovation in Ghana and Nigeria.

Data were collected using a structured electronic questionnaire designed through Google Forms. The questionnaire consisted of both closed-ended and Likert-scale items aligned with the study's specific objectives. Respondents were instructed to rate each statement based on the extent to which it applied to them, using a 5-point Likert scale where 5 represented a Very High Extent, 4 represented a High Extent, 3 indicated Neutral, 2 denoted a Low Extent, and 1 signified a Very Low Extent. The research instrument was distributed electronically to the respondents through institutional mailing lists and professional networking platforms of ICAN and ICAG members. This method ensured wider reach, cost-effectiveness, and convenience, allowing respondents to complete the questionnaire at their own pace while maintaining confidentiality.

The data collected were analyzed using descriptive and inferential statistical methods. Frequency counts and mean scores were used to summarize and present responses related to awareness, opportunities, and challenges of Green AI adoption. The first hypothesis, which focused on the level of awareness and adoption of Green AI, was tested using the one-sample t-test to determine whether the observed awareness level differed significantly from neutrality. The second and third hypotheses were analyzed using Structural Equation Modeling (SEM) to examine the relationships between Green AI adoption, sustainable innovation, and implementation challenges. All statistical tests were conducted at a 5% level of significance ($p < 0.05$) to determine acceptance or rejection of the null hypotheses. Participation in the

study was voluntary, and informed consent was obtained from all respondents before completing the questionnaire. Confidentiality of responses was assured, and no personal identifiers were collected. The data were used solely for academic purposes and stored securely to maintain privacy and integrity.

4.0 DATA ANALYSIS

4.1 Descriptive Analysis

Table 4.1 presents the descriptive statistics on respondents' views regarding the level of awareness and adoption of Green Artificial Intelligence (Green AI), sustainable innovation, and the challenges facing the implementation of Green AI. The responses were measured using a 5-point Likert scale ranging from Very Low Extent (VLE) to Very High Extent (VHE). 211 responses were retrieved from Nigerian professional accountants while 187 responses were retrieved from Ghanaian professional accountants.

Table 4.1 Descriptive Statistics

S/N	Level of Awareness and Adoption of Green AI	VLE	LE	N	HE	VHE	Mean
1	I am aware of the concept of Green Artificial Intelligence.	7	41	126	140	84	3.64
2	My organization or professional community has discussed Green AI initiatives.	8	33	136	140	81	3.64
3	I understand how Green AI can contribute to environmental sustainability.	5	49	146	135	63	3.51
4	Green AI technologies are being adopted in my country or industry.	7	63	145	119	64	3.43
5	Training and educational programs on Green AI are available to professionals in my country.	10	54	129	115	90	3.56
6	My organization uses or plans to use AI systems that are energy-efficient and environmentally friendly.	20	92	111	88	87	3.33
7	Awareness campaigns or workshops on Green AI are common in my professional field.	23	50	125	110	90	3.49
8	The use of AI in my workplace includes consideration of environmental impacts.	10	48	134	113	93	3.58
S/N	**Sustainable Innovation**	**VLE**	**LE**	**N**	**HE**	**VHE**	**Mean**
9	My organization promotes innovation that considers both economic and environmental outcomes.	9	47	132	126	84	3.58
10	AI technologies can support sustainable development goals in developing countries.	6	47	128	116	101	3.65
11	Green AI has the potential to improve resource efficiency and reduce waste.	14	63	107	106	108	3.58
12	Adoption of sustainable innovation improves an organization's competitiveness.	10	58	113	124	93	3.58
13	Green AI can promote responsible production and consumption in industries.	6	40	126	141	85	3.65
14	My sector encourages innovations that reduce environmental pollution.	9	47	113	117	112	3.69
15	Sustainable innovation leads to long-term economic and social benefits.	3	55	113	129	98	3.66
16	The integration of AI with sustainability practices enhances national development.	9	37	134	116	102	3.67
S/N	**Challenges Facing the Implementation of Green AI**	**VLE**	**LE**	**N**	**HE**	**VHE**	**Mean**

