Akadiri, S. S., Akpan, U., & Adesanya, O. (2025). The Green Paradox: Balancing Growth and Ecology in WAEMU and WAMZ Economies. *Energy RESEARCH LETTERS*, *7*(Early View). https://doi.org/10.46557/001c.143660

Peer-reviewed research

The Green Paradox: Balancing Growth and Ecology in WAEMU and WAMZ Economies

Seyi Saint Akadiri[1][a], Usenobong Akpan[2], Oladunni Adesanya[3]

[1] Advanced Research Center, University of Lefke, Lefke, Northern Cyprus, TR-10 Mersin, Turkey, [2] Research Department, Central Bank of Nigeria, Abuja, Nigeria, [3] Department of Economics, University of Leeds, West Yorkshire, United Kingdom

Keywords: Environment, Energy intensity, Institutional quality, Panel data, Africa

JEL Classifications: C54 Quantitative Policy Modeling, D81 Criteria for Decision-Making under Risk and Uncertainty

https://doi.org/10.46557/001c.143660

Energy RESEARCH LETTERS

Vol. 7, Issue Early View, 2026

This study examines the relationship between economic growth, energy intensity, and environmental sustainability in the WAEMU and WAMZ economies from 2002 to 2022, highlighting the role of institutional quality. The findings reveal that energy intensity worsens environmental degradation, while stronger institutions in WAEMU mitigate this effect. Policy recommendations include promoting energy efficiency, increasing renewable energy investments, strengthening governance, and encouraging sustainable urbanization to balance growth with ecological preservation.

I. Introduction

The relationship between environmental degradation, energy intensity, and institutional quality is of utmost importance for developing economies, particularly in the West African Economic and Monetary Union (WAEMU) and the West African Monetary Zone (WAMZ). Both regions are currently facing the urgent challenge of sustaining economic growth while mitigating environmental harm. A key driver of environmental degradation in these economies is energy intensity. The amount of energy consumed per unit of economic output remains high due to the reliance on fossil fuels; this contributes to increased carbon emissions and ecological stress, often described as the "green paradox."

For example, CO_2 emissions remain low across WAMZ (between 0.19 in Sierra Leona and 0.61 mtpc for Nigeria) and WAEMU (between 0.18 in Niger and 0.54 mtpc in Cote d'Ivoire) countries due to lower industrialization but are rising as energy consumption grows. Energy Intensity is higher in landlocked countries (e.g., Niger, Mali, Burkina Faso) due to lower energy efficiency and reliance on fossil fuels. While institutional quality varies significantly, with Ghana (50) and Senegal (50) having relatively stronger governance, while Sierra Leone (18), Liberia (21), and Niger (24) struggle with weak institutions.[1]

Energy-intensive economic activities in WAEMU and WAMZ amplify environmental degradation, as growth-driven increases in energy consumption frequently led to higher emissions. Akpan and Akpan (2012) emphasize that fossil fuel dependency exacerbates greenhouse gas emissions, posing significant threats to ecological stability. However, institutional quality can be a crucial moderating factor in this dynamic. Strong institutions, characterized by government effectiveness, regulatory quality, and corruption control, can influence energy use patterns and environmental policies. Studies such as Akadiri and Akpan (2025) suggest that well-functioning institutions enhance the enforcement of environmental regulations, facilitate clean energy adoption, and promote sustainable growth.

The green paradox, which postulates that efforts to curb future emissions can inadvertently accelerate the current consumption of fossil fuels, poses significant challenges for sustainable development in the WAEMU and the WAMZ (Kohnert, 2022). In these economies, where dependence on natural resources is pronounced, the paradox raises urgent questions on reconciling economic growth with ecological preservation. Azomahou and Ouédraogo (2021) point out that immediate economic incentives often compromise strategic environmental commitments, especially in the mining and agricultural sectors. This tension becomes increasingly critical as regional economic integration efforts, such as those promoted by the field of African continental free trade, can conflict with sustainable practices if they are not carefully managed (Asche, 2021). In addition, regional integration processes, as discussed by Nkala and Monyae (2024), require a framework that aligns economic objectives with environmental sustainability. Consequently, the implications of the green paradox in WAEMU and the WAMZ

a Corresponding author email: sakadiri@eul.edu.tr

1 CO_2 emissions, https://data.worldbank.org; International Energy Agency, https://www.iea.org; Worldwide Governance Indicators (WGI) from the World Bank (https://info.worldbank.org/governance/wgi/).

require a global approach to the formulation of policies, integrating ecological considerations into economic strategies to promote both growth and environmental balance, thus making the continuation of sustainable development in these regions (Kohnert, 2022).

