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Assessment of Science Educators' and Students' Knowledge of Climate Change and Attitude Toward Waste Management Practices

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Abstract: In addressing environmental challenges, education remains a crucial tool for promoting sustainability. This study explored the intersection of knowledge and practices of science educators and students regarding climate change and waste management in Lokoja, Kogi State, Nigeria. The research evaluates awareness levels, determines behaviour patterns, and identifies systemic challenges affecting environmental consciousness. A descriptive survey design was employed, utilising a purposive sample of

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842 participants, comprising 800 students and 42 science educators from selected secondary schools and tertiary institutions. Data were collected using a semi-structured questionnaire and analysed using Microsoft Excel and RStudio for data wrangling and statistical analysis. Findings revealed moderate to low levels of knowledge and awareness regarding climate change and waste management among both students and educators. Notably, practices were inconsistent and did not reflect sustainable waste disposal behaviour. Visual data interpretations (box plots, scatter plots, density plots, and bar charts) showed significant knowledge gaps and a disconnect between awareness and actual environmental practices. A lack of targeted education and limited policy enforcement were identified as key barriers to progress. The study concluded with policy recommendations for structured environmental education, particularly among future influencers such as teachers and students, as well as the integration of climate change and waste management into the academic curriculum. It also contributes to global academic discourse by addressing an understudied region and population. By integrating environmental education properly at all levels of education worldwide, societies can have an environmentally conscious population and advocates who can promote sustainability.

Keywords: climate change awareness, waste management, science education, environmental education, sustainability, assessment.

Introduction

Education is the cornerstone of national development, unlocking individual potential and driving societal progress. Science education, particularly, plays a crucial role as a catalyst for innovation, economic growth, and sustainable development. According to Pember & Humbe (2009), it is a process of teaching or training, especially in schools, to improve one's knowledge about the environment and to develop one's skills of systematic inquiry, as well as natural attitudinal characteristics.

Science education, a specialised facet of learning, propels human development by cultivating a deep understanding of the natural world. It instils a scientific mindset that embraces curiosity, evidence-based inquiry, and analytical thinking. Lewis (2015) stated that science education identifies natural phenomena that are appropriate to a child's interests and skills. He further posited that science education equips teachers, learners, and society with the knowledge, skills, and tools necessary to carry out commendable responsibilities relevant to enhancing socioeconomic benchmarks. According to the World Meteorological Organisation (WMO, 2024), the global temperature has increased by 1.5 °C above the pre-industrial level. The environmental problems caused by climate change, whose effects are increasingly felt day by day, pose a serious threat to the entire world and global biodiversity, with a 50% chance of exceeding 1.5°C between 2024 and 2028 (IPCC, 2024).

The World Health Organisation (WHO, 2023) has described Climate Change as an emerging and significant threat to public health. On human health, the World Health Organisation (WHO) estimated that at least 150,000 deaths each year could be traced to the outcome of Climate change. Moreover, this figure is expected to double by 2030, with connections to harsh temperatures and poor waste disposal practices and to achieve sustainability in the most unequal nation in the world, a basic level of services for all citizens remains central to the democratic project (World Bank, 2018)

Climate change (according to Ani, Anyika, & Mutambara, 2021) refers to a shift in the average characteristics of climate variability over a period of time, which can be decades or a prolonged duration. Like the IPCC 2024, the significant causes of climate change have recently been associated with human impact and atmospheric warming. This calls for urgent attention because, just like other top developed vulnerable countries, the effects of climate change and poor waste disposal have significantly influenced

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land use and land cover, human health, and livelihoods in the country with little or no indication of appropriate adaptation plans (Giri et al., 2021; Jibrillah et al., 2019; Pandey et al., 2017; Omerkhil et al., 2020). Ani, Anyika & Mutambara (2021) further stated that high atmospheric carbon dioxide concentrations have both significant positive and negative effects on crop yield. However, some stated categories of crops thrive under these conditions, while others struggle. Conditions such as floods, droughts, and extreme temperatures are a result of climate change, leading to the loss of crops and threatening the livelihoods of farmers, thereby posing a threat to food security.

Waste management practices involve the generation, collection, handling, transfer, disposal, reuse, recycling, reclaiming, and auditing of waste at a minimal cost (Demibars, 2011). These practices vary from nation to nation, depending on the types and characteristics of waste sources (Coker et al., 2010). Unfortunately, improper waste management practices continue to be carried out (Hilburn, 2015). Knowledge and awareness about waste disposal, as well as the identification of human practices that harm the environment, should be improved to facilitate behavioural change (McNicholas and Cotton, 2019). Studies have shown that the factor influencing improper waste disposal can be attributed to the level of education. Therefore, efforts can be made by providing education to maintain environmental sustainability (Bahri et al., 2020).

Over the years, UNESCO has encouraged academic institutions to make a concerted effort to produce graduates well-equipped to tackle environmental challenges and climate issues, promoting sustainability. SDG 17 is an integral part of the 2030 agenda aimed at investigating environmental challenges to human health and providing solutions to promote environmental sustainability that balances the human ecosystem. In response to this, UNESCO has suggested Education for Sustainable Development (ESD) as a means to curb the current threats to global sustainability. ESD is mandated to address education using a robust curriculum with learning outcomes and content related to the environment (Rieckmann, 2017).

Educational Institutions are expected to develop students with adequate knowledge and skills for sustainability (Lozano et al., 2013). Empowering educators, researchers and advocates for sustainability at higher educational institutions helps to promote environmental communication and sustainable development (Akins et al., 2019; Lambrechts et al., 2017). Teaching sustainability concepts such as climate change and waste management practices goes beyond just embedding the concepts into the curriculum, it entails incorporating these concepts into daily activities and practice by students in an academic institutions which can cause a proactive change in mindset and behavior towards sustainability hence, Universities should not only provide knowledge about sustainability but provide an opportunity to for students actively participate and advocate for environmental sustainability (Tezel et al., 2018), according to programs that integrates teaching strategies and environmental sustainability concepts contributing to the success of Higher educations. The attitude and behaviour of students towards environmental sustainability are shaped by the knowledge acquired (Aliman et al., 2019). Singh and Kumar (2023) noted that high school students are essential peers who promote environmental sustainability awareness. As young adults, they instil values that can influence environmental sustainability efforts in the next generation. This implies that factors such as peer influence, cultural expectations, and resource availability help students engage with environmental practices (Aliman et al., 2019).

