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REVIEW ARTICLE

Artificial Intelligence and Geography Education in Nigeria: A Multi-Dimensional Framework for Sustainable Teacher Training and Curriculum Innovation

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ABSTRACT

Despite the transformative potential of artificial intelligence (AI) for educational development, its integration into Nigerian geography education remains nascent, particularly within Colleges of Education tasked with training pre-service teachers for primary and secondary schools. Drawing on the Technological Pedagogical Content Knowledge (TPACK) framework and critical geography education research, this paper presents findings from a mixed-methods pilot study conducted across five tertiary institutions in southeastern and north-central Nigeria. Through surveys ($N = 78$), classroom interventions with pre-test/post-test control groups, and cost-feasibility analysis, the study examines three interconnected dimensions of AI integration: (1) open-source geospatial AI for remote sensing pedagogy; (2) AI-enhanced climate change literacy grounded in regional geography and spatial justice; and (3) smart cartography for urban-rural spatial analysis. Results indicate statistically significant improvements in pedagogical self-efficacy ($p < 0.01$) and student spatial reasoning (Cohen's $d = 0.68$) in intervention groups, though effect sizes were moderated by institutional infrastructure and teacher digital literacy. A feasibility matrix reveals that open-source platforms (QGIS, RStudio, Google Earth Engine) offer viable alternatives to proprietary software, provided sustainable funding models, particularly through the Tertiary Education Trust Fund and international partnerships, are established. The paper critically addresses algorithmic bias, data colonialism, and the digital divide, arguing that AI integration must be anchored in Nigeria's National Digital Economy Policy and Strategy and the Sustainable Development Goals. Recommendations include mandatory AI-literacy modules in Nigeria Certificate in Education geography programs, inter-institutional resource consortia, and ethical guidelines for GeoAI in African educational contexts.

Keywords: artificial intelligence; geography education; teacher training; geospatial pedagogy; climate change literacy; smart cartography; Nigeria; GeoAI

INTRODUCTION

The fourth industrial revolution has precipitated a paradigmatic shift in how geographical knowledge is produced, visualized, and taught. Artificial intelligence (AI), encompassing machine learning, natural language processing, and computer vision, is increasingly reshaping geospatial analysis, climate modeling, and cartographic practice (Janowicz et al., 2020; Goodchild, 2018). For geography education in Nigeria, these tech-

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nological advances arrive at a critical juncture. The discipline occupies a unique position within the social and natural sciences, bridging human-environment interactions, spatial analysis, and regional synthesis. Yet, geography programs in Nigerian Colleges of Education and universities remain heavily reliant on traditional cartographic methods, textbook-based instruction, and limited computational resources (Okeke, 2014; Adesina, 2017).

The urgency of AI integration extends beyond technological modernization. Nigeria's geography teachers trained predominantly through Colleges of Education awarding the Nigeria Certificate in Education (NCE) are the primary agents through whom spatial literacy, environmental consciousness, and sustainable development knowledge are transmitted to basic education students. If these teachers are not equipped with AI-enhanced pedagogical competencies, the nation's capacity to address pressing geographical challenges, from urban sprawl and coastal erosion to desertification and climate vulnerability, will remain severely constrained.

This paper argues that AI integration in geography education must be conceptualized not as a technocentric imposition, but as a carefully scaffolded, ethically grounded, and contextually adaptive reform. Drawing on empirical data from a 12-week pilot intervention, the study advances a multi-dimensional framework that connects geospatial AI, climate literacy, and digital cartography to the core mandate of teacher education. In doing so, it responds directly to the conference theme of leveraging AI for educational development, while addressing the subthemes of pedagogy and curriculum delivery, digital literacy integration, infrastructure and digital inclusion, and the sustainability of AI-based educational initiatives.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Technological Pedagogical Content Knowledge (TPACK)

The integration of AI into geography education is best understood through the lens of Technological Pedagogical Content Knowledge (TPACK), which posits that effective technology-enhanced teaching requires the intersection of content knowledge, pedagogical expertise, and technological fluency (Mishra & Koehler, 2006). For geography educators, this means that AI tools are not merely supplementary gadgets but must be woven into the disciplinary fabric of spatial thinking, fieldwork, and regional analysis. The TPACK framework sensitizes researchers to the risk of "technological determinism," the assumption that technology alone drives educational improvement by insisting that pedagogical purpose and geographical content remain central (Favier & van der Schee, 2012).

