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A systematic review of challenges facing climate change education in Nigeria and its public health consequences

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Abstract

Climate change poses escalating threats to public health worldwide, with low- and middle-income countries like Nigeria experiencing disproportionate risks from rising temperatures, erratic rainfall, flooding, droughts, and associated vector-borne diseases, malnutrition, respiratory illnesses, and heat stress. Education is widely recognized as a vital tool for building climate resilience, yet climate change education (CCE) in Nigeria faces persistent barriers, including fragmented curricula, inadequate teacher training, resource shortages, and low public awareness. This systematic review maps the challenges facing CCE in Nigeria and examines their linkages to public health consequences. The objectives were to identify barriers to CCE implementation, describe associated public health impacts in the Nigerian context, and explore interconnections between educational gaps and health outcomes. Following PRISMA guidelines, we searched PubMed, ScienceDirect, BMC, Frontiers, Scopus, African Journals Online, and grey literature sources from January 2010 to March 2026 using terms combining climate change indicators with education concepts restricted to Nigeria. Results highlight three dominant themes: curriculum and policy deficits, awareness and capacity gaps, and resource and infrastructural constraints. These barriers collectively limit adaptive behaviors and amplify disease burdens, particularly in rural and northern regions. Deficient CCE correlates with poor hygiene practices during floods and low uptake of heat-mitigation strategies, exacerbating malaria, cholera, and respiratory conditions. In conclusion, strengthening CCE through curriculum reform, teacher training, and multisectoral collaboration is essential to mitigate public health risks. Recommendations include integrating climate-health modules across all educational levels, scaling community awareness programs, and prioritizing rural infrastructure investment. Future research should evaluate intervention effectiveness using longitudinal and mixed-methods designs.

Key words: climate change education, Nigeria, public health consequences, systematic review, curriculum barriers.

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Introduction

Climate change has emerged as one of the most pressing global challenges of the 21st century, profoundly reshaping environmental systems, socioeconomic structures, and human health outcomes.[1] Rising global temperatures, increasing variability in precipitation patterns, and the growing frequency and intensity of extreme weather events have significantly amplified public health risks worldwide.[2] It is estimated that climate change will contribute to approximately 250,000 additional deaths annually between 2030 and 2050, primarily through malnutrition, malaria, diarrhoeal diseases, and heat-related illnesses.[2] These impacts are disproportionately borne by low- and middle-income countries (LMICs), where limited adaptive capacity, fragile health systems, and high dependence on climate-sensitive livelihoods exacerbate vulnerability.[3]

In Africa, climate change is progressing at a rate exceeding the global average, with projected temperature increases of 1.5-2.0°C by mid-century under moderate emission scenarios.[1] These climatic shifts have intensified drought conditions in the Sahel, increased flooding in coastal and riverine regions, and contributed to widespread heat stress across the continent.[4] Such environmental disruptions are closely linked to rising incidences of vector-borne diseases, waterborne infections, food insecurity, and respiratory illnesses, underscoring the intersection between climate dynamics and public health outcomes.[4] Education is increasingly recognized as a critical lever for climate adaptation and resilience. International frameworks, including the United Nations Framework Convention on Climate Change and initiatives led by UNESCO, emphasize the role of climate change education (CCE) in equipping individuals and communities with the knowledge, skills, and behavioral competencies required to mitigate and adapt to climate risks.[5] Effective CCE extends beyond awareness, fostering practical decision-making capacities that influence health-protective behaviors, environmental stewardship, and community resilience.6 However, the implementation of CCE remains uneven across sub-Saharan Africa, where curricular integration is often limited and teacher preparedness inadequate.[6]

Nigeria, Africa's most populous country, faces a particularly acute convergence of climate vulnerability and public health risk.[7] Its diverse ecological zones, ranging from arid northern regions to

humid coastal areas, experience distinct but interconnected climate challenges, including desertification, flooding, coastal erosion, and extreme heat.[8] These environmental stressors have direct and indirect health consequences, including expanded malaria transmission windows, recurrent cholera outbreaks linked to flooding, and increased respiratory conditions associated with air pollution and dust exposure.[9,10] Projections indicate that climate-related health burdens in Nigeria could increase by over 20% by 2050, disproportionately affecting children, older adults, and rural populations.[8] Despite these risks, CCE in Nigeria remains underdeveloped and fragmented. Existing curricula at primary, secondary, and tertiary levels often provide only superficial coverage of environmental issues, with limited integration of climate science and health linkages.[11,12] Teacher capacity is constrained by insufficient training and a lack of instructional resources, while policy frameworks such as the National Climate Change Policy (2021-2030) face challenges in implementation at the institutional level.[13] These deficiencies limit the ability of individuals and communities to adopt adaptive behaviors, thereby amplifying vulnerability to climate-sensitive health risks.[14,15]

