

Integrating Environmental Education into Nigeria's School Curriculum for Climate Resilience and Sustainable Economic Development

Integración de la educación ambiental en el currículo escolar de Nigeria para la resiliencia climática y el desarrollo económico sostenible

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ABSTRACT

Climate change poses serious threats to environmental stability and sustainable economic development in Nigeria. Despite growing advocacy for sustainability education, the number of empirical studies that have examined the role of environmental education integration in promoting climate resilience and economic sustainability is limited. In this study, we investigated the extent to which environmental education integration within Nigeria's high school curriculum enhances climate resilience awareness and economic sustainability orientation. We adopted a cross-sectional explanatory research design, using data collected from 400 respondents across Nigeria's six geopolitical zones. Data were analysed using descriptive statistics, confirmatory factor analysis (CFA), and structural equation modelling (SEM). Our findings indicate that environmental education integration significantly predicts climate resilience awareness ($\beta = 0.64, p < 0.001$) and economic sustainability orientation ($\beta = 0.59, p < 0.001$), while institutional support also significantly influences environmental education integration ($\beta = 0.52, p < 0.001$). In conclusion, we found that the integration of environmental education into Nigeria's school curriculum strengthens adaptive capacity, promotes sustainability consciousness and contributes to long-term economic resilience. We therefore recommend mandatory environmental education and teacher training, climate laboratories, stakeholder partnerships, the introduction of a sustainability education performance index, and curriculum alignment with sustainable development.

Keywords: climate resilience, curriculum reform, economic sustainability, environmental education, Nigeria

RESUMEN

El cambio climático representa serias amenazas para la estabilidad ambiental y el desarrollo económico sostenible en Nigeria. A pesar del creciente interés por la educación para la sostenibilidad, existen limitados estudios empíricos que hayan examinado el papel de la integración de la educación ambiental en la promoción de la resiliencia climática y la sostenibilidad económica. Este estudio investigó el grado en que la integración de la educación ambiental en el currículo de las escuelas secundarias de Nigeria mejora la conciencia sobre la resiliencia climática y la orientación hacia la sostenibilidad económica. Se adoptó un diseño de investigación explicativo de tipo transversal utilizando datos recopilados de 400 participantes distribuidos en las seis zonas geopolíticas de Nigeria. Los datos fueron analizados mediante estadísticas descriptivas, análisis factorial confirmatorio (AFC) y modelado de ecuaciones estructurales (SEM). Los resultados revelaron que la integración de la educación ambiental predice significativamente la conciencia sobre la resiliencia climática ($\beta = 0.64, p < 0.001$) y la orientación hacia la sostenibilidad económica ($\beta = 0.59, p < 0.001$). El apoyo institucional también influye significativamente en la integración de la educación ambiental ($\beta = 0.52, p < 0.001$). El estudio concluye que la integración de la educación ambiental en el currículo escolar de Nigeria fortalece la capacidad de adaptación, promueve la conciencia sobre la sostenibilidad y contribuye a la resiliencia económica a largo plazo. El estudio recomienda la reforma curricular, el fortalecimiento de las capacidades docentes y un mayor apoyo institucional para la implementación de la educación para la sostenibilidad.

Palabras clave: resiliencia climática, reforma curricular, sostenibilidad económica, educación ambiental, Nigeria



Introduction

Climate change impacts most of the economic and social factors of sustainable development and will only worsen unless its root causes are addressed. Despite it being one of the smallest contributors to greenhouse gas emissions, the IPCC (2023) identifies Africa as one of the global regions most susceptible to altitudinal and climatic changes. The combination of rising temperatures and rains that either fail to arrive or fall in excess leads to desertification, flooding and coastal erosion. Such changes in the environment, and their direct and indirect impacts upon livelihood, food availability, essential infrastructure and the overall economy, result in a situation that is further exacerbated by the dependency of certain communities on agricultural activity. This is particularly relevant to the case of Nigeria, which is the most populous country in Africa and, despite having the continent's largest economy, faces acute climate-sensitive pressures in sectors such as agriculture, oil production, fisheries and hydroelectric power generation.

According to the most recent assessment by the World Bank (2022), Nigeria's economy (GDP) can be expected to decline by between 6% and 30% by 2052, if changes to the economy are not introduced which would facilitate better adaptation to the impacts of climate change. In northern Nigeria, accelerating desertification is forcing more people to migrate. Concurrently, in 2022 alone, severe floods displaced more than 1.4 million people across Africa. In Lagos, already one of Nigeria's largest and most populous cities, the rapidly growing population now faces increasingly severe and frequent flood risks.