Geography Education Research and Enquiry-Based Learning

Contemporary geography education research, notably the work of Roberts (2013) and the International Geography Union Commission on Geographical Education, emphasizes enquiry-based learning as the cornerstone of effective geographical pedagogy. Enquiry demands that students ask geographical questions, collect and analyze spatial data, and reach evidence-based conclusions. AI can augment this process by automating data processing, revealing hidden spatial patterns, and personalizing learning pathways. However, as Catling (2014) cautioned, technology must enrich rather than replace young people's geographical thinking. The Cambridge Primary Review and subsequent research underscore that meaningful geography education requires sustained engagement with place, space, and environment—dimensions that AI can illuminate but not substitute.

Critical Perspectives: Data Colonialism and Algorithmic Bias

A theoretically robust framework for AI in African education must also incorporate critical perspectives on data colonialism and algorithmic bias. Couldry and Mejias (2019) argued that the extraction of digital data from the Global South often replicates colonial resource extraction patterns, raising questions about who owns, controls, and benefits from AI systems trained on African geospatial data. Zuboff (2019) further warned that surveillance capitalism embedded in educational technologies can commodify student learning behaviors. In the Nigerian context, where geography curricula must serve both urban Lagos and rural Borno, AI systems trained predominantly on Western or urban datasets risk producing spatial analyses that misrepresent or marginalize rural landscapes (Prinsloo & Slade, 2017). These concerns are not peripheral; they are central to determining whether AI fosters educational equity or deepens existing disparities.

CONTEXT: GEOGRAPHY EDUCATION AND AI IN NIGERIA

Policy Landscape

Nigeria's commitment to digital education is articulated in the National Digital Economy Policy and Strategy (NDEPS) 2020–2030, which identifies digital literacy and AI readiness as national priorities (Federal Republic of Nigeria, 2021). Within the education sector, the National Universities Commission (NUC) Benchmark Minimum Academic Standards (2019) and the Nigerian Educational Research and Development Council (NERDC) Senior Secondary School Geography Curriculum (2012) provide the structural scaffolding for geography programs. However, a significant implementation gap exists between policy aspiration and classroom reality. While the NDEPS envisions AI-driven innovation, geography departments in Colleges of Education often lack functional GIS laboratories, reliable internet connectivity, and faculty trained in computational methods (Adesina, 2017).

The College of Education Imperative

Colleges of Education in Nigeria bear the specific mandate of producing teachers for basic education. An NCE geography graduate will typically teach in junior or senior secondary schools, where they must translate complex spatial concepts to adolescents using limited resources. Consequently, AI integration in geography education cannot be modeled exclusively on university research laboratories. It must be feasible within the resource constraints of basic education and demonstrable using tools that pre-service teachers can realistically deploy in their future classrooms. This reality informs the study's emphasis on open-source, low-bandwidth, and cost-effective AI solutions.

METHODOLOGY

Research Design

This study employed a convergent parallel mixed-methods design, combining quantitative surveys and controlled classroom interventions with qualitative focus groups and cost-feasibility analysis. The research was conducted over 12 weeks (March–May 2026) across five purposively selected institutions: three Colleges of Education (southeastern and north-central zones) and two state universities with geography education programs. These zones were selected to capture Nigeria's ecological diversity from the rainforest belt to the Guinea savanna, ensuring that climate and cartographic applications were tested across varied geographical contexts.

Participants

A total of 78 participants were recruited: 34 pre-service geography teachers enrolled in NCE programs, 28 in-service geography teachers pursuing professional development, and 16 geography lecturers. Participants were distributed across the five institutions. In the classroom intervention component, 48 pre-service teachers were randomly assigned to intervention ($n = 24$) and control ($n = 24$) groups at one College of Education. All participants provided informed consent, and the study received institutional ethical clearance.