Socioeconomic and geographic inequalities further compound these challenges. Rural populations, which rely heavily on rain-fed agriculture, face heightened exposure to climate hazards yet have limited access to educational resources and adaptive information.[16] Gender disparities also persist, with women and girls bearing disproportionate burdens related to resource scarcity while remaining underrepresented in targeted educational interventions.[17] Regional disparities are evident, with northern Nigeria experiencing higher vulnerability but lower levels of climate awareness compared to southern regions.[18] While previous studies have explored climate-health linkages or environmental education independently, there remains a lack of comprehensive synthesis examining the intersection between CCE challenges and public health outcomes in Nigeria.[16,19] This systematic review addresses this gap by mapping the existing evidence, identifying key barriers to effective CCE, and analyzing how these barriers translate into health vulnerabilities. By integrating findings from empirical studies, policy reports, and grey literature, this review provides a critical evidence base to inform policy, practice, and future research. Given Nigeria's commitments under the Paris Agreement and the Sustainable Development Goals, strengthening CCE represents a strategic opportunity to enhance both climate resilience and population health.[20]

Objectives of the study

This systematic review maps the challenges facing CCE in Nigeria and examines their linkages to public health consequences. Specific objectives include: i) to identify and describe the main challenges facing the implementation of CCE in Nigeria; ii) to examine the public health consequences of climate change in the Nigerian context; iii) to explore the interconnections between CCE deficiencies and heightened public health risks; iv) to map gaps in the literature and propose directions for future research and policy.

Methods

Study design

This study employed a systematic review design with narrative synthesis, conducted in accordance with the PRISMA 2020 guidelines,[21] and subsequently refined by Joanna Briggs Institute (JBI) methodology for systematic reviews.[22]

Information sources

A comprehensive search was conducted across PubMed, ScienceDirect, BMC, Frontiers, Google Scholar, Scopus, and African Journals Online from 1 January 2010 to 31 March 2026. Grey literature came from the World Health Organization Institutional Repository for Information Sharing, UNICEF Nigeria repositories, Nigerian Federal Ministry of Health, and the Environment websites.

Search strategy

The search strategy was developed iteratively and refined following preliminary systematic searches. Keywords combined MeSH and free-text terms. Search terms were combinations of "climate change education" OR "CCE" OR "environmental education" AND "Nigeria" AND "challenges" OR "barriers" OR "curriculum" OR "public health" OR "health impacts".

Searches were limited to publications in English. Eligibility screening focused on studies published between January 2010 and March 2026. Boolean operators (AND/OR) and truncation were applied. The final search was conducted on April 1, 2026.

Eligibility criteria

Inclusion criteria

Studies were included if they focused on Nigeria or any Nigerian subpopulation; addressed challenges in CCE implementation, curriculum gaps, teacher training, awareness, or resources, public health consequences of climate change (*e.g.*, vector-borne diseases, malnutrition, respiratory illness, heat stress), or explicit linkages between CCE deficiencies and health outcomes; were empirical, qualitative, quantitative, mixed-methods studies, reviews, policy/vulnerability assessments, or credible grey literature; published between 2010 and 2026; and were in English.

Exclusion criteria

Studies were excluded if they had no Nigeria-specific data, lacked focus on CCE or climate-related public health, were editorials, opinion pieces, abstracts, or purely theoretical; were duplicates; published before 2010, or were unavailable in full text. Table 1 further explains the inclusion and exclusion criteria for the study.

Table 1. Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Geographic focus	Nigeria or Nigerian subpopulations	Outside Nigeria
Topic	CCE challenges or climate-health linkages	No education or health focus
Document type	Peer-reviewed articles, reports, grey literature	Editorials, abstracts only
Time period	January 2010 - March 2026	Pre-2010
Language	English	Other languages

Risk of bias assessment

Mixed Methods Appraisal Tool (MMAT) version 2018 was used for quality appraisal.[23] This enables appraisal across qualitative, quantitative, and mixed-methods designs. Findings from quality appraisal informed the interpretation of results and generalizability. The risk of bias assessment score of the included studies is presented in Table 2.

Study selection

Two reviewers independently screened titles and abstracts, then full texts. Disagreements were resolved by consensus.

Data extraction and synthesis approach

A standardized form captured author, year, design, sample/setting, objectives, key findings, conclusions, and health-education linkages. Thematic synthesis followed Braun and Clarke's six-phase approach.[24]

Study selection and screening procedure (with PRISMA flow chart navigation)

A total of 350 records were identified from database and register searches. After the removal of 52 duplicate records, 298 records were screened by title and abstract. Of these, 216 records were excluded. The full texts of 82 articles were assessed for eligibility, and 50 articles were excluded for reasons including duplication, inappropriate study design, or non-Nigerian study setting. Ultimately, 32 Nigeria-specific studies were included in the review.