17	There is limited awareness of Green AI among professionals in my country.	114	100	125	50	9	2.35
18	High cost of implementation discourages the adoption of Green AI.	97	114	116	61	10	2.43
19	Lack of clear government policy on AI sustainability limits adoption.	88	108	121	75	6	2.51
20	There is insufficient infrastructure to support Green AI technologies.	88	95	119	79	17	2.60
21	Inadequate technical skills among professionals hinder Green AI implementation.	90	116	114	76	2	2.46
22	Limited collaboration among government, industry, and academia affects progress.	91	122	142	43	0	2.34
23	Organizations give little priority to environmental sustainability in AI projects.	110	95	104	81	8	2.45
24	Inadequate funding and investment opportunities slow down the adoption of Green AI.	115	100	104	75	4	2.38

Source: Field Survey (2025)

For the level of awareness and adoption of Green AI, the results generally indicate a moderate to high level of awareness among respondents. A majority (140 respondents) agreed to a high extent that they are aware of the concept of Green AI, with a mean score of 3.64, suggesting fair knowledge among professionals. Similarly, 140 respondents also agreed to a high extent that their organizations or professional communities have discussed Green AI initiatives, showing growing engagement in sustainability conversations. When asked about understanding Green AI's contribution to environmental sustainability, 135 respondents agreed to a high extent, though the mean of 3.51 implies a moderate understanding overall. Regarding the adoption of Green AI technologies in their countries or industries, 145 respondents were neutral, showing uncertainty about actual implementation, reflected in a slightly lower mean of 3.43. On the availability of Green AI training and education, 115 respondents agreed to a high extent, with a mean of 3.56, indicating that such programs are becoming more accessible. Concerning the use of energy-efficient AI systems, responses were more varied, with 111 neutral and 92 low-extent responses, giving a lower mean of 3.33, suggesting limited application. Awareness campaigns and workshops on Green AI were also rated moderately, with a mean of 3.49, showing they occur occasionally but not widely. Finally, 113 respondents agreed that environmental considerations are included in workplace AI use, with a mean of 3.58, reflecting growing but uneven attention to sustainability in AI practices.

On sustainable innovation, the responses were generally positive, indicating a high recognition of its importance. For example, 126 respondents agreed to a high extent that their organizations promote innovation considering both economic and environmental outcomes, with a mean of 3.58. Similarly, 116 respondents agreed that AI can support sustainable development goals, and 101 rated this to a very high extent, yielding a strong mean of 3.65. When asked if Green AI improves resource efficiency and reduces waste, 106 respondents agreed to a high extent, resulting in a mean of 3.58, suggesting broad agreement on its potential benefits. The same mean (3.58) was recorded for the view that sustainable innovation enhances competitiveness. A high number of respondents (141) agreed that Green AI promotes responsible production and consumption, supported by a mean of 3.65. Respondents also acknowledged that their sectors encourage innovations that reduce pollution, with 117 agreeing to a high extent and 112 to a very high extent, giving the highest mean in this section (3.69). Views on long-term economic and social benefits of sustainable innovation also remained strong, with 129 agreeing to a high extent and a mean of 3.66. Similarly, 116 respondents agreed that integrating AI with sustainability practices enhances national development, yielding a mean of 3.67. Overall, this section shows a strong consensus that Green AI and sustainable innovation are interlinked and essential for development.

Conversely, the section on challenges facing the implementation of Green AI reveals significant obstacles, as reflected in the low mean scores across all items. A total of 114 respondents agreed to a very low extent that professionals in their countries are aware of Green AI, resulting in a mean of 2.35, which confirms widespread low awareness. Similarly, the high cost of implementation was identified as a challenge by 114 respondents at a low extent level, with a mean of 2.43, implying financial constraints are a major barrier. Lack of clear government policy also had a low mean of 2.51, showing that weak regulatory support hinders adoption. Insufficient infrastructure was another concern, with 95 respondents indicating a low extent and a mean of 2.60, the highest among the challenges but still showing inadequate readiness. Regarding technical skills, 116 respondents reported a low extent, resulting in a mean of 2.46, highlighting skill gaps among professionals. Limited collaboration between government, academia, and industry recorded the lowest mean (2.34), reflecting poor institutional linkages. The perception that organizations give little attention to environmental sustainability in AI projects had a mean of 2.45, indicating minimal prioritization. Lastly, inadequate funding and investment had a mean of 2.38, confirming that financial limitations significantly slow the adoption of Green AI.