Despite these insights, the extent to which institutional quality mitigates the adverse environmental effects of energy intensity in WAEMU and WAMZ remains underexplored. This study seeks to bridge this gap by addressing two key questions: (1) Is economic growth in these regions environmentally sustainable? (2) Can stronger institutional frameworks promote efficient energy use and reduce environmental harm? Employing empirical approaches from Akadiri and Akpan (2025), we develop a model to examine the influence of energy intensity and institutional factors on environmental degradation, incorporating control variables such as GDP, trade openness, renewable energy adoption, and urbanization.

By comparing WAEMU and WAMZ, this study contributes to the literature on sustainability in West Africa. It emphasizes the potential impact of institutional quality in balancing economic growth and environmental outcomes. The findings of this study could provide valuable insights for policymakers and practitioners, guiding the formulation of policies to help these regions achieve a sustainable development trajectory.

II. Methodology and Data

A. Methodology

Is economic growth in WAMZ and WAEMU environmentally friendly? Could institutional quality play any role in promoting efficient energy use and cleaner environmental outcomes in these regions? These fundamental questions constitute the key drivers of the current study. To evaluate these concerns, we have meticulously followed the empirical strategy outlined by Akpan et al. (2025) and specified a comprehensive baseline model.

$$EnvD_{it} = \phi_0 + \phi_1 EnergyInt_{it} + \phi_2 Inst_{it} + \beta X_{it} + \mu_i + \eta_t + \varepsilon_{i,t} \quad (1)$$

Where $EnvD_{it}$ denotes a measure of environmental degradation, $EnergyInt_{it}$ is energy intensity, $Inst_{it}$ is a measure of institutional quality, $X_{i,t}$ is a vector of control variables, namely real GDP, trade openness, renewable energy, and urbanization growth, μ_i accounts for the country-specific heterogeneity, η_t and $\varepsilon_{i,t}$ captures the time-specific fixed effects and the error term, respectively. To assess whether the quality of institutions in WAMZ and WAEMU are capable of mitigating the environmental impact of energy intensity in the regions, we specify the extended model as follows:

$$EnvD_{it} = \phi_0 + \phi_1 EnergyInt_{it} + \phi_2 Inst_{it} + \phi_3 (Inst_{it} \times EnergyInt_{it}) + \beta X_{it} + \mu_i + \eta_t + \varepsilon_{i,t} \quad (2)$$

Where the parameter ϕ_3 provides a measure of how institutional quality affects the relationship between energy use and environmental degradation.

B. Data

The dataset spans 2002–2022, with CO_2 emissions per capita as the dependent variable. Energy intensity, sourced from the IEA, represents energy efficiency, while institutional factors, government effectiveness, regulatory quality, control of corruption, and rule of law, shape energy use and environmental outcomes. These institutional measures (scaled 0–100) influence policy enforcement, resource management, and adherence to energy regulations, all crucial for sustainability.

Control variables include real GDP, trade openness, renewable energy, and urbanization growth. While GDP and trade openness can increase emissions, they may also drive clean technology investments. Renewable energy reduces pollution, while urbanization's impact depends on infrastructure management. For estimation, we employ the fixed and random effects models. The F-test and Breusch-Pagan LM test validated model selection, followed by the Hausman test to determine the preferred approach.

III. Empirical Results

The fixed effects model was deemed appropriate after diagnostic checks, with results for WAMZ and WAEMU provided in Tables 1 and 2. In WAMZ, energy intensity significantly worsens environmental quality, implying that reducing energy consumption per unit of economic output is crucial for environmental sustainability (see Hilili et al., 2024). Renewable energy shows potential for reducing environmental damage, but its contribution is statistically insignificant, possibly due to limited investment in renewable energy infrastructure. Institutional factors, such as corruption control and government effectiveness, had minimal impact on environmental quality in WAMZ (Akadiri & Akpan, 2025; Akpan et al., 2025). Corruption control was weak, potentially due to high corruption levels undermining ecological efforts, while government effectiveness paradoxically contributed to ecological problems, reflecting challenges in policy execution (Akadiri & Akpan, 2025; Akpan et al., 2025). Although regulatory quality and rule of law showed positive potential, their influence on energy efficiency remains weak. Control variables, including economic growth, trade openness, and urbanization, significantly contributed to environmental damage (Akadiri & Akpan, 2025; Akpan et al., 2025; Akpan & Atan, 2016). A 1% increase in economic growth results in a 1.2% rise in environmental degradation, with trade openness and urban growth contributing 0.1% and 0.3%, respectively.