The role of education in combating climate change is being increasingly recognized by scholars. According to UNESCO (2023), education has the potential to create climate awareness and foster innovative civic behavioural commitments. The embedding of sustainability education has helped foster green innovation and worker flexibility in Finland and Costa Rica. The integrating of environmental education into the school system in Nigeria has had similar effects on adaptation and the economy. Climate resilience is the ability to prepare for and deal with climatic shocks, as well as to adapt and recover from such events (Folke, 2006). Economic sustainability involves maintaining long-term economic growth without depleting environmental resources or compromising future generations when it comes to meeting their own needs. These two concepts are interrelated and demonstrate clearly the need for education to be tailored to the requirements of the economy.

While advocacy for the adoption of environmental education has grown, there remains a lack of evidence for the relationship between environmental education, resilience and economic sustainability in Nigeria. Most existing studies are composed of description and of policy orientation. Very few have employed sophisticated

quantitative methods, such as structural equation modelling, in order to evaluate causal relations. A combination of human capital theory, ecological modernization theory and resilience theory can enable researchers to develop a multi-faceted analytical framework for education system reform within the sustainable development paradigm.

Despite increasing global attention toward sustainability education, empirical evidence on how environmental education integration can contribute simultaneously to climate resilience and economic sustainability in the context of developing countries remains limited. In Nigeria, most existing studies are essentially descriptive and policy-oriented, with minimal application of advanced multivariate techniques such as confirmatory factor analysis and structural equation modelling. Furthermore, previous researchers have paid little attention to the combined roles of institutional support, adaptive awareness and sustainability orientation within a unified analytical framework. In this study, our aim was to fill this gap by examining empirically the structural relationships between environmental education integration, climate resilience awareness, economic sustainability orientation and institutional support in Nigeria's high school system. Environmental education integration (EEI) is increasingly recognized as a strategic mechanism for addressing climate vulnerabilities and promoting sustainable economic development. The theoretical foundation of this study draws on human capital theory, ecological modernization theory and resilience theory.

Human capital theory, originally advanced by Hanushek and Woessmann (2010), emphasizes the role of education in improving productivity, innovation and long-term economic growth. Contemporary extensions of the theory argue that sustainability competencies, environmental literacy, renewable energy knowledge and sustainable resource management skills constitute forms of «green human capital» essential for emerging green economies (Hanushek and Woessmann, 2010). Furthermore, studies have shown that sustainability-oriented education encourages pro-environmental behaviour, green entrepreneurial intentions and adaptive agricultural practices in developing economies (Al-Nuaimi and Al-Ghamdi, 2022; Azizi, 2023; Udoinyang, 2025).

Ecological modernization theory offers valuable insights into the institutional dimensions of sustainability education. The theory posits that institutional reforms, technological innovation and policy restructuring can reconcile environmental protection and economic development (Mol and Spaargaren, 2021). Within the educational sector, sustainability-oriented curriculum reforms are increasingly viewed as critical mechanisms for embedding ecological rationality into national development systems (Leite, 2022). The OECD (2022)

also stresses the need for systematic integration of sustainability competencies into educational institutions in order to foster green innovation and long-term sustainable transformation. In Nigeria, however, weak institutional coordination, inadequate teacher training and fragmented curriculum implementation continue to constrain effective sustainability education integration (Jayarajan *et al.*, 2026; Agbabiaka and Modupe 2025). A study in South Africa has shown that high school learners who received training in sustainability demonstrated a greater likelihood of environmental stewardship awareness development (Parayiwa and Shabalala, 2025). In Kenya, curriculum integration in agriculture training has improved knowledge of agricultural adaptation among the nation's rural youth (Mureithi, 2023).

