

CHALLENGES IN DEPLOYING ARTIFICIAL INTELLIGENCE IN SCHOOL, COMMUNITY AND ENVIRONMENTAL HEALTH EDUCATION AND PRACTICES

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Abstract

Artificial Intelligence (AI) holds significant promise for advancing education, community health, and environmental health practices in Nigeria. Despite this potential, AI deployment in these sectors faces critical challenges including inadequate infrastructure, limited human capacity, fragmented governance and ethical concerns, and financial constraints. This paper uses a literature-driven conceptual approach grounded in a socio-technical systems framework to critically analyze these barriers within Nigeria's unique socio-economic and institutional context. Findings highlight that without addressing systemic infrastructural deficits, building digital and AI literacy, establishing robust regulatory frameworks, and ensuring sustainable funding, AI integration will remain limited in scope and impact. It is recommended that policymakers and stakeholders implement coordinated strategies focusing on infrastructure development, capacity building, ethical governance, and financial sustainability to realize AI's transformative benefits in Nigerian schools, community health programs, and environmental health initiatives.

Keywords: Artificial intelligence, Education, community health, Environmental health, Deployment challenges, Nigeria, Socio-technical systems

Introduction

Artificial Intelligence (AI) is one of the most significant technological developments of the 21st century. According to Jordan and Mitchell (2020) and Tegmark (2021), this development encompasses machine learning, natural language processing, robotics and intelligent systems capable of analyzing complex data, learning patterns, predicting outcomes, and optimizing interventions. Across the globe, AI has been deployed to enhance education, improve public health outcomes, and facilitate environmental monitoring and conservation. In Nigeria, AI presents significant potential to address longstanding challenges in these sectors, including under-resourced schools, overburdened health systems, and environmental degradation.

Holmes *et al*, (2022), opinioned that in the education sector, AI technologies such as intelligent tutoring systems, adaptive learning platforms and automated assessment tools have demonstrated improvements in student learning outcomes and individualized learning support. AI can identify students at risk of underperformance, tailor lesson content to individual learning styles and provide real-time feedback to teachers. In Nigerian schools, pilot programs like the Learning Passport and EdTech platforms have sought to leverage AI for improved access to curriculum-aligned content, though access remains uneven due to infrastructural limitations and the digital divide (UNICEF, 2025).

According to Topol (2019) and Obermeyer and Emanuel, (2016), in community health, AI supports disease surveillance, predictive analytics, telemedicine, and health education through mobile chatbots and messaging systems. These tools have been used to track vaccination schedules, disseminate health information, and predict outbreak patterns. Abubakar *et al.*, (2024) mentioned that in Nigeria, maternal and child health programs, immunization campaigns, and nutritional interventions have the potential to benefit from AI-supported decision-making, yet uneven access to mobile devices, literacy gaps, and insufficient training among community health workers limit scalability. Similarly, AI applications in environmental health can enhance predictive modeling, remote sensing, and hazard detection to support water quality management, waste control, and pollution monitoring (Nwoye, 2023). By integrating environmental data with AI analytics, policymakers and practitioners can implement evidence-based interventions to safeguard public health and mitigate environmental risks. However, Akinsemolu (2025) emphasized that infrastructural deficits, weak technical capacity and reliance on donor-driven projects pose significant barriers to sustained implementation. The deployment of AI in these sectors is influenced by systemic, socio-cultural, and ethical factors. Nigeria's limited investment in education and health, coupled with uneven infrastructure, digital illiteracy, fragmented governance, and limited research capacity, creates an environment where AI adoption is constrained (World Bank, 2025). Ethical issues related to privacy, algorithmic bias, and accountability further complicate deployment, particularly when data collection involves vulnerable populations such as children or patients (Crawford, 2021; Karran *et al.*, 2024). Cultural perceptions and community trust also shape adoption, with skepticism and resistance often impeding AI integration (Onuoha, 2023).

The COVID-19 pandemic highlighted both the potential and limitations of AI in Nigeria. Adediran (2021) opined that remote learning initiatives, AI-enabled predictive health models, and digital health campaigns underscored AI's capacity to bridge service gaps, yet millions of students and community members were excluded due to lack of digital access and technical literacy. These experiences emphasize the importance of addressing infrastructural, human, and ethical challenges to ensure equitable and effective AI deployment. Given the transformative potential of AI and the persistent challenges in Nigeria, this paper critically examines the barriers to AI deployment in schools, community health programs, and environmental health education and practice. It synthesizes contemporary literature, policy documents, and program evaluations to highlight gaps, analyze systemic obstacles, and propose actionable recommendations for sustainable, equitable, and responsible AI integration.

