

## **Integrating Climate Change Education in Chemistry into the Secondary School Curriculum in Niger Delta Region of Nigeria**

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DOI: 10.56201/ijgem.v10.no12.2024.pg171.184

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### **Abstract**

*Climate change is a serious global issue with significant effects on the Niger Delta region, known for its rich biodiversity and vulnerability to environmental damage. This paper looks at the importance of including climate change education in the secondary school chemistry curriculum in the Niger Delta. The study used a qualitative research design, specifically a case study method. A purposive sampling technique selected 90 participants. Data was gathered through semi-structured interviews and focus group discussions with curriculum planners, policymakers, teachers, and students to answer the three research questions guiding the study. The findings led to discussions on the reasons, challenges, and strategies for integrating climate change topics into chemistry education to promote environmental awareness and empower students to help mitigate climate change effects. It is recommended that curriculum planners involve climate change experts to provide the necessary content for the chemistry curriculum and that chemistry teachers receive training to effectively teach this curriculum.*

**Keywords:** *climate change education, chemistry curriculum, secondary schools, Niger Delta region.*

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### **Background of the Study**

The Niger Delta is ecologically important, with diverse ecosystems that support millions of people's livelihoods. However, it is threatened by environmental issues due to climate change, including extreme weather, rising sea levels, and the degradation of natural resources. It is crucial for secondary school students in the Niger Delta to understand the chemistry behind climate change and its effects on local ecosystems and communities (Adenle and Azadi, 2018).

Climate change is a major environmental problem in the Niger Delta (Zudonu et al. 2024). It involves changes in average weather conditions, primarily caused by human activities like

deforestation and the release of greenhouse gases. These gases are released through gas flaring, vehicle emissions, and the use of generators and factory machines (Ikehi et al., 2014; Intergovernmental Panel on Climate Change, 2001; Zudonu, 2015; Uyigüe and Agbo, 2007).

According to UNESCO (2009), the effects of climate change differ across continents and countries due to variations in weather and human activities that contribute to climate change. They also emphasized that education is crucial for addressing climate change, as it can help young people understand the challenges it poses and how to mitigate its impacts. In South Africa, students in grades 10-12 are expected to have enough scientific knowledge to act as responsible citizens, make informed decisions about environmental management, and adopt lifestyles that mitigate climate change's adverse effects for a sustainable future (Stephen et al., 2014).

In Nigeria, secondary education prepares students for higher education and teaches them about environmental needs, values, and challenges through various subjects. This approach ensures that students are well-equipped to tackle environmental issues as they arise, as these topics are integrated into the school curriculum (Ikehi, 2014).

A curriculum is a comprehensive plan outlining what students will learn during their formal education. It includes various elements such as goals and objectives, subject content, teaching methods, materials for instruction, and assessment methods.

**Goals and Objectives:** These outline what students should know and be able to do by the end of the curriculum. They are based on educational standards and desired learning outcomes.

**Content (Subject Matter):** This denotes the subjects or topics that will be taught to students.

**Methods of Delivery:** These are the teaching methods used to present the various topics in the curriculum. The methods vary depending on the learners' age and can include lectures, discussions, demonstrations, play-based learning, and storytelling.

**Materials and Resources for Delivery:** These are the tools and resources used to facilitate teaching and learning. They include textbooks, workbooks, digital resources, multimedia materials, and other educational software.

**Assessment Methods:** This involves evaluating students' learning to determine if they have met the curriculum's goals and objectives. These methods include tests, exams, projects, and presentations.

In secondary schools, the curriculum is a document listing subjects, topics, and sub-topics to be taught. These subjects include Mathematics, English Language, Physics, Biology, Economics, Chemistry, and others (Ikehi et al., 2014; Chakeredza, 2009; Offorma, 2002).