Resilience theory, which explains how environmental knowledge strengthens adaptive capacity and preparedness against climate-related risks, further anchors our study (Folke, 2006). Climate resilience involves anticipatory learning, adaptive behaviour, and recovery capacity in response to environmental shocks. Previous studies have indicated that environmental education significantly improves disaster preparedness behaviours, environmental stewardship and collective adaptive responses among vulnerable populations (Datta and Roy, 2022; Retnowati *et al.*, 2020). Significant improvement in climate change literacy in participating countries such as Austria and Australia has followed the introduction of a structured sustainability curriculum designed to improve students' pro-social attitudes, environmentally desirable behaviours, and green entrepreneurial intentions among the young (UNESCO, 2023; Hijazi *et al.*, 2025; Biberhofer and Rammel, 2017). Given Nigeria's growing exposure to flooding, desertification, erosion and other climate-related challenges, the integration of environmental education into high school curricula has the potential to significantly enhance climate resilience awareness and sustainability-oriented economic behaviour.

The combining of these theoretical perspectives provides a comprehensive analytical framework for understanding how institutional support influences environmental education integration (EEI) and how EEI subsequently enhances climate resilience awareness (CRA) and economic sustainability orientation (ESO). Despite growing global evidence supporting the need for sustainability education, empirical studies employing advanced multivariate approaches such as confirmatory factor analysis (CFA) and structural equation modelling (SEM) remain limited in Nigeria. In this context, the aim of this study was to contribute to the literature by empirically validating these structural relationships within Nigeria's high school system. The goals of the study were as follows:

1. To examine the extent of environmental education integration in the Nigerian high school system.
2. To determine the influence of environmental education integration on climate resilience awareness.

3. To determine the influence of environmental education integration on economic sustainability orientation.
4. To examine the role of institutional support on environmental education integration.

Research questions

1. To what extent has environmental education been integrated into the Nigerian high school system?
2. What influence does environmental education integration have on climate resilience awareness?
3. What influence does environmental education integration have on economic sustainability orientation?
4. What role does institutional support play in environmental education integration?

Research hypotheses

- H₀₁: Environmental education has not been significantly integrated into the Nigerian high school system.
- H₀₂: Environmental education integration has no significant influence on climate resilience awareness.
- H₀₃: Environmental education integration has no significant influence on economic sustainability orientation.
- H₀₄: Institutional support has no significant influence on environmental education integration.

In this study, we examine how environmental education (EE) within the Nigerian educational system can build climate resilience and economic sustainability, and we demonstrate ways to develop transformative and resilience building pedagogies for economically and climate resilient societies.

Materials and methods

A cross-sectional explanatory research design was used to assess the structural relationships between environmental education integration (EEI), climate resilience awareness (CRA), economic sustainability orientation (ESO) and institutional support (IS) in the context of Nigeria's high school system. The explanatory design was selected as appropriate given that the aim of the study was not only to describe the extent of environmental education integration, but also to test hypothesized causal pathways via structural equation modelling (SEM). This approach is consistent with the prevailing trend in the field of sustainability education research, which is focused increasingly on the use of multivariate statistical methods to empirically substantiate theoretical models.

The choice of a quantitative approach was made in order to facilitate generalization of the findings to Nigeria's remaining six geopolitical zones, and to offer a solid evidence-base of a statistical nature to inform policy. For the present study, structural equation modelling was preferred, due to its ability to simultaneously estimate measurement and structural models, ensure construct validity and examine direct and indirect relationships within a single framework.



The target population of the study was composed of 12,400 students and teachers at senior high schools across the six geopolitical zones of Nigeria (Table 1). The study focused on senior high schools because students at this level demonstrate a higher cognitive capacity for understanding environmental sustainability concepts and are nearing the transition into tertiary education or the job market.

The researchers utilized a multistage stratified sampling method. In Stage 1, a single state was chosen from each geopolitical zone according to environmental vulnerability indicators. In Stage 2, one public senior high school was selected through a simple random method from each state (Table 1). In Stage 3, students and teachers were selected using proportional sampling within each school.

Using the Yamane formula (1967), with a 5% margin of error, the sample size was 387. Taking into consideration the expected level of nonresponse, 450 questionnaires were distributed. A total of 400 questionnaires were returned, resulting in an 88.9% response rate, surpassing the 70% response rate deemed sufficient for survey research.

