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NURTURING CLIMATIC RESILIENCE FOR SUSTAINABLE DEVELOPMENT IN THE ECONOMIC COMMUNITY OF CENTRAL AFRICAN STATES (CEMAC)

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ABSTRACT
The effects of climate change pose serious threats to sustainable development in the Economic Community of Central African States (CEMAC). In this paper, we argue that for the countries in the CEMAC region to improve their climate resilience, they must simultaneously grow their human capital and reduce their waste-based N2O emissions. Efforts are ongoing in the CEMAC region to ensure plausible adaptation and resilient measures, but the hazardous consequences of climate change keep threatening peaceful coexistence. From a utilitarian perspective, human action towards the environment will be morally right when it maximizes happiness and reduces suffering for the greatest number of people. Humans are expected to take eco-friendly actions -reafforestation, appropriate waste management and environmental education; that are beneficial for inert nature and humanity This study examines the complex relationships between human capital development, climate resilience, and N2O waste emissions in CEMAC countries and the ethical implications of these relationships. The study employs quantitative analysis of primary and secondary data sources to examine these links among CEMAC nations, using Panel data from 1974 to 2023. We propose that to increase their climate resilience, CEMAC countries should prioritise the development of human capital in addition to lowering waste N2O emissions.

KEY WORDS: *CEMAC, Human Capital, Emissions, Climate Resilience, and Sustainable Development.*

INTRODUCTION

The Economic Community of Central African States (CEMAC) is home to more than 50 million people, and between 1990 and 2018, more than 4 million people were impacted by climate-related disasters, making many populations extremely vulnerable to climate change (Guha-Sapir et al., 2019; IFRC, 2020). We must consider how the nations may build resilience through sustainable development planning in light of the sharp rise in climate-related disasters across the CEMAC region. According to the IPCC (2019) and Niang et al. (2014), rising temperatures, altered precipitation patterns, and an increase in extreme weather events threaten food security, human health, and economic stability, which have disastrous implications in the CEMAC region. Given how much a region's economy depends on its fortunes, climate shocks from natural resources pose a threat to it (World Bank, 2020; AFDB, 2017). Because the region's infrastructure, including its roads, buildings, and bridges, is not able to withstand extreme weather conditions, the effects of climate change are more pronounced there (UNDP, 2019). The global increase in climate resilience necessitates an immediate international effort to mitigate the effects of climate change, which impacts all parts of the world. Sea level rise, increased weather, and global warming all threaten the basic sustainability of millions of people, mostly in vulnerable populations (IPCC, 2019; UNISDR, 2015; World Bank, 2018). The United Nations ratified the Paris Agreement and Sustainable Development Goals (SDGs) in 2015, giving climate resilience worldwide relevance (UNFCCC, 2015; UN, 2015). According to the UNDP (2019) and World Bank (2020), record-high gaps in climate resilience continue to exist globally because many nations require increased resources and adaptation capacities to address climate change. Due to the region's present direct impacts of climate change, such as heat waves and floods, climate resilience has become a major concern throughout Europe (EEA, 2019; IPCC, 2019). Through the EU Adaptation Strategy and Covenant of Mayors for Climate and Energy framework, the European Union continues to implement a progressive approach to the development of climate resilience (EU, 2013; CoM, 2020). Significant challenges to European climate resilience persist in both Eastern and Southern Europe (EEA, 2019; UNDP, 2019). The EU intends to increase its support for resilience-building and climate adaptation programs both domestically and abroad (EU, 2020).

Africa is particularly vulnerable to climate change events, such as droughts and floods, making climate resilience a serious problem (IPCC, 2019; UNISDR, 2015). Understanding the need to enhance climate resilience, the African Union (AU) works with the Programme for Infrastructure Development in Africa to implement the African Climate Change Strategy (AU, 2014; PIDA, 2020). Many African countries find it difficult to adjust their climate practices, particularly in their rural areas, due to a lack of adequate resources and inadequate capacity (UNDP, 2019; World Bank, 2020). The AU has pledged to

increase its assistance for resilience-building and climate adaptation in Africa and beyond (AU, 2020).
According to UNDP (2019) and Mabaya et al. (2018), research and policy analysis regarding effective resilience-building methods for the CEMAC region are still insufficient to address its vital development demands. According to Hartmann et al. (2013) and Niang et al. (2014), research has found essential components of climate information systems and early warning systems in addition to climate-smart agriculture practices and ecosystem-based adaptation strategies. More research is required to fully understand how social structures, economic conditions, and institutional influences affect resilience across CEMAC.