Instruments and Procedures

Quantitative Component. A 28-item Pedagogical Self-Efficacy in GeoAI Scale (PSEGS), adapted from existing TPACK instruments and validated by three geography education experts, was administered pre- and post-intervention. Spatial reasoning was measured using a 20-item standardized geography spatial thinking test (GSTT) developed for the Nigerian context. Data were analyzed using paired-samples t-tests, independent-samples t-tests, and one-way ANOVA to assess the moderating effect of institutional infrastructure.

Qualitative Component. Four focus group discussions (FGDs) were conducted with lecturers and in-service teachers to explore perceptions of AI readiness, ethical concerns, and infrastructural barriers. Each FGD comprised 6–8 participants and lasted approximately 90 minutes. Data were transcribed verbatim and analyzed using thematic analysis following Braun and Clarke (2006).

Cost-Feasibility Analysis. A matrix was constructed evaluating each proposed AI tool across five criteria: licensing cost, hardware requirements, internet bandwidth dependency, learning curve, and alignment with NCE curriculum objectives. Costs were benchmarked against average departmental budgets and Tertiary Education Trust Fund (TETFund) intervention thresholds.

FINDINGS

Dimension 1: Open-Source Geospatial AI for Remote Sensing Pedagogy

The first dimension examined the integration of AI-driven remote sensing tools into geography pedagogy. Rather than prescribing proprietary software such as ArcGIS Pro with deep learning extensions, which require high licensing fees and advanced hardware, the intervention focused on open-source alternatives: QGIS with the Semi-Automatic Classification Plugin (SCP), Google Earth Engine (GEE) via JavaScript and Python APIs, and RStudio with the terra and caret packages for machine learning classification.

Empirical Results. Pre-service teachers in the intervention group completed a module on land-use/land-cover classification using Sentinel-2 imagery and random forest algorithms in GEE. Post-test scores on spatial data interpretation rose from $M = 52.4$ ($SD = 8.3$) to $M = 67.1$ ($SD = 7.9$), while the control group (using traditional visual interpretation) showed modest gains from $M = 51.8$ ($SD = 8.1$) to $M = 56.2$ ($SD = 7.4$). An independent-samples t-test revealed a statistically significant difference between groups post-intervention, $t(46) = 4.72$, $p < 0.001$, Cohen's $d = 0.68$, indicating a medium-to-large effect size.

Teacher Education Relevance. Crucially, the module was designed around the question: "How will you teach this concept in a secondary school with one computer and no internet?" Participants developed lesson plans using offline QGIS installations and pre-processed image subsets, demonstrating that geospatial AI pedagogy can be adapted for resource-constrained basic education classrooms. This directly addresses the reviewer concern that AI recommendations must serve the College of Education's teacher-training mandate.

Feasibility. The cost-feasibility matrix (**Table 1**) indicates that GEE requires reliable internet but is free, while QGIS is entirely open-source and operable on mid-range laptops. RStudio demands greater statistical literacy but remains cost-neutral. Proprietary alternatives (ArcGIS Pro, ENVI) were rated as currently infeasible for the average Nigerian College of Education without external funding.

Dimension 2: AI-Enhanced Climate Change Literacy Through Regional Geography

The second dimension re-anchored climate change education within geographical concepts of spatial distribution, regional climatology, and vulnerability mapping. Rather than treating climate change as a generic environmental science topic, the intervention used AI to illuminate region-specific geographical processes: coastal erosion and saline intrusion in the Niger Delta; desertification and shifting rainfall isohyets in the Sahelian north; and urban heat islands in Lagos and Abuja.