University campuses and secondary schools in Nigeria generate a diverse array of waste, including paper, plastic, electronic waste, and chemical byproducts. Inadequate waste management practices in educational institutions not only harm the environment but also jeopardise human health and community well-being. According to Dongo et al. (2012), the immediate health signs of hazardous waste exposure include dizziness, headaches, and nausea, while long-term exposure can lead to cancers, disabilities, or death, neurological acute symptoms, and respiratory and digestive system concerns. This research aims to

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assess the knowledge level and awareness of climate change and waste management practices among students and science educators in Lokoja, to promote environmental sustainability.

Research Problem

The city of Lokoja, Kogi State, Nigeria, has been experiencing noticeable changes in weather patterns and harsh climatic conditions, such as floods, increasing temperatures, and erratic rainfall, which contribute to food scarcity in the state. One of the potential contributors to these environmental shifts is the inadequate management of waste, as well as the impacts of climate change. Science educators and students play significant roles in shaping community perceptions. They are in a unique position to disseminate information and raise awareness among the public easily. Recognising that poor waste management practices and climate change could be interconnected with and influence local weather conditions, this research aims to assess the knowledge, attitudes, and practices of science educators and students in Lokoja regarding climate change topics and waste management.

Below are images showcasing waste management and disposal practices in various areas of Lokoja Figure 1.

Figure 1

Waste management and disposal practices in various areas of Lokoja

Although several studies have assessed the impacts of climate change and waste management practices across Nigeria, it is also essential to evaluate knowledge and attitudes towards climate change and waste management practices to determine if they reflect a sufficient level of preparedness for projected future trends in climate change.

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Research Focus

Lokoja is located in the North Central part of Nigeria and is known to have one of the hottest climates in the country. The hot season lasts for 2.7 months, from January 28 to April 19, with an average daily high temperature above 93°F. The hottest month of the year in Lokoja is March, with an average high of 95°F and a low of 76°F. The incredible season lasts for 4.0 months, from June 22 to October 22, with an average daily high temperature below 87°F. The coldest month of the year in Lokoja is December, with an average low of 67°F and a high of 90°F (Weather Sparks, 2024). Based on the research reviewed, the focus of research in this area has neglected the impact of education at all levels on environmental sustainability. It is on this background that the researcher seeks to assess students' and science educators' knowledge of climate change and poor waste management practices across tertiary institutions and secondary schools in Lokoja.

Research Aim and Research Questions

This study aims to assess the knowledge, attitudes, and practices of science educators and students regarding climate change topics and waste management in Lokoja, Kogi State, Nigeria. The specific objectives are to:

i. Assess the knowledge and attitude among science educators and students towards waste management and climate change issues.
ii. Determine the existing practices related to climate change awareness and waste management among science educators and students in Lokoja.

Literature Review

Several studies have been conducted on Climate Change and methods of waste disposal globally; however, a gap in research exists that specifically addresses the knowledge, awareness, and attitudes of the current population regarding climate change and waste management practices. For instance, Ugwu (2018) pointed out that knowledge about the causes as well as risks of Climate Change is essential for translating public concern into practical daily actions and further stated that, until people understand Climate Change, they may not support regulation against it or help to reduce greenhouse gas production. Regarding attitude and knowledge of climate change, it was found that students' knowledge and attitudes towards climate waste management practices are influenced by the extent of available science and environmental education. They added that to achieve substantial and sustainable levels of separation of municipal waste, it is essential to engage students, as they are important drivers of change and will have a significant impact on the world's future. Ultimately, an adequate understanding of the impact of climate change on health and the importance of planetary health in medicine is essential for students.

Environmental education improves students' awareness of the impact of human activities on the environment. Affirmed that a certain level of environmental education is an indispensable prerequisite towards the development of sufficient awareness on the relevance of appropriate municipal waste management among students of higher institutions. Edward and Ofili (2023) found that community participation can play a critical role in improving solid waste management in communities. According to Adetayo (2022), news outlets are not sufficient information channels for students on climate change issues, but rather are strongly associated with an unconcerned attitude towards climate change. Abdirashid, A. I (2022) investigated the knowledge, attitude, and practice towards solid waste management among Mogadishu residents in Somalia and found a positive relationship between knowledge, attitude and practice among residents. Monroe et al. (2017) conducted a study to identify effective climate change and waste management practices in science education, finding that topics such as climate change are not adequately addressed in the science education curriculum. The reviewed works were mostly done outside

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Lokoja, Kogi State, and all agreed that poor waste management practices, as well as the effect of climate change, are detrimental to human health. From the reviewed studies, it is evident that research has been conducted on waste management practices and the impact of climate change. However, no study has explicitly been carried out to assess the knowledge, attitudes, and practices of science educators and students regarding climate change topics and waste management in Lokoja, Kogi State, Nigeria.

The theoretical background of this study is based on Bandura's Social Cognitive Learning Theory (SCLT). Propounded the theory of learning by discovery, which states that individuals learn from observing others and the consequences of their actions. Bandura's fundamental assumptions of SCLT pointed to that:

- Behaviour is directed toward goals.
- Behaviour eventually becomes self-regulated.
- Cognition plays a role in learning.

The Implication of Bandura's theory to this study is that individuals learn about environmental issues by observing the behaviours and attitudes of others in their social environment and social interactions, role modelling, and, in this context, observational learning contribute to the environmental knowledge, attitudes, and practices of science educators and students in Lokoja, Kogi State, Nigeria.

Rationale/ Justification

To promote environmental sustainability literacy, science educators and students play significant roles in shaping community perceptions; therefore, the study established a link between their knowledge and awareness of climate change and waste management practices, as this aligns with global sustainability goals.