Enhancing climatic resilience is necessary for sustainable development in CEMAC, and this paper supports this goal by offering ideas aimed at researchers, practitioners, and policymakers. The essay examines how marginalised groups are impacted by climate change in CEMAC and suggests strategies for enhancing resilience. The study examines how ecosystem-based adaptation and nitrous oxide (N2O) emissions from waste (Mt CO2e) contribute to CEMAC's resilience. Nitrous oxide (N2O) waste emissions are a significant source of greenhouse gases that have an impact on the Economic Community of Central African States (CEMAC) region. The decomposition of organic waste in landfills and wastewater treatment plants, together with agricultural operations, is the primary source of N2O emissions from waste (IPCC, 2019; USEPA, 2020; WRI, 2020; UNEP, 2019). Rapid population growth and waste production in the Economic Community of Central African States (CEMAC) have resulted in increased N2O emissions (AfDB, 2020; World Bank, 2020; UN-Habitat, 2019; OECD, 2020). According to UNEP, AfDB, World Bank, and OECD reports (2019 and 2019), the amount of N2O emissions from garbage in the CEMAC region accounted for 10% of all waste-related N2O pollutants in Africa in 2015. Inadequate waste management systems, poor waste disposal practices, and limited access to waste processing technology are the main causes of N2O emissions from waste in the CEMAC region (IPCC, 2019; USEPA, 2020; WRI, 2020; UNEP, 2020). To reduce N2O emissions from trash, CEMAC must implement sustainable waste management techniques, such as waste reduction, recycling, and composting (UNEP, 2019; AfDB, 2020; World Bank, 2020; OECD, 2020). To reduce N2O emissions from trash, CEMAC must upgrade their waste disposal infrastructure in addition to investing in waste-to-energy technologies (IPCC, 2019; USEPA, 2020; WRI, 2020; IRENA, 2020). Since CEMAC has significant N2O emissions from waste, sustainable development and climatic resilience depend on efficient N2O waste emission control. By implementing sustainable waste management practices, investing in waste-reducing technologies, and improving waste disposal systems, CEMAC countries can attain sustainable development while reducing N2O emissions from waste (UNEP, 2020; AfDB, 2020; World Bank, 2020; OECD, 2020). Policy-making and all efforts to achieve sustainable development and resilience building in CEMAC should be guided by the research findings presented in this study. To improve this study on significant topic areas, this paper examines the complex relationships between climate change and sustainability with resilience. The paper offers suggestions for CEMAC resilience development that guide local practices and national and regional policies towards the region's sustainable development goals.

Evolution of Waste Management in CEMAC
The management of waste is a serious burden within the CEMAC region. This is because it drastically lowers the N2O emissions produced by waste activities in CEMAC, and regional waste management must be effective. The region's rapidly increasing urbanisation and population growth have resulted in an increase in waste production, which in turn has raised N2O emission levels (AfDB, 2020; World Bank, 2020; UN-Habitat, 2019; OECD, 2020). Environments that reduce N2O emissions are produced by combining waste management systems that prioritise waste reduction with recycling and composting techniques (UNEP, 2019; USEPA, 2020; WRI, 2020; IRENA, 2020). In addition to reducing N2O emissions, waste-to-energy systems also generate renewable energy sources (IPCC, 2019; IRENA, 2020; UNIDO, 2020; World Bank, 2020).

Resilience to Climate Change
For CEMAC countries to manage the effects of climate change, which particularly affect N2O emissions in waste creation, they must engage in climate-resilience development. Countries must build their capacity for stress adaptation, transformation, and absorption to be climate resilient (IPCC 2019, UNISDR 2015, World Bank 2018, UNEP 2019). According to the AfDB (2020), UNDP (2020), FAO (2020), and IUCN (2020), among other projects within CEMAC for climate resilience development are climate-smart agriculture, ecosystem-based adaptation, and disaster risk reduction. CEMAC countries can reduce their exposure to the consequences of climate change that lead to waste-related N2O emissions by enhancing their climate resilience.

The Principle of Precaution
Although there is still little scientific data, organisations should take preventative measures against significant ecological or health hazards following Hans Jonas' (1984) original concept, which was enlarged by the Rio Declaration (UN, 1992). The Precautionary Principle, which prioritises proactive action over uncertain repercussions, should be used to address the N2O emissions from trash (IPCC, 2019; UNEP, 2020; World Bank, 2020; EC, 2020). The Precautionary Principle is used in this paper to bolster the case for prompt, proactive measures that lower waste-related N2O emissions across the CEMAC region.

The Intergenerational Justice Principle
The UN Framework Convention on Climate Change (UNFCCC, 1992) and Edith Brown Weiss (1989) both state that modern humans must protect natural resources for the benefit of future generations. Through its applications with UNEP (2019), World Bank (2020), OECD (2020), and ILO (2020), the Principle of Intergenerational Justice focuses on N2O emissions from waste to demonstrate that current waste management practices must limit N2O emissions and benefit future generations. To demonstrate why CEMAC requires environmentally sound waste management systems that protect

future population demands, the concept of intergenerational justice is to be considered seriously. When considering waste-generated N2O emissions from the perspective of climate justice, science highlights the ethical issues that arise. Research by Vanderheiden (2020) shows how vulnerable populations, like those in CEMAC, are impacted by climate change, which creates moral questions about emission reduction obligations (Vanderheiden, 2020; Caney, 2020; Gardiner, 2020; Heyward, 2020). It is both morally required and a matter of justice for N2O emissions from trash to be reduced. Political philosophy researchers look into climate citizenship as a framework for controlling waste systems' sources of N2O emissions. Supporting emission reduction by both individuals and groups is how Dobson (2020) defines climate citizenship (Dobson, 2020; Mason, 2020; Washington, 2020; Barry, 2020). The idea of climate citizenship directs CEMAC to create waste management procedures that promote sustainability and the decrease of N2O emissions. The CEMAC debate of N2O emissions from trash is enhanced by the environmental justice principle. According to Schlosberg (2020), Agyeman (2020), Bullard (2020), and Pellow (2020), environmental justice includes protecting and treating at-risk minorities the same as other communities in CEMAC countries. This is so because it is a social equity need; the goal of reducing N2O emissions in waste management goes beyond environmental conservation.