In WAEMU, we observe similar trends in energy intensity and control variables. Higher energy consumption per unit of output led to increased greenhouse gas emissions. The impact of renewable energy was largely insignificant, aligning with earlier studies that attributed much of the energy consumption to fossil fuels. However, unlike WAMZ, institutions in WAEMU significantly improved energy intensity outcomes. Corruption control, government effectiveness, regulatory quality, and rule of law helped reduce greenhouse gas emissions by 0.6%, 0.2%, 0.8%, and 0.5%, respec-

tively; this highlights the role of stronger institutions in mitigating environmental harm from energy consumption.

Descriptive statistics reveal that WAEMU has higher institutional quality than WAMZ, which helps explain the better environmental outcomes in the former.[2] Following earlier studies, the study used Principal Component Analysis (PCA) to derive a composite institutional index (Akadiri & Akpan, 2025; Abiodun et al., 2014). The results, re-estimated using this index (see Table 3), confirmed that energy intensity continued to degrade the environment in both regions, while institutions played a significant mediating role in WAEMU but remained insignificant in WAMZ (see Akadiri & Akpan, 2025; Akpan et al., 2025).

IV. Conclusion

This study has examined the complex relationship between economic growth, energy intensity, institutional quality, and environmental sustainability in the WAEMU and WAMZ economies. The findings reveal that energy intensity significantly degrades environmental quality in both regions, reflecting the inefficient use of energy and the continued reliance on fossil fuels. While renewable energy can improve environmental outcomes, its impact is currently limited due to inadequate infrastructure and investment. Moreover, the role of institutions in mediating this relationship varies significantly between the two regions. In WAEMU, stronger institutions, especially corruption control, regulatory quality, and rule of law, can effectively reduce the negative impact of energy intensity on the environment. In contrast, institutions in WAMZ exhibit weaker influence, reflecting challenges in governance, policy implementation, and enforcement.

Consequently, both WAEMU and WAMZ should prioritize policies to reduce energy intensity by improving energy efficiency across sectors; this could involve investing in cleaner technologies and incentivizing businesses to adopt energy-saving practices. Governments should also provide subsidies for energy-efficient appliances and equipment to encourage widespread adoption.

Given the limited impact of renewable energy observed in both regions, scaling up investments in renewable energy infrastructure is crucial. Public-private partnerships could be leveraged to finance solar, wind, and hydroelectric projects. Additionally, governments should offer tax incentives and grants to companies engaged in renewable energy development.

The findings highlight the importance of institutional quality, particularly in WAEMU, where improvements in governance significantly mitigate environmental degradation. Both regions should focus on enhancing the regulatory framework, tightening corruption control, and improving government effectiveness. Strengthening environmental oversight bodies and ensuring strict enforcement of energy-related regulations are essential for better environmental governance.

In addition, WAEMU and WAMZ economies should diversify away from energy-intensive industries to reduce environmental pressure. Governments can promote sectors like agriculture, services, and technology with lower environmental footprints by encouraging innovation in green technologies and eco-friendly practices.

Conclusively, as urbanization contributes to environmental strain, both regions should adopt sustainable urban planning policies. Investments in efficient public transportation, green spaces, and eco-friendly infrastructure can help mitigate the adverse effects of rapid urban growth. Proper waste management and recycling programs should be introduced in urban planning initiatives. Lastly, WAEMU and WAMZ economies should collaborate on cross-border initiatives promoting clean energy and environmental sustainability; this could involve sharing best practices in energy management, institutional reforms, and regulatory frameworks. Regional cooperation can enhance the capacity to attract international funding and technical support for environmental projects.

Submitted: September 08, 2024 AEST. Accepted: March 09, 2025 AEST. Published: October 25, 2025 AEST.

