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Impact of Climate Change Education on Agricultural Adaptation Practices for Sustainability in Rivers State

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ABSTRACT

This study examined the impact of climate change education on agricultural adaptation practices for sustainability in Rivers State. Three research questions and three null hypotheses guided the study. The study adopted the analytic descriptive survey research design. The population of the study was 3,488 farmers and agricultural extension officers in rural areas who are registered with the Rivers State Agricultural Development Programme (RSADP) and have attended climate Change awareness programmes organized by RSADP. The sample size of this study was 348 respondents consisting of 332 Farmers and 20 Agricultural Experts in Rivers State. The study used a self-designed questionnaire for data collection. The instruments were validated by the researcher's supervisor, one expert in Community Development and one in Measurement and Evaluation from Rivers State University. A test of internal consistency was carried out using the Chronbach Alpha method to determine the reliability of the instrument. Reliability coefficients of 0.79, 0.96 and 0.97 were obtained for the three sections of the instrument respectively. From the analysed quantitative data, the findings of the study among others revealed that to a high extent, climate change education enhances diversification of income sources for sustainable agriculture in Rivers State. Based on the findings of the study, it was recommended among other things that the Rivers State Ministry of Commerce and industry should provide training and start-up grants for rural farmers to establish complementary agricultural enterprises such as food processing, beekeeping, and aquaculture.

Keywords: *Diversification of Income Sources*, *Post-harvest Management*, *crop selection practices*

INTRODUCTION

Climate change has emerged as one of the most pressing challenges facing agricultural systems globally, with particularly severe implications for rural farming communities in developing regions. The increasing frequency and intensity of extreme weather events, shifting seasonal patterns, and overall climate variability have ceated unprecedented challenges for agricultural productivity and rural livelihoods (Fadina & Barjolle, 2018). Within this context, climate change education has gained recognition as a crucial intervention to enhance farmers' adaptive capacity and promote sustainable agricultural practices. Simultaneously, income diversification has become an essential strategy for risk management and resilience-building in volatile agricultural environments. This review examines the interconnection between climate change education and income diversification among rural farmers as complementary approaches to achieving sustainable agriculture. Climate change education encompasses structured

learning experiences designed to enhance understanding of climate change phenomena, impacts, and appropriate response strategies. According to Mochizuki and Bryan (2015), effective climate change education goes beyond mere awareness-raising to include practical knowledge transfer, skill development, and attitudinal changes that enable proactive adaptation. For rural farmers, climate change education provides critical knowledge about changing weather patterns, adaptation techniques, and sustainable farming practices that can mitigate climate-related risks. Kabir, Alauddin, and Crimp (2017) emphasise that climate change education for farmers should integrate local knowledge systems with scientific information, creating contextually relevant learning experiences that farmers can readily apply.

The content and delivery of climate change education significantly influence its effectiveness in promoting sustainable agricultural practices. Wolfe and Patel (2019) found that participatory approaches to climate education that actively engage farmers in the learning process result in higher adoption rates of climate-smart practices. Similarly, Anderson (2018) notes that farmer field schools and demonstration plots offer experiential learning opportunities that enhance knowledge retention and application. Climate change education programmes increasingly incorporate digital technologies to improve reach and impact. Mobile-based information services, for instance, provide timely weather advisories and agricultural tips directly to farmers, enhancing their decision-making capacity in uncertain climatic conditions (Aker, Ghosh, & Burrell, 2016). Income diversification represents a strategic response to agricultural vulnerability and serves as a crucial element of sustainable farming systems. Defined as the process of households constructing diverse portfolios of activities and assets to improve their standard of living and manage risk (Ellis & Freeman, 2016), income diversification has become increasingly important in the context of climate change. According to research by Khanal, Wilson, Shankar, and Hoang (2021), agricultural households that diversify their income sources demonstrate greater resilience to climate shocks and experience less severe income fluctuations during adverse weather events. The strategies for income diversification among rural farmers span across various activities including off-farm employment, value addition to agricultural products, and the integration of complementary agricultural enterprises such as livestock rearing or aquaculture alongside crop production (Gautam & Andersen, 2017).