Conducting this study on students and Science educators is essential because the weather changes in Lokoja, which record higher temperatures than usual, suggest local environmental impacts. By examining the nuances of knowledge and awareness regarding waste management and climate change, the research addressed a research gap that had not been previously investigated in the study area. This research contributes to promoting sustainable practices and helps identify the need for curriculum review at both secondary and tertiary levels regarding knowledge and awareness of waste management practices in Nigeria. Additionally, the involvement of students and educators fosters participatory and community-based research aimed at contributing to global sustainability goals, providing critical insights into local environmental dynamics, and guiding targeted interventions for climate change and waste management challenges in Lokoja, Kogi State, Nigeria.

Materials and Methods

Study design

The research design for this study will be a descriptive survey. It develops a profile of what is, and not why it is so.

Sample and Participants

The population for this study will comprise all the science educators and students in the selected tertiary institutions and secondary schools in Lokoja, Kogi State. The study employed a purposive sampling technique, targeting all Science teachers in senior secondary schools, SS II students, and science Education lecturers with year two students at tertiary institutions in Lokoja, Kogi State. The population comprises all Science teachers in 73 senior secondary schools (56 Private and 17 public), totalling 1,213 teachers, and 609 senior secondary school science teachers in Lokoja. The sample size was 842, purposively selected

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based on students' classes in secondary school and University level and selected through simple random sampling, with eight areas chosen from the twelve major areas in Lokoja.

The selected sample includes 27 private and nine public secondary schools, with three tertiary institutions purposively chosen based on location within Lokoja. Two lecturers from each institution and one science teacher from each secondary school participated in the study, along with 800 students in each tertiary institution and SS II students in secondary schools. This sample of 842 served as a representative sample of the entire population, allowing for a comprehensive examination of the knowledge, attitudes, and practices of science educators and students regarding climate change and waste management in Lokoja, Kogi State.

Instrument and Procedure

The research instrument was a semi-structured questionnaire constructed based on the research topic and objectives. Section A consisted of biodata for the respondents. In contrast, Section B consisted of questions to evaluate the knowledge and attitudes of science educators and students towards waste management and climate change issues. Section C aims to examine the existing practices related to climate change awareness and waste management among science educators and students in Lokoja.

Data analysis

Each complete questionnaire was reviewed for completeness before analysis. The data collected was sorted and coded using SoftExcel and further wrangled and analysed using RStudio. The study successfully optimised data organisation and in-depth analysis.

Results

Figure 2

Knowledge and Attitudes of Science Educators Towards Climate Change and Waste Management Practices

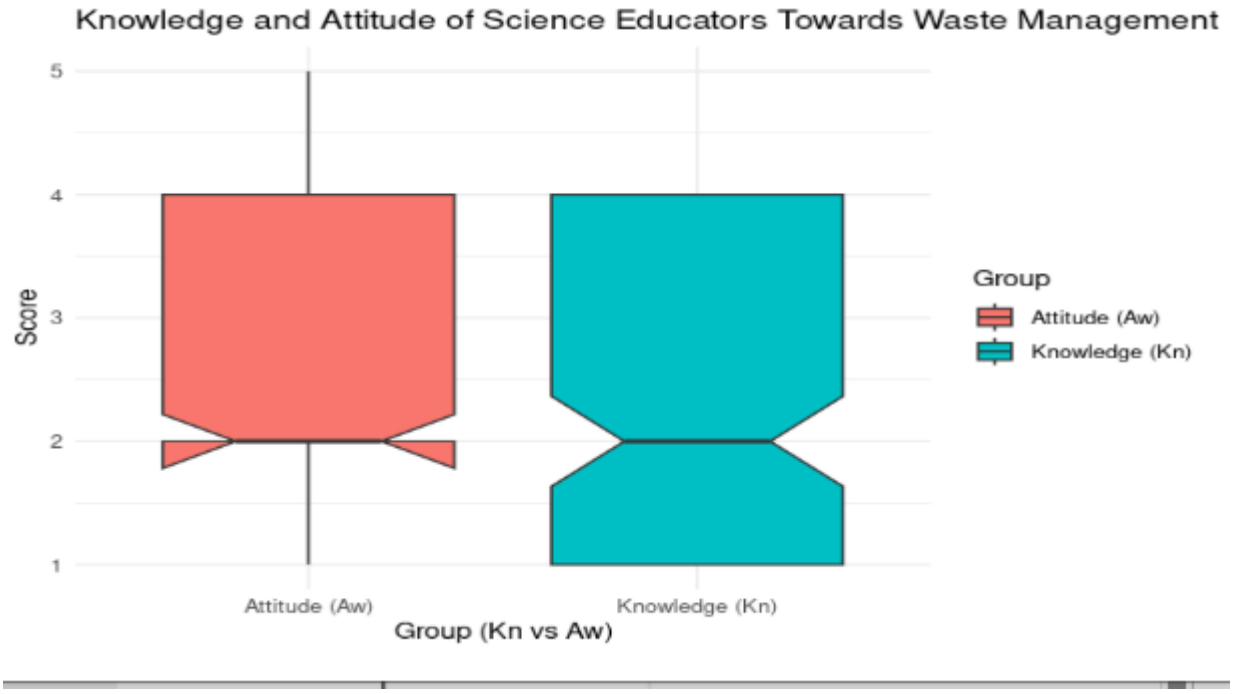

Figure 2 presents a box plot examining science educators' knowledge (Kn) and attitudes (Aw) towards climate change and waste management practices. The x-axis of the box plot represents the two

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categories — knowledge (Kn) and attitudes (Aw) — while the y-axis represents the scores assigned to responses on a 5-point scale. Higher scores indicate greater knowledge or more positive attitudes. Specifically, the result showed that:

- The median knowledge score was slightly higher than the attitude score, but both
- were concentrated near a score of 2 on the 5-point scale.
- The interquartile range (IQR) shows moderate variability, with most responses clustered within the lower score ranges.

