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Artificial Intelligence and Environmental Sustainability in Benue State, Nigeria

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Abstract

This research investigates the application of artificial intelligence (AI) in addressing critical environmental challenges in Benue State, Nigeria, specifically focusing on increasing flooding, deforestation, waste mismanagement, and unsustainable agricultural practices, collectively termed the "four environmental issues." Employing a descriptive survey design, data were gathered from a sample of 400 respondents across five local government areas selected via stratified random sampling using a structured questionnaire and were subsequently evaluated using descriptive and inferential statistics. The descriptive analysis revealed severe environmental challenges alongside a moderate level of awareness regarding various AI technologies, with respondents indicating a strong consensus on the potential of AI to enhance environmental management. Furthermore, regression analysis demonstrated a statistically significant positive relationship between AI adoption and environmental sustainability, while identifying infrastructural deficits, technical skill gaps, and policy limitations as primary adoption barriers. Anchored in the technology acceptance model, systems theory, and sustainable development theory, the study concludes that AI serves as a transformative catalyst for advancing environmental sustainability (SDGs 13, 14, and 15) in Benue State. Consequently, the research recommends targeted investments in AI infrastructure, capacity-building initiatives, and supportive policy frameworks to ensure effective implementation.

Keywords**:** Artificial Intelligence, Environmental sustainability, Climate change, Benue state

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Introduction

As demonstrated in research, the most severe impact of rapid environmental degradation occurs in developing countries with limited governance structures, rapid population growth, and no environmental concerns in dominant economic activities. A number of recent studies in Nigeria demonstrate that significant economic costs can be attributed to rapid deforestation, flooding, and soil erosion, as well as the increasing complexity of waste management (Isukuru et al., 2024); (Dinneya-Onuoha, 2025). Benue State is often referred to as the "Food Basket" of the Nation as it is the most affected by the described phenomena, experiencing the greatest devastation of agriculture due to the combination of climate change and unregulated human activity (Manucharyan, 2025; Semeraro et al., 2023). The growing attention to the use of Artificial Intelligence (AI) as possible solutions to various technological concerns has begun to permeate eenvironmental challenges. Some of the available AI technologies, such as machine learning (ML), predictive analytics and remote sensing; and a combination of the above with Data-Driven Decision Making (DDDM) tools, have demonstrated usefulness in the sub-disciplines of environmental management, climate change, and sustainable resource management (Lozano et al., 2021; Wang et al., 2022). Artificial Intelligence has the capacity to derive meaningful and predictive pathways from large volumes of data and establish patterns that can enhance governance structures associated with environmental policy (Farooq et al., 2022; Fellmann et al., 2018).

AI has become a global phenomenon and has example applications in various environmental sectors such as the prediction of wildfires, monitoring biodiversity, and managing water resources (Oise, 2026; Olafimihan et al., 2024). Unfortunately, in Sub-Saharan Africa, the use of AI as an enabler of environmental sustainability is still greatly limited due to poor infrastructure, insufficient technical capacity, and the absence of supportive policies. Environmental management in Benue State continues to be implemented in a reactive manner, with poor use of proactive methods. AI technology coupled with environmental governance practices in Benue State will undoubtedly allow for improvements in monitoring, early warning, and overall impact of policies (Kalogiannidis et al., 2024; Behera et al., 2026). For instance (Emezirinwune et al., 2024; Ogunbode, 2025), flood prediction models, which utilize AI, will help lessen the impact of disasters, and smart agriculture systems will promote productivity while lessening the impact of agriculture on the environment (Ossai & Alordiah, 2024; Fróna et al., 2021).