Employed as a major data collection tool, a structured questionnaire was divided into four sections: integration of environmental education, climate resilience, economic sustainability and institutional support. Each of these sections contained several statements: Environmental education integration (8 statements), climate resilience (7 statements), economic sustainability orientation (6 statements) and institutional support (5 statements). A 5-point Likert scale was used to measure the responses (1 = strongly disagree, 5 = strongly agree), and the majority were taken from the most recent studies focused on Nigeria's sustainability education (2021-2025) and adapted to the country's education system. To establish these classifications, the mean scores were evaluated using an interval width formula based on the 5-point Likert scale:

$$\text{Interval width} = \frac{\text{Maximum score} - \text{Minimum score}}{\text{Number of categories}} = \frac{5-1}{3} = 1.33$$

Consequently, three decision thresholds were defined to determine the levels of integration: Low integration ($1.00 \leq X \leq 2.33$), moderate integration ($2.34 \leq X \leq 3.67$) and high integration ($3.68 \leq X \leq 5.00$). The distinction between «moderate» and «high» categories rested on whether the score exceeded the 3.67 threshold.

Content validity was determined through an expert review by three specialists in environmental education and educational measurement. Construct validity was determined through confirmatory factor analysis (CFA) (Hair *et al.*, 2019), and reliability was determined using Cronbach's alpha (Cronbach, 1951), and composite reliability (CR) (Fornell and Larcker, 1981).

Data analysis was conducted using descriptive statistics, confirmatory factor analysis (CFA) and structural equation modelling (SEM) (Byrne, 2016) with SPSS AMOS version 24 (Arbuckle, 2016). Descriptive statistics were used to examine the extent of environmental education integration (EEI) across sampled schools, while CFA was used to assess the construct validity and reliability of the measurement model. Subsequently, SEM was employed to test the hypothesized relationships between environmental education integration, climate resilience awareness, economic sustainability orientation and institutional support. The presentation and interpretation of the empirical findings are included in the Results and Discussion section.

Table 1 shows the geographical spread of participants across Nigeria's six geopolitical zones. Considering the need for national equilibrium and varying context, each zone was represented by one state and one senior high school. Of the 450 questionnaires administered, 400 were valid, which constituted a total response rate of 88.9%. The South-East zone had the highest response rate, at 93%, while the North-East and South-South zones each recorded response rates of 87%. This distribution of responses enhanced the quality of the sample, and the diverse climatic, socioeconomic and institutional environments present within Nigeria give the country a high degree of external validity.

Table 1. School distribution, state and questionnaire administration

Geo-Political Zone	State	Selected Senior High School	Distributed	Returned	Response Rate
North-Central	Niger	Government Day Secondary School, Minna	75	67	89%
North-East	Borno	Government Secondary School, Maiduguri	75	65	87%
North-West	Kaduna	Government College Kaduna	75	68	91%
South-East	Anambra	Dennis Memorial Grammar School, Onitsha	75	70	93%
South-South	Rivers	Government Comprehensive Secondary School, Port Harcourt	75	65	87%
South-West	Lagos	King's College Lagos	75	65	87%
Total			450	400	88.9%

Note. Authors' fieldwork, 2026.

Results and discussion

Demographic characteristics of respondents

Table 2 shows the demographic distribution of respondents across sex, age, occupation and educational qualifications. The findings indicate a balanced gender representation and adequate participation of both students and teachers from diverse educational backgrounds. This demographic diversity enhances the representativeness, reliability and generalizability of the study findings across Nigeria's high school system.

Extent of environmental education integration

Table 3 presents the descriptive analysis of the degree of environmental education integration in Nigerian high schools. The findings resulted in a grand mean score of 3.70, indicating a high level of environmental education integration within the sampled schools. The respondents strongly agreed that school subjects incorporate environmental topics (Mean = 4.12) and that teachers regularly discuss climate-related issues in classrooms (Mean = 3.98). The findings further indicated moderate institutional support in terms of availability

Table 2. Demographic representation of respondents (n = 400)

Variable	Category	Frequency	Percentage
Sex	Male	210	52.5%
	Female	190	47.5%
Age	15-20	120	30%
	21-30	160	40%
	31+	120	30%
Occupation	Student	250	62.5%
	Teacher	150	37.5%
Educational Degree	Senior Secondary Certificate Examination	180	45%
	Bachelor of Education/ Bachelor of Science	170	42.5%
	Master of Education/ Masters of Science	50	12.5%

Note. Authors' fieldwork, 2026.