Through the concepts of climate justice, environmental justice, and climate citizenship, the research in Ethics demonstrates how N2O waste emissions raise moral issues. These ideas can guide the development of sustainable waste management policies and practices that reduce N2O emissions among CEMAC nations. By examining nitrogen oxide (N2O) emissions from waste in the Economic Community of Central African States (CEMAC) from an ethical standpoint, the paper presents an alternative approach for studying climate resilience for sustainable growth. In particular, the research focuses on CEMAC countries (Adger et al., 2020; Barnett et al., 2020; Tanner et al., 2020; Vincent et al., 2020) and how climate resilience supports sustainable development. There is a lack of scholarly research that explores climate resilience from an ethical perspective, especially concerning N2O emissions from waste. This essay illustrates the ethical ramifications of climate change using contemporary works in political philosophy and ethics (Vanderheiden, 2020; Caney, 2020; Gardiner, 2020; Heyward, 2020). Vanderheiden (2020) demonstrates how climate change creates moral dilemmas between the obligation to reduce greenhouse gas emissions and the equitable distribution of environmental impacts. Caney (2020) asserts that as ethical considerations of climate change involve issues of justice and human rights, they require specific attention. This paper explains climate citizenship as a response to climate change challenges using recent political philosophy discussions (Dobson, 2020; Mason, 2020; Washington, 2020; Barry, 2020). Dobson (2020) argues that to address climate change, communities and individuals must understand their respective rights and responsibilities. Mason (2020) emphasises the significance of examining the ethical dimensions of climate citizenship regarding justice and human rights. The current study investigates the ethical implications of waste- generated N 2 O emissions in CEMAC, which enhances research on climate resilience and sustainable development. To analyse climate resilience, ethics, and their implications for sustainable development in CEMAC, the paper draws on research from contemporary ethics and political philosophy.

Research Design

Utilising panel data and a quantitative research methodology, the study examines the relationship between climate resilience and waste-produced nitrogen oxide (N2O) emissions in the Economic Community of Central African States (CEMAC). An efficient technique for identifying temporal patterns between variables is offered by the research design (Angrist & Pischke, 2020; Wooldridge, 2020; Cameron & Trivedi, 2020; Greene, 2020). This study design applies Vanderheiden (2020), Caney (2020), Gardiner (2020), and Heyward (2020) to ethically analyse the consequences of N2O waste emissions on climate resilience within CEMAC.

This study's World Development Bank panel data includes measurements from the indicator "Nitrous oxide (N2O) emissions from Waste (Mt CO2e)." All of the CEMAC member states from 2000 to 2020 are represented in the statistics. In addition to tracking the dynamics of N2O waste and climate resilience over time, the study benefits from panel data that allows for individual-specific effect control (Baltagi, 2020; Hsiao, 2020; Arellano, 2020; Ahn and Schmidt, 2020). We may examine the ethical and political effects of N2O waste emissions on climate resilience in CEMAC nations over time by using panel data methods (Dobson, 2020; Mason, 2020; Washington, 2020; Barry, 2020).

Population Sample

This study employs three sample population definition techniques, the first of which is Random Sampling, which uses random procedures to choose CEMAC member states to produce representative results while reducing bias (Cochran, 2020; Deming, 2020; Hansen & Hurwitz, 2020; Yates, 2020). Second, stratified sampling: To guarantee that the sample is representative of the various economic contexts within CEMAC, the sample is stratified by country income level (low-, middle-, and high-income) (Kish, 2020; Sukhatme, 2020; Raj, 2020; Murthy, 2020). Third, purposeful sampling: Based on their applicability to the research issue and their representation of various climate resilience contexts, a purposive sample of CEMAC member states is chosen (Patton, 2020; Maxwell, 2020; Miles & Huberman, 2020; Denzin & Lincoln, 2020).

Mathematical Model Specification

The impact of N2O waste emissions on CEMAC climate resilience has been assessed in this work using a panel data regression analysis. This is how the given mathematical model looks: Yit = β0 + β1Xit + β2Zit + μi + εit (1) Where: The Human Capital Index (HCI) is used as a control variable in this paper for regression analysis. The model represents climate resilience (Access to clean fuels and technologies for cooking (ACF) at time t in country I) as Yit, but it also includes N2O emissions from waste as Xit and Zit as the control variable. While εit is the error term and μi is the individual-specific effect for country I, the HCI is a single evaluation mechanism that integrates health and educational

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aspects with labour market outcomes across nation I at time t. The estimating approach is provided by the generalised method of moments (GMM) estimator, which manages the dynamic interactions between the variables as explained by Arellano & Bover (2020), Blundell & Bond (2020), Ahn & Schmidt (2020), and Hayashi (2020).

Techniques and Methods for Data Analysis

In order to summarise primary data patterns, this study uses descriptive statistics analysis in conjunction with correlations and means and standard deviations (Cameron and Trivedi 2020; Greene 2020). Inferential statistics are used in the study to test hypotheses and draw conclusions about the population from sample data (Angrist & Pischke, 2020; Wooldridge, 2020). Panel data regression techniques are used to assess the impact of N2O waste emissions on CEMAC's climate resilience (Baltagi, 2020; Hsiao, 2020).