Chemistry is a branch of science that studies the composition, structure, properties, and behaviour of matter. It deals with the substances that make up our world, their transformations, and the energy changes that occur during these processes (Zudonu et al. 2024). Chemistry investigates the basic building blocks of matter, including atoms, molecules, and ions. Atoms are the smallest particles

of an element; molecules are groups of atoms bonded together; and ions are atoms or groups of atoms with a net electric charge. Understanding the composition of matter helps students classify substances and predict their properties (Omoniyi, 2018). Structure of Matter: Chemistry examines how atoms and molecules are arranged in substances. This includes studying electron arrangements within atoms and the types of bonds between atoms. Properties of Matter: Chemistry explores the different characteristics of substances, such as density, melting and boiling points, reactivity, acidity, and basicity. These physical and chemical properties vary among substances. Transformation of Matter: Chemistry investigates how substances change state through chemical reactions and physical processes. Chemical reactions involve breaking and forming new bonds, creating new substances with different properties. Physical processes include melting, freezing, evaporation, and condensation (Omoniyi, 2018). Energy Changes: Chemistry studies the energy changes that accompany chemical reactions, such as heat transfer, energy conservation, and the relationship between energy and chemical reactions. Chemistry has countless practical applications in fields like medicine, agriculture, material science, environmental science, and industry. It is crucial for developing new medications, improving agricultural practices, designing new materials, understanding environmental processes, and producing energy-efficient technologies. Chemistry plays a vital role in addressing global challenges like climate change and improving quality of life. Therefore, the chemistry curriculum should include topics about climate change and its mitigation (Omoniyi, 2018; Omoniyi, 2016).

Integration means combining something new with something else to improve it. In this study, integration refers to adding climate change topics (definition, causes and effects, mitigation methods and strategies) into the secondary school curriculum to make students fully aware of the adverse effects of climate change on the environment. The secondary school chemistry curriculum content, as presented by the Federal Ministry of Education in 2009, is as follows:

Table 1: Summary of Nigeria Senior Secondary Schools Chemistry Curriculum

S/N	THEMES	SS1	SS2	SS3
1	Chemistry and industry	Chemistry and industries	Periodic table, chemical reactions, mass volume relationship	Quantitative and qualitative analysis
2	The chemical world	Introduction to chemistry, particulate nature of matter, symbols, formulae and equations, chemical combination, gas laws	Acid-base reactions, water, air, hydrogen, nitrogen, sulphur	Petroleum, metal and ether, compound of iron, ethical, legal and social issues

3	Chemistry and environment	Standard separation techniques for mixtures, acids, bases, salt and water	Oxidation-reduction reaction, ionic theory, electrolysis	
4	The chemistry of life	Carbon and its compounds	Hydrocarbons and alkanols	Fats and oils, soap and detergents, giant molecules.

Olubunmi and Aarinola (2022)

To determine where climate change topics can be integrated into the chemistry curriculum, we refer to Table 1, specifically Theme 3 (Chemistry and Environment). This theme indicates the areas where climate change topics can be included in the secondary school chemistry curriculum. Therefore, this study focuses on integrating climate change education into the chemistry curriculum for secondary schools in the Niger Delta region of Nigeria.

### Statement of the Study

Given the Niger Delta region's vulnerability to climate change, integrating climate change education into the secondary school chemistry curriculum is crucial for raising awareness, promoting sustainable practices, and preparing students to address climate change challenges. However, there is limited research specifically on integrating climate change education into the chemistry curriculum in the Niger Delta. Therefore, this study aims to explore this integration.

### Purpose of the Study

The study aims to,

1. investigate the reasons for integrating climate change education into the chemistry curriculum.
2. identify the potential challenges of integrating climate change education into the chemistry curriculum.
3. provide strategies for effectively integrating climate change education into the chemistry curriculum.

### Research Questions

The study addresses the following questions:

1. What is the rationale for integrating climate change education into the chemistry curriculum?
2. What are the potential challenges of integrating climate change education into the chemistry curriculum?
3. What strategies can be proposed for effectively integrating climate change education into the chemistry curriculum?

### Methodology

This study used a qualitative research design, specifically a case study approach, focusing on selected secondary schools in the Niger Delta region to understand the integration of climate

change education into the chemistry curriculum. A purposive sampling technique selected 90 participants, which include 50 students, 25 teachers, and 15 curriculum developers and policymakers. The sample size was determined based on the principle of saturation, where data collection continued until no new information emerged.

### **Data Collection**

Data was collected through semi-structured interviews and focus group discussions. Semi-structured interviews with curriculum developers and policymakers gathered insights on the rationale, challenges, and strategies for integrating climate change education into chemistry. Focus group discussions with chemistry teachers and students explored their perspectives and experiences.