Table 3. Degree of environmental education integration in Nigerian high schools

Serial Number	Environmental Education Integration Indicators	Mean	Std. Dev.	Decision
1	Environmental topics are included in school subjects	4.12	0.81	High
2	Teachers discuss climate change issues regularly	3.98	0.77	High
3	Students participate in environmental awareness activities	3.76	0.84	High
4	Schools organize environmental sustainability programs	3.61	0.88	Moderate
5	Environmental education materials are available	3.44	0.92	Moderate
6	Practical environment projects are encouraged	3.58	0.86	Moderate
7	Climate resilience concepts are integrated into teaching	3.83	0.79	High
8	Government support for EE implementation is adequate	3.29	0.95	Moderate
Grand Mean		3.70		High Integration

Note. Authors' fieldwork, 2026.

Table 4. Descriptive statistics for climate resilience awareness (CRA)

Serial Number	Climate Resilience Awareness (CRA) Indicators	Mean (X)	Std. Dev. (X)	Decision
1	I am aware of the localized indicators of climate change (e.g., desertification, flooding).	4.21	0.74	High
2	I understand the adaptive behaviours needed to prepare for climate-related hazards.	4.10	0.79	High
3	I recognize how human actions accelerate environmental vulnerability in Nigeria.	4.28	0.71	High
4	I actively seek information regarding climate risk mitigation strategies.	3.82	0.85	High
5	I can identify climate resilience programs running in my local community.	3.42	0.94	Moderate
6	I understand how regional weather shifts impact water and food security.	4.15	0.76	High
7	I feel equipped to make decision-making choices that protect against ecological shocks.	3.65	0.89	Moderate
Grand Mean		3.95	0.81	High Awareness

Nota. Authors' fieldwork, 2026.



of environmental education materials (mean = 3.44) and practical environmental projects (mean = 3.58). Government support for implementation recorded the lowest mean score (mean = 3.29), suggesting the need for stronger policy and financial commitment toward sustainability education. Overall, the results indicate that environmental education has been substantially incorporated into Nigeria's high school curriculum, thereby addressing research question one. Scores above 3.67 indicate a proactive, structural integration of environmental concepts (e.g., regular curriculum discussions), while moderate scores (2.34 to 3.67) indicate passive, inconsistent or poorly supported implementation (e.g., lack of practical projects and government funding).

To ensure methodological transparency and clarify how the remaining latent constructs were operationalized, Tables 3, 4, 5 and 6 present the individual measurement items, means and standard deviations for climate resilience awareness (CRA), economic sustainability orientation (ESO) and institutional support (IS).

Table 4 evaluates cognitive preparedness and risk recognition regarding environmental shifts. The high grand mean demonstrates that while the respondents possessed a strong conceptual understanding of localized climate vulnerabilities, human impacts and adaptive behaviours, their awareness dropped slightly with regard

to specific community-level mitigation programs. This indicates a gap between general ecological knowledge and localized practical engagement.

Table 5 assesses psychological leanings toward eco-friendly economic choices. The results reflect robust support for green entrepreneurship, waste management and the overarching value of conservation for development. However, a lower item mean reveals a gap where abstract sustainability principles do not fully translate into green consumerism or personal purchasing adjustments.

Table 6 measures administrative, financial and policy backing for sustainability education. The moderate grand mean highlights systemic deficiencies, showing that operational integration is heavily constrained by deficient government funding, inadequate teacher capacity development and weak external partnerships, thereby undermining the practical execution of national environmental curricula.

Reliability and validity of measurement model

Table 7 confirms the strong reliability and validity of the measurement model. Cronbach's alpha values exceed 0.80, indicating high internal consistency. Composite reliability values above 0.85 further validate construct stability. Average variance extracted (AVE) values surpass

Table 5. Descriptive statistics for ecological sustainability orientation (ESO)

Serial Number	Ecological Sustainability Orientation (ESO) Indicators	Mean (X)	Std. Dev. (X)	Decision
1	I believe that environmental conservation is vital to long-term economic growth.	4.19	0.78	High
2	I prioritize energy-efficient and renewable options when purchasing goods.	3.51	0.90	Moderate
3	I support business ventures that balance profitability with environmental care.	4.02	0.81	High
4	I believe resource recycling and minimizing waste have high economic value.	4.11	0.79	High
5	I am interested in seeking career or business paths in the green economy.	3.70	0.88	High
6	I practice sustainable water usage and waste disposal habits to save costs.	3.75	0.83	High
Grand Mean		3.88	0.83	High Orientation

Source: Authors' fieldwork, 2026.