4.2 Test of Hypotheses

H_{01}: There is no significant level of awareness and adoption of Green AI in Ghana and Nigeria.

Table 4.2Test of Hypothesis I

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Level of Awareness and Adoption of Green AI	398	3.52	.714	.036

One-Sample Test

	Test Value = 3					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
Level of Awareness and Adoption of Green AI	14.521	397	.000	.519	.45	.59

Source: SPSS V. 26 (2025)

The results from the one-sample t-test reveal a statistically significant level of awareness and adoption of Green Artificial Intelligence (Green AI) among professional accountants in Ghana and Nigeria. With a test value of 3 (the neutral benchmark), the observed mean of 3.52 indicates a moderate to high level of awareness and adoption. The t-value of 14.521 and a p-value of .000 (less than the 0.05 significance level) confirm that the difference between the sample mean and the test value is significant. Therefore, the null hypothesis (H_{01}), which states that there is no significant level of awareness and adoption of Green AI in Ghana and Nigeria, is rejected. This implies that respondents generally demonstrate a meaningful level of understanding and engagement with Green AI initiatives in these developing economies.

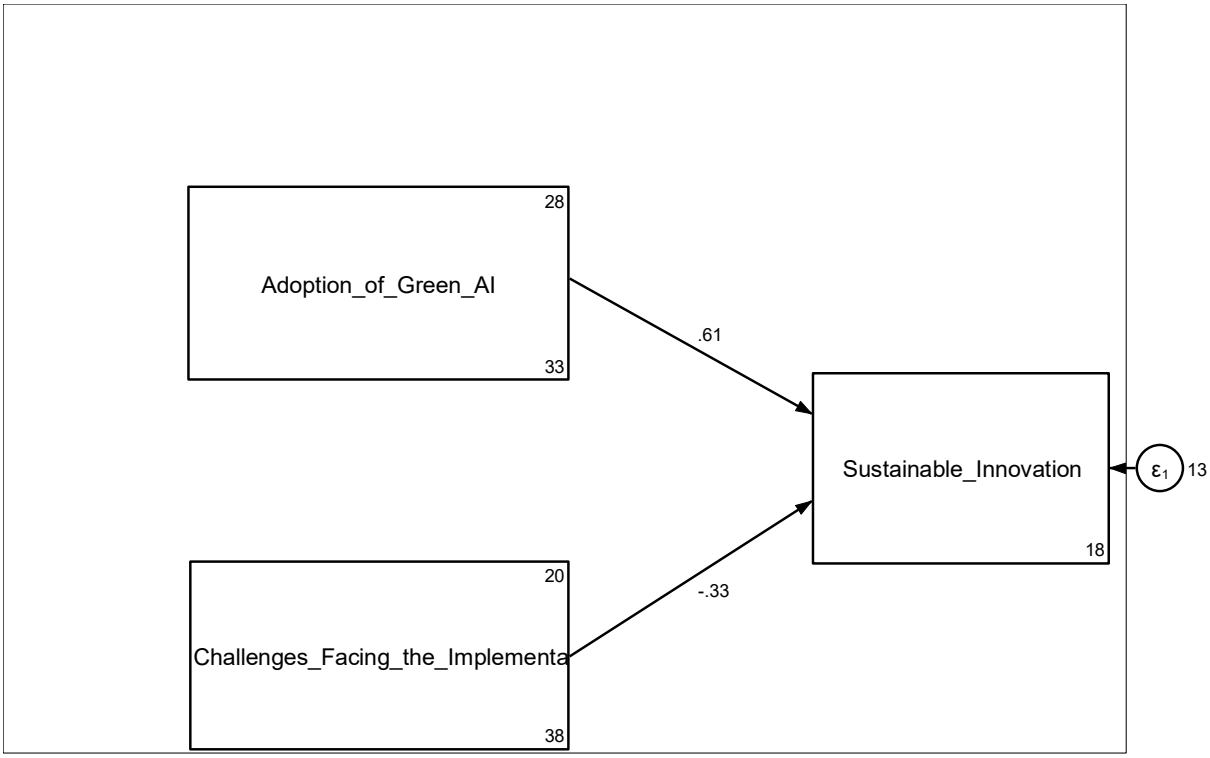

Figure 1 Structural Equation Modelling Building
Source: Stata V. 14 (2025)