Effective post-harvest management is crucial for reducing losses, optimizing quality, and ultimately enhancing food security, particularly in regions adversely affected by climate variations (Vagadia & Choudhury, 2019). Rural farmers' awareness of climate change is the first variable influencing their capacity to manage post-harvest processes effectively. Research indicates that a significant knowledge gap exists among rural farmers regarding climate change and its implications for agricultural practices (Ogunniyi, 2020). When farmers have limited awareness of how climate factors such as temperature fluctuations, altered rainfall patterns, and increased pest prevalence impact post-harvest quality, they are less likely to adopt suitable practices that mitigate these challenges (Mango et al., 2020). Therefore, increasing farmers' awareness about climate change is fundamental to enhancing their adaptation strategies, especially in post-harvest management.

The relationship between climate change education and post-harvest management is further reinforced by the role of community-based learning. According to Kabuye and Dondo (2021), peer learning and collaboration among farmers provide a platform for the exchange of knowledge and practices concerning climate change adaptation techniques. These community dynamics facilitate the dissemination of information regarding successful post-harvest strategies, which can be particularly beneficial in rural settings where formal education systems may be lacking. By participating in community conversations and learning groups, farmers can share personal experiences and collectively develop solutions to overcome the challenges posed by climate change on post-harvest management. Moreover, the integration of sustainable practices into post-harvest management is a pivotal outcome of effective climate change education. Sustainable agriculture emphasises practices that maintain the health of ecosystems while providing for human needs. Climate-smart practices, such as proper drying and storage

techniques, are essential to minimizing losses and ensuring food security (Mithra et al., 2023). Educated farmers are more likely to adopt such practices, as they understand the long-term benefits of sustainability in agriculture, which include increased resilience to climate impacts, improved product quality, and enhanced marketing opportunities. Additionally, the ability of farmers to access and utilize technology is significantly influenced by climate change education. Technological advancements relating to post-harvest management, such as improved storage facilities, moisture meter tools, and pest control systems, can dramatically reduce losses and maintain product quality (Chirambo et al., 2021). However, without a foundational understanding of climate impacts, farmers may struggle to implement these technological solutions effectively. Educated farmers are more likely to embrace new technologies and innovate their own solutions to fit local conditions, thus enhancing post-harvest management outcomes. In conclusion, the relevance of climate change education in enhancing post-harvest management among rural farmers for sustainable agriculture cannot be overstated. The intricate relationship between awareness, education effectiveness, community dynamics, and technology access illustrates how crucial education is in shaping farmers' responses to climate change. As climate challenges continue to escalate, prioritizing climate change education will be essential in fostering resilient agricultural practices that not only improve post-harvest management but also ensure food security and sustainable livelihoods for

Climate change education plays a vital role in enhancing crop selection practices among rural farmers for sustainable agriculture. The changing climate has significantly impacted agricultural productivity, necessitating informed decisions in selecting crops that can withstand extreme weather conditions and environmental stressors (FAO, 2021). Crop selection practices involve choosing suitable crops and varieties that can adapt to specific climatic conditions, resist pests and diseases, and optimize yields under changing environmental conditions (Lal, Brevik, Dawson, Field, Glaser, Hartemink & Hatano, 2020). Climate change education equips farmers with the knowledge and skills to understand these challenges and make informed decisions regarding crop selection to sustain food security and economic stability (IPCC, 2022). Understanding the role of climate change education in crop selection involves examining how knowledge dissemination influences farmers' choices. Climate change education provides rural farmers with scientific information on climate variability, soil characteristics, water availability, and crop resilience, which are essential in selecting suitable crops (UNESCO, 2020). In many rural communities, farmers rely on traditional knowledge and historical weather patterns, which may no longer be reliable due to climate change (Sietz, Choque & Breschini, 2019). Educating farmers about climate adaptation strategies, including drought-resistant and early-maturing crops, can significantly improve their ability to cope with climate-induced agricultural risks (Ozor, Odoemelam, Nnaji & Achike, 2019).