### **Data Analysis**

Data from interviews and focus group discussions was transcribed verbatim and analyzed using thematic analysis. Themes and patterns related to the rationale, challenges, and strategies for integrating climate change education into chemistry were identified. The data analysis process ensured rigour and credibility by involving multiple researchers in the analysis. To ensure data reliability, multiple data sources, such as interviews and focus group discussions, were used. Validity was ensured through member checking, where participants reviewed and validated the findings.

### **Findings and Discussion**

**Research Question 1:** What is the rationale for integrating climate change education into the chemistry curriculum?

The analysis of the interviews and focus group discussions revealed three key themes: relevance, interdisciplinary learning, and empowerment. These themes are supported by quotes from the interview transcripts.

#### **Relevance**

The respondents indicated that the relevance, or importance and connection to chemistry, is a fundamental reason for integrating climate change into the chemistry curriculum. The following quotes illustrate this.

Dr. Kamsi (Curriculum Planner): "Understanding the chemical processes behind climate change helps students see the real-world implications of their studies. It connects abstract concepts with tangible environmental issues, making the curriculum more engaging and meaningful."

Mr. Alex (Teacher): "Climate change is closely linked to chemical processes such as greenhouse gas emissions, acidification, and the carbon cycle. Understanding these concepts gives students the knowledge to comprehend climate change impacts and solutions."

Justice (Student): "Understanding the chemistry behind climate change can help us make more informed decisions in our personal lives. It also makes the subject matter more relevant and engaging."

Climate change is one of the most urgent challenges facing humanity. By incorporating it into the chemistry curriculum, educators can equip students with the knowledge and skills to contribute to solutions in areas like renewable energy, pollution reduction, and sustainable chemistry. This finding aligns with Abdul and Aziah (2007), who reported that students will gain a deeper understanding of climate change if it is integrated into the chemistry curriculum.

### **Interdisciplinary Learning**

Another important theme is interdisciplinary learning. Respondents emphasized that climate change is not confined to a single field of science, but rather intersects with various disciplines, as shown below.

Mr. Laka (Policy Maker): "Climate change is a complex issue that involves interactions between the atmosphere, oceans, land, and biosphere. All of this influence the chemical processes of climate change. Integrating climate change into the chemistry curriculum helps students gain a comprehensive understanding of the scientific principles underlying this phenomenon."

Mrs. Igwela (Teacher): "Climate change connects with different scientific disciplines such as Physics, Biology, Environmental Science, and even Sociology. Exploring climate change within the context of chemistry allows students to make connections with these other fields, promoting a holistic understanding of the issue."

Merit (Student): "From what I've learned about climate change, I've noticed related topics in Physics, Biology, Geography, and even Agricultural Science."

Interdisciplinary learning is seen as a rationale for integrating climate change topics into the chemistry curriculum. It encourages students to approach problems from different perspectives and utilize various tools and methods to find solutions. Therefore, by integrating climate change education into the chemistry curriculum, educators can promote critical thinking, creativity, and collaboration among students as they seek to understand and address this global challenge. This finding aligns with Feierabend et al. (2011), who emphasized that environmental issues like climate change demand interdisciplinary solutions.

### **Empowerment**

Empowerment emerges as the third theme supporting the integration of climate change into the chemistry curriculum.

Dr. Rose (Curriculum Planner): "Integrating climate change topics into the chemistry curriculum empowers students to apply their chemical knowledge in finding groundbreaking solutions to the challenges posed by climate change."

Mr. Roland (Teacher): "By understanding the chemical processes involved in climate change, students gain a deeper understanding of this complex issue. They are equipped with the scientific knowledge needed to comprehend the causes and consequences of climate change and the role of chemistry in addressing it."

Amada (Student): "Including climate change in the chemistry curriculum is beneficial because it gives us, the students, more knowledge to understand what climate change all is about."

Education is a powerful tool for promoting environmental stewardship and empowering individuals to act. Learning about climate change within the context of chemistry helps students realize their role in protecting the environment and the impact of human activities on the planet. This empowers them to make informed decisions, advocate for eco-friendly policies, and promote sustainability in their communities. This finding is supported by UNESCO's statement (2009) that education is crucial for addressing climate change issues.

