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CARBON EMISSION AND ECONOMIC GROWTH IN WEST AFRICA; A QUEST FOR AN AVERAGE CARBON EMISSION

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Abstract

The study provides a substantiation of a positive relationship between carbon emission and economic growth in West Africa. Seven counties including Cote d'Ivoire, Ghana, Nigeria, Benin, Niger, Senegal and Togo makes up the sample with carbon emission per capita, economic growth, and electricity consumption as variables. A panel Autoregressive Distributive Lag model was employed to test for the short and long run relationships considering the nature of the study and outcome of panel unit testing. In the findings of this study in the short run, five counties carbon emission has a negative relation with economic growth while the remaining two counties portend a positive relationship. In the long run, as the economies continue to expand; carbon emission has a significant and positive relationship with economic growth. The study recommends a need for an average carbon emission per country to enable developing countries set up industries and grow their economies with sustainability.

Keywords: CO_2, GHGs, UNFCCC, REDD+, GDP, African Development Bank, West Africa.

1. Introduction

Growth in West Africa is estimated to have slowed to 3.6 per cent in 2022 from 4.4 per cent in 2021. It is projected to pick up in the medium term, to 4.1 per cent in 2023 and 4.3 per cent in 2024. In all countries in the region except Gambia, Guinea, Niger, and Togo, growth decelerated in 2022. Sustained economic performance in the region's more diversified economies is projected to drive average regional growth to 4.1 per cent in 2023 and 4.3 per cent in 2024.(African Development Bank, 2023).

In the macroeconomic performance outlook of African Development Bank, (2023), in Ghana growth dipped to an estimated 3.6 per cent in 2022 from 5.4 per cent in 2021, weighed down by deep macroeconomic imbalances; higher inflation, depreciating local currency, and high public debt, estimated at 91 per cent of GDP. In Côte d'Ivoire, investment in strategic logistics infrastructure, expanded construction projects to meet growing urbanization, and planned energy projects to enhance the country's renewable energy sector are projected to boost growth from an estimated 6.8 per cent in 2022 to 7.2 per cent in 2023.

Senegal, poised to become an oil and gas exporter in 2023 and capitalizing on a recovery in tourism and agricultural output, could ascend to the list of Africa's fastest growing economies. In this context, growth in Senegal is projected to accelerate from 4.7 per cent in 2022 to 10.2 per cent in 2023. In Nigeria, the region's largest economy, growth is estimated to have declined to 3.0 per cent in 2022 from 3.6 per cent in 2021, but still above the country's population growth rate of about 2.4 per cent (African Development Bank, 2023).

Countries had sign up to the UNFCCC with the ultimate objective of the convention to stabilize greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system." It states that "such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a

sustainable manner." The UNFCCC parties have reached a consensus to limit climate change to 2 degrees Celsius relative to the pre-industrial level (*UNFCCC*, 2023)

Protecting the world's forests is crucial for the climate. Forests absorb vast amounts of carbon dioxide and can be a source of greenhouse gas emissions when destroyed or damaged. Countries established the 'REDD+' framework to protect forests as part of the Paris Agreement. 'REDD' stands for 'Reducing emissions from deforestation and forest degradation in developing countries. The '+' stands for additional forest-related activities that protect the climate, namely sustainable management of forests and the conservation and enhancement of forest carbon stocks. Under the framework with these REDD+ activities, developing countries can receive results-based payments for emission reductions when they reduce deforestation. That serves as an incentive for their efforts (*UNFCCC*, 2023). Ghana has become the first country in west Africa to receive payments from a World Bank trust fund for reducing emissions from deforestation and forest degradation, commonly known as REDD+. Ghana was assisted with the tune of about USD 4.8 million for reducing 972,456 in the year 2019.(World Bank, 2023)

Ghana is the second largest exporter of cocoa beans with and export value of USD 1.15 billion in the year 2021 *OEC*, (2023). The Global Cocoa and Chocolate Market Size was valued at USD 47.1 Billion in 2021 and the worldwide cocoa and chocolate market size is expected to reach USD 68.2 Billion by 2030, according to a research report published by US based Consulting firm Insights Spherical, (2022), Ghana is forgoing 98 percent of the total market share of the chocolate industry amounting to USD 46 Billion for an assistance of USD 4.8 Million.