Crop selection is a critical determinant of agricultural productivity and sustainability. Climate change affects soil fertility, water availability, and pest prevalence, all of which influence crop growth and yield (Rockström, Falkenmark, Karlberg, Hoff, Rost & Gerten, 2019). Choosing the wrong crop varieties can lead to poor yields, economic losses, and food insecurity (Lal et al., 2020). Climate change education provides farmers with insights into climate-smart agricultural practices, enabling them to select crops that can thrive under specific climatic conditions (Adu, Kuwornu, Anim-Somuah & Sasaki, 2018). For instance, the adoption of heat-tolerant maize and flood-resistant rice varieties has been linked to improved yields and resilience among farmers who have received climate education (Nyong, Adesina & Elasha, 2019). Empirical studies have shown a positive relationship between climate change education and improved crop selection practices. Research by Kogo, Kumar and Koech (2021) found that farmers who participated in climate education programmes were more likely to adopt climate-resilient crops and diversify their crop choices to minimize risks. Similarly, Alemayehu, Bewket, Gebremariam, Eshetu, Melesse and Steenhuis (2022) demonstrated that extension services integrating climate education increased farmers' awareness and adoption of improved crop varieties. These findings highlight the crucial role of education in enabling

farmers to make data-driven crop selection decisions (Leal Filho, Azeiteiro, Alves, Pace, Mifsud & Brandli, 2021).

Statement of the Problem

Agriculture remains the backbone of rural livelihoods in Rivers State, providing food, income, and employment opportunities for the majority of households. However, the increasing variability of rainfall patterns, rising temperatures, flooding, soil degradation, and frequent pest and disease outbreaks caused by climate change have posed significant threats to agricultural productivity and food security in the region. These challenges demand urgent adaptation measures to ensure sustainable farming practices and livelihood resilience among rural farmers. Climate change education has been identified globally as a critical tool for enhancing farmers' capacity to adopt innovative adaptation practices such as diversification of income sources, improved post-harvest management, and climate-resilient crop selection. However, despite various interventions and sensitization programmes in Nigeria, rural farmers in Rivers State still struggle with limited awareness, inadequate technical knowledge, and low adoption of effective adaptation practices.

This situation raises pertinent questions about the extent to which climate change education has translated into practical agricultural adaptation strategies among rural farmers in Rivers State. Are farmers applying climate change education to diversify their income sources, adopt better post-harvest management practices, and make informed crop selection decisions for sustainability? Or does a gap still exist between the provision of climate change education and its practical application in rural farming communities? It is against this backdrop that this study seeks to examine the impact of climate change education on agricultural adaptation practices for sustainability among rural farmers in Rivers State.

Purpose of the Study

The purpose of this study was to examine the impact of climate change education on agricultural adaptation practices for sustainability in Rivers State. The specific objectives of this research were to:

1. ascertain the extent to which climate change education enhances diversification of income sources among rural farmers for sustainable agriculture in Rivers State;
2. assess the extent to which climate change education enhances post-harvest management among rural farmers for sustainable agriculture in Rivers State;
3. determine the extent to which climate change education enhances crop selection practices among rural farmers for sustainable agriculture in Rivers State;

Research Questions

The following research questions guided the study:

1. To what extent does climate change education enhance diversification of income sources among rural farmers in Rivers State?
2. To what extent does climate change education enhance post-harvest management among rural farmers in Rivers State?
3. To what extent does climate change education enhance crop selection practices among rural farmers in Rivers State?

METHODOLOGY

The study adopted the analytic descriptive survey research design. The population of the study was 3,488 farmers and agricultural extension officers in rural areas who are registered with the Rivers

State Agricultural Development Programme (RSADP) and have attended climate change awareness programmes organized by RSADP. The sample size of this study was 352 respondents consisting of 332 Farmers and 20 Agricultural Experts in Rivers State. The sample size was determined using the Krejcie and Morgan table of sample size determination. The multistage method was used to distribute the sample for the study. Firstly, the respondents were clustered into the three senatorial districts in Rivers State, which are Rivers East, Rivers West and Rivers Southeast senatorial districts. Secondly, simple random sampling technique was used to select three local governments areas each from the three senatorial districts, making a total of nine local government areas. Finally, 20% was selected from the sample of farmers and agricultural extension officers from the nine local government areas selected for the study.