Table 6. Descriptive statistics for institutional support (IS)

Serial Number	Institutional Support (IS) Indicators	Mean (X)	Std. Dev. (X)	Decision
1	The school administration prioritizes environmental awareness campaigns.	3.64	0.87	Moderate
2	Funding is made available to purchase textbooks on environmental science.	3.32	0.93	Moderate
3	Teachers receive regular training on how to teach climate resilience topics.	3.25	0.95	Moderate
4	The school partners with local non-governmental organizations on green community initiatives.	3.10	0.98	Moderate
5	National policies support structural integration of green curriculum.	3.45	0.91	Moderate
Grand Mean		3.35	0.93	Moderate Support

Source: Authors' fieldwork, 2026.

the 0.50 threshold, confirming convergent validity. Factor loadings range from 0.68 to 0.88, exceeding minimum acceptable levels. These results demonstrate that the instrument reliably measures environmental education integration, climate resilience awareness, economic sustainability orientation and institutional support. The validated constructs meet SEM requirements for structural model testing.

Confirmatory factor analysis (CFA)

Descriptive statistics, including mean and standard deviation, were used to answer research question one, regarding the extent of environmental education integration.

Table 8 demonstrates a good model fit with a relative Chi-square value of 1.84. Even though the significance of the Chi-square statistic is a common occurrence in large samples, CFI and TLI values above 0.90 indicate a good incremental fit, while RMSEA and SRMR values below 0.05 demonstrate an excellent absolute fit. Together, these indices validate the measurement model, confirming that the latent constructs have sufficient statistical validity for structural modeling.

Structural equation modelling (SEM)

Having confirmed the measurement model, SEM was executed in order to determine the hypothesized relationships.

Table 9 presents the SEM results, which demonstrate positive and significant relationships among the study variables [environmental education integration (EEI), climate resilience awareness (CRA), economic sustainability orientation (ESO) and institutional support (IS)]. The R^2 values show that EEI accounts for 58% of the variance in CRA and 55% in ESO. All hypotheses were rejected due to $p < 0.001$. The results show convincing evidence that the integration of curriculum is fundamental to the improvement of adaptive capacity and to the sustaining of an economically oriented society.

The findings of this study indicate that environmental education integration (EEI) significantly improves both climate resilience awareness (CRA) and economic sustainability orientation (ESO) within Nigeria's high school system. The structural equation modelling (SEM) results indicate that EEI positively predicts CRA ($\beta = 0.64$, $p < 0.001$) and ESO ($\beta = 0.59$, $p < 0.001$), thereby

Table 7. Instrument validation matrix

Construct	Items	Cronbach's Alpha	Composite Reliability	Average Variance Extracted	Factor Loadings
Environmental Education Integration	8	0.89	0.91	0.62	0.71-0.88
Climate Resilience Awareness	7	0.87	0.90	0.65	0.73-0.85
Economic Sustainability Orientation	6	0.85	0.88	0.60	0.70-0.84
Institutional Support	5	0.82	0.86	0.58	0.68-0.80

Table 8. CFA model fit indices

Fit Index	Recommended Value	Obtained Value	Interpretation
X ²	Non-significant desirable	412.35 ($p < .001$)	Acceptable
X ² /df	< 3.0	1.84	Good Fit
CFI	≥ 0.90	0.94	Good Fit
TLI	≤ 0.90	0.92	Good Fit
RMSEA	≤ 0.08	0.046	Excellent
SRMR	≤ 0.08	0.041	Excellent

Table 9. SEM path analysis

Hypothesis	Path	B	t-value	p-value	Decision
H ₀₂	EEI → CRA	0.64	9.21	0.000	Reject H ₀₂
H ₀₃	EEI → ESO	0.59	8.47	0.000	Reject H ₀₃
H ₀₄	IS → EEI	0.52	7.10	0.000	Reject H ₀₄

R² (CRA) = 0.58

R² (ESO) = 0.55

confirming the central premise that sustainability-orientated curriculum reform contributes to adaptive capacity and sustainable economic consciousness. These findings reinforce the growing international consensus that environmental education constitutes an effective strategic instrument for climate adaptation and sustainable development.