Most of this developing countries have a positive relationship between economic growth and carbon emissions (see Alege et al., 2016; Chindo, 2014; Olubusoye & Musa, 2020). Recently among the largest and buoyant economies in the world emits higher co2 per capita than these developing economies in West Africa. In the most recent and available data United Kingdom, United State and China emit 4.5, 13.0 and 7.8 metric tonnes per capita respectively in the year 2022, which is far ahead of the total 5.8 metric tonnes per capita emission of the west African states (*World Development Indicators | DataBank*, 2023)

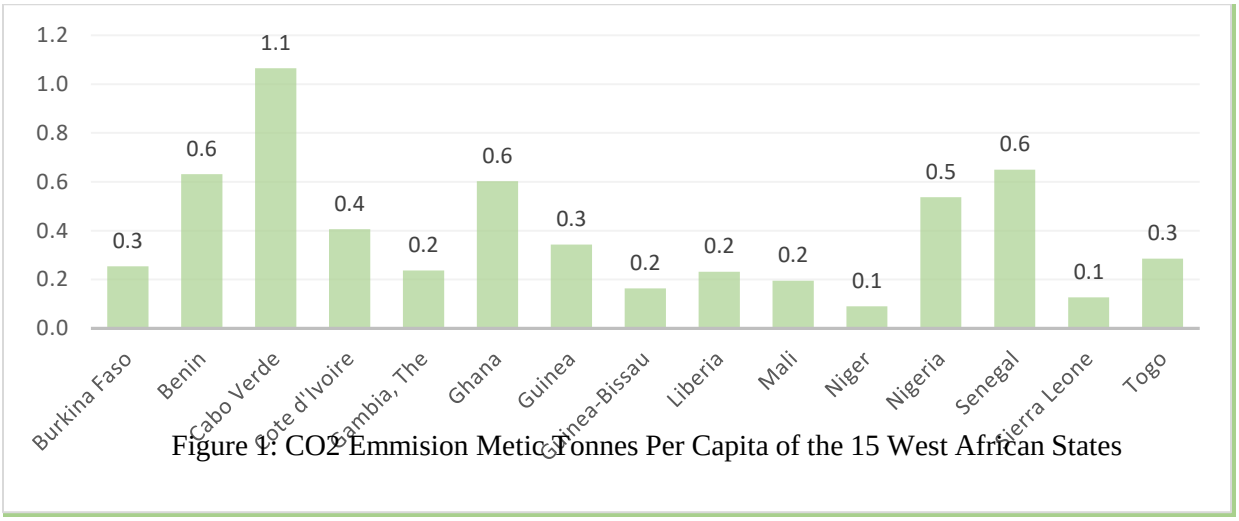

Figure 1: CO2 Emmision Metic Tonnes Per Capita of the 15 West African States

Largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low. Recognizing the special difficulties of developing countries, whose economies are particularly dependent on fossil fuel production, use and exportation, as a consequence of action taken on limiting greenhouse gas *Paris Agreement*, (2015). No doubts green energy is another way of reducing the carbon emission significantly. However, this might be very costly to adopt by industries within the countries in

the scope of this study considering the size of their economies.

With respect to both mitigation of carbon emission per capita and adaptation of a green energy, developed country shall provide financial resources to assist developing countries in continuation of their existing obligations under the UNFCCC article 9 (1) *Paris Agreement*, (2015). This study is looking at the possibilities of developing economies to be compensated and not assistance as earlier state by the convention in other to forgo the exploitation of their natural resources to invest in a green energy which can be very costly for their industries to adopt, at the same time looking forward for a possible average carbon emission per countries for equitable responsibility in stabilizing greenhouse gases concentration. Therefore, the main objective of this study is to establish a short and long run relationship between carbon emission and economic growth in West African states.

2. Literature Review

2.1 Empirical Review

Osadume and Edith, (2021) in a study investigated the impact of economic growth on carbon emissions on selected West African countries between 1980 and 2019. Simon-Steinmann's economic growth model provides the relevant theoretical foundation. The main objective of this study was to ascertain whether economic growth will impact carbon emissions. The study selected six-sample countries in West Africa and used secondary data obtained through the World Bank Group online database covering the period 1980–2019, employing panel econometric methods of statistical analysis. The outcome indicates that the independent variable showed a positively significant impact on the dependent variable for the pooled samples in the short-run, with significant cointegration.