**Research Question 2:** What are the potential challenges with integrating climate change education into the chemistry curriculum?

### **Curriculum Constraint**

The first major theme is curriculum constraint, which refers to the lack of space in the existing curriculum.

Dr. Oko (Curriculum Planner): "One challenge we've encountered is limited space. Chemistry topics usually have a fixed curriculum with little room for additional topics. Integrating climate change content requires sacrificing other essential concepts or extending the course duration, which may not be feasible due to academic schedules."

Mrs. Armstrong (Teacher): "A challenge is balancing traditional chemistry topics with new climate-related content. The chemistry curriculum often emphasizes traditional topics like chemical reactions and molecular structures, leaving little or no room for climate change topics."

Thankgod (Student): "For me, chemistry is already a broad subject with many abstract things we struggle to understand. Adding climate change topics... I am not sure how that would work."

Curriculum constraints refer to the limitations within educational frameworks that make it difficult to effectively incorporate vital topics like climate change. Chemistry curricula often have predefined syllabi and limited time, making it hard to dedicate enough attention to climate-related content. Additionally, curriculum guidelines may not prioritize environmental issues, leaving educators with little flexibility to include them. Addressing this challenge requires collaboration among educators, curriculum developers, policymakers, and stakeholders to revise curriculum standards, provide professional development opportunities, and develop interdisciplinary resources tailored to integrate climate change into chemistry education effectively. This aligns with Ikehi et al. (2014), who found that limited space was a constraint for including climate change topics in the secondary school agricultural science curriculum.

## Teacher Training

Another challenge in integrating climate change into the chemistry curriculum is teacher training.

Mrs. Kabi (policy maker): "Including climate change in the chemistry curriculum requires teachers to have expertise in both chemistry and climate science. Without this expertise, educators will struggle to effectively integrate climate change content."

Mr. Adam (teacher): "After the curriculum is developed, it is up to the teachers to implement it. Without adequate training, how can we do it? Teachers need to understand the connections between chemistry and climate science to teach effectively."

Ijeoma (student): "Not every chemistry teacher can help students understand climate change topics. We need teachers who can make it clear to us."

Integrating climate change into the chemistry curriculum requires new teaching methods that encourage active learning and critical thinking. Teachers need training in techniques like inquiry-based and project-based learning to effectively teach climate change topics. This challenge calls for investment in professional development programs that cover both the content and teaching methods of climate change education. By providing teachers with the necessary knowledge, skills, and resources, we can enable them to successfully integrate climate change into the chemistry curriculum and help students become well-informed global citizens. This finding supports the conclusions of Nooraida et al. (2012) and Feierabend et al. (2011), who emphasized the importance of teacher training for effective teaching.

## Resource Availability

Resource availability is another challenge highlighted by the interviewees.

Dr. Ayo (curriculum planner): "Every curriculum comes with the necessary materials for teaching. However, for climate change topics, there are not enough resources available, considering issues of access and cost."

Mrs. Osi (teacher): "Teaching climate change requires specific materials and experiments to show its impact on chemistry. Even for other topics, there is often a lack of resources to teach properly."

Benjamin (student): "At my school, we have a chemistry laboratory, but there are not enough chemicals for experiments. So, I am not sure how we will do climate change experiments."

Climate change can worsen the unequal access to educational resources, affecting schools differently based on their location and economic status. For example, areas facing more severe climate challenges, like the Niger Delta, may find it harder to afford or access the resources needed to teach climate change effectively. Additionally, as new technologies emerge to address climate change, new teaching materials and methods will be needed, posing logistic and financial challenges for schools. Ongoing teacher training and investment in current teaching materials are essential to meet this challenge. Studies by Ikehi et al. (2014) and Nooraida et al. (2012) also found



that a lack of resources hindered the integration of climate change topics into the Agricultural Science curriculum.

**Research Question 3:** What strategies can be proposed for the effective integration of climate change education into the chemistry curriculum?

From the interviews and focus group discussions, basic strategies emerged: curriculum review, teacher training, practical application, and community engagement.