With all of the above potential benefits, little to no research exists on the use of technology, and specifically AI, to solve the environmental problem of Benue State. Most research has been focused on national or global environmental systems, living the regional and local impact of AI on environmental sustainability (Mujeeb et al., 2025; Adeyemo et al., 2024). This research hopes to address this gap and answer the research question of how AI can be used in solving environmental problems (SDGs 13, 14, & 15) of Benue State. The purpose of this research is to assess the prospective benefits of artificial intelligence and its potential to improve some of the many environmental issues experiencing in Benue State. The main goals of this study include to: Determine the key environmental problems of Benue State; Measure the degree of knowledge and level of usage of available AI technology in Benue State; Assess the impact and extent of Artificial Intelligence in the management of environmental problems in Benue State.; Recommend how AI can be effectively utilized in environmental problems in Benue State.

Methodology

The type of survey for this research was descriptive survey. This type of survey is good for looking at variables and collecting data from a large audience in a structured way. In this case, it was useful for determining Artificial Intelligence potential for solving environmental issues in the case of Benue State. The people that make up the study population include the major players in the environment like the staff of the environmental agency, the farmers, the civil servants, and the people that live in urban and semi-urban areas of the selected local government areas of Benue State. The approximate population size was taken to be 500,000. Using Yamane (1967), a 5% margin of error was used to calculate a sample size of 400 people. A stratified random sampling method was utilized to ensure proper representation in the sample across different demographics and professions to improve the reliability of the results.

Primary data was collected using a questionnaire which was designed using a 5-point Likert scale, where 5 was Strongly Agree and 1 was Strongly Disagree. The questionnaire was subdivided into parts in order to capture demographic data, environmental issues, the respondent's knowledge regarding AI, and the potential of AI to facilitate better environmental management. In order to improve the validity of the questionnaire, it was reviewed by experts in the field of environmental studies and educational technology. Reliability was assessed using the Cronbach's Alpha method, which returned a reliability coefficient of 0.82, implying that the results were very consistent. The data collection lasted one month and was done by research assistants that were trained for this purpose in the selected LGAs.

Descriptive statistics such as response frequency, participant percentage, score averages, and standard deviations were calculated. For hypothesis testing, inferential statistics were employed, specifically regression analysis, determined at a 0.05 level of significance using SPSS. The entire study process was under rigid ethical consideration. An ethical review was conducted and approved for this study. The study was explained, and respondents chose whether to participate. No personally identifiable information was collected, and participants could depart at their own discretion at any point, and no reason, no further harm would result. The ethical measures taken are their rightful complaisance with ethical research standards and the study's credibility.

Results

Table 1. Demographic characteristics of respondents

Variable	Category	Frequency	Percentage
Sex	Male	220	55%
	Female	180	45%
Age	18-30	120	30%
	31-45	180	45%
	46+	100	25%
Education	Secondary School	90	22.5%
	Tertiary	310	77.5%
Occupation	Farmer	150	37.%
	Civil Servant	120	30%
	Others	130	32.5%

From the demographic analysis, the male gender slightly dominates, while gender representation is relatively equal, while the participants of the survey the most economically active

age group (31-46 years). This tells us that the data represents views of those involved in both the environmental and economic activities. A good number of respondents have tertiary education, and even in the group of farmers, there is significant representation. This group was the most numerous, and the constitutive of Benue State and agriculture. This distribution shows a good number of key informants in the findings and strengthens its validity.

Table 2. Demographic and local government area distribution of respondents

LGA	Distributed	Returned	Percentage	Male	Female
Makurdi	80	75	18.8%	40	35
Gboko	80	76	19.0%	42	34
Otukpo	80	72	18.0%	38	34
Katsina-Ala	80	70	17.5%	40	30
Vandeikya	80	67	16.7%	35	32
Total	400	360	100%	195	165