Description: Records identified: n=350 (databases + grey literature) → Duplicates removed: n=52 → Records screened: n=298 → Excluded at title/abstract: n=216 → Full-text assessed: n=82 → Excluded: n=50 (not Nigeria-specific n=22; no education-health link

Table 2. Quality and risk of bias assessment.

Authors (year)	Study design	Screening passed	Criteria met (/5)	Quality	Risk of bias
Federal Ministry of Health Nigeria (2024)[8]	National assessment	Yes	5	High	Low
Niyi-Odumosu *et al.* (2025)[9]	Scoping review	Yes	5	High	Low
Oluwatimilehin *et al.* (2022)[10]	Correlational study	Yes	1	Low	High
Amanchukwu *et al.* (2015)[11]	Narrative review	Yes	0	Low	High
Akinbami & Akinbami (2017)[12]	Survey	Yes	2	Moderate	Moderate
Oruonye *et al.* (2023)[13]	Analytical review	Yes	0	Low	High
Aborode *et al.* (2025)[14]	Mixed-methods	Yes	1	Low	High
Akatah *et al.* (2025)[15]	Review	Yes	0	Low	High
Okon *et al.* (2021)[16]	Systematic review	Yes	5	High	Low
Pinchoff *et al.* (2025)[17]	Participatory qualitative	Yes	5	High	Low
Oyelakin and Bisiriyu, (2026)[18]	Secondary analysis of Afrobarometer	Yes	5	High	Low
Mbonu (2024)[19]	Content analysis	Yes	5	High	Low
Monday (2020)[25]	Investigative review	Yes	0	Low	High
Abdulqadir *et al.* (2022)[26]	Survey	Yes	2	Moderate	Moderate
Surge Africa (2024)[27]	Narrative review	Yes	0	Low	High
UNICEF Nigeria (2025)[28]	Programme document	Yes	0	Low	High
UBEC (2025)[29]	Policy handbook	Yes	0	Low	High
Delprato *et al.* (2024)[30]	Non-parametric analysis	Yes	5	High	Low
Ayanlade *et al.* (2020)[31]	Cross-sectional survey	Yes	2	Moderate	Moderate
Eze *et al.* (2022)[32]	Survey	Yes	2	Moderate	Moderate
Okafor *et al.* (2025)[33]	Narrative review	Yes	0	Low	High
Omokaro *et al.* (2025)[34]	Literature review	Yes	0	Low	High
Tshabalala *et al.* (2025)[35]	Literature review	Yes	0	Low	High
Okereke *et al.* (2025)[36]	Survey	Yes	2	Moderate	Moderate
Ajagbe (2025)[37]	Review	Yes	5	High	Low
Obi *et al.* (2026)[38]	Narrative review	Yes	0	Low	High
Leal Filho *et al.* (2025)[39]	Scoping review	Yes	5	High	Low
Gkouliaveras *et al.* (2025)[40]	Scoping review	Yes	5	High	Low
Adodo *et al.* (2023)[41]	Cross-sectional survey	Yes	2	Moderate	Moderate
Fada *et al.* (2024)[42]	Survey	Yes	2	Moderate	Moderate
Baba *et al.* (2023)[43]	Qualitative	Yes	5	High	Low
Elias and Omojola (2015)[44]	Case study	Yes	0	Low	High

Screening passed: clear research question + adequate data; criteria met: number of the Mixed Methods Appraisal Tool criteria satisfied (max = 5); quality rating (high = 4-5, moderate = 2-3, low = 0-1); risk of bias interpretation (low risk: high-quality studies, moderate risk: moderate-quality studies, high risk: low-quality studies).

n=18; duplicates n=10) → Studies included: n=32. Figure 1 illustrates the screening procedures and PRISMA flow chart of the included studies.

Results

Characteristics of the included studies

A total of 32 studies met the inclusion criteria:[8-19,25-44] 13 were empirical surveys or cross-sectional studies, 10 were narrative or systematic reviews, 6 were policy or vulnerability assessments, and 3 were qualitative or mixed-methods. Sample sizes in primary studies ranged from undergraduates to national modelling covering millions. Settings spanned rural southwestern Nigeria, urban centers, northern states, and multi-state samples. Most publications appeared between 2020 and 2026, reflecting growing research interest after the Paris Agreement and recent extreme weather events. Studies predominantly examined either CCE barriers or health impacts, with eight explicitly linking the two domains. Geographic coverage showed a slight southern bias, but northern vulnerability assessments were prominent in health-focused papers. Table 3 presents a summary of the included studies.