The Structural Equation Model (SEM) results show that the adoption of Green AI has a strong and positive effect on sustainable innovation (path coefficient = 0.81), indicating that greater implementation of Green AI significantly enhances sustainable innovation in developing economies like Ghana and Nigeria. Conversely, challenges facing the implementation of Green AI have a negative effect on sustainable innovation (path coefficient = –0.33), suggesting that obstacles such as limited infrastructure, high costs, and low technical expertise hinder progress toward sustainability goals. Overall, the model demonstrates that while Green AI adoption promotes sustainable innovation, implementation challenges substantially weaken this positive effect.

Table 4.3 Structural Equation Modelling for Test of Hypothesis II& III

Structural equation model — Number of obs = 398
Estimation method = ml
Log likelihood = -3541.9631

	OIM Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
Sustainable_Innovation <-						
Adoption_of_Green_AI	.6138035	.0391002	15.70	0.000	.5371685	.6904386
Challenges_Facing_the_Implementa	-.3290165	.0361878	-9.09	0.000	-.3999433	-.2580896
_cons	18.20231	1.626341	11.19	0.000	15.01474	21.38987
var(e.Sustainable_Innovation)	13.14286	.931673			11.438	15.10185

LR test of model vs. saturated: chi2(0) = 0.00, Prob > chi2 = .

Source: Stata V. 14 (2025)

H_{02}: Green AI does not significantly contribute to sustainable development in Ghana and Nigeria.

H_{03}: The challenges faced in implementing Green AI have no significant effect on its adoption in the two countries.

The structural equation model presented in the table above was estimated using the Maximum Likelihood (ML) method based on 398 valid observations, with a log-likelihood value of –3541.9631. The likelihood ratio (LR) test statistic of the model against the saturated model yielded $\chi^2(0) = 0.00$ with an associated probability value greater than 0.05. This result implies that the model is well-fitted, indicating that the specified structural model adequately represents the observed data. The low chi-square value and non-significant p-value further confirm that the hypothesized model is statistically valid and suitable for explaining variations in sustainable innovation among the sampled respondents.

The constant term of 18.20231 represents the average baseline level of sustainable innovation when all explanatory variables—namely, *Adoption of Green AI* and *Challenges Facing the Implementation of Green AI*—are held constant at zero. The corresponding p-value (p = 0.000) indicates that the constant is statistically significant at the 5% significance level. This means that even in the absence of Green AI adoption and implementation challenges, there exists a positive underlying level of sustainable innovation within the system studied. The magnitude of the constant suggests that inherent or structural factors independent of the explanatory variables contribute to sustainable innovation in both Ghana and Nigeria.

The coefficient of 0.6138035 measures the marginal effect of the adoption of Green AI on sustainable innovation. This implies that, on average, a one-unit increase in the adoption of Green AI leads to an increase of approximately 0.61 units in sustainable innovation, assuming other factors remain constant. The positive sign of the coefficient indicates that greater adoption of Green AI technologies enhances the level of sustainable innovation in the two countries. The p-value of 0.000 shows that this effect is statistically significant at the 5% level. Consequently, the null hypothesis (H_{02}) stating that "Green AI does not significantly contribute to sustainable development in Ghana and Nigeria" is rejected. The finding therefore supports the conclusion that Green AI adoption has a significant positive effect on sustainable innovation across the studied economies.