2 For brevity, the descriptive statistics will be made available upon request.

Table 1. Relationship between energy intensity, carbon emission, and institutions in WAMZ

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Real GDP	1.258***	1.259***	1.304***	1.302***	1.205***	1.207***	1.250***	1.253***
	(0.128)	(0.128)	(0.126)	(0.126)	(0.128)	(0.128)	(0.123)	(0.123)
Trade Openness	0.145***	0.136***	0.119***	0.106***	0.156***	0.153***	0.157***	0.154***
	(0.042)	(0.042)	(0.038)	(0.040)	(0.039)	(0.039)	(0.038)	(0.038)
Urbanisation Growth	0.298***	0.314***	0.297***	0.297***	0.314***	0.320***	0.292***	0.301***
	(0.048)	(0.050)	(0.047)	(0.046)	(0.048)	(0.048)	(0.046)	(0.047)
Energy Intensity	1.123***	1.500***	1.248***	0.785*	0.942***	0.594	0.919***	1.274***
	(0.225)	(0.384)	(0.226)	(0.423)	(0.240)	(0.478)	(0.230)	(0.431)
Renewable Energy	-0.059*	-0.050	-0.054	-0.065*	-0.046	-0.046	-0.057*	-0.042
	(0.035)	(0.036)	(0.033)	(0.034)	(0.034)	(0.034)	(0.033)	(0.036)
Control of Corruption	-0.018	0.236						
	(0.042)	(0.213)						
Energy intensity X Control of Corruption		-0.139						
		(0.115)						
Gov. Effectiveness			0.151**	-0.178				
			(0.065)	(0.262)				
Energy Intensity X Gov. Effectiveness				0.174				
				(0.135)				
Regulatory Quality					-0.134*	-0.362		
					(0.073)	(0.280)		
Energy Intensity X Regulatory Quality						0.122		
						(0.145)		
Rule of Law							-0.150**	0.097
							(0.057)	(0.260)
Energy Intensity X Rule of Law								-0.123
								(0.127)
Constant	-34.053***	-34.842***	-35.737***	-34.710***	-32.259***	-31.647***	-33.158***	-33.987***
	(3.450)	(3.503)	(3.438)	(3.518)	(3.494)	(3.574)	(3.338)	(3.446)
Observations	113	113	113	113	113	113	113	113

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R-squared	0.594	0.600	0.614	0.621	0.607	0.609	0.619	0.623
F-ratio	24.64	21.43	26.79	23.36	25.96	22.29	27.35	23.56
P-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: Standard errors are reported in parentheses. *, **, and *** indicates statistical significance at 10%, 5%, and 1% levels, respectively. The dependent variable is CO2 emissions per capita. Number of Id = 6.

Table 2. Relationship between energy intensity, carbon emission and institutions in WAEMU

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Real GDP	1.036***	1.067***	1.106***	1.138***	1.071***	1.097***	1.055***	1.088***
	(0.063)	(0.060)	(0.056)	(0.055)	(0.060)	(0.057)	(0.062)	(0.061)
Trade Openness	0.423***	0.284***	0.200**	0.188**	0.318***	0.254***	0.370***	0.293***
	(0.091)	(0.093)	(0.086)	(0.083)	(0.091)	(0.086)	(0.090)	(0.092)
Urbanisation Growth	-0.004**	-0.004***	-0.004**	-0.004**	-0.005***	-0.006***	-0.004**	-0.004**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Energy Intensity	1.006***	2.993***	0.545***	1.254***	0.805***	3.628***	0.867***	2.406***
	(0.144)	(0.506)	(0.135)	(0.266)	(0.136)	(0.666)	(0.162)	(0.560)
Renewable Energy	-0.011	-0.022	-0.030**	-0.034**	-0.025	-0.028*	-0.015	-0.019
	(0.016)	(0.015)	(0.014)	(0.014)	(0.016)	(0.015)	(0.016)	(0.015)
Control of Corruption	0.085	1.063***						
	(0.063)	(0.247)						
Energy Intensity X Control of Corruption		-0.605***						
		(0.148)						
Gov. Effectiveness			-0.230***	0.179				
			(0.044)	(0.140)				
Energy Intensity X Gov. Effectiveness				-0.201***				
				(0.066)				
Regulatory Quality					-0.174**	1.200***		
					(0.087)	(0.328)		
Energy Intensity X Regulatory Quality						-0.820***		
						(0.190)		
Rule of Law							-0.023	0.784***
							(0.050)	(0.286)
Energy Intensity X Rule of Law								-0.474***
								(0.165)
Constant	-29.015***	-32.439***	-27.975***	-30.120***	-28.170***	-33.291***	-28.628***	-31.761***
	(1.486)	(1.632)	(1.366)	(1.497)	(1.524)	(1.853)	(1.652)	(1.943)
Observations	136	136	136	136	136	136	136	136

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R-squared	0.779	0.806	0.816	0.829	0.783	0.812	0.776	0.790
F-ratio	72.25	72.18	91.15	84.78	73.84	75.06	71.06	65.65
P-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: Standard errors are reported in parentheses. *, **, and *** indicates statistical significance at 10%, 5%, and 1% levels, respectively. The dependent variable is CO2 emissions per capita. Number of Id = 6.