The study used a self- designed questionnaire titled "Climate Change Education and Sustainable Farming Strategies of Rural Farmers in Rivers State" (CCESFSFRFQ). The instrument was validated by three experts, two in Community Development and one in Measurement and Evaluation from Rivers State University. A test of internal consistency was conducted using Cronbach's Alpha method to assess the reliability of the instrument. Reliability coefficients of 0.89, 0.82 and 0.98 were obtained for the three sections of the instrument, respectively. Data were analyzed using mean, standard deviation, and z-test statistics. The questionnaire was constructed based on the modified 4-point rating scale of: Very High Extent (4-points), High Extent (3-point), Low Extent (2-points), and Very Low Extent (1-point).

RESULTS AND DISCUSSION

Research Question 1: To what extent does climate change education enhance diversification of income sources among rural farmers in Rivers State?

Table 1: Mean Response on the Extent Climate Change Education Enhance Diversification of Income Sources Among Rural Farmers in Rivers State

S/N	Items	Farmers (N = 332)			Agric. Ext. Officers (N = 20)		
		Mean	SD	Remark	Mean	SD	Remark
1	To what extent has climate change education increased your awareness of the importance of diversifying income sources to mitigate climate-related agricultural risks?	2.95	1.11	HE	2.86	1.10	HE
2	To what extent has climate change education influenced your decision to engage in non-farm income-generating activities, such as trading or craftsmanship, alongside farming?	2.77	1.01	HE	2.68	1.11	HE
3	To what extent has climate change education motivated you to adopt alternative agricultural practices, such as livestock rearing or fish farming, to supplement crop production income?	2.87	1.13	HE	3.19	0.96	HE

S/N	Items	Farmers (N = 332)			Agric. Ext. Officers (N = 20)		
4	To what extent has climate change education enhanced your understanding of the financial benefits of cultivating a variety of crops (crop diversification) to ensure a stable income?	2.83	1.14	HE	2.72	1.13	HE
5	To what extent has climate change education encouraged you to participate in cooperative societies or savings groups to strengthen financial resilience against climate variability?	2.19	1.08	HE	3.18	0.90	HE
6	To what extent has climate change education led you to explore agro-processing activities, such as producing and selling processed agricultural products, to increase income streams?	3.41	1.12	HE	2.96	1.12	HE
7	To what extent has climate change education influenced your awareness and utilization of microfinance opportunities to support diversified income ventures?	2.75	1.39	HE	3.70	1.42	VHE
	Grand Mean	3.01		HE	3.20		HE

Table 1 above on research question one, shows the mean responses of farmers and agricultural extension officers on the extent to which climate change education enhances diversification of income sources among rural farmers in Rivers State. The grand mean scores of 3.01 and 3.20 for farmers and agricultural extension officers respectively fall within the decision mean of 3.50 - 4.00. This indicates that both groups agreed that to a very high extent climate change education enhanced diversification of income sources among rural farmers in Rivers State.

Research Question 2: To what extent does climate change education enhance post-harvest management among rural farmers in Rivers State?

Table 2: Mean Response on the Extent Climate Change Education Enhance Post-Harvest Management Among Rural Farmers in Rivers State

S/N	Items	Farmers (N = 332)			Agric. Ext. Officers (N = 20)		
		Mean	**SD**	**Remark**	**Mean**	**SD**	**Remark**
8	To what extent has climate change education increased your awareness of the importance of	2.86	1.12	HE	3.18	0.95	HE

S/N	Items	Farmers (N = 332)		Agric. Ext. Officers (N = 20)	
	proper post-harvest management in reducing food loss?				
9	To what extent has climate change education influenced your adoption of improved storage techniques to protect harvested crops from climate-related spoilage?	2.87	1.13 HE	2.71	1.12 HE
10	To what extent has climate change education enhanced your understanding of the impact of temperature fluctuations on the quality and shelf-life of stored produce?	2.74	1.38 HE	2.69	1.41 HE
11	To what extent has climate change education motivated you to implement pest and disease control measures during storage to minimize post-harvest losses?	2.76	1.16 HE	3.11	1.00 HE
12	To what extent has climate change education encouraged you to utilize drying methods that are resilient to changing weather patterns for preserving harvested crops?	2.94	1.10 HE	2.85	1.10 HE
13	To what extent has climate change education improved your knowledge about the timing of harvest to optimize yield quality in the face of unpredictable weather conditions?	3.78	1.02 VHE	3.56	0.80 VHE
14	To what extent has climate change education enhanced your collaboration with other farmers or agricultural organizations to share knowledge and resources for effective post-harvest management under changing climatic conditions?	3.71	1.11 VHE	3.22	0.91 HE
	Grand Mean	3.11	HE	3.23	HE