Several studies in education emphasize AI's ability to enhance personalized learning, improve assessment accuracy and support teachers in monitoring student progress (Holmes *et al.*, 2022). Adaptive learning platforms and intelligent tutoring systems have shown measurable improvements in literacy and numeracy. However, Nigerian contexts present unique challenges. Schools often lack reliable electricity, internet access, and digital devices, limiting AI integration (UNESCO, 2023). Teachers frequently lack training in digital literacy or AI pedagogical methods, resulting in underutilization of available technologies (Balogun *et al.*, 2024). Additionally, platforms

designed for Western curricula may not align with local language, cultural norms, and classroom practices, reducing relevance and engagement (Ogunode and Abiodun, 2024). Evidence also suggests that AI is most effective when combined with continuous teacher support, monitoring, and contextual adaptation (World Bank, 2025).

AI tools facilitate disease surveillance, predictive modeling, telemedicine, and health education campaigns in community health, (Topol, 2019; Obermeyer and Emanuel, 2016). Chatbots and AI-enabled messaging systems can track vaccinations, disseminate nutrition guidance, and provide real-time information to communities. However, digital literacy, language barriers, and unequal access to mobile devices restrict reach. Studies indicate that when local health workers are trained and engaged, AI tools significantly enhance intervention efficiency and decision-making, yet capacity gaps remain a major barrier (Balogun *et al.*, 2024). Ethical considerations, particularly regarding data privacy, consent, and potential bias, further shape community adoption (Crawford, 2021). AI applications in environmental health focus on predictive modeling, remote sensing, hazard detection, and resource optimization (Nwoye, 2023). In Nigeria, AI has been applied in flood risk assessment, air and water quality monitoring, and waste management. However, many projects rely on donor funding, external expertise, and limited local technical capacity, threatening sustainability (Akinsemolu, 2025). Environmental and ethical concerns, including energy consumption, algorithmic bias, and equitable resource allocation, highlight the need for sustainable, context-sensitive AI deployment (Karran *et al.*, 2024). Moreover, literature reveals persistent gaps: limited evidence on locally adapted AI solutions, insufficient research on long-term impact and equity, weak ethical and governance frameworks, and underexplored infrastructural and financial sustainability issues. These gaps justify the need for a comprehensive analysis of AI deployment challenges in Nigeria.

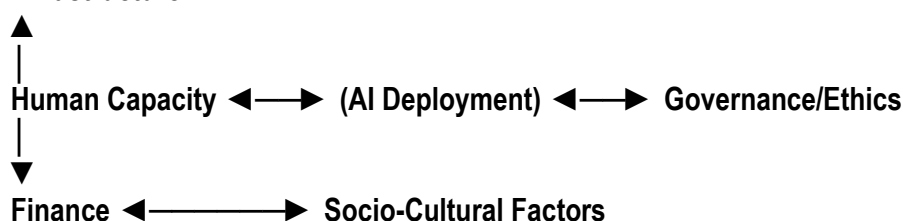
Conceptual/Theoretical Framework

This study adopts the socio-technical systems perspective, which emphasizes that technological adoption is not solely dependent on the technical capability of a system but also on the social, cultural, and organizational contexts in which it is deployed. The socio-technical framework originated from the work of Trist (1981) and was later advanced by Bijker *et al.* (2012), who argued that technology and society are co-constructed. From this perspective, technology is not neutral but shaped by human actors, institutions, and cultural values, while also shaping how people interact with their environment.

The framework is particularly relevant to Artificial Intelligence (AI) deployment in Nigeria, where challenges cannot be reduced to technical issues alone. For instance, infrastructural limitations such as poor electricity supply and inadequate broadband internet directly affect the feasibility of AI, but these problems are compounded by human capacity gaps among teachers and health workers. Similarly, organizational and governance structures, including weak policies, lack of accountability, and inadequate regulatory frameworks, determine how AI is adopted and monitored. Socio-cultural factors such as resistance to change, ethical concerns, and trust in AI systems also play a critical role in shaping outcomes.