The estimated coefficient for *Challenges Facing the Implementation of Green AI* is –0.329016, which represents the marginal effect of these challenges on sustainable innovation. This indicates that for every one-unit increase in the level of challenges encountered in implementing Green AI, the level of sustainable innovation decreases by approximately 0.33 units, holding other variables constant. The negative coefficient suggests that obstacles such as lack of technical capacity, inadequate funding, and weak policy support hinder the growth of sustainable innovation. The associated p-value (p = 0.000)

shows that this effect is statistically significant at the 5% level. Therefore, the null hypothesis (H_{03}) stating that "The challenges faced in implementing Green AI have no significant effect on its adoption in the two countries" is rejected. This implies that challenges significantly and adversely affect sustainable innovation outcomes driven by Green AI initiatives in Ghana and Nigeria.

4.3 DISCUSSION OF FINDINGS

The finding shows that there is a significant level of awareness and adoption of Green AI among professional accountants in Ghana and Nigeria ($t(397) = 14.521$, $p = .000$, $M = 3.52$) indicates that accountants in both countries are becoming increasingly conscious of how AI can be applied to support environmental sustainability within their profession. This outcome may be attributed to the growing global recognition of sustainability principles in accounting and financial reporting, alongside professional exposure to digital transformation initiatives. Similar results were reported by Raman et al. (2024), who highlighted that awareness of Green AI and its potential for sustainable development is rapidly increasing worldwide due to the emphasis on responsible and energy-efficient AI practices. Likewise, Umoudo et al. (2024) found that awareness and use of green technologies in Nigeria's energy and agricultural sectors were expanding, driven by the need for resource efficiency and environmental protection. In support, Ridwan et al. (2024) demonstrated that increased awareness and usage of AI technologies improved environmental capacity in the United States, implying that better understanding enhances the adoption of sustainable digital tools. Similarly, Ali (2023) emphasized that awareness of AI's environmental benefits has prompted many professionals to integrate AI-driven optimization into circular economy models.

The second finding, which shows that adoption of Green AI has a positive and significant effect on sustainable innovation ($\beta = 0.6138035$, $p = 0.000$), implies that applying AI technologies in environmentally conscious ways enhances innovative practices that promote sustainability. This effect can be explained by Green AI's ability to reduce waste, optimize energy usage, and encourage eco-efficient innovations across business operations. Al Halbusi et al. (2025) support this result, revealing that AI capabilities significantly improve green innovation and sustainable performance in Qatar's industrial sectors. Similarly, Chen et al. (2024) reported that integrating AI with big data analytics enhances sustainable innovation performance, especially in supply chain operations. Mijit et al. (2025) also found that firms within China's AI Innovation and Development Pilot Zones experienced improved quality and quantity of green innovations due to AI adoption. Furthermore, Song and Deng (2025) discovered that AI strengthens green economic efficiency across regions, particularly in technologically advanced areas.

The final finding, showing that challenges facing the implementation of Green AI have a negative and significant effect on sustainable innovation ($\beta = –0.329016$, $p = 0.000$), suggests that barriers such as high costs, limited expertise, and infrastructural constraints hinder the ability of organizations to fully utilize AI for sustainable outcomes. This negative effect highlights how technical, economic, and policy-related challenges slow down innovation, even when awareness and interest are high. Varshney et al. (2023) similarly identified economic barriers, policy limitations, and low public awareness as major constraints to effective adoption of AI-driven green technologies. In agreement, Umoudo et al. (2024) found that while green technologies boost sustainability in Nigeria, challenges such as high implementation costs and inadequate technical capacity remain significant obstacles. Song and Deng (2025) further observed that regional disparities and governance inefficiencies limit AI's contribution to green economic efficiency, echoing the current study's result. Additionally, Ali (2023) pointed out that despite its potential, Green AI's progress is constrained by the high energy demand and cost of developing environmentally friendly algorithms.