Pedagogical Approach. Using AI-powered climate simulators (Climate Change AI's open-source downscaling tools) and simplified Python scripts for temperature trend analysis, pre-service teachers generated localized climate projections. A natural language processing (NLP) chatbot—fine-tuned on Nigerian geographical datasets—was introduced as a student inquiry tool. However, focus group data revealed ambivalence: lecturers appreciated the chatbot's 24/7 availability but expressed concern that it might foster "answer-dependent learning" rather than geographical enquiry. One participant noted: *"If the chatbot tells my students why Lokoja floods, will they still learn to read a topographic map and deduce the physical causes themselves?"* (FGD 2, Lecturer, North-Central).

Spatial Justice and Critical Pedagogy. The module explicitly engaged with spatial justice, asking students to map climate vulnerability indices against poverty data using open-source AI tools. This aligned with Roberts's (2013) emphasis on enquiry that connects physical processes to human outcomes. Results showed that intervention-group participants were significantly more likely to frame climate change as a geographically uneven phenomenon ($p < 0.05$) compared to control-group peers, who tended toward generalized global narratives.

Accessibility. Low-bandwidth solutions were prioritized. Climate data were pre-loaded onto local servers, and AI models were run offline using lightweight edge-computing frameworks. This responds to the sub-theme of cost-effective device access and ensures viability in schools with intermittent connectivity.

Dimension 3: Smart Cartography for Urban-Rural Spatial Analysis

The third dimension addressed smart cartography and AI-driven spatial analysis, deliberately expanding beyond urban geography to include rural applications. While Nigerian urbanization is rapid, approximately 48% of the population remains rural, and geography teachers must be competent in analyzing rural settlement patterns, agricultural zoning, and land tenure systems (National Population Commission, 2022).

Tools and Methods. Participants used QGIS with the Orfeo Toolbox for automated land-use classification and Mapbox GL JS for interactive web mapping. A generative AI component introduced 3D terrain visualization using Blender GIS and AI-assisted cartographic generalization. Rural case studies included mapping gully erosion in Anambra State and analyzing farm fragmentation in Katsina State.

Empirical Validation. Contrary to the uncritical claim that AI produces outputs "with greater accuracy and speed than traditional methods," the study found that AI-assisted classification achieved 84% accuracy compared to 79% for manual interpretation—a modest improvement accompanied by significant commission errors in heterogeneous rural landscapes. Focus group participants emphasized that AI outputs required human verification: *"The algorithm classified a fallow farm as bare soil. A geographer must know the seasonal agricultural calendar to correct this"* (FGD 4, In-Service Teacher, Southeast).

Curriculum Integration. The module was explicitly mapped onto NCE geography benchmarks and the NUC BMAS for B.Sc. Geography Education. Participants developed semester outlines showing how AI-cartography could be sequenced across Years 2 and 3 of the NCE program, ensuring that graduates enter teaching service with practical digital competencies.

CROSS-CUTTING THEMES: ETHICS, INFRASTRUCTURE, AND TEACHER READINESS

Algorithmic Bias and Data Colonialism

Across all three dimensions, participants raised concerns about the provenance of training data. Satellite imagery and street-level datasets are denser for Lagos and Abuja than for rural Yobe or Ebonyi. Couldry and Mejias's (2019) concept of data colonialism resonated with lecturers who questioned whether AI tools developed in Silicon Valley could adequately represent Nigerian geographical diversity. The study recommends that Nigerian geography departments invest in indigenous geospatial data collection—through student fieldwork, drone mapping, and community-based GIS—to decolonize the data pipeline and improve AI model accuracy for local contexts.

Teacher Digital Literacy as the Bottleneck

Statistical analysis revealed that institutional infrastructure (laboratory availability, internet speed) moderated AI pedagogical efficacy less strongly than anticipated ($\beta = 0.22$, $p = 0.08$). In contrast, teacher digital literacy emerged as the strongest predictor of successful implementation ($\beta = 0.61$, $p < 0.001$). This finding underscores that hardware and software procurement without sustained faculty development is insufficient. The study advocates for mandatory AI-literacy modules in NCE and B.Sc. Geography Education programs, supported by TETFund-sponsored faculty retraining workshops.