Outliers were observed in both categories, indicating that a small subset of educators demonstrated higher levels of knowledge or attitudes.

Figure 3

Practices and Awareness of Science Educators Towards Climate Change and Waste Management.

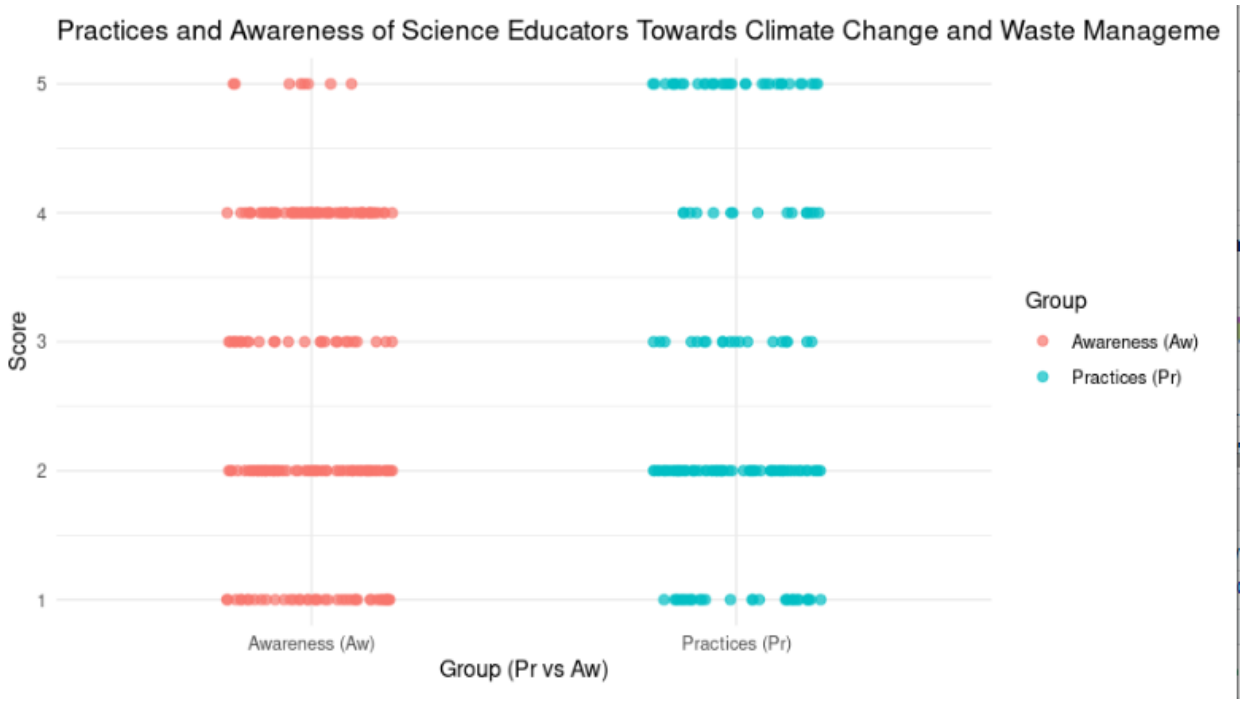

Figure 3 is a scatter plot illustrating the distribution of scores for science educators' awareness (Aw) and practices (Pr) regarding climate change and waste management. The y-axis represents the score, ranging from 1 to 5, where 1 indicates low awareness or practices and 5 indicates high awareness or practices. The x-axis displays two groups: Awareness (Aw) and Practices (Pr), with awareness indicated by red dots and practices indicated by blue dots.

The results show that science educators in the awareness group (red) predominantly scored between 2 and 5, with a concentration of scores around 3 and 4. In contrast, the practices group (blue) had scores mainly ranging from 2 to 4, with a clustering around 3. There is a noticeable overlap between the two groups in the 3- and 4-score range, indicating that the educators' awareness and practices regarding climate change and waste management are somewhat aligned but not identical.

The spread of scores suggests that while there is a moderate level of awareness and practice among science educators, there is room for improvement in both areas.

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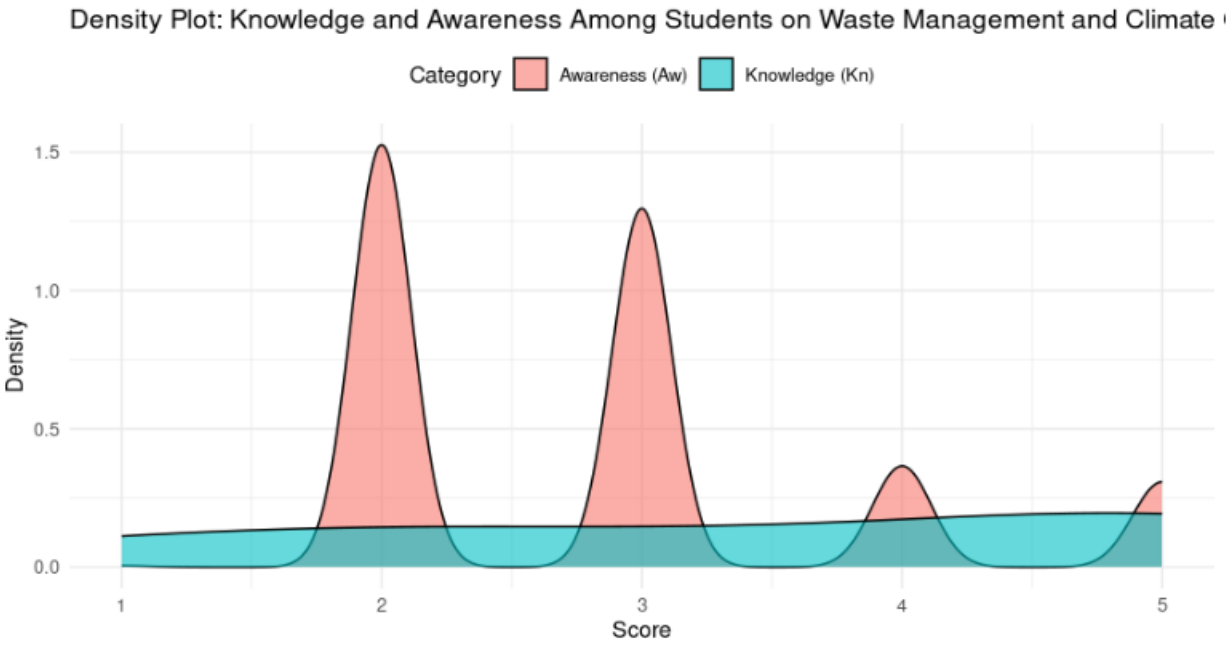
Figure 4