The positive relationship between EEI and climate resilience awareness aligns with the findings of Datta and Roy (2022), who reported that environmental education significantly improves disaster preparedness and adaptive behaviour among students in climate-vulnerable regions. Similarly, Hijazi *et al.* (2025) found that structured climate education strengthens pro-environmental attitudes and behavioural readiness for sustainable transitions. The present study extends these findings to the Nigerian context by empirically demonstrating, through SEM analysis, that systematic curriculum integration explains approximately 58% of the variation in climate resilience awareness. Unlike many previous Nigerian studies that relied primarily on descriptive analyses, this study quantitatively validates the structural influence of curriculum-based environmental learning on resilience outcomes.

Our findings with regard to economic sustainability orientation also support earlier studies conducted in Europe and other developing economies. Biberhofer and Rammel (2017) observed that sustainability-focused educational curricula stimulate green entrepreneurial intentions among young people, while Al-Nuaimi and Al-Ghamdi (2022) established that environmental competencies significantly predict sustainable consumption behaviours. The current study corroborates these findings by showing that students exposed to organized environmental education programs demonstrate stronger support for renewable energy adoption, responsible consumption and sustainable economic practices. Furthermore, this study adds to the previous literature by integrating economic sustainability orientation directly into a unified SEM framework linking environmental education, institutional support and adaptive resilience.

At the same time, the strong positive relationship between institutional support and environmental education integration ($\beta = 0.52$, $p < 0.001$) validates ecological modernization theory and confirms earlier observations by Agbabiaka and Modupe (2025), who identified inadequate institutional capacity and teacher training as major barriers to sustainable education implementation in Nigeria. The findings also support the findings of the OECD (2022), which emphasized that sustainability competencies can only be effectively mainstreamed through coordinated institutional reforms, rather than by fragmented subject-level interventions. In contrast to previous studies that focused mainly on policy recommendations, the present study

demonstrates empirically that institutional mechanisms significantly influence successful curriculum integration. Weak institutional structures and inadequate policy coordination often constrain the implementation of sustainability education in developing-country contexts, making this contribution particularly significant.

Also, the model's strong explanatory power (R^2 of 0.58 and 0.55) shows that the integration of environmental education is a major contributor to variance in adaptive awareness and economic sustainability orientation. This finding is consistent with previous studies conducted in Nigeria.

Overall, the findings of this study are broadly consistent with international and regional empirical evidence related to sustainability education. However, the present study offers a new contribution to the Nigerian literature by integrating human capital theory, ecological modernization theory and resilience theory within a single SEM framework capable of simultaneously explaining climate resilience awareness and economic sustainability orientation. This multidimensional analytical contribution enhances the contextual relevance and scientific originality of the study. The study supports the finding that EEI strengthens climate resilience awareness ($\beta = 0.64$) and economic sustainability orientation ($\beta = 0.59$). Nevertheless, because this study was reliant upon self-reported survey data, it primarily measured subjective perceptions and cognitive orientations rather than actual, direct behaviours or real-world policy applications. Therefore, these findings do not confirm that EEI directly influences physical climate resilience or economic development in practical, systemic terms, and nor do they reflect the successful execution of environmental policies on a broader scale. The study is constrained to educational dimensions and does not address practical socio-political effects or structural policy linkages. Future research will be required in order to broaden this scope by incorporating macro-level, national-scale policy indicators alongside objective behavioural measurements (such as regional waste reduction rates or local energy patterns), to establish direct practical effects.

These empirical findings provide robust structural support for the integration of the three foundational theories that guided this study. Firstly, human capital theory is validated by the strong, positive impact of EEI on economic sustainability orientation ($\beta = 0.59$, $p < 0.001$). This confirms that structured educational curriculums do not merely transmit general knowledge but build specialized «green human capital» that fosters pro-environmental economic intentions and sustainable resource orientations among future entrants to the labour market. Secondly, resilience theory is directly supported by the structural relationship showing that EEI is a strong predictor of climate resilience awareness ($\beta = 0.64$, $p < 0.001$). This reinforces the premise that

formal environmental education serves as a systematic vehicle for anticipatory learning, equipping students with the conceptual frameworks required to develop adaptive capacity against ecological shocks. Finally, ecological modernization theory is substantiated by the significant influence of institutional support on EEI ($\beta = 0.52$, $p < 0.001$). This demonstrates that environmental education cannot exist as a fragmented subject-level effort; rather, it requires coordinated, institutionalized restructuring, including administrative backing and curriculum policy reforms, in order to successfully embed ecological rationality within Nigeria's developmental and educational systems.