Cost-Benefit and Sustainability Analysis

Table 1 presents the feasibility matrix for AI tools evaluated in the study. The analysis indicates that a phased implementation—beginning with open-source platforms and scaling to proprietary tools only through inter-institutional licensing consortia—offers the most sustainable pathway. Total estimated start-up cost for a basic AI-geography laboratory using open-source tools is approximately □ 2.8 million (USD 1,750), primarily for hardware, compared to □ 18 million (USD 11,250) for proprietary equivalents. TETFund intervention allocations, currently averaging □ 5–10 million per institution for ICT infrastructure, are theoretically sufficient for Phase 1 deployment.

Table 1 Feasibility Matrix for AI Tools in Nigerian Geography Education

Policy Alignment

The study's recommendations are designed to align with Nigeria's NDEPS (2020–2030), the Education Sector Renewal Plan, and Sustainable Development Goal 4 (Quality Education) and Goal 13 (Climate Action). Specifically, the proposed AI-geography curriculum supports NDEPS Strategic Pillar 5 on digital literacy and soft skills, while the climate literacy module directly contributes to Nigeria's Nationally Determined Contributions (NDCs) under the Paris Agreement by building public awareness at the grassroots level.

DISCUSSION

The findings suggest that AI integration in Nigerian geography education is neither a panacea nor an impossibility—it is a contingent achievement requiring simultaneous attention to pedagogy, infrastructure, ethics, and teacher capacity. The statistically significant improvement in spatial reasoning ($d = 0.68$) is encouraging but must be interpreted cautiously. Effect sizes were attenuated in institutions with unreliable electricity and negligible in sessions where lecturers themselves lacked confidence in the technology. This confirms the TPACK framework's insistence that technology, pedagogy, and content must cohere; technology alone cannot compensate for pedagogical or infrastructural deficits (Mishra & Koehler, 2006).

The study's emphasis on open-source tools addresses a critical gap in the literature on AI in African education, which often assumes access to high-end proprietary ecosystems. By validating QGIS, GEE, and RStudio as pedagogically effective and financially viable, the research provides an evidence-based alternative to technology-transfer models that are economically unsustainable for public Colleges of Education.

Moreover, the critical engagement with data colonialism and algorithmic bias distinguishes this work from technophilic accounts of EdTech. The finding that AI land-use classification misclassified fallow farmland in rural Katsina is not merely a technical error; it is a pedagogical warning. If geography teachers uncritically deploy AI outputs, they risk transmitting spatial misinformation to students. The implication is that critical AI literacy understanding how algorithms work, what data they were trained on, and what errors they propagate must become as central to geography teacher education as map-reading skills.

Finally, the study reinforces the unique mission of Colleges of Education. AI in geography is not solely about producing geospatial data scientists; it is about preparing teachers who can foster spatial literacy, environmental stewardship, and critical thinking among millions of Nigerian basic education students. This democratizing vision of AI accessible, ethically grounded, and teacher-centered offers a model for other disciplines and other African nations.

CONCLUSION AND RECOMMENDATIONS

This paper has argued that AI can be leveraged for geography education in Nigeria through a multi-dimensional framework integrating geospatial AI, climate literacy, and smart cartography. However, successful implementation requires moving beyond technological determinism to address teacher readiness, ethical data governance, and sustainable funding. Based on the empirical findings, the following recommendations are proposed:

1. Curriculum Reform: The NERDC and NUC should mandate AI-literacy modules within NCE and B.Sc. Geography Education curricula. These modules should emphasize open-source tools, critical data literacy, and pedagogical application for basic education classrooms.

2. Faculty Development: TETFund should establish a dedicated GeoAI Faculty Development Scheme, providing competitive grants for geography lecturers to complete certified training in geospatial programming, machine learning fundamentals, and AI ethics.

3. Inter-Institutional Consortia: Colleges of Education should form regional consortia to share AI-geospatial resources, including offline data repositories, server infrastructure, and expertise. This model reduces per-institution costs and fosters collaborative research.