Quality appraisal of included studies

Quality appraisal was conducted using MMAT version 2018,[23] enabling a structured evaluation across qualitative, quantitative, and mixed-methods designs. Overall, the methodological quality of included studies ranged from moderate to high, though important limitations were identified that influence the interpretation of findings. Most empirical studies demonstrated appropriate alignment between research questions, study design, and analytical methods, with 13 cross-sectional studies employing standardized survey instruments and 10 reviews applying systematic or semi-systematic approaches.

However, several studies lacked detailed reporting on sampling strategies, particularly in rural and hard-to-reach populations, introducing potential selection and response biases. Response rates were inconsistently reported, and where available, were often lower in northern and rural settings, potentially under-representing the most vulnerable populations. Validated measurement tools were used in the majority of quantitative studies assessing awareness, knowledge, or health outcomes, enhancing internal validity. Nevertheless, heterogeneity in measurement approaches limited comparability across studies. Grey literature sources contributed valuable large-scale and policy-relevant data but frequently lacked methodological transparency, particularly regarding data collection procedures and analytical frameworks.

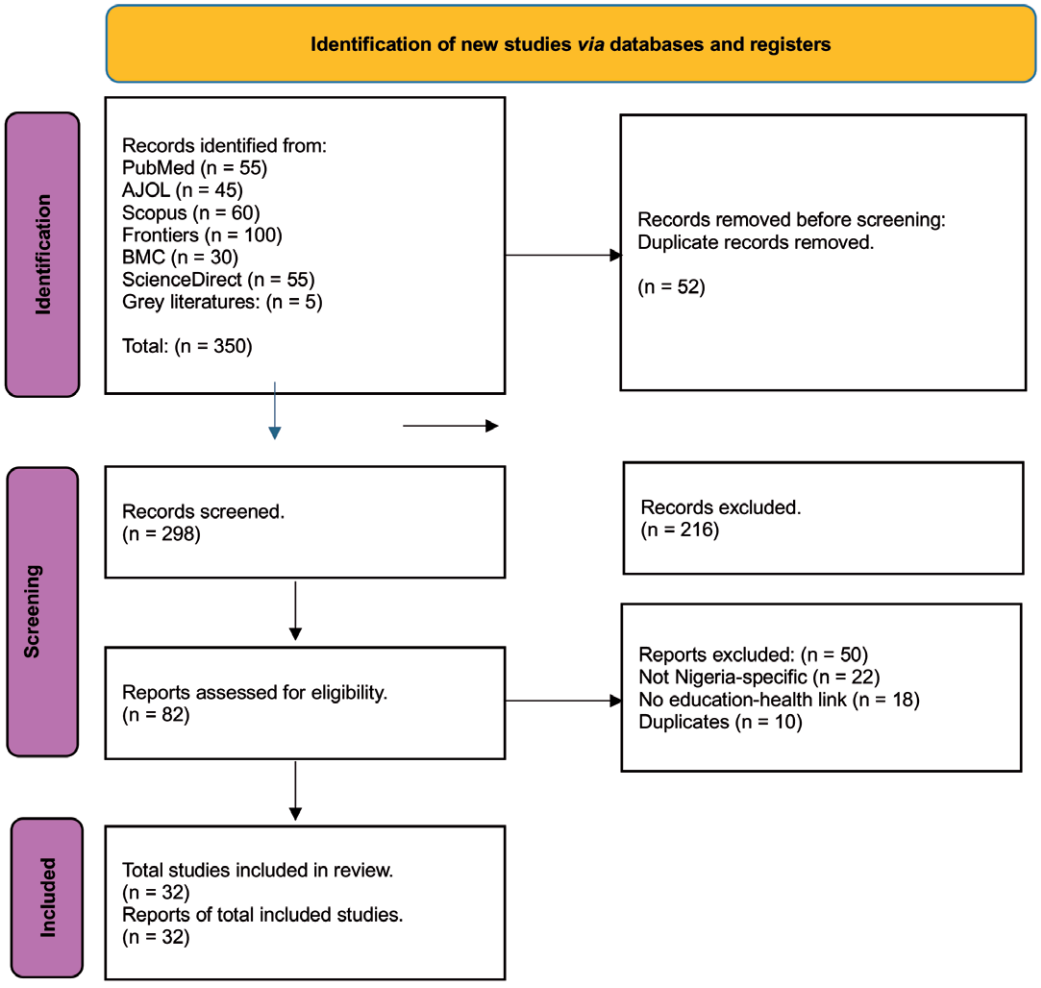

Figure 1. Diagram of the PRISMA 2020 Process for Systematic Reviews and Meta-Analyses.

Table 3. Summary of included studies.