By framing AI adoption within a socio-technical context, this paper underscores the interconnectedness of these elements. It clarifies why infrastructure investment alone cannot ensure successful AI integration unless human skills are developed, policies are strengthened, and cultural readiness is cultivated. Consequently, the framework guided the identification of four main challenges (infrastructure, human capacity, governance/ethics, and finance) and influenced the recommendations presented. The socio-technical perspective guarantees that the solutions proposed are not merely technical fixes but context-aware strategies that acknowledge the systemic and interactive aspects of AI implementation in education, community health, and environmental health in Nigeria.

Infrastructure



Method and Analytical Approach

This study uses a conceptual and literature-based approach, emphasizing the synthesis of existing knowledge rather than gathering new data. The goal is to critically analyze the challenges of implementing Artificial Intelligence (AI) in education, community health, and environmental health in Nigeria. The data for this paper was collected from peer-reviewed journal articles, sector reports, and relevant policy documents published between 2020 and 2025. These years were selected because they include the most recent discussions on AI adoption in education and health, especially in the post-COVID-19 era when digital transformation accelerated across various sectors. Sources were identified through a focused search of online databases such as Google Scholar, ResearchGate, and institutional repositories, using keywords like "Artificial Intelligence in Nigeria," "AI in Education," "AI and Community Health," and "AI and Environmental Health." Policy documents were sourced from organizations including UNESCO, UNICEF, and the World Bank, as well as from Nigerian ministries and agencies.

A qualitative thematic analysis was employed to identify recurring themes and patterns across the selected literature. Specifically, challenges were grouped under four major categories: infrastructural deficits, human capacity gaps, governance and ethical concerns, and financial sustainability. This process ensured that the analysis was systematic and reflective of dominant issues documented across multiple sources.

The socio-technical theoretical framework guided the interpretation of these findings. By situating AI deployment within the interaction of technology, humans, organizations, and culture, the framework allowed the study to go beyond technical limitations and explore systemic, ethical, and contextual barriers. This integration of theory with literature-driven

evidence ensured that the recommendations provided are both context-sensitive and grounded in established scholarship.

Although this is a conceptual study, the methodological approach enhances its credibility by ensuring transparency in data sourcing, rigor in analysis, and alignment with theoretical underpinnings. This method also provides a foundation for future empirical studies that may wish to test the framework or validate the findings through fieldwork.

Table 1: Summary of Challenges and Recommendations for AI Deployment in Nigerian Education, Community Health, and Environmental Health