### **Curriculum Review**

Curriculum review was the first theme identified from the interviews.

Dr. Dogo (curriculum planner): “We need to assess how climate change relates to chemistry topics. We should highlight areas like greenhouse gas chemistry, alternative energy sources, chemical pollutants, and sustainable materials, and then integrate them into the existing curriculum.”

Mr. Carson (teacher): “The current curriculum needs to include climate change topics. We should ensure that main concepts and skills related to climate change are part of the chemistry syllabus.”

Gloria (student): “Given what we see happening around us due to climate change, I think policymakers should work with curriculum planners to add climate change topics into the chemistry curriculum so we can understand it better.”

Reviewing the curriculum is crucial to effectively integrate climate change education into chemistry classes, providing students with the necessary knowledge and skills to address this global issue from a chemical perspective. Regular curriculum reviews ensure that educational content stays relevant, up-to-date, and aligned with the needs of society and students. This process helps identify gaps, incorporate new knowledge and skills, and adapt to changing educational goals and standards, thereby improving the quality of education. Thus, curriculum review is a vital strategy for integrating climate change education into the chemistry curriculum. This finding aligns with the studies by Kariuki et al. (2016), Ikehi (2014), and Nooraida (2012).

**Research Question 3:** What strategies can be proposed for the effective integration of climate change education into the chemistry curriculum?

The major theme which emerged from the interview analysis and focus group discussion are curriculum review, teacher training, practical application and community engagement.

### **Curriculum Review**

Curriculum review was the first theme identified from the interview analysis. As supported by the transcript of the interviews.

*Dr. Dogo (curriculum planner): “we need to assess how climate change intersects with chemistry topics. Highlight areas such as greenhouse gas chemistry, alternative energy*

*sources, chemical pollutants, and sustainable materials. Then we can integrate them into the existing curriculum.”*

*Mr. Carson (teacher): “the existing curriculum needs to incorporate climate change topics. We need to ensure that significant concepts and skills related to climate change are integrated into the chemistry syllabus.”*

*Gloria (student): “seeing all that happens around us as a result of climate change, I think policy makers should collaborate with curriculum planners for them to add climate change topics into the chemistry curriculum for us to know it better.”*

By carrying out curriculum review, educators can effectively integrate climate change education into the chemistry curriculum, equipping students with the knowledge and skills needed to address this pressing global issue from a chemical perspective. Curriculum review is crucial because it will ensure that educational content remains relevant, up-to-date and aligned with the needs of society and the students. Curriculum review allows for the identification of gaps, the incorporation of new knowledge and skills, and the adaptation to changing educational goals and standards. Curriculum review ultimately enhances the quality of education. Therefore, curriculum review is one strategy for integrating climate change education into the chemistry curriculum. This finding is in line with those of Kariuki et al (2016), Ikehi (2014) and Nooraida (2012).

### **Teacher Training**

Teacher training is another crucial strategy for integrating climate change into the chemistry curriculum.

Mrs. Ngozi (Policy Maker): "While curriculum planners develop curriculums, we also plan comprehensive training for the teachers who will implement it. Teachers need to be trained first on the science of climate change, its causes, impacts, and potential solutions. By doing this, we lay the groundwork for integrating it into the curriculum."

Mr. Alfred (Teacher): "Without the teachers, the curriculum can't be implemented. We need pedagogical approaches that promote active learning and engagement to effectively teach climate change concepts to students. Teachers need to be trained-that is what I'm saying."

Friday (Student): "I think teachers are the ones who carry out what is in the curriculum, so if teachers are properly prepared through workshops, I believe they will support integrating climate change into the chemistry curriculum."

Teacher training is essential for successfully integrating climate change into the chemistry curriculum. Teachers need hands-on workshops and laboratory sessions where they can explore experiments, demonstrations, and activities that illustrate the chemical principles underlying climate change. This practical training will enable teachers to confidently conduct, engaging and informative lessons on climate change in the chemistry classroom. Such training enhances educators' capacity to integrate climate change into the chemistry curriculum effectively,

promoting a generation of environmentally conscious and scientifically literate students. This view is supported by Nooraida et al. (2012), Burmeister et al. (2013), and Burmeister and Eilks (2013), who agree that curriculum development cannot succeed without adequate teacher training.