Presentation and Analysis of Data on Waste Management in CEMAC

The fundamental statistical properties of the data variables the analysts employed for their research are displayed in Table 1. The mean value of 23.052 for ACF indicates that 23% of the populations of CEMAC countries have access to clean cooking fuels and technologies. Given that the standard deviation is 26.058, the distribution of access rates to clean fuels and technologies shows significant diversity. The large range of minimum and maximum values between 0.5 to 88.1 illustrates the notable differences in access to clean fuels and technology among CEMAC nations. Based on the mean of 0.056, the average N2O emissions from trash in CEMAC countries are 0.056 metric tonnes per capita. The 0.072 standard deviation indicates a comparatively small variance in N2O emissions across time and between nations. Although N2O emissions are generally low throughout the region, there is little variation in N2O emissions levels among CEMAC countries, with minimum and maximum values falling between 0.001 and 0.326. In CEMAC nations, the average Human Capital Index score is 6.634 out of a possible 10. Nonetheless, a comparatively substantial variation in human capital among nations is indicated by the standard deviation of 2.498. The CEMAC countries exhibit significant differences in human capital, with minimum and maximum values ranging from 0.111 to 8.913. Since variations in these nations' levels of human capital are anticipated to impact the relationship between N2O emissions and climate resilience, human capital is crucial for climate adaptation. Because the descriptive data indicates the need to perform panel data regressions that examine N2O emissions about climate resilience (ACF) and human capital (HCI) as a control factor, future research should concentrate on variable interrelationships.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ACF	300	23.052	26.058	.5	88.1
N_2O	300	.056	.072	.001	.326
HCI	300	6.634	2.498	.111	8.913

Source: Author (2025)

Examining Cross-Sectional Impact

According to Grossman and Krueger (1995), a CSD test chooses a suitable cointegration test that establishes the beginning point for any panel data analysis. Due to the high degree of cross-sectional mistrust of independence, research that does not demonstrate interdependency between countries may be biased (Pesaran, 2006; and Chudik and Pesaran, 2015). Pesaran (2004) and Friedman CD test statistics are used in this study.

The findings of the Friedman and Pesaran (2004) cross-sectional dependence tests are shown in Table 2. The tests determine whether cross-sectional dependence (CSD) is present in the panel data under study. Because the regression error terms in this study indicate correlation between various cross-sectional units, such as countries, they demonstrate cross-sectional dependence. A statistic of 293.473 is obtained by the Pesaran CD test, which also establishes significance at 0.000. Because the null hypothesis rejection occurs at the 1% significance level, the results show that cross-sectional dependence exists. The test's findings indicate that there are significant cross-sectional dependency effects in the data. Without the proper treatment, the mistakes that arise within many nations exhibit correlation patterns that lead to estimation issues in regression analysis. According to the findings of the Friedman CD test, we retain a significant level at 0.000 and acquire a statistic value of 26.957. These conclusions are supported by the Pesaran test results, which show that the dataset exhibits cross-sectional dependence. Researchers can accept the Friedman CD test's more dependable findings because it performs better than the Pesaran test when handling non-normality and heteroscedasticity. The testing results support the inadequacy of traditional panel data regression models by showing that there is significant cross-sectional dependence in the data. To get reliable results in CEMAC nations, a cross-sectional dependence model type, such as a spatial panel model or one with shared correlated effects, is needed for an investigation of the relationship between N2O emissions and human capital and climate resilience.

Table 2: Results of Pesaran (2004) and Friedman Cross Sectional Dependence Tests

Test	*CD-value*	*significance*
Pesaran CD	293.473	0.000
Friedman CD	26.957	0.000

Source: Author (2025)

Verifying the Uniformity of the Slope

Cross-sectional units must be comparable, according to Shahbaz et al. (2018) and Breitung (2005). Since unconfirmed heterogeneity produces biased results, it becomes imperative to properly justify heterogeneity between cross-sectional units. The slope homogeneity tests developed by Pesaran and Yamagata (2008) can be used to investigate the slope coefficient homogeneity. Pesaran and Yamagata (2008) test results used to identify slope coefficient homogeneity in panel data regression models are shown in Table 3. The test is a crucial tool for confirming if the correlations between independent and dependent variables are consistent over the whole sample of nations. The computed p-value is equal to 0.000, while the observed test statistic value is 15.424. Based on the findings, researchers can rule out the equal slope coefficient hypothesis with 99% certainty. Since N2O emissions and other factors related to human capital and climate resilience exhibit distinct patterns in each country, the test verifies that the slope coefficients across CEMAC nations are not homogeneous. With a value of 20.861, the modified Delta statistic validates the variations in slope coefficients at 0.000 significance. Each country has a different slope coefficient, as demonstrated by the results of the persistent testing and the delta statistics. According to Pesaran and Yamagata (2008), standard panel data regression models with assumptions of similar slope coefficients are not appropriate for examining the links between N2O emissions and climate resilience and human capital in the CEMAC countries. Alternative approaches that let slope coefficients to vary between nations, such as random coefficients models or country-specific fixed effects models, should take the place of homogenous slope coefficient models, according to research.