Density Plot of Knowledge and Awareness Among Students on Waste Management and Climate Change



The above figure is a density plot that illustrates the distribution of scores for students' knowledge (Kn) and awareness (Aw) regarding waste management and climate change issues. The x-axis represents the scores (ranging from 1 to 5), which reflect the level of knowledge and awareness. In contrast, the y-axis represents the density, indicating the relative frequency of students' scores within each category.

Key Findings:

1. The density curve for awareness (shaded in red) peaks at scores of 2 and 3, suggesting that most students have low to moderate awareness regarding waste management and climate change issues.

2. Similarly, the density curve for knowledge (shaded in blue) also peaks at scores of 2 and 3, indicating that students possess little or moderate knowledge about these issues. There is no significant concentration at higher scores, indicating a limited overall understanding.

3. Both knowledge and awareness curves demonstrate similar patterns, with peaks concentrated in the lower to moderate range (scores of 2 and 3). This suggests that students have comparable, albeit low, levels of knowledge and awareness.

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Figure 5

Stacked Bar Chart of Practices and Awareness Related to Climate Change Among Students in Lokoja

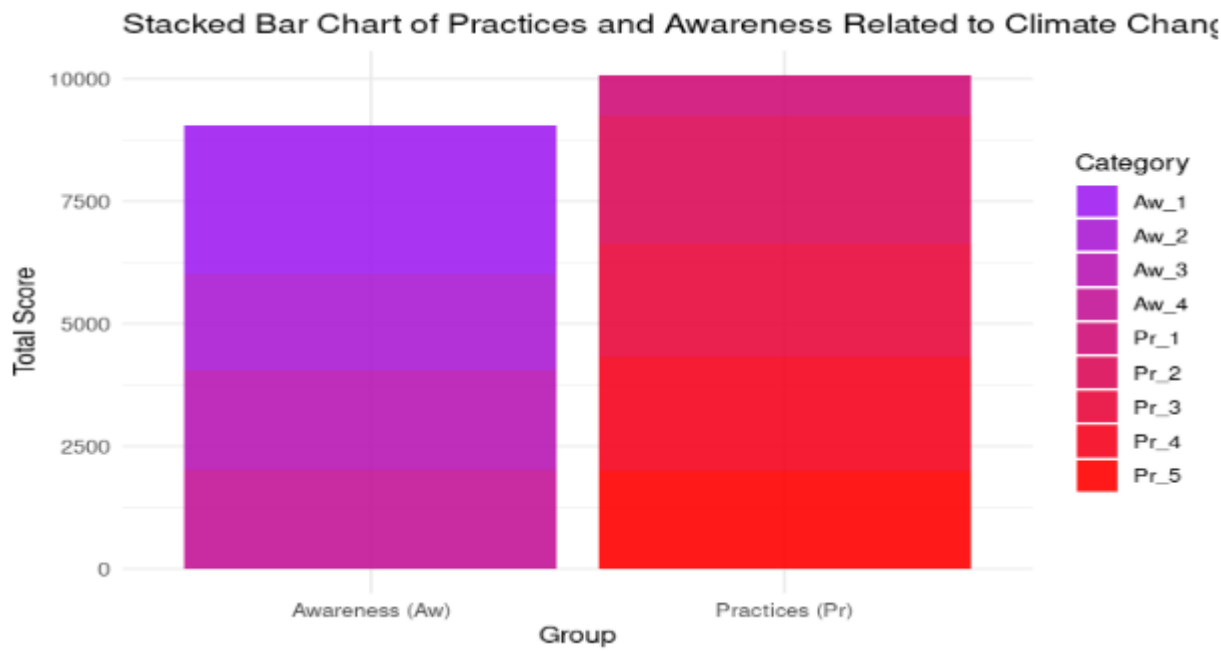

Figure 5 is a stacked bar chart that compares two grouped categories, Awareness (Aw) and (Pr), related to climate change and waste management among students. The y-axis represents the total scores, which were computed by aggregating responses from students across specific subcategories within each group (e.g., Aw_1 to Aw_4 and Pr_1 to Pr_5). These scores reflect the cumulative responses to questions measuring various dimensions of awareness and practice. The x-axis separates the data into Awareness (Aw) and Practices (Pr), with each colour block within the stacked bars representing individual subcategories.

The data reveals that:

- Students scored moderately or low on Awareness (Aw). This indicates that their understanding of climate change concepts and issues is not comprehensive and may lack depth in certain areas.
- Students also scored moderately or low on Practices (Pr), suggesting that while they engage in some waste management behaviours, these practices are inconsistent and may not fully align with sustainable waste management principles.

The cumulative scores for both Awareness (Aw) and Practices (Pr) are comparable, with Practices (Pr) slightly higher. This suggests that students may be taking some actions related to waste management, but a sound understanding of climate change does not always inform these actions.

Discussion

Results from Figures Two and Three show little to moderate awareness of waste management practices among science educators. This finding corroborates the work of Ani and Anyika (2021), who argue that educators' lack of comprehensive knowledge limits their ability to teach environmental topics effectively. The gap between educators' knowledge and practices suggests a need for systemic reforms, as highlighted by UNESCO. This result also aligns with the work of Dodds & Holmes (2018). Pro-environmental behaviour may be affected by individual awareness, environmental education, and social

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norms. Environmental behaviour is essential in waste management, as it aims to minimise risks for future generations (Bamberg & Moser, 2007). Hence, clean environmental management requires awareness and participation from the community and students (Tian & Robertson, 2019).