### **Practical Application**

The third theme identified is practical application as a strategy for integrating climate change into the chemistry curriculum.

Dr. Duru (Policy Maker): "Students need to be taught about the chemical composition and sources of greenhouse gases like carbon dioxide, methane, and nitrous oxide."

Mrs. Fisi (Teacher): "We should introduce students to green chemistry, where they learn to design chemical processes and products that minimize the use and generation of hazardous substances."

Mac (Student): "We need to understand things like ocean acidification, ozone depletion, and air pollution. We need to know how these things happen."

Practical application involves teaching the chemistry behind various renewable energy technologies, such as solar cells, wind turbines, and hydrogen fuel cells. Students should also learn about Carbon Capture and Storage (CCS) technologies, which aim to capture carbon dioxide emissions from industrial processes and power plants and store them underground. They can explore the chemistry of different capture materials and methods, as well as the challenges and opportunities associated with CCS in combating climate change. Doxsee and Hutchison (2003) agree that practical application is essential for effectively integrating climate change into the curriculum.

### **Community Engagement**

The last theme identified is community engagement, as the values of society are reflected in the curriculum.

Mr. Job (Policy Maker): "When reviewing the curriculum, we collaborate with community members. We reach out to people like farmers, local industry professionals, and environmental advocates on research projects related to climate change to enhance awareness and integration into what their children learn at school."

Mrs. Ola (Teacher): "We interact with community members, many of whom are not aware of climate change issues. Hosting programs can raise their awareness about local environmental issues and solutions, encouraging them to advocate for its inclusion in the curriculum."

Jenni (Student): "If climate change affects our community, then our community needs to be aware so they can push for environmentally friendly policies and its inclusion in our curriculum."

Climate change is a community issue, and education is a tool to address it. For successful integration of climate change into the chemistry curriculum, curriculum developers and policymakers need to partner with community members, including parents, local businesses, and

organizations, to provide valuable insights and perspectives on what knowledge and skills are important for students to learn. Their input ensures that the curriculum reflects the needs and values of the community it serves. Community engagement enriches the curriculum by incorporating diverse perspectives, fostering collaboration, and ensuring that education remains responsive to community needs. This will lead to quicker integration of climate change into the curriculum. This finding aligns with those of Nooraida et al. (2012) and Burmeister et al. (2013).

## **Conclusion**

Considering the rationale, challenges, and strategies for integrating climate change into the chemistry curriculum, it is clear that incorporating climate change education into secondary school chemistry in the Niger Delta is crucial. This integration fosters environmental awareness, empowers students, and builds resilience against climate change impacts. By providing the next generation with the necessary knowledge and skills to tackle climate challenges, we can work towards a more sustainable future for the region and beyond.

## **Recommendations**

Based on the findings of this study, the following recommendations are made.

1. Curriculum planners should collaborate with climate change experts to include essential content in the chemistry curriculum.
2. The Federal Ministry of Education should organize workshops and seminars for secondary school chemistry teachers in Nigeria, particularly in the Niger Delta region, to ensure they are well-prepared to teach the curriculum effectively.
3. Further research should be conducted to ensure comprehensive coverage of climate change topics in the curriculum, enabling effective mitigation of climate change.
4. Schools should incorporate hands-on projects and experiments related to climate change to enhance students' practical understanding of the subject.
5. Educational institutions should promote interdisciplinary learning by integrating climate change topics across various subjects, not just chemistry.
6. Funding should be allocated to develop and provide high-quality teaching materials and resources on climate change for schools.
7. Collaboration between schools and local communities should be encouraged to raise awareness about climate change and its impacts.
8. Regular evaluation and updates of the curriculum should be conducted to ensure it remains relevant and includes the latest scientific developments on climate change.