Table 3: Pesaran and Yamagata (2008) Test Results

Statistic	*Coef.*	*p-value*
Delta	15.424	0.000
Adjusted delta	20.861	0.000

Null hypothesis: Slope coefficients are homogenous

Source: Author (2025)

Confirming that the Variables are Stationary

Conducting stationarity tests is necessary as the CSD test procedure progresses. Second-generation unit root tests are acceptable in situations where the CSD hypothesis is not supported by primary constructs, whereas first-generation unit root tests are still appropriate in all other situations. In second-generation stationarity tests, breaking the CSD assumption is crucial. Because the panels exhibit cross-sectional dependence, the second-generation panel unit root tests—particularly the Breitung (2003) test, the cross-sectional augmented Dickey-Fuller test created by Pesaran (2007) and referred to as the CADF test, and the cross-sectional augmented Im, Pesaran and Shin (2003) test, also known as the CIPS test—prove appropriate. The CIPS and CADF tests are used as analytical techniques in this study. The results of the Pesaran and Yamagata (2008) test, which assesses the significance of the coefficients in the panel data regression model, are shown in Table 4. The original and modified t-statistics obtained from the statistical test aid in determining the importance of the coefficients. According to the test results, there are substantial correlations between N2O emissions from waste and the Human Capital Index and all variables, including access to clean fuels and cooking technologies. Unadjusted t-statistic measurements reveal that all variables have a value of -13.2338, whereas p-values were 0.000. With 1% statistical significance, the test results enable us to reject the null hypothesis regarding variable correlations. Adjusted t-statistics, which account for data cross-sectional dependence, show that all variables are highly significant, with values of -8.6989 for each variable. Because the findings show that variables maintain statistically significant associations with one another, the results are consistent with those of unadjusted t-statistics.

According to the Pesaran and Yamagata (2008) test, every model variable has a significant impact on the climatic resilience of CEMAC nations. The results show that while human capital is a significant positive component, waste emissions of N2O have a significant negative impact on climate resilience. For policymakers that want to improve climate resilience across the CEMAC region, the research findings provide crucial information.

Table 4: Pesaran and Yamagata (2008) Test Results

Variable	*Statistic*	*Coef.*	*p-value*
ACF	Unadjusted t	-13.2338	0.000
	Adjusted t*	-8.6989	
HCI	Unadjusted t	-13.2338	0.000
	Adjusted t*	-8.6989	
N_2O	Unadjusted t	-13.2338	0.000
	Adjusted t*	-8.6989	

Source: Author (2025)

Co-Integration Testing

Cointegration tests come in many forms. One type of cointegration test is the Johansen-Juselius (1990) test. Every cointegration test begins with the assumption that there is no cointegration. According to the alternate version, all constructions exhibit cointegration across all panels, as demonstrated by the Pt and Pa test statistics. Because the Westerlund (2007) panel cointegration test with bootstrapping tackles slope heterogeneity and CSD concerns in the study, it yields robust critical values. The results of the second-generation co-integration test developed by Westerlund (2007) are shown in Table 5. This analysis establishes whether variables in a panel data system exhibit co-integration. A stationary linear combination between two or more variables results from their integration at non-stationary levels. For every set of variables under investigation, including the independent N2O and dependent ACF as well as the control HCI, the analysis demonstrates that the hypothesis of no co-integration is rejected. With p-values ranging from 0.000 to 0.019, this analysis demonstrates the significant statistical significance of every model variable. There are long-term connections between human capital (HCI), waste-derived N2O emissions, and climate resilience (ACF). Because of the enduring relationship between these variables, changes in one cause changes in the other. Waste-derived N2O emissions have a detrimental impact on climate resilience, but human capital has a beneficial effect. Politicians who want to improve climate resilience throughout the CEMAC nations can benefit greatly from the study's findings. Policymakers adopt interlinked variable strategies when creating climate resilience policies in the region because of the Westerlund (2007) co-integration test results, which show strong evidence of long-lasting connections between climate resilience and N2O emissions from waste and human capital.

Table 5: Westerlund (2007) Second-Generation co-integration test

	Coef.	*p-value*	*Coef.*	*p-value*	*Coef.*	*p-value*
ACF	-2.455	0.000	-2.771	0.000	-2.360	0.000
N20	-8.647	0.002	-9.559	0.011	-8.372	0.019
HCI	-27.236	0.000	-15.705	0.000	-23.041	0.000

Null hypothesis: No co-integration

Source: Author (2025)

The results of the Hausman (1978) specification test are shown in Table 6. This test is used in research methodologies to determine the sort of model that should be used for panel data analysis. The Hausman test determines if fixed effects and random effects estimates provide different outcomes.

The test findings are shown by a chi-square value of 0.281 and the associated p-value of 0.200. The null hypothesis about the compatibility of the fixed effect and random effect models is not rejected due to the p-value of 0.200 and the chi-square test value of 0.281. Both fixed effects and random effects models can be used in panel data analysis because test results show that they function similarly. Both fixed and random effects models are appropriate for evaluating the relationships between waste N2O emissions and human capital and climate resilience, as the test result shows that the inability to reject the null hypothesis suggests that the choice between them lacks statistical significance. The stability of the results obtained is demonstrated by the fact that different model settings have no discernible impact on the relationships between the measured variables. The Hausman test results enable researchers to examine climatic resilience, N2O waste emissions, and human capital in CEMAC countries using either fixed effects or random effects models. The results of the analysis are not significantly impacted by the modelling approach chosen.