Authors (year)	Objectives of the study	Study design	Sample size and study setting	Key findings	Conclusions
Federal Ministry of Health Nigeria (2024)[8]	Vulnerability and adaptation assessment	National assessment	National modelling	21% additional disease burden projected by 2050	Develop costed Health National Adaptation Plan
Niyi-Odumosu *et al.* (2025)[9]	Scoping review of respiratory health	Scoping review	National	Climate change worsens asthma and pollution-related illness	Reform policies and enforce pollution controls
Oluwatimilehin *et al.* (2022)[10]	Assess CC on disease occurrence	Correlational study	Hospital records, Lokoja	Temperature and rainfall linked to malaria, cholera spikes	Strengthen disease surveillance
Amanchukwu *et al.* (2015)[11]	Examine curriculum gaps in CCE	Narrative review	National	Curriculum lacks dedicated CCE modules and health linkages	Urgent curriculum reform needed
Akinbami and Akinbami (2017)[12]	Assess graduate knowledge of CC	Survey	450 university graduates, national	Limited understanding of causes, effects, and adaptation	Improve tertiary CCE content
Oruonye *et al.* (2023)[13]	Explore legal impediments to sustainable health	Analytical review	National	Low health budget despite CC and COVID threats	Incorporate legal frameworks for adaptation
Aborode *et al.* (2025)[14]	Examine flooding, water diseases, malnutrition	Narrative review with field notes	Borno State communities	Flooding triggers cholera outbreaks and malnutrition	Strengthen healthcare adaptation measures
Akatah *et al.* (2025)[15]	Analyse heatwave challenges	Review	National	Heat stress causes cardiovascular and mental health risks	Implement early warnings and resilient infrastructure
Okon *et al.* (2021)[16]	Review CC impact research	Systematic review	National	Research gaps in northern states; rising health burdens	Advance quantitative adaptation research
Pinchoff *et al.* (2025)[17]	Youth perceptions of CC on health	Participatory qualitative	Youth FGDs, Nigeria component	Heat/drought shifts gender roles and increases GBV	Invest in climate literacy programmes
Oyelakin and Bisiriyu, (2026)[18]	Perceptions of CC and health	Secondary analysis of Afrobarometer	National	Marked north-south disparities in awareness and risks	Use education-focused communication strategies
Mbonu (2024)[19]	Analyse newspaper coverage of child health	Content analysis	Newspaper articles, national	Media focus on child malnutrition and disease	Strengthen media advocacy and education
Monday (2020)[25]	Investigate CC health risks	Investigative review	National	Increased meningitis, malaria, skin cancer risks	Raise awareness among vulnerable groups
Abdulqadir *et al.* (2022)[26]	Examine awareness and socio-emotional wellbeing	Survey	589 undergraduates, Kwara State	Low awareness negatively affects wellbeing beliefs	Enhance higher-education CCE
Surge Africa (2024)[27]	Highlight CC health impacts	Narrative review	National	Pollution, heatwaves, and food insecurity major risks	Adopt multi-pronged collaborative solutions
UNICEF Nigeria (2025)[28]	Promote CCE for resilience	Programme document	National	Schools can serve as vehicles for climate action	Integrate green schools nationwide
UBEC (2025)[29]	Handbook for schools	Policy handbook	National	Schools face respiratory and vector-borne risks	Embed CCE in basic education curriculum

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Table 3. Continued from previous page.

Authors (year)	Objectives of the study	Study design	Sample size and study setting	Key findings	Conclusions
Delprato *et al.* (2024)[30]	Impact on education completion	Non-parametric analysis	2,524 communities, Nigeria included	Higher temperatures reduce school completion rates	Target policies for disadvantaged areas
Ayanlade *et al.* (2020)[31]	Public perception in rural areas	Cross-sectional survey	Rural southwestern Nigeria	Poor knowledge but positive attitude toward adaptation	Sustained health-promotion programmes needed
Eze *et al.* (2022)[32]	Teachers' climate science literacy	Survey	410 teachers, Enugu State	Low to moderate literacy; high training needs	Establish school-university partnerships for PD
Okafor *et al.* (2025)[33]	Research on CC initiatives	Narrative review	National	Persistent policy gaps and weak implementation	Strengthen enforcement and funding
Omokaro *et al.* (2025)[34]	Multi-impacts on agriculture and food security	Literature review	National	Reduced yields, pest pressure, and land degradation	Adopt targeted adaptation strategies
Tshabalala *et al.* (2025)[35]	Preparing African youth for CC	Literature review	Africa (Nigeria focus)	Capacity gaps in clean technologies and skills	Promote youth-led climate action
Okereke *et al.* (2025)[36]	Assessment of climate awareness and policy	Survey	1,306 subnational officials, national	Low knowledge and weak public awareness	Improve subnational governance and training
Ajagbe (2025)[37]	Antidote to impacts of CC	Review	National	Environmental degradation directly threatens health	Promote sustainable practices and education
Obi *et al.* (2026)[38]	Mainstreaming CC in school curricula	Narrative review	National	Inadequate teacher training and resources	Prioritise curriculum reform and PD
Leal Filho *et al.* (2025)[39]	CC, education, and malaria at universities	Scoping review	Africa (Nigeria included)	Limited curriculum coverage of malaria-CC links	Integrate malaria education in curricula
Gkouliaveras *et al.* (2025)[40]	Health professionals' perceptions	Scoping review	Global (Nigeria context)	Barriers to adaptation in health systems	Enhance training for health workers
Adodo *et al.* (2023)[41]	People's perceptions of CC impacts	Cross-sectional survey	Low-income communities, national	Flood, drought, and temperature ranked highest impacts	Community-based adaptation programmes essential
Fada *et al.* (2024)[42]	Assessment of issues on CC for education	Survey	Teachers and students, national	Outdated curriculum and low awareness levels	Full-scale CCE implementation required
Baba *et al.* (2023)[43]	Challenges of developing CC curricula for basic education	Qualitative	Curriculum developers, national	Resistance to reform and severe resource limits	Urgent basic education curriculum overhaul
Elias and Omojola (2015)[44]	Challenges of climate change for Lagos	Case study	Lagos state	Haphazard, top-down adaptation responses	Coordinated urban planning needed