This analysis calculates the total number of questionnaires from five (5) chosen LGAs of Benue State. Makurdi and Gboko have recorded the most number of respondents. This shows that there is more involvement from the urban and semi-urban dwellers. For the 360 questionnaires returned, there was an impressive level of participation across the area of study. The respondents were more men than women. Having an unequal number of women and men is acceptable in research because the inclusion of multiple LGAs increases geographical coverage and increases the confidence level of the results. The chosen LGAs are Makurdi, Gboko, Otukpo, Katsina-Ala, and Vandeikya Local Government Areas (LGAs). These choices are justifiable, given the diversity in the environment and the socio-economic status in Benue State. Makurdi is the State capital and has been chosen because of its urban nature, large population, and flooding problems that result from water overflowing the River Benue. This situation is good for the studying of the AI-flood prediction system and urban waste management. Gboko has been chosen because it is a semi-urban centre that has many industries and commerce, which cause waste and environmental stress. Otukpo is an important transitional zone where there are many environmental problems such as deforestation and waste disposal. Katsina-Ala has problems of flooding and erosion, which makes it easy to use AI to monitor the environment. In contrast, Vandeikya is predominantly an agrarian area, has problems of soil erosion and degradation and poor farming practices. This area makes it possible for the research and examine the use of AI in farming and land management. In sum, the choice of locations demonstrates a fair representation of various urban, semi-urban, and rural environments with distinct types of environmental challenges, improving the generalizability of the results and giving an all-encompassing perspective of the possible ways AI may be utilized in the different ecological and socio-economic complexities of Benue State.

Table 3. Descriptive statistics on AI and environmental issues

Variable	Mean	Std. Dev
Environmental Challenges Severity	4.21	0.78
Awareness of AI Technologies	3.65	0.82
AI Effectiveness in Environmental Management	4.05	0.75
Barriers to AI Adoption	3.89	0.80

The constituents of the examined environmental challenges in Benue State, which returned a mean score of above 4, are very significant. The challenges stakeholders face when trying to adopt AI in their different fields are considerable. Although awareness of AI technology is low, the respondents agree that AI can be used to solve environmental challenges. Implementation challenges are significant and mainly of an infrastructural and policy nature. The findings highlight the need for awareness, investment, and policy to facilitate AI.

Table 4. Regression analysis

Variable	Coefficient	p-value
AI Adoption	0.65	0.000
Environmental Sustainability (SDGs 13, 14, & 15)	0.72	0.000

The results indicate that adoption of AI has positive effects on the management of the environment. The results are consistent with the findings of regression analysis that suggested that use of AI leads to improvement in environmental management. Results show statistically significant findings as p (0.000) <0. 05. This means that adoption of AI improved the management of environmental sustainability in Benue State. There is sufficient evidence to support AI technologies and solutions to environmental problems in Benue State. Results are consistent with the findings of other studies on the positive effects of AI in environmental management.

Discussion

The descriptive statistics reveal the level of seriousness of the environmental problems as the mean score (4.21) provides a high level of severity regarding the crises of environmental degradation and reveals the severe level of neglect of flooding, land degradation, and the mismanagement of waste. This is in line with the previous empirical evidence about the level of the developing regions of the world and their increased vulnerabilities to the environmental problems as it stems from the poorly managed systems of the developing regions and the high variability of the climate (Gerlich, 2025); (Marzuki et al., 2023). From this perspective, it can be seen to align with Sustainable Development Theory, which is reliant on the innovations and proactive management systems to ensure positive steady states of socio-economic systems, decline of negative states and problems with respect to the environmental protection systems (Surbakti, 2025).

The moderate level of awareness of AI technologies (mean = 3.65) is an indication that, in this respect, while it is true that the stakeholders have in one way or another been knowledgeable about AI, it is rather conspicuous that a significant level of knowledge is for the most part non-existent. This is consistent with the Technology Acceptance Model (TAM) (Vaccaro et al., 2024), which primarily focuses on the level of awareness and level of usefulness as the two most important variables for the level of acceptance of a given technology (Vieriu & Petrea, 2025). This is evident in relation to (Khalifa & Albadawy, 2024), as the presence of the so-called innovations of technologies in developing economies is almost entirely dependent on the level of awareness and the level of capacity. For the same reason, (Bastani et al., 2025); (Mogaji et al., 2025) pointed out that the lack of knowledge of the technologies involved remains an area of concern in the adoption of the so-called smart solutions to the environmental problems of Nigeria.