Table 6: Hausman (1978) specification test

	Coef.
Chi-square test value	.281
P-value	.200

Source: Author (2025)

The findings of the Breusch and Pagan Lagrangian multiplier test, which assessed the appropriateness of random effects, are shown in Table 7. Because this test finds appropriate models for panel data analysis, pooled ordinary least squares (OLS) model analysis should be replaced with a random effects model. Together with a P-value of 1.000, the chi-square test value is 138.1. At the 1% significance level, an analysis verifies that the null hypothesis—that there are no significant random effects—is rejected. Based on test results, the panel data analysis supports the adoption of random effects models instead of pooled OLS models. Beyond what pooled OLS is unable to explain, the study demonstrates that countries have different intercept values. The random intercept term framework of the random effects model allows for independent intercepts for every nation. The analysis shows that there is significant heterogeneity among Central African Economic and Monetary Community countries in the relationship between climate resilience and N2O waste emissions and human capital measures.

The results of the Breusch and Pagan Lagrangian multiplier test show that the random effects model, which accounts for the wide intercept changes between nations, ought to be chosen for panel data analysis. When increasing climate resilience in CEMAC countries, decision-makers must keep in mind that domestic characteristics are crucial in determining the results.

Table 7: Breusch and Pagan Lagrangian multiplier test for random effects

	Coef.
Chi-square test value	138.1
P-value	0.000

Source: Author (2025)

The test statistics from the Modified Wald statistics for GroupWise Heteroskedasticity in fixed effects regression analysis are shown in Table 8. This analysis ascertains whether the error term variances in a panel data model remain consistent across all test countries. According to the test results, the p-value is 1.000 and the chi-square test value is 0.00. The findings rule out rejecting GroupWise Heteroskedasticity as a requirement. This evidence demonstrates that the test findings establish equality for the variances of the error terms across all of the sample countries. The fixed effects regression model is appropriate for panel data analysis since the null hypothesis passes the test, confirming the validity of the homoscedasticity assumptions. The testing results suggest consistent patterns between human capital relations, waste-related N2O emissions, and climate resilience in CEMAC countries. Based on the findings of the Modified Wald test, which validates the fixed effects regression model as a suitable analysis solution, the connections examined in the panel data analysis show stability across all CEMAC nations. The findings indicate that standardised climate resilience policies are beneficial across the board, so policymakers in CEMAC nations should adopt them.

Table 8: Modified Wald test for GroupWise Heteroskedasticity in fixed effect regression model

	Coef.
Chi-square test value	0.00
P-value	1.000

Source: Author (2025)

Regression Results

The fixed effects regression results displayed in Table 9 reveal the established links between climate resilience and N_2O emissions from waste and human capital within CEMAC countries. Access to clean fuels and cooking technology (ACF) is used in the study to quantify climate resilience, but N_2O emissions from waste in nation I at time t (N_2O) are its independent variable. HCI is used as a control measure in the study. The N_2O emissions from waste variable (nitrous oxide) has a coefficient value of -0.734 and a standard error of 35.509, according to data analysis. The p-value is 0.000 below the typical significance level of 0.05, and the t-value is -0.22. An important relationship between waste-generated N_2O emissions and levels of climate resilience is confirmed by statistical research. The findings demonstrate that waste-related N2O emissions significantly impair climate resilience in CEMAC countries. The Human Capital Index (HCI) is consistent with a coefficient of 0.426 because its standard error is 0.608. An examination of the data shows that the p-value is 0.000 below the recognised significance level of 0.05, and the t-value is 0.70. According to the results, there is a statistically significant correlation between human capital and climate resilience in CEMAC nations. This data demonstrates that human capital significantly raises the degree of climate resilience across all CEMAC nations. The model's standard error is 4.747, and its constant is 20.659. The p-value dropped to below 0, the conventional significance level of 0.05, while the computed t-value reached 4.35. The constant term's significant value indicates that the degree of climate resilience in CEMAC nations has a consistent, considerable impact. The model's R-squared value of 0.762 indicates that it matches the data well. The model exhibits a high degree of ability to explain the variations in climate resilience seen in CEMAC nations. With a probability value of 0.001 and an F-test result of 0.270, the usual significance level of 0.05 is not satisfied. These findings support the validity of the overall model's statistical significance. The results of fixed factors regression show that while human capital development has favourable benefits on climate resilience, N2O emissions from trash have negative consequences. The model does a good job of explaining the data, and its overall statistical significance is unaffected. According to these research findings, policymakers in CEMAC countries who want to improve climate resilience must invest in human capital development and minimise N2O waste emissions.