Table 2 above on research question five shows the mean responses of farmers and agricultural extension officers on the extent to which climate change education enhances post-harvest management among rural farmers in Rivers State. The grand mean scores of 3.11 and 3.23 for farmers and agricultural extension officers respectively fall within the decision mean of 2.50 - 3.49. This indicates that both groups agreed that to a high extent climate change education enhanced post-harvest management among rural farmers in Rivers State.

Research Question 3: To what extent does climate change education enhance crop selection practices among rural farmers in Rivers State?

Table 3: Mean Response on the Extent Climate Change Education Enhance Crop Selection Practices Among Rural Farmers in Rivers State

S/N	Items	Farmers (N = 332)			Agric. Ext. Officers (N = 20)		
		Mean	SD	Remark	Mean	SD	Remark
15	To what extent has climate change education increased your awareness of the importance of selecting climate-resilient crop varieties?	3.25	0.90	HE	3.22	0.91	HE
16	To what extent has climate change education influenced your adoption of drought-tolerant crop species in response to changing rainfall patterns?	2.76	1.14	HE	3.41	1.53	HE
17	To what extent has climate change education motivated you to incorporate flood-resistant crops into your farming system to mitigate the effects of increased flooding?	3.99	0.89	VHE	3.61	1.00	VHE
18	To what extent has climate change education enhanced your understanding of the benefits of diversifying crops to reduce vulnerability to climate-related risks?	3.29	0.89	HE	3.55	1.00	HE
19	To what extent has climate change education led you to consider soil type and fertility in selecting appropriate crops for sustainable production?	2.98	1.13	HE	2.94	1.15	HE
20	To what extent has climate change education improved your knowledge about integrating indigenous knowledge with scientific recommendations for crop selection?	2.84	1.41	HE	3.66	1.43	VHE
21	To what extent has climate change education affected your willingness to experiment with new crop varieties that are better suited to evolving climatic conditions?	3.11	0.95	HE	3.14	0.97	HE
22	To what extent has climate change education enhanced your collaboration with agricultural	3.32	1.10	HE	2.93	1.12	HE

S/N	Items	Farmers (N = 332)		Agric. Ext. Officers (N = 20)	
	extension services to make informed crop selection decisions?				
	Grand Mean	3.22	HE	3.34	HE

Table 3 above on research question six, shows the mean responses of farmers and agricultural extension officers on the extent to which climate change education enhances crop selection practices among rural farmers in Rivers State. The grand mean scores of 3.22 and 3.34 for farmers and agricultural extension officers respectively fall within the decision mean of 2.50 - 3.49. This indicates that both groups agreed that to a high extent climate change education enhanced crop selection practices among rural farmers in Rivers State.

Discussion of Findings

Extent to which Climate Change Education Enhances Diversification of Income Sources Among Rural Farmers for Sustainable Agriculture

The results of the findings in question one indicate that the respondents agree that to a high extent, climate change education enhances diversification of income sources for sustainable agriculture in Rivers State. According to Ellis and Freeman (2016), income diversification represents a strategic response to agricultural vulnerability and serves as a crucial element of sustainable farming systems. Defined as the process of households constructing diverse portfolios of activities and assets to improve their standard of living and manage risk income diversification has become increasingly important in the context of climate change. Furthermore, research by Khanal, Wilson, Shankar, and Hoang (2021), indicates that agricultural households that diversify their income sources demonstrate greater resilience to climate shocks and experience less severe income fluctuations during adverse weather events. In a related view, Moniruzzaman (2015) opined that climate change education also provides farmers with specific technical knowledge and skills necessary for implementing diversification strategies. For example, educational programmes on climate-smart agriculture have been shown to enhance farmers' capacity to integrate livestock with crop production, establish agroforestry systems, or develop small-scale irrigation for high-value crops, all of which contribute to income diversification.