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study's results demonstrate that the growing awareness and use of Green Artificial Intelligence (AI) among professional accountants in Ghana and Nigeria are shaping a new direction for sustainable business practices and innovation in the accounting profession. The strong adoption rate indicates that accountants are increasingly integrating environmentally responsible technologies into their work processes, which signals a transition from traditional accounting systems to more digitally driven and eco-conscious practices. This trend enhances the profession's contribution to corporate sustainability by promoting efficiency, reducing resource waste, and fostering innovative approaches to data management and reporting. Moreover, the positive association between the adoption of Green AI and sustainable innovation highlights how technological advancement can serve as a catalyst for environmentally aligned creativity and transformation in professional services. However, the finding that implementation challenges exert a negative influence highlights the structural and operational barriers that still constrain the full potential of these technologies. These barriers—such as limited infrastructure, knowledge gaps, and resistance to change—suggest that while accountants recognize the value of Green AI, institutional and contextual realities continue to hinder its seamless integration into professional routines. Collectively, these outcomes reveal a profession that is gradually evolving toward sustainability through digital intelligence, yet still negotiating the practical difficulties of embedding such technologies within existing frameworks. The findings therefore capture a critical moment in the accounting sector's technological evolution, marked by a balance between progress and constraint, innovation and adaptation, as professionals align their practices with global trends toward greener and more sustainable economies.

5.2 Recommendations

1. To Professional Accounting Bodies in Ghana and Nigeria: Since the findings show a significant level of awareness and adoption of Green AI, professional accounting bodies such as the Institute of Chartered Accountants of Nigeria (ICAN) and the Institute of Chartered Accountants, Ghana (ICAG) should develop structured training programs and certification courses focused on the practical use of Green AI tools in accounting. This would help sustain and expand the current momentum by equipping accountants with deeper technical expertise to apply these technologies effectively in their daily operations and sustainability reporting.
2. To Accounting Firms and Corporate Organizations: Given that adoption of Green AI positively influences sustainable innovation, accounting firms and corporate organizations should integrate Green AI technologies into their strategic operations and innovation processes. Doing so would enable them to streamline auditing, financial analysis, and environmental accounting in ways that reduce energy consumption and promote eco-friendly data processing, thereby strengthening their contribution to sustainable development goals.
3. To Policy Makers and Regulatory Authorities: Since challenges in implementing Green AI negatively affect sustainable innovation, regulatory bodies such as the Financial Reporting Council of Nigeria and the Ghana National Information Technology Agency should establish enabling policies and financial incentives that support the deployment of Green AI infrastructure. Providing access to funding, technical support, and favorable regulations will reduce the barriers to implementation, allowing professional accountants and firms to fully harness the transformative potential of Green AI in driving sustainability across the accounting profession.

REFERENCES

Adebola, F., Kehinde,O., Temitope,A., & Bunmi, S. (2024).Can AI grow Green? Evidence of a Kuznits curve among AI, Rewable energies and emission.. *Global journal of Engineering and Technology Advances.* 21 (01), 154-166

Aderibigbe, A. O., Ohenhen, P. E., Nwaobia, N. K., Gidiagba, J. O., & Ani, E. C. (2023). Artificial intelligence in developing countries: Bridging the gap between potential and implementation. *Computer Science & IT Research Journal*, *4*(3), 185-199.

Agyeman, E., Quansah, D. A., Ntiamoab, A., & Ramde, E. W., (2025). Towards a circukar economy in Ghana renewable Energy sector: A quatitative assessment of waste from solar photovoltaic modules in Ghana. *International journal of Green Energyl*

Ahmad, M. (2024, October 7). Green AI: A path toward sustainable innovation. LinkedIn. https://www.linkedin.com/pulse/green-ai-path-toward-sustainable-innovation-muzaffar-ahmad-6gl3e/

Al Halbusi, H., Al-Sulaiti, K. I., Alalwan, A. A., & Al-Busaidi, A. S. (2025). AI capability and green innovation impact on sustainable performance: Moderating role of big data and knowledge management. *Technological Forecasting and Social Change*, *210*, 123897.

Ali, A. H. (2023). Green AI for sustainability: leveraging machine learning to drive a circular economy. *Babylonian Journal of Artificial Intelligence*, *2023*, 15-16.