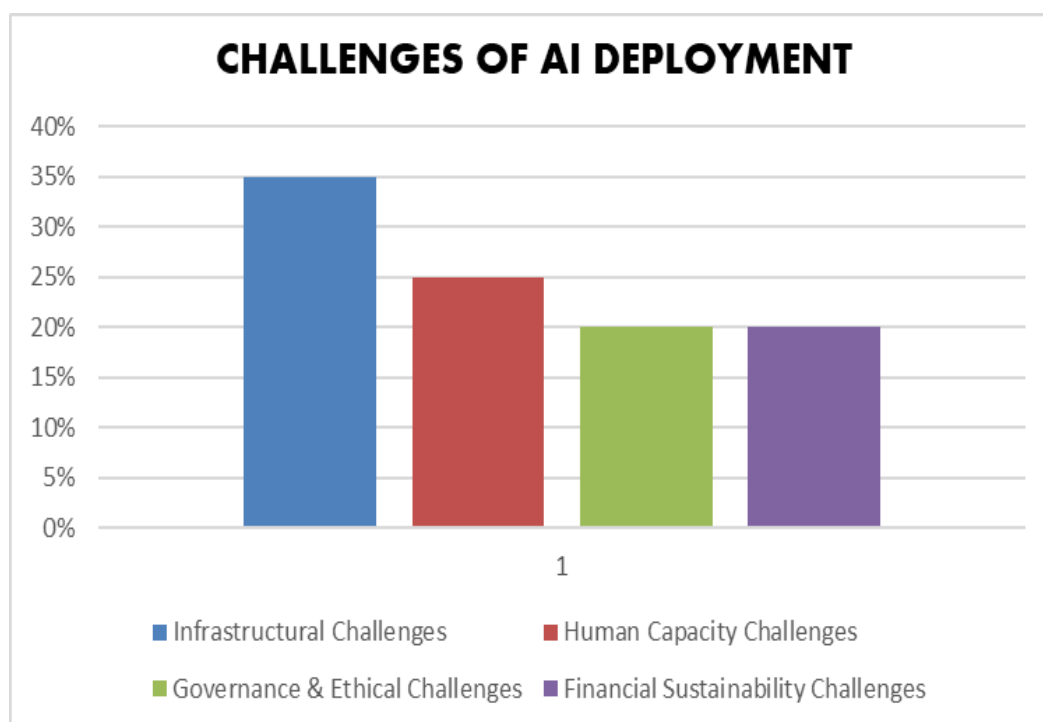
Category of Challenge	Key Issues Identified	Recommendations
Infrastructural Challenges	<ul style="list-style-type: none"> - Unstable electricity supply - Limited broadband internet - Inadequate access to digital devices - Poor ICT teacher capacity 	<ul style="list-style-type: none"> - Invest in renewable energy (e.g., solar) - Expand broadband through telco partnerships - Supply affordable devices via PPPs - Institutionalize ICT/AI teacher training
Human Capacity Challenges	<ul style="list-style-type: none"> - Low digital literacy among teachers/health workers - Weak AI skills in practice - Limited training opportunities 	<ul style="list-style-type: none"> - Continuous professional development - Integrate AI modules in teacher/health curricula - Incentivize training with certification/career advancement
Governance and Ethical Challenges	<ul style="list-style-type: none"> - Weak policies on AI use - Data privacy concerns - Algorithmic bias - Lack of accountability 	<ul style="list-style-type: none"> - Enforce AI ethics/data protection laws - Establish oversight/monitoring bodies - Engage all stakeholders in policy-making
Financial Sustainability Challenges	<ul style="list-style-type: none"> - Over-dependence on donor funding - Lack of domestic investment - High cost of digital infrastructure 	<ul style="list-style-type: none"> - Create dedicated government budget lines - Tax incentives for private investors - Strengthen PPPs for shared funding - Promote cooperative/community-driven financing

Table 2: Weighted Distribution of Challenges in AI Deployment
Data Presentation

Category of Challenge	Relative Weight (%)	Rationale
Infrastructural Challenges	35%	Infrastructure (power, internet, devices) is the most cited barrier in Nigeria.
Human Capacity Challenges	25%	Teacher/health worker skills and training gaps are widespread but secondary to infrastructure.

Governance & Ethical Challenges	20%	Weak regulations, data privacy, and accountability issues remain pressing but less immediate than infrastructure/human capacity.
Financial Sustainability Challenges	20%	Funding gaps and over-dependence on donors are consistent obstacles across sectors.
Total	100%	

Source: UNICEF (2025)



Conclusion

Artificial Intelligence deployment in Nigeria's education, community health, and environmental health sectors remains at an early and uneven stage. While interest and experimentation have grown in recent years, large-scale implementation continues to face structural and systemic barriers that reflect broader developmental challenges. The interplay between technology and context, particularly infrastructure, human expertise, institutional capacity, and socio-cultural dynamics, has shaped both the possibilities and limitations of AI integration. Rather than a smooth or linear process, AI deployment in these sectors has revealed deep dependencies on local conditions, revealing that digital tools alone cannot drive transformation. The outcomes of AI initiatives so far have largely depended on how well systems can adapt to the realities on the ground, including limitations in access, trust, and continuity.

Ultimately, AI is not simply being introduced into neutral environments; it is interacting with deeply rooted inequalities, fragmented systems, and evolving policy landscapes. Understanding this complexity is essential to making sense of both the current state and the future direction of AI deployment in Nigeria's critical public sectors.

Discussion of Finding

The deployment of Artificial Intelligence in Nigerian education, community health, and environmental health education faces multifaceted challenges. These barriers can be grouped into four broad dimensions: infrastructural, human capacity, governance and ethical, and financial sustainability.

i. Infrastructural Challenges

One of the most critical obstacles to the successful deployment of Artificial Intelligence in Nigerian schools is the inadequacy of basic infrastructure. Reliable electricity remains a persistent challenge, with less than 55 percent of schools having a consistent power supply, and the situation is far worse in rural areas, where barely one-third of schools are connected to the national grid (UNESCO, 2023). Without electricity, the operation of AI-enabled learning platforms, intelligent tutoring systems, and digital assessment tools is severely undermined.