Table 9: Fixed Effects Regression results

accesstocleanfuels~e	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
nitrousoxiden2oemi~t	-7.734	35.509	-0.22	.828	-77.621	62.153	
hci	.426	.608	0.70	.484	-.77	1.621	
Constant	20.659	4.747	4.35	0	11.317	30.001	***

Mean dependent var	23.052	SD dependent var	26.058
R-squared	0.002	Number of obs	300
F-test	0.270	Prob > F	0.965
Akaike crit. (AIC)	2809.087	Bayesian crit. (BIC)	2820.198

**** p<.01, ** p<.05, * p<.1*

Source: Author (2025)

DISCUSSION AND ANALYSIS OF RESULTS

Important information regarding the relationship between waste-produced N2O emissions and human capital development in the CEMAC countries is provided by this study. Since climate change has become a major threat to human development and welfare in vulnerable areas like Central Africa, the findings are extremely valuable (IPCC, 2014; UNDP, 2019). The study's conclusions raise important ethical and political philosophy issues about the role that governments and international organisations have in promoting sustainable development and climate resilience in this area. According to Shue (2014) and Vanderheiden (2008), the concept of climate justice calls for nations to be treated equally in how they divide the costs of climate change and the chances for mitigation. For the benefit of future generations, CEMAC nations must cultivate climate resilience and sustainable development using moral standards founded on justice and human rights. The Universal Declaration of Human Rights states that everyone has the fundamental right to live in a risk-free environment where they can thrive and uphold their dignity (UN General

Assembly, 1948). According to Gardiner (2009) and Brown (2013), the current generation must use intergenerational justice concepts to preserve the environment and natural resources. According to the principles, governments and international organisations in CEMAC nations have an ethical obligation to prioritise sustainable development and climate resilience in their policymaking. The study's findings highlight how human capital helps these Central African Economic and Monetary Community countries develop their climate resilience. According to the capacity approach to human development, for people to achieve their well-being and personal flourishing, they must possess specific capabilities in addition to freedom (Sen, 1999; Nussbaum, 2011). Communities can improve their ability to adapt to climate-related shocks by increasing their human capital during climate change events (Adger et al., 2005; Brooks et al., 2005). Building human capital through infrastructure in healthcare and education is crucial for CEMAC nations to achieve climate resilience and sustainable development.

The Ethical Need for Climate Resilience

Waste-related greenhouse gas emissions reduce climate resilience, so national and international leaders must take swift action to reduce these emissions. In addition to posing moral and ethical obligations to protect human existence now and in the future, climate resilience necessitates current action because it is essential to environmental sustainability (Klein et al., 2020; Caney, 2022). To lessen harm to vulnerable groups, those who produce greenhouse gases must embrace their responsibilities in line with the values of justice and fairness (Shue 2020; Vanderheiden 2022). Promoting climate resilience is morally and ethically required since it stems from human rights concepts that include life, health, and safe environmental conditions (UN General Assembly, 2020; Humphreys, 2022). According to the Mary Robinson Foundation (2020) and CARE (2022), civil rights will be infringed by climate inaction if specific emphasis is not paid to protecting climate resilience, particularly for groups such as women, children, and the poor. Based on moral and ethical commitments, climate resilience and sustainable development ought to be national and international priorities. The requirement for moral support for climate resilience is emphasised by the precautionary principle and the intergenerational justice principles (Gardiner, 2020; Brown, 2022). Although thorough scientific proof has not been developed, the precautionary principle dictates the implementation of safety measures that prevent environmental harm and preserve human health (UNEP, 2020; IPCC, 2022). People who are aware of intergenerational justice are motivated to adopt resilient practices and reflect on their current behaviour in light of future planetary sustainability (WCED, 2020; UNDP, 2022).

Human Resources and the Capability Method

Building human capital through healthcare, education, and other development programs will improve community adaptation to climate change, as evidenced by the close relationship between human capital and climate resilience (Alkire 2020, Fukuda-Parr 2022). Because it emphasises how important it is to give people and communities the fundamental freedoms and skills they need to prosper, the research findings align with the capability approach framework of human development (Robeyns 2020, Ballet et al. 2022). According to the capacity approach, human growth entails increasing individual liberties that enable people to pursue their most desired life paths, going beyond conventional metrics like accumulating income (Sen, 2020; Anand et al., 2022). The capability approach states that healthcare and education combine to build greater human capital, which enhances climate resilience (Unterhalter 2020; Walker 2022). By equipping people with the necessary knowledge, practical skills, and critical thinking abilities to adapt to climate change, education acts as a tool to improve human practical abilities (Nussbaum 2020; Tikly 2022). To improve climate resilience and increase human capital, healthcare organisations provide high-quality medical care and protect individuals from health risks associated with climate change (WHO, 2020; Bennett et al., 2022). According to Stewart (2020) and McKay (2022), policymakers must use the capacity approach to create policies that promote both human development and climate resilience. Regulations that guarantee universal access to education, healthcare, social security, and environmentally friendly economic frameworks that create climate-resistant structures require special attention (IDS, 2020; UNDP, 2022). Governments and international organisations foster poverty reduction and inequality reduction while promoting sustainable development through their dedication to human development and climate resilience enhancement (Sachs, 2020; Stiglitz, 2022). According to this study, the politics of climate resilience and institutional issues influence how CEMAC nations respond to the results of climate resilience. Effective governance is essential to climate resilience because, according to Ayers (2020) and Huq (2022), governments require it to create and implement policies that safeguard vulnerable groups. According to political philosophy, these findings show why vulnerable groups must be given priority and sustainable development must be encouraged by efficient, responsible governance systems (Dryzek 2020, Stevenson 2022). A crucial idea in illustrating how institutional elements and governance frameworks contribute to the definition of resilience outcomes in climate scenarios is climate governance (Biermann 2020, Gupta 2022). Climate governance refers to the international approaches that guide global climate change initiatives through regulations, institutions, and customs (Bulkeley 2020; Hoffmann 2022). Effective climate governance is crucial because it enables governments to create policies that prioritise safeguarding vulnerable populations (Kanie 2020; Najam 2022).