CC, climate change; CCE, climate change education; FGDs, focus group discussions; GBV, gender-based violence; PD, professional development; UBEC, Universal Basic Education Commission; UNICEF, United Nations Children's Fund; WHO, World Health Organization.

Geographic bias was evident, with a concentration of studies in southern Nigeria, while northern and conflict-affected regions, despite higher vulnerability, were comparatively underrepresented. This imbalance introduces contextual bias, limiting the generalizability of findings to the national level. Importantly, the predominance of cross-sectional designs constrains causal inference, as relationships between CCE gaps and health outcomes are largely correlational rather than experimentally verified. No study employed longitudinal or controlled intervention designs to directly assess causal pathways.

No studies were excluded on the basis of quality; instead, methodological limitations were explicitly considered in the synthesis. Overall, while the evidence base is sufficiently robust to identify consistent patterns and associations, caution is warranted in interpreting causality and generalizing findings across diverse Nigerian contexts. Table 2 presents the quality appraisal results of the included studies.

Thematic review/key themes

The synthesis of the included studiesrevealed five interrelated themes that collectively illustrate how structural challenges in CCE shape public health vulnerabilities in Nigeria.[8-19,25-44]

Curriculum and policy deficits

Across educational levels (primary, secondary, and tertiary) in Nigeria, climate change content remains fragmented and insufficiently integrated into core curricula.[11,25-29] Existing materials are typically embedded within geography or basic science subjects, with minimal emphasis on health linkages, thereby limiting students' ability to translate climate knowledge into protective behaviours.[8,13] Although national frameworks such as the Climate Change Policy (2021-2030) exist, weak enforcement mechanisms and a lack of operational guidelines at the school level result in inconsistent implementation.[30-38] This policy-practice gap undermines the development of climate-health literacy as a functional competency and reduces the effectiveness of education as a tool for resilience.

Awareness and capacity gaps

Low levels of climate literacy among teachers, students, and communities represent a significant barrier to effective adaptation.[12,26,32] Evidence indicates that many educators lack both the technical knowledge and pedagogical skills required to deliver CCE effectively, particularly in rural and resource-constrained settings.[31,36] These deficiencies contribute to widespread misconceptions regarding climate risks and health impacts, hindering early recognition and response to hazards such as heat stress and waterborne diseases.[17] Consequently, communities remain ill-equipped to adopt preventive measures, reinforcing vulnerability.

Resource and infrastructural constraints

Material and infrastructural limitations further undermine CCE delivery. Many schools, particularly in rural areas, lack essential teaching resources, including instructional materials, laboratories, and climate-monitoring tools.[30] Climate-related disruptions, such as flooding and extreme heat, also damage school infrastructure and interrupt learning processes.[33] These constraints not only diminish educational quality but also expose students to health risks during environmental events, creating a cyclical relationship between educational disruption and health vulnerability.[14,39,40]

Public health consequences of climate change

The reviewed literature consistently highlights the growing burden of climate-sensitive diseases in Nigeria. Rising temperatures contribute to heat-related illnesses, dehydration, and cardiovascular stress, while flooding increases the incidence of cholera and other waterborne infections.[4,14,15] Drought conditions exacerbate malnutrition and respiratory illnesses linked to dust exposure and biomass use.[9] Additionally, changing climatic conditions have expanded the geographic and temporal distribution of malaria.[39] These impacts disproportionately affect vulnerable populations, particularly children, the elderly, in rural communities, and northern regions.[40-44]

