DRIVERS OF CO2 EMISSIONS IN UGANDA: EMPIRICAL EVIDENCE FROM ECONOMIC GROWTH AND URBANIZATION

Darious Mugabe, Department of Applied Economics, Makerere University Business School, +256 782 858617, dmugabe@mubs.ac.ug

Overview

Uganda, like many developing nations, is undergoing rapid socioeconomic transformation characterized by economic growth, urbanization, and industrialization. These changes have led to increased energy consumption and rising carbon emissions (Twinomuhangi et al., 2022). Uganda's CO2 emissions increased from 0.13 metric tons per capita in 1993 to 0.23 metric tons in 2022, reflecting significant environmental challenges despite remaining relatively low on a global scale (World Bank, 2024). The growth of urban areas has intensified energy demand, particularly in the residential, industrial, and transportation sectors (Namukasa et al., 2020; Twinomuhangi et al., 2022).

The country's energy mix is heavily reliant on biomass, which accounts for 88% of energy consumption, with inefficient traditional cooking methods contributing significantly to emissions (Ministry of Energy and Mineral Development, 2023). Additionally, the use of fossil fuels for transportation and electricity generation has been rising, further exacerbating Uganda's carbon footprint (Bongomin & Nziu, 2022). Industrial activity, though limited in scale, is characterized by reliance on outdated and inefficient technologies that contribute to emissions (Namukasa et al., 2020).

Given these dynamics, addressing Uganda's emissions challenges requires a nuanced understanding of the drivers of CO2 emissions to inform targeted and effective policy interventions. This study aims to provide such insights through empirical analysis.

Methods

The study adopts a time-series econometric approach, leveraging data from 1993 to 2022 to capture both short-term and long-term dynamics. The Auto-Regressive Distributed Lag (ARDL) model is employed for its robustness in analyzing relationships between variables with differing integration orders (Pesaran et al., 2001).

Variables: CO2 emissions (dependent variable) are analyzed against urbanization (urban population) and economic growth (GDP growth).

Framework: The research is grounded in the Environmental Kuznets Curve (EKC) hypothesis, which posits an inverted U-shaped relationship between economic growth and environmental degradation (Dinda, 2004; Panayotou, 1994).

Diagnostics: Statistical tests for stationarity, multicollinearity, cointegration, heteroskedasticity, and autocorrelation were performed to ensure data validity and model accuracy.

Results

Economic growth significantly increases CO2 emissions. A 1% rise in GDP growth leads to a 0.016% increase in CO2 emissions. This aligns with studies in developing countries, which highlight the energy-intensive nature of economic activities during growth phases (Khobai & Sithole, 2022; Sarkodie, 2018).

Urbanization exhibited no statistically significant effect on emissions. However, rapid urban expansion and reliance on inefficient energy sources underscore its potential as a driver of future emissions (Zhang et al., 2017).

Conclusions

This study investigates the drivers of CO2 emissions in Uganda from 1993 to 2022, identifying economic growth as the most significant contributor, while urbanization had statistically insignificant effects. The findings highlight the urgent need for cleaner energy sources.

The study contributes to knowledge by providing empirical evidence on the socioeconomic factors driving emissions in Uganda and advancing the application of the Environmental Kuznets Curve (EKC) hypothesis in a low-income, rapidly developing context. It offers actionable recommendations, including implementing green growth strategies, institutionalizing CO2 emissions monitoring framework and energy-efficient urban planning, to guide

policymakers in achieving sustainable growth. These insights form a foundation for future research and policy aimed at balancing economic development with environmental conservation in Uganda.

References

Twinomuhangi, R., Martin Kato, A., & M. Sebbit, A. (2022). The Energy and Climate Change Nexus in Uganda: Policy Challenges and Opportunities for Climate Compatible Development. In *The Nature, Causes, Effects and Mitigation of Climate Change on the Environment*. https://doi.org/10.5772/intechopen.99353

World Bank. (2024). *CO2 emissions (metric tons per capita) - Uganda*. https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?name_desc=false&locations=UG

Namukasa, J., Namagembe, S., & Nakayima, F. (2020). Fuel Efficiency Vehicle Adoption and Carbon Emissions in a Country Context. *International Journal of Global Sustainability*, *4*(1). https://doi.org/10.5296/ijgs.v4i1.16227

Ministry of Energy and Mineral Development. (2023). *Energy Policy*. www.iea.org

Bongomin, O., & Nziu, P. (2022). A Critical Review on the Development and Utilization of Energy Systems in Uganda. In *Scientific World Journal* (Vol. 2022). https://doi.org/10.1155/2022/2599467

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3). https://doi.org/10.1002/jae.616

Dinda, S. (2004). Environmental Kuznets Curve hypothesis: A survey. *Ecological Economics*, *49*(4). https://doi.org/10.1016/j.ecolecon.2004.02.011

Panayotou, T. (1994). Empirical tests and policy analysis of environmental degradation at different stages of economic development. *Pacific and Asian Journal of Energy*, *4*(1).

Khobai, H., & Sithole, K. (2022). The Relationship between Economic Growth and Carbon Emissions in South Africa. *International Journal of Energy Economics and Policy*, *12*(2). https://doi.org/10.32479/IJEEP.11194

Sarkodie, S. A. (2018). The invisible hand and EKC hypothesis: what are the drivers of environmental degradation and pollution in Africa? *Environmental Science and Pollution Research*, *25*(22). https://doi.org/10.1007/s11356-018-2347-x

Zhang, N., Yu, K., & Chen, Z. (2017). How does urbanization affect carbon dioxide emissions? A cross-country panel data analysis. *Energy Policy*, *107*. https://doi.org/10.1016/j.enpol.2017.03.072

Fatumah, N., Mohammed, S., Ashraf, N., Abasi, K., & Shadia, N. (2023). Adoption of novel climate-smart farming systems for enhanced carbon stock and carbon dioxide equivalent emission reduction in cattle corridor areas of Uganda. *Heliyon*, *9*(3). https://doi.org/10.1016/j.heliyon.2023.e14114