Boso, N., & Essuman, D. (2021). *ICAG member satisfaction research report* (commissioned by The Institute of Chartered Accountants Ghana). The Institute of Chartered Accountants (Ghana). https://www.icagh.org/wp-content/uploads/2025/03/ICAG-Members-Satisfaction-Survey.pdf

Chen, C. T., Khan, A., & Chen, S. C. (2024). Modeling the impact of BDA-AI on sustainable innovation ambidexterity and environmental performance. *Journal of Big Data*, *11*(1), 124.

Chen, M., Wang, S., & Wan, X., (2024). How Artificial Intelligence Impact Green Development? Evidence from China. ***Sustainability*** 2024, ***16***(3), 1260

Dua, I. K., & Patel, P. G. (2024). Sustainable AI Lifecycle Management. In *Optimizing Generative AI Workloads for Sustainability: Balancing Performance and Environmental Impact in Generative AI* (pp. 259-287). Berkeley, CA: Apress.

El Khirani, S. (2024, September 20). Green AI: Balancing innovation and sustainability in the age of artificial intelligence. Medium. https://medium.com/data-science-clarity/green-ai-balancing-innovation-and-sustainability-in-the-age-of-artificial-intelligence-a3259d455370

Elbasi, E., Mostafa, N., Zaki, C., AlArnaout, Z., Topcu, A. E., & Saker, L. (2024). Optimizing agricultural data analysis techniques through AI-powered decision-making processes. *Applied Sciences*, *14*(17), 8018.

Ikwuo, A. K., Nworie, G. O., & Moedu, V. O. (2024). Implementation of AI-driven automation: A game-changer in accounting research. *International Journal of Financial, Accounting, and Management*, *6*(3), 385-398.

Imafidon, H., Enwerem, M., & Boye, A. (2024). Adapting Green Building Practices and Smart Technology in Developing Countries: A Review. *African Journal of Environmental Sciences and Renewable Energy*, *16*(1), 183-202

Imafidon, H., Enwerem, M., & Boye, A., (2024). Adapting Green Building, Practices and smart Technology in Developing Countries. *African journal of Environment Science and Renewable Energy* ISSN: 3027-2114.

Institute of Chartered Accountants of Nigeria. (2025). *About ICAN*. https://icanig.org/ican/about.php

Mijit, R., Hu, Q., Xu, J., & Ma, G. (2025). Greening through AI? The impact of Artificial Intelligence Innovation and Development Pilot Zones on green innovation in China. *Energy Economics*, 108507.

Mitu, N. E., & Mitu, G. T. (2024). The hidden cost of AI: carbon footprint and mitigation strategies. *Revista de Stiinte Politice*, (84), 9-16.

Mmadubuobi, L. C., Nworie, G. O., & Aziekwe, O. P. (2024). Industry 4.0 and Corporate Technological Responsibility of Manufacturing Firms in Nigeria. *Central Asian Journal of Innovations on Tourism Management and Finance*, *5*(4), 67-80.

Nworie, G. O., & Orji-Okafor, T. G. (2024). Quadruple Bottom Line Disclosure Among Listed Manufacturing Firms in Nigeria: A Paradigm for Cost Savings. *International Journal of Management, Accounting & Economics*, *11*(10).

Okafor, T. G., & Nworie, G. O. (2025). Achieving Environmental Sustainability: The Contribution of Digital Automation Technologies of Industry 4.0 Used by Companies in Nigeria. *Quantitative Economics and Management Studies*, *6*(5).

Oksanen, K., & Hautamäki, A. (2015). Sustainable innovation: A competitive advantage for innovation ecosystems. *Technology Innovation Management Review*, (10).

Oppong, N. B. (2022). Sustainable development goals and small and medium enterprises: a comparative study of emerging economies and Sub-Saharan Africa. *Global Business Review*, 09721509221087848.

Patnaik, P., & Bakkar, M. (2024). Exploring determinants influencing artificial intelligence adoption, reference to diffusion of innovation theory. *Technology in Society*, *79*, 102750.

Pinho, C., Franco, M., & Mendes, L. (2021). Application of innovation diffusion theory to the E-learning process: higher education context. *Education and Information Technologies*, *26*(1), 421-440.