Extent to which Climate Change Education Enhances Post-Harvest Management Among Rural Farmers for Sustainable Agriculture

The results of the findings in question two indicate that to a high extent, climate change education enhances post-harvest management for sustainable agriculture in Rivers State. This is in line with the findings of Ogunniyi (2020) when he observed that rural farmers' awareness of climate change is the first variable influencing their capacity to manage post-harvest processes effectively. Therefore, increasing farmers' awareness about climate change is fundamental to enhancing their adaptation strategies, especially in post-harvest management. The relationship between climate change education and post-harvest management is further reinforced by the role of community-based learning. According to Kabuye and Dondo (2021), peer learning and collaboration among farmers provide a platform for the exchange of knowledge and practices concerning climate change adaptation techniques. These community dynamics

facilitate the dissemination of information regarding successful post-harvest strategies, which can be particularly beneficial in rural settings where formal education systems may be lacking. By participating in community conversations and learning groups, farmers can share personal experiences and collectively develop solutions to overcome the challenges posed by climate change on post-harvest management. Additionally, the ability of farmers to access and utilize technology is significantly influenced by climate change education. Technological advancements relating to post-harvest management, such as improved storage facilities, moisture meter tools, and pest control systems, can dramatically reduce losses and maintain product quality (Chirambo et al., 2021).

Extent to which Climate Change Education Enhances Crop Selection Practices Among Rural Farmers for Sustainable Agriculture

The results of the findings in question three indicate that to a high extent, climate change education enhances crop selection practices for sustainable agriculture in Rivers State. According to Lal, Brevik, Dawson, Field, Glaser, Hartemink and Hatano (2020), crop selection practices involve choosing suitable crops and varieties that can adapt to specific climatic conditions, resist pests and diseases, and optimize yields under changing environmental conditions. Climate change education equips farmers with the knowledge and skills to understand these challenges and make informed decisions regarding crop selection to sustain food security and economic stability. In a related view, Lal (2020), observed that climate change education provides farmers with insights into climate-smart agricultural practices, enabling them to select crops that can thrive under specific climatic conditions. Furthermore, combining indigenous knowledge with climate change education enables farmers to refine their selection criteria, incorporating both traditional practices and modern agricultural advancements to enhance productivity and sustainability (FAO, 2021). In conclusion, climate change education is essential for enhancing crop selection practices among rural farmers, thereby contributing to sustainable agriculture. By increasing awareness and promoting adaptive strategies, climate education enables farmers to choose crops that can withstand climate variability, ensuring food security and economic stability. The relationship between climate change education and crop selection is evident in empirical studies that demonstrate increased adoption of climate-resilient crops among educated farmers. However, addressing barriers such as access to training, resource availability, and institutional support is critical for maximizing the impact of climate education on crop selection. Strengthening climate education through participatory approaches, digital innovations, and policy support will empower rural farmers to make informed crop selection decisions and sustain agricultural productivity in the face of climate change.

CONCLUSION

This study highlights the critical role of climate change education in fostering sustainable agricultural practices among rural farmers in Rivers State. The findings indicate that enhanced education significantly contributes to the diversification of income sources, effective post-harvest management, and improved crop selection practices. By equipping farmers with the necessary knowledge and skills, climate change education not only promotes resilience against environmental challenges but also supports economic stability and food security. This underscores the need for continued investment in educational programs that empower farmers to adapt to changing climatic conditions, thereby ensuring sustainable agricultural development in the region. Future policies should prioritize integrating climate change education into agricultural training initiatives to maximize its benefits for rural communities.

RECOMMENDATIONS

Based on the findings of the study, it was recommended that:

1. The Rivers State Ministry of Commerce and Industry should provide training and start-up grants for rural farmers to establish complementary agricultural enterprises such as food processing, beekeeping, and aquaculture.
2. The Rivers State Ministry of Agriculture should establish post-harvest training centers in key agricultural zones with demonstrations of appropriate storage technologies and value addition techniques in the State.
3. The Rivers State Agricultural Development Programmes should establish demonstration farms in each local government area showcasing climate-adapted crop varieties and their management practices.

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