Table 3. Energy intensity, carbon emission and composite index of institutions

	(1) WAMZ	(2) WAMZ	(3) WAEMU	(4) WAEMU
Real GDP	1.232***	1.231***	1.059***	1.104***
	(0.130)	(0.132)	(0.060)	(0.056)
Trade Openness	0.147***	0.147***	0.321***	0.167*
	(0.041)	(0.042)	(0.094)	(0.092)
Urbanisation Growth	0.301***	0.301***	-0.004**	-0.005***
	(0.048)	(0.048)	(0.002)	(0.002)
Energy Intensity	1.044***	1.039***	0.772***	0.787***
	(0.249)	(0.273)	(0.155)	(0.143)
Renewable Energy	-0.060*	-0.059	-0.019	-0.030**
	(0.035)	(0.036)	(0.016)	(0.015)
Institutional Quality	-0.025	-0.021	-0.036	0.299***
	(0.039)	(0.078)	(0.023)	(0.073)
Energy Intensity X Institutional Quality		-0.002		-0.209***
		(0.048)		(0.044)
Constant	-33.392***	-33.372***	-28.424***	-28.960***
	(3.518)	(3.555)	(1.518)	(1.404)
Observations	113	113	136	136
R-squared	0.595	0.595	0.780	0.815
F-ratio	24.73	20.99	72.74	76.66
P-value	(0.000)	(0.000)	(0.000)	(0.000)
Number of Id	6	6	7	7

Note: Standard errors are reported in parentheses. *, **, and *** indicates statistical significance at 10%, 5%, and 1% levels, respectively. The dependent variable is CO2 emissions per capita. Number of Id = 6.

References

Akadiri, S. S., & Akpan, U. (2025). Urban Sprawl and Environmental Sustainability in WAMZ: An Institutional Perspective. *Energy Research Letters*. https://doi.org/10.46557/001c.126028

Akpan, U., & Akpan, G. E. (2012). The Contribution of Energy Consumption to Climate Change: A Feasible Policy Direction. *International Journal of Energy Economics and Policy*, *2*(1), 21–33.

Akpan, U., & Atan, J. A. (2016). Relationship between Trade Openness, Institutions and Economic Growth in Sub-Saharan Africa: A Further Look at the Evidence. *British Journal of Economics, Management and Trade*, *15*, 1–20. https://doi.org/10.9734/BJEMT/2016/28877

Akpan, U., Saint Akadiri, S., & Adesanya, O. (2025). WAEMU's Urban Jungle: Can Good Governance Tame the Green Monster? *Energy RESEARCH LETTERS*. https://doi.org/10.46557/001c.125867

Asche, H. (2021). On the African Continental Free Trade Area. In *Regional Integration, Trade and Industry in Africa* (pp. 95–117). Springer International Publishing.

Azomahou, T. T., & Ouédraogo, M. (2021). *Strategic Environmental Commitment and Climate Change in Africa: Evidence on Mining and Deforestation*. Working Paper Series. https://publication.aercafricalibrary.org/bitstreams/3bb87ae5-5efe-4378-b744-38ddbc529465/download

Hilili, M. J., Akadiri, S. S., & Eneanya, C. N. (2024). Powering Nigeria's future: balancing renewable and non-renewable energy for environmental sustainability. *Energy Systems*, 1–22. https://doi.org/10.1007/s12667-024-00686-4

Kohnert, D. (2022). *French domination of Francophone African markets: Post-colonialism at its finest?* SSRN 4037625. https://doi.org/10.2139/ssrn.4037625

Nkala, S., & Monyae, D. (Eds.). (2024). *The Quest for Unity: An Appraisal of Regional Integration in Africa*. Taylor & Francis. https://doi.org/10.4324/9781003521334