Additionally, the high average score on AI management tool effectiveness (4.05) shows that most participants feel that AI can improve the management of the environment, and supports the findings of (Chan et al., 2024); (Okafor et al., 2024) that AI applications improve the efficiency of Waste management and Environmental monitoring. This also supports the findings of UNEP

(2022) that environmental management and decision-making can be supported and improved by AI technologies. Within the context of the "Systems Theory" framework, it implies that AI technology fosters more enhanced integration and interaction of systems of Environmental data, and therefore more effective and timely management of environmental issues (Slimani et al., 2025); (Wheeler et al., 2026).

The barriers identified to AI adoption (mean = 3.89) also confirm existing empirical findings. Respondents attributed the absence of digital/information technology infrastructure, absence of skilled human resources, and inadequate legislation and policies to support technology as the main barriers. This confirms the findings of (Tiago & Almeida, 2026); (Alexandro, 2025) that absence of sufficient digital infrastructure and lack of institutional capacity are major barriers to the adoption of AI technologies in Sub-Saharan Africa. In the same vein, (Faiz et al., 2024); (Al-Faouri et al., 2024); (El Garem, 2026) argued that the lack of supportive institutional frameworks and sufficient investment in human resources, are critical in determining the extent to which the available technology is used.

The regression analysis shows that there is a statistically significant positive correlation for the implementation of AI and improving environmental sustainability ($p < 0.05$); therefore, AI technologies being used more frequently has positive impacts on the environment outcomes for the state of Benue. This is result is empirically supported from the literature and most notably that systems designed with AI significantly improve the efficiency and sustainability within an environment (Khan & Khan, 2024). This positive effect is also empirically supported from global population about the use of AI for improving environmental sustainability, more specifically with UNEP (2022).

Integrating all the findings from both the description and regression analysis, and supported both the theory and literature empirically, provides positive evidence that AI has the ability improve the state of Benue environmental sustainability (SDGs 13, 14, & 15) (Flores et al., 2008); (Straub et al., 2026), provided that the awareness, the infrastructure, and the policy challenges are addressed. This fortifies the notion that a technological solution for improving sustainable environment is possible, provided that the policy framework and the institutional structure are also improved (Harsanto et al., 2026); (Hariram et al., 2023).

Conclusion

The research illuminates the ways Artificial Intelligence (AI) can help solve climate-related challenges in Benue State. From the findings, the issue of environmental sustainability is a broad issue that covers flooding, waste, and land degradation and is of great concern among the respondents. Stakeholders know that the use of AI in environmental management is relative as most have a limited understanding of the technology, while management, and more broad, increased during the use of the technology. In relation to the above, management increased during the use of the technology. To address most of the concerns, there is a need to create an infrastructure that consists of knowledge and most of the technology, which is a real need. Most of the above mentioned concerns can be solved with the right technology. AI coupled with good strategy governance can foster environmental sustainability (SDGs 13, 14, & 15). This should be the main goal as missing elements can be corrected with the right environment policies and ensure that development, system theory, and technology can all be coupled to create a sustainable environment. Focus should be on the gaps that the used elements are enabling and allow for growth and development in the AI systems. This is not as a state, but systems and management, and systems using. From the findings of the research, the study recommends the following: Government of Benue State should invest in AI infrastructure; Training programs should be

developed in Benue State; Policies supporting AI adoption should be enacted; Public-private partnerships should be encouraged in the state.

Conflicts of interest

No conflicts of interest

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Author Contributions

N. U: Conceptualization, Methodology, Software, Data curation, Writing-original draft preparation.: J. N. O: Visualization, Investigation, Supervision, Software, Validation, Writing-reviewing, and editing. All authors have read and agreed to the published version of the manuscript.

Declaration of generative AI in scientific writing

The author acknowledges the use of generative artificial intelligence technologies in drafting parts of this article. Specifically, Grammarly was employed to assist with text polishing and stylistic enhancement. No AI tools were used for generating core scientific data, formulating research hypotheses, or conducting data analysis. The author has verified all outputs and takes full accountability for the published work.

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