Quarsine, P. T., Abdulahi, S., & Eran, F. D., (2023). Assessing Climate-Smart Agriculture Practices foe Sustainable food system outcomes in Subsaharan Africa: A case of Borno East region Ghana. *Journal of Geography and Sustainability.* 112-126

Raman, R., Pattnaik, D., Lathabai, H. H., Kumar, C., Govindan, K., & Nedungadi, P. (2024). Green and sustainable AI research: an integrated thematic and topic modeling analysis. *Journal of Big Data*, *11*(1), 1-28.

Rashid, A., Baloch, N., Rasheed, R., & Ngah, A. H.,(2025). Big data Analytics- Artificial Intelligence and Sustainable performance through Green Supply Chain practices in Manufacturing Firms of Develop[ing Country. Journal of Science and Technology Policy Management (2025) 16 (1): 42–67.

Ridwan, M., Bala, S., Shiam, S. A. A., Akhter, A., Asrafuzzaman, M., Shochona, S. A., & Shoha, S. (2024). Leveraging AI for a greener future: Exploring the economic and financial impacts on sustainable environment in the United States. *Journal of environmental science and economics*, *3*(3), 1-30.

Salaheldeen, M., Ateeq, A., Ani, Z., Alzonaiki. M., Ali. S. A., & Milhem, M. (2024). Green Entrpreneurship and Sustainability in Developing countries: Opportunities, Challengies, and future research directions. *Business Innovation and Research* pp 525-534.

Saxena, P. K., Seetharaman, A., & Shawarikar, G. (2024). Factors that influence sustainable innovation in organizations: A systematic literature review. *Sustainability*, *16*(12), 4978.

Song, Z., & Deng, Y. (2025). The impact of artificial intelligence on green economy efficiency under integrated governance. *Scientific Reports*, *15*(1), 25919.

Tabbakh, A., Anun, L., Islam, M., & Mahmud, G. M., Chowdhury, I. K., & Mukta. H. S.(2024). Towards Sustainability AI: a comprehensive Framework for Green Ai. *Case study- Discover Sustainability* 5:408.

Ukoh, U. M., Nduokafor, C. O., & Nworie, G. O. (2024). Sustainability reporting among oil and gas firms: a strategic tool for enhanced firm value. *International Journal of Economics and Financial Management*, *9*(2), 144-166.

Umoudo, E. N., John, I. A., & Augustine, D. (2024). Impact of green technologies on sustainable economic development in Nigeria. In Operational uncertainty: Present and future prospects in art, science, engineering, social science, education, climate change, health care and business (pp. 188–199). https://www.researchgate.net/profile/Hannah-Ivwighren/publication/383213551

Varshney, Y., Dubey, D., Kumar, V., Sharma, S., & Singh, S. (2023). Enhancing Sustainable Practices through AI Driven Green Technology. *International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)*, *3*(2).

Vergallo, R., & Mainetti, L. (2024). Measuring the Effectiveness of Carbon-Aware AI Training Strategies in Cloud Instances: A Confirmation Study. *Future Internet*, *16*(9), 334.

Yang, J., Xiao, W., Jiang, C., Hossain, M. S., Muhammad, G., & Amin, S. U. (2018). Ai-powered green cloud and data center. *IEEE Access*, *7*, 4195-4203.

Yigitcanlar, T., Mehmood, R., & Corchado, J. M. (2021). Green artificial intelligence: Towards an efficient, sustainable and equitable technology for smart cities and futures. *Sustainability*, *13*(16), 8952.

Yir, K., Cai, F., & Huang, G., (2023). How does Artificial Intelligence Development affect Green Technology Innovation in China? Evidence from dynamic panel data analysis. *Journal of Environmental Science and Pollution research.* Pages 28066-28090

Yousaf, Z., Radulescu, M., Sinisi, C. I., Serbanescu, L., & Păunescu, L. M. (2021). Towards sustainable digital innovation of SMEs from the developing countries in the context of the digital economy and frugal environment. *Sustainability*, *13*(10), 5715.

Zhu, S., Ota, K., & Dong, M. (2022). Energy-efficient artificial intelligence of things with intelligent edge. *IEEE Internet of Things Journal*, *9*(10), 7525-7532.