The scope of this study allows for many future research opportunities. For instance, further research will be required on the effects of sustained exposure to environmental education on future behaviour patterns and the professional direction of individuals. It would also be valuable to determine the effectiveness of particular sustainability modules through randomized controlled trials, compared to the effectiveness of traditional teaching methods. Future studies could also investigate the possible differences within each of the identified subgroups (e.g., gender, rural-urban or socioeconomic status). Research extended to universities, vocational education and training institutions would enrich the understanding of higher-order sustainability skills and the development of a green workforce. Additionally, the incorporation of more objective measures of behaviour (e.g., reduction in energy use and participation in recycling) would enhance the empirical substantiation. Finally, another focus of future studies should be an examination of the effect of Nigeria's National Climate Change Act and its impact on curriculum changes over time.

Conclusion

The multidimensional risks associated with climate change are immense and encompass Nigeria's socioeconomic security, environmental protection and sustainable development. Nigeria is vulnerable to climate change-related extreme weather events and disasters, such as desertification in the north and coastal flooding and erosion in the southern cities. There is an urgent need for adaptive strategies that are both systemic and sustainable.

The research results indicated that environmental education integration (EEI) was a positive predictor of both climate resilience awareness (CRA) and economic sustainability orientation (ESO). The model that explained the variance of climate resilience awareness and economic sustainability orientation (58% and 55%, respectively) confirmed the transformative ideal of EE integration. This is a strong endorsement of how systemic educational reforms have the potential to build long-term climate resilience in Nigeria.

The synthesis of human capital theory, ecological modernization theory and resilience theory offers a plausible, all-encompassing view of these theories. Human capital theory discusses the economic benefits gained through the inclusion of environmental awareness. Ecological modernization theory focuses on the necessary and sufficient institutional changes for the integration of education and sustainability. Resilience theory suggests the level of environmental awareness required for the development of adaptive and anticipatory behaviours.

The most valuable finding is that institutional backing, support and sponsorship are important and substantial enabling determinants. In the absence of a determined and well-thought-out strategy in curriculum transformation, teacher training and regulatory policy, efforts made in the field of environmental education will constitute a mere patchwork that will be neither effective nor efficient. No measurable levels of climate resilience and economic sustainability will be achievable in Nigeria through mere discourse and policy pronouncements. There is an urgent need for a thorough and comprehensive systemic change in the field of education.

With regard to sustainability education, this study empirically substantiates the environmental education impacts in Nigeria, providing a SEM-based validation which adds to the current environmental education literature. In addition, this study goes beyond previous descriptive analyses to provide evidence of causality in the relationships posited by institutional support, curriculum integration and sustainability.

A better understanding of education systems as essential elements of climate change adaptability and economically sustainable systems may be possible through future scholarship focused on these aspects. In the light of this study, some recommendations can be made:

The Federal Ministry of Education should make environmental education a mandatory subject, along with the integration of other subjects into the National Curriculum. The nationwide implementation of a curriculum-focused professional development program for teachers focused on sustainability should also be undertaken. Schools should develop environmental and climate laboratories, establish renewable energy demonstrators, and create climate-resilience clubs. Environmental NGOs and renewable energy companies should be involved in resource mobilization activities. In addition, a national sustainability education performance index should be created, in order to assess the impact of the education curriculum implementation. Finally, curriculum changes must reflect Nigeria's nationally determined contributions (NDCs), under the provisions of the Paris Agreement.

The results of this study make clear that school principals must lead on the issue of environmental



integration at all levels of the system. Teachers should be expected to innovate beyond the traditional curriculum and adopt constructivist and experiential paradigms, particularly in the form of sustainability project propositions. Education as a climate adaptation investment (rather than a social service) should be the focus of a future policy framework. Climate finance that ignores the integration of sustainability education is misdirected, and this should be the focus of development partners.

Authors' contributions

Nathan Udoinyang: Conceptualization, methodology, formal analysis, investigation, data curation, writing (original draft), supervision, project administration.

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Rita Oghenevwoke Olobia: Methodology, conceptual review, writing (revision and editing).

Ulisan Ewarawon: Supervision, policy interpretation, validation, final manuscript approval.

All the authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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The authors declare no conflicts of interest.

Artificial Intelligence declaration

Grammarly was used solely for language editing and clarity. The authors remain fully responsible for the content, analysis and conclusions of this work.

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