These findings also align with the work of Chowdhury et al. (2021), who conducted a comparative study of teachers' perceptions of climate change in Bangladesh and identified a statistically significant relationship between teachers' total knowledge scores about climate change and their total attitude scores towards climate change. These results reveal a gap in knowledge, attitudes, and practices regarding climate change education. The findings of this research are also in line with those of Dixit & Sehrawat (2022), who assessed education for sustainability through curriculum provisions and teaching-learning in India and found that teachers' knowledge and attitude about climate and sustainability were limited and not often scientific, as well as Worlu & Glory (2016), who investigated teachers' awareness of climate change in Nigeria and found the awareness of teachers on climate change and the sources of information are significantly low. This finding corroborates with the study of (Winter et al., 2022) that assessed teachers'attitudes towards climate science in the USA showed that less than half (48%) of the participants were concerned about climate change and its severity and also agrees with the study that shows that around half of teachers had a moderate level of knowledge, a moderate attitude, and a low level of practice. In contrast, Karami et al. (2018) investigated teachers' attitudes toward environmental education and their readiness to teach it and found that most teachers were well-informed about climate change.

Figure four revealed that students' awareness of climate change is moderate to low. This is consistent with the study that emphasised the level of material content taught can create clean environmental behaviour (Atmaja et al., 2021; George et al., 2020). While some students demonstrate basic knowledge of climate change impacts, most lack a comprehensive understanding, indicating gaps in the curriculum and teaching strategies. The finding coincides with Ani et al. (2021), who argue that the absence of practical climate education contributes to limited awareness of anthropogenic factors driving climate change and in contrast with Adedotun (2014), who observed a significant relationship between students' sex, age, and class and their level of awareness, knowledge, and practices of waste management. This finding underscores the need to reform science education by integrating real-world climate challenges into lessons, as advocated by UNESCO's Education for Sustainable Development framework. The finding also reinforces the need for education on waste management to improve household decisions regarding waste disposal, whether it is disposed of illegally or adequately through methods such as incineration, open dumping, and landfilling (Azizi et al., 2016). The findings differ from those of Saro et al. (2025), who found that students exhibit strong awareness and practices related to personal conservation efforts. They also disagree with studies by Wierzbinski et al. (2021), which suggest that ecological behaviour is strongly influenced by environmental awareness, with students who are more informed about environmental issues adopting more responsible behaviours.

Figure 5 indicates that waste management practices among students are largely inadequate, with improper waste disposal being a prevalent issue. According to the theory of planned behaviour, there is a positive and significant relationship between environmental knowledge gained during lectures and environmental behaviour and involvement in waste management (Amoah & Addoah, 2021; Janmaimool & Denpaiboon, 2016). However, the current study found minimal engagement in sustainable practices, such as recycling and composting, among students. The observed practices resonate with the findings by Mmereki et al. (2016), which stated that the lack of infrastructure and awareness are barriers to effective waste management in African educational institutions. Similarly, Ugwu (2018) also pointed out that poorly implemented waste policies exacerbate the problem. This is also in agreement with (Wichels et al., 2016), who found that environmental behaviour or responsibility results from environmental concern and the work of (Agboola et al., 2024), who found unsatisfactory current waste management practices in Benue South, as the majority of respondents reported encountering environmental problems, such as odours and

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leachate pollution. To encourage the behaviour of protecting the environment from waste, it is necessary to transfer knowledge in environmental education because having sufficient knowledge, such as clear instructions given in communication and collection campaigns, can increase the likelihood of recycling behaviour (Welfens et al., 2016).

Conclusions

Understanding the knowledge and awareness of Science students and educators about climate change and waste management practices is necessary because they play a crucial role in shaping society's understanding of phenomena and behaviour. Additionally, understanding sustainability through the lens of academic institutions, considering students' knowledge, attitudes, and practices, as well as sustainability concepts in their curriculum and personal awareness, will guide how to tackle environmental sustainability efforts, starting with the academic environment. Addressing this knowledge gap helps to assess sustainability in the academic environment by providing solutions to sustainability issues through education and peer influence. These findings and recommendations, based on this study, provide a good approach to addressing sustainability issues and achieving a sustainable future.

Findings from this study show that both students and science educators in Lokoja lack adequate knowledge, awareness of the causes of climate change and proper waste management practice and by implication, lack of environmental awareness and sufficient knowledge among science educators and students might truncate both Nigeria and the global sustainability interventions as they play a significant role in shaping the environment. This superficial knowledge highlights a noticeable knowledge gap in environmental education that necessitates swift policy interventions and the need to properly incorporate environmental science education into both tertiary institutions' and secondary schools' curricula.

Suggestions for Future Research

We recommend integrating climate change and waste management practices as topics that should be taught across all educational levels. We also recommend providing professional training to teachers at all levels to teach climate change and environmental sustainability effectively. Lastly, we recommend that future research efforts focus on evaluating the effectiveness of educational interventions over time and conducting a comparative regional study to investigate environmental knowledge and practices in Nigeria, to identify best practices. Our work also raises questions about how educators' attitudes and motivation influence students' outcomes in waste management practices.

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Conflict of Interest

The authors declare that they have no competing interests regarding this study.

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References

Abdirashid, A. I. (2022). Knowledge, attitude and practice towards solid waste management among Mogadishu residents – Somalia. *International Journal of Scientific & Engineering Research, 13*(7), 711–721. https://doi.org/10.14299/ijser.2022.07.06

Adedotun, T. (2014). Assessment of secondary school students' knowledge, attitude and practice towards waste management in Ibadan, Oyo State, Nigeria. *Journal of Research in Environmental Science and Toxicology, 3*(3), 66–73. https://doi.org/10.14303/jrest.2014.021

Adetayo, A. J. (2022). News sources and climate change attitude among students: Implications for libraries. *The Serials Librarian, 83*(3–4), 215–227. https://doi.org/10.1080/0361526X.2022.2143374

Agboola, O., Abah, E., Ijimbili, S., Andrew, O., Unazi, I., & Onyemocho, A. (2024). Assessment of waste management practices among residents of Benue South. *Lafia Journal of Scientific and Industrial Research, 5*(1), 78–82.