Closely related to this is the problem of internet connectivity. Only about 28 percent of Nigerian schools have functional internet access, and even where connections exist, bandwidth is often slow and unstable, limiting real-time interaction with AI-driven platforms (UNICEF, 2025). This digital divide between urban and rural areas compounds existing inequalities, as schools in cities are four times more likely to have broadband access compared to those in rural communities.

Another dimension of the infrastructural barrier is inadequate access to digital devices. The ratio of computers to students in public secondary schools is as high as 1:40, far above global best practices, which recommend at least one computer for every five learners (World Bank, 2025). Furthermore, less than 20 percent of schools have access to tablets or smart devices, restricting the opportunities for students to interact with adaptive learning systems and other AI-powered applications.

Beyond facilities, teacher preparedness remains a fundamental concern. Balogun et al. (2024) report that nearly 70 percent of Nigerian teachers lack adequate digital literacy and training in AI-based pedagogy. Even when infrastructure is available, the absence of skilled human capital hinders its effective utilization. This means that infrastructural challenges are not only technological but also human-centered, as they cut across access, usability, and maintenance.

ii. Human Capacity Challenges

Human capacity limitations remain a serious barrier to effective AI integration. Teachers, health practitioners, and environmental officers frequently lack digital literacy and AI-specific skills, which reduces the efficacy of training and limits integration into practice

(Balogun et al., 2024). Without continuous professional development and support, the adoption of AI technologies risks remaining superficial and unsustainable.

iii. Governance and Ethical Challenges

Fragmented governance and weak regulatory frameworks exacerbate implementation problems. Gaps in data protection, accountability, and ethical oversight create risks when deploying AI systems in education and health (Suleiman, 2024; Crawford, 2021). Ethical concerns surrounding privacy, algorithmic bias, and potential harm further complicate deployment, particularly in sensitive areas like child education and patient health data (Karran et al., 2024).

iv. Financial Sustainability Challenges

AI deployment requires continuous investment in hardware, software, training, and maintenance. Many Nigerian projects rely on donor funding or external expertise, which threatens sustainability (Akinsemolu, 2025). Without domestic financial strategies to address recurring costs, adoption risks collapsing once external funding ends. To address the challenges identified in the deployment of Artificial Intelligence in Nigerian education, community health, and environmental health education, the following context-specific recommendations are proposed:

v. Addressing Infrastructural Challenges

Government and private stakeholders should prioritize investments in reliable electricity, particularly in rural schools, by expanding access to renewable energy solutions such as solar mini-grids. Expanding broadband internet coverage through partnerships with telecommunication providers is also critical. In addition, programs should be introduced to ensure equitable access to digital devices, with public-private partnerships supplying affordable tablets and laptops to schools. Finally, teacher training in basic ICT and AI pedagogy should be institutionalized as part of teacher education programs to ensure the effective utilization of available infrastructure.

vi. Addressing Human Capacity Challenges

There is an urgent need for continuous professional development for teachers, health workers, and environmental practitioners. Training programs should focus on building digital literacy, data interpretation skills, and AI-assisted teaching or practice. Universities and teacher training colleges should integrate AI-related modules into their curricula. Incentivizing teachers and practitioners through certification, allowances, or career advancement opportunities can also drive higher participation and long-term skill retention.

vii. Addressing Governance and Ethical Challenges

Policymakers should develop and enforce comprehensive regulations guiding the ethical use of AI in education and health sectors. This includes clear frameworks for data protection, accountability, and responsible use of AI tools. Establishing independent

oversight bodies can help monitor compliance and prevent algorithmic bias. Stakeholder engagement, including students, teachers, parents, and community representatives, should be central to the policy-making process to ensure inclusiveness and trust.

viii. Addressing Financial Sustainability Challenges

To reduce over-reliance on donor funding, Nigeria should develop domestic funding strategies for AI deployment. This can include dedicated government budget lines for educational and health technologies, tax incentives for private companies investing in AI infrastructure, and community-driven financing models such as cooperative funding for digital devices. Public-private partnerships should also be strengthened to provide cost-sharing arrangements that make long-term adoption viable and sustainable.

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