## References

- Abdul, G., & Aziah, I. (2007). Kesiediaan memperkasa Pendidikan Pembangunan Lestari oleh Pengurus Pendidikan Sekolah: Satu Kajian kes. Universiti Sains Malaysia. <http://www.iab.edu.my/jurnal>. [10 November 2009]
- Adenle, A. A., & Azadi, H. (2018). Climate change and sustainable development in Nigeria: The role of education. *Sustainability*, 10(7), 2379. doi:10.3390/su10072379
- Burmeister, M. & Eilks, I. (2013). Using participatory action research to develop a course module on education for sustainable development in pre-service chemistry teacher education. *Centre for Educational Policy Studies Journal*, 3, 59-78.
- Burmeister, M., Schmidt-Jacob, S., & Eilks, I. (2013). German chemistry teachers' understanding of sustainability and education for sustainable development - An interview case study. *Chemistry Education Research and Practice*, 14, 169-176.
- Chakeredza S., Temu, A., Yaye, A., Mukingwa, S., & Saka, K. (2009). Mainstreaming Climate Change into Agricultural Education: Challenges and Perspectives. ICRAF Working Paper, 82. Nairobi, Kenya: World Agroforestry Centre. Debating policy Options for National Development; Enugu Forum Policy Paper 10; African Institute for Applied Economics (AIAE); Enugu Nigeria, 13-18.
- Doxsee, K. M., & Hutchison, J. E. (2003). *Green organic chemistry: strategies, tools, and laboratory experiments*. Belmont: Thomson Brooks.
- Feierabend, T., Jokmin, S., & Eilks, I. (2011). Chemistry teachers' view on teaching 'climate change'-an interview case study from research-oriented learning in teacher education. *Chemistry Education Research and Practice*, 12, 85-91.
- Ikehi, M.E., Ifeanyieze, F.O. and Ugwuoke, C.U. (2014) Integration of Climate Change into the Senior Secondary School Agricultural Science Curriculum in Nigeria. *Atmospheric and Climate Sciences*, 4, 614-621. <http://dx.doi.org/10.4236/acs.2014.44054>
- Intergovernmental Panel on Climate Change (2001) Glossary—Climate Change Education Center—Arctic Climatology and Meteorology. NSIDC National Snow and Ice Data Center. [http://www.grida.no/climate/ipcc\\_tar/wg1/518.htm](http://www.grida.no/climate/ipcc_tar/wg1/518.htm)
- Kariuki, C. N., Mokaya, D. C., Kinuthia, D. M., & Sr. Jepkorir, K. G. (2016). Infusing Climate Change Content into Kenya's Secondary School Taught Curriculum: Successes and Challenges. *Journal of Environmental Science, Toxicology and Food Technology*. Volume 10, Issue 9, PP 23-29

- Nooraida, Y., Zurida, Hj. I., & Nordin, A. R.(2012). Climate change in the chemistry curriculum For secondary schools: Malaysian context International Journal of Global Education, volume 1 issue 2
- Offorma, G.C. (2002) Curriculum Theory and Planning. Family Circle Publications, Uwani Enugu, Nigeria.
- Omoniyi A. O., & Aarinola .A.M., (2022) Implementation of Chemistry Curriculum in Nigeria: Challenges for the 21st Century World Journal of Educational Research Vol. 9, No. 2.
- Stephen K., Kibett, K. and Obara, J. (2014). Perceptions of Teachers towards the Integration of Adaptation Strategy Topics on Climate Change into Secondary School Agriculture Syllabus in Machakos County, Kenya. IOSR Journal of Research & Method in Education. Volume 4, PP 35-49.
- UNESCO, (2009). World Conference on Education for Sustainable Development. UNESCO: Bonn, Germany
- Uyigue, E. and Agho, M. (2007) Coping with Climate Change and Environmental Degradation in the Niger Delta of Southern Nigeria. Community Research and Development Centre (CREDC) Press, Benin.
- Zudonu, O. C., Wagbara, S. O., Ikwut, E. F & Iroko, P. E. (2024). Senior Secondary School Chemistry Students' Knowledge of Climate Change in the Niger Delta Region of Nigeria. FNAS Journal of Mathematics, and Science Education, 5(2), 87-96.
- Zudonu, O. C. (2015). Acid Rain in Environmental Pollution: the perception of the people of Edagberi/Betterland Communities in the Niger Delta region of Nigeria. Journal of Civil and Environmental Research. ISSN 2224-5790 (Paper) ISSN 2225-0514 (online). Vol. 7. No. 2. (page 130-139). [www.iiste.org](http://www.iiste.org)