Akins, E. E., Giddens, E., Glassmeyer, D., Gruss, A., Kalamas Hedden, M., Slinger-Friedman, V., & Weand, M. (2019). Sustainability education and organizational change: A critical case study of barriers and change drivers at a higher education institution. *Sustainability, 11*(2), Article 501. https://doi.org/10.3390/su11020501

Aliman, M., Budijanto, B., Sumarmi, S., & Astina, I. K. (2019). Improving environmental awareness of high school students in Malang city through Earthcomm learning in the geography class. *International Journal of Instruction, 12*(4), 79–94. https://doi.org/10.29333/iji.2019.1246a

Amoah, A., & Addoah, T. (2021). Does environmental knowledge drive pro-environmental behaviour in developing countries? Evidence from households in Ghana. *Environment, Development and Sustainability, 23*(2), 2719–2738. https://doi.org/10.1007/s10668-020-00698-x

Ani, K. J., Anyika, V. O., & Mutambara, E. (2021). The impact of climate change on food and human security in Nigeria. *International Journal of Climate Change Strategies and Management, 14*(2), 148–167. https://doi.org/10.1108/IJCCSM-11-2020-0119

Atmaja, R. T. P., Sulastri, S., & Nazli, N. (2021). Development of students learning module for disaster and environmental knowledge subject for undergraduate students of Universitas Syiah Kuala. *JIPI (Jurnal IPA dan Pembelajaran IPA), 5*(1), 48–56. https://doi.org/10.24815/jipi.v5i1.18188

Azizi, A., Malakmohamadi, B., & Jafari, H. R. (2016). Land use and land cover spatiotemporal dynamic pattern and predicting changes using integrated CA-Markov model. *Global Journal of Environmental Science and Management, 2*(3), 223–234. https://doi.org/10.22034/gjesm.2016.02.03.004

Bahri, R., Rachmaniyah, & Darjati. (2020). Evaluation of waste management facilities through land-based marine litter data: Case study of Kenjeran Beach, Surabaya. *Journal of Environmental Science and Sustainable Development, 3*(1), 156–176. https://doi.org/10.7454/jessd.v3i1.1043

Bamberg, S., & Moser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology, 27*(1), 14–25. https://doi.org/10.1016/j.jenvp.2006.12.002

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Chowdhury, M. T. A., Ahmed, K. J., Ahmed, M. N. Q., & Haq, S. M. A. (2021). How do teachers' perceptions of climate change vary in terms of importance, causes, impacts and mitigation? A comparative study in Bangladesh. *SN Social Sciences, 1*(7), Article 194. https://doi.org/10.1007/s43545-021-00194-7

Coker, A. O., Awopetu, M. S., & Awopetu, R. G. (2010). Assessment of residents' awareness, attitude and participation in solid waste management in Makurdi Metropolis, Nigeria. *International Journal of Engineering, 4*(1), 39–45.

Demirbas, A. (2011). Waste management, waste resource facilities and waste conversion processes. *Energy Conversion and Management, 52*(2), 1280–1287. https://doi.org/10.1016/j.enconman.2010.09.025

Dixit, S., & Sehrawat, G. (2022). Education for sustainability: Curriculum provisions and teaching–learning in India. *Current Science, 122*(1), 87–92. https://doi.org/10.18520/cs/v122/i1/87-92

Dodds, R., & Holmes, M. R. (2018). Education and certification for beach management: Is there a difference between residents versus visitors? *Ocean & Coastal Management, 160*, 124–132. https://doi.org/10.1016/j.ocecoaman.2018.04.011

Dongo, K., Tiembré, I., Koné, B. A., Zurbrugg, C., Odermatt, P., Tanner, M., & Zinsstag, J. (2008). Dynamics of solid waste management in the urban environment of Côte d'Ivoire. *Journal of Environmental Health, 70*(7), 34–40.

Edward, E., & Ofili, A. N. (2023). Effect of community participation on knowledge, attitude and practice of domestic solid waste management in Uyo, Nigeria. *Ibom Medical Journal, 16*(3), 237–245. https://doi.org/10.61386/imj.v16i3.361

George, T. E., Karatu, K., & Edward, A. (2020). An evaluation of the environmental impact assessment practice in Uganda: Challenges and opportunities for achieving sustainable development. *Heliyon, 6*(9), Article e04758. https://doi.org/10.1016/j.heliyon.2020.e04758

Giri, M., Bista, G., Singh, P. K., & Pandey, R. (2021). Climate change vulnerability assessment of urban informal settlers in Nepal, a least developed country. *Journal of Cleaner Production, 307*, Article 127213. https://doi.org/10.1016/j.jclepro.2021.127213

Hilburn, A. M. (2015). At home or to the dump? Household garbage management and the trajectories of waste in a rural Mexican municipio. *Journal of Latin American Geography, 14*(2), 29–52. https://doi.org/10.1353/lag.2015.0024

Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the sixth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. https://doi.org/10.1017/9781009325844

Janmaimool, P., & Denpaiboon, C. (2016). Evaluating determinants of rural villagers' engagement in conservation and waste management behaviors based on integrated conceptual framework of pro-environmental behavior. *Life Sciences, Society and Policy, 12*(1), Article 12. https://doi.org/10.1186/s40504-016-0045-3

Jibrillah, A. M., Ja'afar, M., & Choy, L. K. (2019). Monitoring vegetation change in the dryland ecosystem of Sokoto, northwestern Nigeria using geoinformatics. *The Indonesian Journal of Geography, 51*(1), 9–17. https://doi.org/10.22146/ijg.36168

©Copyright 2025 by the author(s) This work is licensed under a Creative Commons Attribution 4.0 International License.