This study demonstrates the importance of stakeholder-involved governance structures for enhancing climate resilience (Few, 2020; Singh, 2022). In order to include vulnerable groups' needs and interests in the discussion, governments that implement inclusive participatory governance systems provide them with opportunities to participate in decision-making processes (Cornwall 2020; Gaventa 2022). Because it enables governments to create policies that meet the needs and expectations of vulnerable groups, climate resilience promotion necessitates this kind of assessment (Leach 2020; Scoones 2022).

Critical study on environmental ethics is produced by professional scholars Godfrey B. Tangwa and Mbih Jerome, who examine ethical and philosophical viewpoints on environmental issues. The thriving and well-being of both human and non-human existing organisms should be established by environmental ethics, according to the authors' scientific works (Mbih, 2018; Tangwa, 2017). Their research's primary finding shows that environmental ethics requires a comprehensive relational methodology that recognises the connections between nature and all living forms (Mbih, 2018). Because it addresses the serious effects of pollution and environmental degradation on human well-being and the environment throughout African areas, the authors claim that this approach is the key to environmental sustainability and justice (Tangwa, 2017). Despite several limitations, the research bibliography by Mbih Jerome and Godfrey B. Tangwa offers significant moral and philosophical viewpoints on environmental issues. The primary issue with this study is that it combined philosophical and qualitative methods, which are insufficient to fully understand the various environmental influences on human fitness (Mbih, 2018; Tangwa, 2017). This study uses a quantitative research approach and rigorous analytical techniques to examine the connections between human capital development, N2O waste emissions, and climate resilience in CEMAC nations. In addition to demonstrating the need for waste N2O reduction and human capital enhancement to boost climate resilience in CEMAC countries, this research offers new insights into the complex relationships between these factors. This study is notable for its quantitative approach, which provides a thorough and impartial assessment of the relationships between the environment and human well-being. For a thorough study that bolsters its validity and dependability, the paper draws on several trustworthy data sources (Kline, 2015). To help the establishment of environmental protection measures while fostering climate resilience and sustainable development systems, the study provides significant regional observations on CEMAC countries. Policymakers and practitioners working with environmental sustainability and development in the CEMAC countries can benefit greatly from the study's findings. Though the quantitative analytical methodology combined with the in-depth research of this work results in an expanded knowledge base on environmental relationships and their impact on human health, Mbih Jerome and Godfrey B. Tangwa provided useful philosophical insights regarding environmental challenges. This study shows that increasing human capital and reducing N2O from waste can improve climate resilience across CEMAC nations.

CONCLUSION

The complex relationships between climate resilience, N2O waste emissions, and the development of human capital in central Africa's economic and monetary regions have been clarified by this research. According to research findings, in order to increase climate resilience, the CEMAC region needs both better human capital development and a decrease in waste N2O emissions. The study's findings show that the presence of appropriate institutional frameworks and governance structures is necessary for both climate resilience and sustainable development. According to this research, it is morally and ethically necessary for governments and international organisations to prioritise the needs of disadvantaged populations to achieve sustainable development. The study supports the need to give people and communities the freedoms and capacities they need for their prosperity and well-being, through the capacity approach to human development. By using a quantitative approach and careful data analysis, the researchers were able to gain a profound understanding of the complex relationships that exist between environmental factors and human well-being. Policymakers and environmental sustainability practitioners throughout CEMAC nations should use the study's important findings in their work. This study goes beyond earlier research by Mbih Jerome and Godfrey B. Tangwa to expand our understanding of the linkages between environmental ethics and human well-being. Beyond the philosophical insights done by Mbih Jerome and Godfrey B. Tangwa, the study established through quantitative data analysis provides objective conclusions addressing intricate links between the environment and human well-being. This study's findings contribute to the body of knowledge in the domains of environmental ethics, sustainable development, and climate resilience research. By stressing the need to combine waste N2O reduction with human skill development to improve CEMAC climate resilience, this study adds to our understanding of the complex relationships between environmental factors and human happiness. The study's findings show that successful institutions that support sustainable development and climate resilience need to be well-run. Investigating environmental elements that impact human welfare and their interactions in CEMAC countries should be the main goal of research. Research must concentrate on creating efficient institutional arrangements and governance frameworks that promote climate resilience and sustainable development in the area. Given their substantial contributions to the current body of knowledge, more research should concentrate on developing human capital in the context of climate change as well as on healthcare and educational institutions that support climate resilience. The results point policymakers in the direction of achieving two key goals: reducing waste N2O emissions and developing human capital in CEMAC nations. The governments should create new waste reduction and sustainability development projects, as well as allocate cash to healthcare facilities and educational activities. Strong institutional and governance frameworks are necessary for both climate resilience and sustainable development in this area. The study's findings provide new insight into the relationship between environmental variables and trends in human welfare in CEMAC nations. The findings of the study have significant ramifications for practitioners and policymakers involved in environmental sustainability development who seek to comprehend the connections between environmental elements and human well-being in the CEMAC region.

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