Interplay between climate change education challenges and health risks

A critical contribution of this review is the identification of a feedback loop linking education deficits to health outcomes. Inadequate CCE leads to poor awareness and maladaptive behaviors, such as unsafe water practices during floods or a lack of heat protection strategies.[16,18] These behaviors increase disease incidence, which in turn disrupts education through illness, absenteeism, and infrastructure damage.[27] This feedback loop perpetuates cycles of vulnerability, particularly in regions with limited resources and high exposure to climate hazards.[8] Regional disparities amplify this cycle, with northern areas facing heightened vulnerability due to lower educational access and higher climate exposure.[8] Collectively, these findings position CCE not merely as an educational issue, but as a structural determinant of public health resilience. Addressing this interplay requires integrated approaches that simultaneously strengthen education systems and public health responses.

Discussion

Overview and interpretation of findings

This systematic review synthesized evidence from 32 studies examining CCE challenges and their public health implications in Nigeria. The findings demonstrate a consistent pattern in which curriculum deficits, low climate literacy, and infrastructural constraints collectively weaken adaptive capacity and contribute to increased vulnerability to climate-sensitive health outcomes.[8-19,25-44] Across studies, inadequate CCE was associated with reduced awareness of climate risks and limited adoption of preventive behaviors, including flood hygiene practices, heat protection strategies, and disease prevention behaviors. These behavioral gaps translate into increased exposure to malaria, cholera, malnutrition, and heat-related illnesses. While the direction of these relationships is consistent across the literature, most evidence remains correlational due to the predominance of cross-sectional study designs. Importantly, the findings position CCE not merely as an educational intervention but as a structural determinant of population health resilience.

Comparison with global and regional evidence

The findings of this review align with global evidence indicating that CCE plays a pivotal role in enhancing resilience and reducing vulnerability in LMICs.[6,17] Studies across sub-Saharan Africa have similarly identified gaps in curriculum integration, teacher preparedness, and resource availability as key barriers to effective CCE implementation.[6] However, the Nigerian context presents distinct features. Compared to countries such as South Africa, where climate education is more systematically embedded within national curricu-

la, Nigeria's approach remains fragmented and inconsistently implemented across regions.[38] Furthermore, the interaction between climate vulnerability and socio-political factors, including insecurity and displacement in northern Nigeria, introduces additional complexity not uniformly observed across the region.[8,18] The review also extends existing literature by explicitly linking educational deficits to public health outcomes, thereby bridging a gap between traditionally siloed domains of education and health research.[16,19]

Equity and contextual vulnerabilities

A critical insight from this review is the uneven distribution of both educational access and climate-related health risks across Nigeria. Rural populations are disproportionately affected due to their reliance on climate-sensitive livelihoods and limited access to formal education and health services.[16] Similarly, northern regions experience heightened vulnerability due to environmental conditions, lower literacy rates, and ongoing insecurity, yet remain underrepresented in the literature.[8,18] Gender disparities further compound these challenges. Women and girls often bear increased burdens related to water and resource scarcity during climate events, while having limited access to targeted educational interventions.[17] These inequities highlight the need for context-specific and inclusive CCE strategies that address the unique needs of vulnerable populations. The findings underscore that without deliberate attention to equity, efforts to strengthen CCE may inadvertently reinforce existing disparities rather than mitigate them.

Policy and implementation gaps

The review identifies a critical gap between policy formulation and implementation. While Nigeria has developed strategic frameworks, such as the National Climate Change Policy (2021-2030), their translation into effective educational practice remains limited.[13] Weak institutional coordination, inadequate funding, and insufficient teacher training are key barriers to implementation. To address these challenges, a structured implementation pathway is required. This includes integration of climate-health content into national curricula; investment in teacher training and professional development; development of monitoring and evaluation systems with measurable indicators; and strengthening intersectoral collaboration between education, health, and environment sectors. Evidence from included studies suggests that interventions are more effective when they are contextually adapted, community-based, and supported by institutional frameworks.[14,30] This framework strengthens the operational relevance of CCE and aligns it with Sustainable Development Goals and national adaptation strategies. Without such alignment, policy initiatives risk remaining aspirational rather than operational.