Karami, S., Bidhendi, M. E., & Naderi, M. (2018). Assessment of teachers' attitude toward environmental education and its relevance to their readiness to educate. *Journal of Human, Environment, and Health Promotion, 6*(4), 9–18. https://doi.org/10.29252/jhehp.6.4.2

Lambrechts, W., Verhulst, E., & Rymenams, S. (2017). Professional development of sustainability competences in higher education: The role of empowerment. *International Journal of Sustainability in Higher Education, 18*(5), 697–714. https://doi.org/10.1108/IJSHE-02-2016-0035

Lewis, A. (2015). *Science teaching in Africa*. Heinemann Educational Books.

Lozano, R., Lozano, F. J., Mulder, K., Huisingh, D., & Waas, T. (2013). Advancing higher education for sustainable development: International insights and critical reflections. *Journal of Cleaner Production, 48*, 3–9. https://doi.org/10.1016/j.jclepro.2013.03.034

McNicholas, G., & Cotton, M. (2019). Stakeholder perceptions of marine plastic waste management in the United Kingdom. *Ecological Economics, 163*, 77–87. https://doi.org/10.1016/j.ecolecon.2019.04.022

Mmereki, D., Baldwin, A., Hong, L., & Li, B. (2016). The management of hazardous waste in developing countries. In A. A. Badr (Ed.), *Management of hazardous wastes* (pp. 3–28). IntechOpen. https://doi.org/10.5772/64376

Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying effective climate change education strategies: A systematic review of the research. *Environmental Education Research, 25*(6), 791–812. https://doi.org/10.1080/13504622.2017.1360842

Omerkhil, N., Kumar, P., Mallick, M., Meru, L. B., Chand, T., Rawat, P. S., & Pandey, R. (2020). Micro-level adaptation strategies by smallholders to adapt climate change in the least developed countries (LDCs): Insights from Afghanistan. *Ecological Indicators, 118*, Article 106781. https://doi.org/10.1016/j.ecolind.2020.106781

Pandey, R., Aretano, R., Gupta, A. K., Meena, D., Kumar, B., & Alatalo, J. M. (2017). Agroecology as a climate change adaptation strategy for smallholders of Tehri-Garhwal in the Indian Himalayan region. *Small-Scale Forestry, 16*(1), 53–63. https://doi.org/10.1007/s11842-016-9342-1

Pember, S. T., & Humbe, T. T. (2009, October 6–9). *Science education and national development* [Conference presentation]. ASSUTIBS Maiden National Conference, College of Education Katsina-Ala, Nigeria.

Rieckmann, M. (2017). *Education for sustainable development goals: Learning objectives*. UNESCO Publishing. https://unesdoc.unesco.org/ark:/48223/pf0000247444

Saro, J. M., Taray, J. D., Cinso, J. S., Ingaling, B. S., Enguio, M. J. A., & Hayon, C. P. B. (2025). Level of attitude, behavior, and awareness of senior high school students toward environmental conservation. *JPBI (Jurnal Pendidikan Biologi Indonesia), 11*(1), 111–124. https://doi.org/10.22219/jpbi.v11i1.37861

Singh, B., & Kumar, S. (2024). Assessment of nursing staff's knowledge, attitude and practice regarding oral hygiene care in intensive care unit patients: A multicenter cross-sectional study. *Indian Journal of Critical Care Medicine, 28*(1), 48–52. https://doi.org/10.5005/jp-journals-10071-24616

Tezel, E., Giritli, F. H., & Uğural, M. N. (2018). *Towards green campuses: Students' perceptions and expectations*[Conference presentation]. International Congress on Health and Environment in Developing Countries, Ankara, Turkey.

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Tian, Q., & Robertson, J. L. (2019). How and when does perceived CSR affect employees' engagement in voluntary pro-environmental behavior? *Journal of Business Ethics, 155*(2), 399–412. https://doi.org/10.1007/s10551-017-3497-3

Ugwu, N. F. (2018). *Climate change knowledge, attitude, mitigation practices and enhancement strategies for secondary school teachers in Enugu State* [Unpublished doctoral dissertation]. University of Nigeria, Nsukka.

WeatherSpark. (2024). *Average weather in Lokoja, Nigeria, year round*. https://weatherspark.com/y/52967/Average-Weather-in-Lokoja-Nigeria-Year-Round

Welfens, M. J., Nordmann, J., & Seibt, A. (2016). Drivers and barriers to return and recycling of mobile phones: Case studies of communication and collection campaigns. *Journal of Cleaner Production, 132*, 108–121. https://doi.org/10.1016/j.jclepro.2016.04.082

Wichels, A., Harth, B., & Gerdts, G. (2016). Linking education and science to increase awareness of marine plastic litter—Distribution of plastic waste on beaches of the German Bight. In M. Bergmann, L. Gutow, & M. Klages (Eds.), *Marine anthropogenic litter* (pp. 329–343). Springer. https://doi.org/10.1007/978-3-319-16510-3_12

Wierzbinski, B., Surmacz, T., Kuzniar, W., & Witek, L. (2021). The role of the ecological awareness and the influence on food preferences in shaping pro-ecological behavior of young consumers. *Agriculture, 11*(4), Article 345. https://doi.org/10.3390/agriculture11040345

Winter, V., Kranz, J., & Möller, A. (2022). Climate change education challenges from two different perspectives of change agents: Perceptions of school students and pre-service teachers. *Sustainability, 14*(10), Article 6081. https://doi.org/10.3390/su14106081

World Bank. (2018). *GINI index* [Data set]. https://data.worldbank.org/indicator/SI.POV.GINI

World Health Organisation. (2023). *Climate change and health*. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

World Meteorological Organisation. (2022). *2021 one of the seven warmest years on record, WMO consolidated data shows* [Press release]. https://public.wmo.int/en/media/press-release/2021-one-of-seven-warmest-years-record-wmo-consolidated-data-shows

Worlu, J., & Glory, N. (2016). Teachers' awareness of climate change: Implications for innovative teaching. *International Journal of Development and Sustainability, 2*(6), 24–31.

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