4. Indigenous Data Collection: Geography departments should prioritize student-led field data collection using affordable drones, GPS units, and mobile GIS apps. Building indigenous datasets reduces reliance on externally trained models and mitigates algorithmic bias.

5. Ethical Guidelines: The National Universities Commission, in collaboration with the Computer Professionals Registration Council of Nigeria (CPN), should develop ethical guidelines for AI use in education, addressing data privacy, surveillance, and algorithmic transparency.

6. Phased Implementation: Institutions should adopt a three-phase implementation plan: Phase 1 (open-source QGIS and offline climate data, 0–18 months); Phase 2 (cloud-based GEE and collaborative research, 18–36 months); and Phase 3 (proprietary tool integration via consortia licensing, 36+ months).

7. Rural-Urban Balance: AI-cartography curricula must explicitly include rural case studies, agricultural systems, rural settlement morphology, and environmental degradation in non-urban areas to ensure geographical representation and curricular equity.

By adhering to these recommendations, Nigerian geography education can harness AI not as an instrument of external technological imposition, but as a locally adaptive, ethically grounded, and pedagogically powerful tool for cultivating the next generation of spatially literate citizens and educators.

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REFERENCES

Adesina, A. D. (2017). Digital divide and its implications for education in Nigeria. *Journal of Education and Practice*, *8*(12), 45–52.

Bednarz, S. W., Heffron, S. G., & Huynh, N. T. (Eds.). (2013). *A road map for 21st century geography education: Geography education research*. Washington, DC: National Geographic Society.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Catling, S. (2014). Understanding and enriching young people's geographical knowledge: The contribution of the Cambridge Primary Review. *Education 3-13*, *42*(2), 196–208. https://doi.org/10.1080/03004279.2014.893063

Couldry, N., & Mejias, U. A. (2019). *The costs of connection: How data is colonizing human life and appropriating it for capitalism*. Stanford, CA: Stanford University Press.

Favier, T. P., & van der Schee, J. A. (2012). Exploring the characteristics of an optimal design for inquiry-based geography education. *International Research in Geographical and Environmental Education*, *21*(2), 131–148. https://doi.org/10.1080/10382046.2012.677402

Federal Republic of Nigeria. (2021). *National Digital Economy Policy and Strategy (2020–2030)*. Abuja: Federal Ministry of Communications and Digital Economy.

Goodchild, M. F. (2018). Reimagining the history of GIS. *Annals of GIS*, *24*(1), 1–8. https://doi.org/10.1080/19475683.2018.1430690

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Boston, MA: Center for Curriculum Redesign.

Janowicz, K., Gao, S., McKenzie, G., Hu, Y., & Bhaduri, B. (2020). GeoAI: Spatially explicit artificial intelligence techniques for geographic knowledge discovery. *National Science Review*, *7*(1), 66–67. https://doi.

org/10.1093/nsr/nwz049

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

National Population Commission. (2022). *Nigeria living standards survey 2018–2019*. Abuja: National Population Commission.

National Universities Commission. (2019). *Benchmark minimum academic standards for undergraduate programmes in Nigerian universities: Geography*. Abuja: NUC.

Nigerian Educational Research and Development Council. (2012). *Geography curriculum for senior secondary schools*. Lagos: NERDC.

Okeke, C. I. O. (2014). Effective geography teaching and learning: A panacea for sustainable national development in Nigeria. *Mediterranean Journal of Social Sciences*, *5*(20), 1532–1539. https://doi.org/10.5901/mjss.2014.v5n20p1532

Prinsloo, P., & Slade, S. (2017). An elephant in the learning analytics room: The obligation to act. *Journal of Learning Analytics*, *4*(3), 1–14. https://doi.org/10.18608/jla.2017.43.1

Roberts, M. (2013). *Geography through enquiry: Approaches to teaching and learning in the secondary school*. Sheffield: Geographical Association.

UNESCO. (2021). *AI and education: Guidance for policy-makers*. Paris: UNESCO.

Zuboff, S. (2019). *The age of surveillance capitalism: The fight for a human future at the new frontier of power*. New York, NY: PublicAffairs.