Causal pathways and the education-health nexus

While the included studies predominantly report associations, the evidence suggests plausible causal pathways linking CCE deficits to adverse health outcomes. Low levels of climate literacy limit individuals' ability to recognize environmental risks and adopt preventive behaviors, thereby increasing exposure to climate-sensitive diseases such as malaria, cholera, and heat-related illnesses.[9,14,39] However, it is important to emphasize that causal relationships remain underexplored due to methodological limitations. The reliance on cross-sectional and descriptive studies constrains the ability to establish temporality and causation. As such, the observed relationships should be interpreted as associative rather than causal, underscoring the need for longitudinal and intervention-based research to validate these pathways. Despite these limitations, theoretical frameworks such as the knowledge-attitude-practice model and socio-ecological models provide conceptual support for the observed linkages, suggesting that improved knowledge can influence attitudes and behaviors, ultimately shaping health outcomes.[6,17]

Integration of quantitative evidence and scale of the problem

Although qualitative insights dominate the literature, available quantitative evidence underscores the scale and urgency of the issue. Projections indicate significant increases in climate-related disease burdens, including malaria, cholera, and heat-related illnesses.[2,8] Surveys consistently report low levels of climate awareness among students and teachers, particularly in rural and northern regions.[12,26,31] However, the heterogeneity of measurement approaches and outcomes limits the ability to generate pooled estimates or conduct meta-analysis. This highlights the need for standardised indicators and measurement frameworks in future research to enable comparability and evidence synthesis.

Strengths and limitations of the study

The evidence base demonstrates several strengths, including increasing research attention to climate-health linkages and the inclusion of diverse study designs and data sources. The integration of grey literature provides valuable policy-relevant insights that complement empirical findings.

However, important limitations persist. The predominance of cross-sectional studies limits causal inference, while geographic bias restricts generalizability. Underrepresentation of northern and conflict-affected regions represents a significant gap, given their heightened vulnerability. Furthermore, variability in study design and measurement approaches limits comparability across studies. Despite these limitations, the review provides a robust synthesis of available evidence and identifies consistent patterns across multiple study types.

Conclusions

This systematic review demonstrates that challenges facing CCE in Nigeria, such as curriculum deficits, awareness gaps, and resource constraints, directly contribute to heightened public health risks from climate change. By limiting adaptive behaviors, these barriers perpetuate cycles of disease, malnutrition, and health inequities, particularly in rural and northern regions. Addressing them requires urgent, integrated action across education, health, and environment sectors. Strengthening CCE will not only build knowledge and skills but also foster resilience, reduce disease burdens, and support sustainable development. Nigeria's commitments under international agreements provide a foundation, yet implementation must move from policy to practice. The evidence mapped here underscores that effective CCE is not a peripheral educational issue but a core public health strategy. Without decisive reforms, climate impacts will continue to outpace adaptive capacity, threatening the health and future of millions in Nigeria.

Recommendations

To enhance impact, recommendations are now prioritized.

High-priority actions

1. Mandate integration of climate-health education into national curricula.
2. Implement nationwide teacher training programs with competency assessment.
3. Establish monitoring systems using defined indicators (*e.g.*, literacy, behavior change, disease trends).

Medium-term actions

1. Invest in resilient school infrastructure, particularly in rural areas.
2. Develop community-based awareness programs targeting vulnerable populations.
3. Strengthen multisectoral coordination between education, health, and environment sectors.

Long-term actions

1. Institutionalize CCE within national development planning.
2. Scale digital and community-based education platforms.
3. Conduct longitudinal and intervention-based research.

Implications of the study

Public health implications: strengthening CCE has the potential to significantly reduce the burden of climate-sensitive diseases by promoting preventive behaviors and enhancing community resilience. Improved awareness can facilitate early response to climate hazards, reducing morbidity and mortality associated with heat stress, infectious diseases, and malnutrition.

Practice implications: the findings highlight the importance of integrating climate education into both formal education systems and community-based programs. Collaboration between educators, health professionals, and policymakers is essential to deliver context-specific interventions that address local vulnerabilities.

Research implications: there is a critical need for longitudinal and intervention-based studies to establish causal relationships between CCE and health outcomes. Future research should also prioritize underrepresented regions and populations, including rural communities and vulnerable groups.

Policy implications: policymakers should prioritize the integration of climate-health education into national curricula, supported by adequate funding, teacher training, and monitoring frameworks. Addressing regional and socioeconomic disparities must be central to policy design.

Global health implications: Nigeria's experience provides valuable insights for other LMICs facing similar challenges. Strengthening CCE can serve as a scalable strategy for improving climate resilience and health outcomes across comparable settings.

Educational implications: curriculum reform and teacher capacity development are essential to ensure that future generations are equipped to navigate climate challenges. Education systems must evolve to incorporate interdisciplinary approaches linking climate science with health and sustainability.

Future directions

Future research should include longitudinal studies evaluating the effectiveness of CCE interventions on health behaviors and outcomes. Digital and community-based CCE tools tailored for remote and conflict-affected areas warrant exploration. Gender-disaggregated analyses and comparative studies across African countries would enrich the evidence base. Cost-effectiveness research on school-based adaptation measures is also needed to guide resource allocation.

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