Similarly, Omojolabi, (2010) The relationship between environmental quality-as measured by carbon emission (CO2) and economic growth- as measured by gross domestic product (GDP) is determined with the aid of the Environmental Kuznets Curve (EKC). The study tests the Environmental Kuznets Curve (EKC) hypothesis using panel data methodology to estimate the relationship between carbon emission and GDP in Ghana, Nigeria, and Sierra Leone over the period of 1970-2006. For the panel, as a whole, both pooled ordinary least square (OLS) and the fixed effects (FE) results were analysed. The pooled OLS results were in consonance with EKC, while the FE results were at variance with the applicability of EKC in West Africa. The findings suggest that these countries should enact policy options to ensure efficiency in energy use and reduction in carbon emissions, increase investment in energy infrastructure to improve delivery efficiency, continue to promote alternative energy sources, and put in place energy conservation policies to reduce unnecessary wastage.

A study titled Environmental quality and economic growth: Searching for environmental Kuznets curves for air and water pollutants in Africa, which the specific objective was to estimate environmental Kuznets curves for two indicators of environ- mental quality and to establish whether the estimated relationships conform to the inverted U-shape hypothesis. The results of the empirical investigation generally suggest the existence of an environmental Kuznets curve for suspended particulate matter. In the case of organic water pollutants, the evidence weighs more in favour of rising pollution as per capita income increases. The turning point levels of income established for the two indicators of environmental quality were however generally low, when compared to evidence from existing studies. On the face value, this suggests that African countries may be turning the corner of the environmental Kuznets curve, much faster, and at lower levels of income, much in line with the emerging idea of a ''revised environmental Kuznets curve'' (Orubu & Omotor, 2011).

In a study Musah *et-al*., (2020), examined the nexus between carbon emissions, renewable energy consumption, and the economic growth of West African countries for the period 1990 to 2018. More robust panel estimation methods were employed for the study from the heterogeneity and cross-sectional dependence tests the study's panels were heterogeneous and cross-

sectionally dependent. The Fisher test and the Westerlund and Edgerton bootstrap test found the variables to be cointegrated in the long run. The CCEMG and the DCCEMG estimators were used to explore the long-run equilibrium relationship amid the series, and from the results of the whole sample, CO2 emissions and renewable energy consumption (REC) had no vital influence on economic growth (GDP) in both estimators. However, the results were a bit different in the sub-panels. Also from the whole sample, control variables urbanization (URB) and population growth (POP) had no material effect on GDP in both estimators.

Olubusoye and Musa, (2020) in their study tried to relate Carbon Emissions and Economic Growth in Africa. The study employed the ARDL model, Mean Group (MG), and the Pooled Mean Group (PMG) model to examine the Environmental Kuznets Curve (EKC) hypothesis in 43 African countries pooled into 3 income groups from 1980–2016. The EKC hypothesis is accepted in only 21% of the sample but rejected in 70% of the countries in the total sample. This result shows that carbon emissions increase as economic growth increases in 79% of the countries while economic growth will lead to lower carbon emissions in only a few countries (21%). The study concludes that an increase in economic growth will induce higher emissions in most countries in Africa. These countries should take all possible policy actions such as the massive deployment of renewable energy, carbon tax policy, and the carbon emissions trading scheme to curtail growth in carbon emission.

2.2 Theoretical Framework

The Environmental Kuznets Curve

The environmental Kuznets curve (EKC) is a hypothesized relationship between various indicators of environmental degradation and income per capita. Stern, (2015) in the early stages of economic growth, pollution emissions increase and environmental quality declines, but beyond some level of income per capita (which will vary for different indicators) the trend reverses, so that at high income levels economic growth leads to environmental improvement. This implies that environmental impacts or emissions per capita are an inverted U-shaped function of income per capita.

Concentrations of some local pollutants have clearly declined in developed countries but emissions of pollutants in the countries are much higher than that of the developing countries. According to Stern, (2015) studies of the relationship between per capita emissions and income that attempt to avoid various statistical pitfalls find that per capita emissions of pollutants rise with increasing income per capita when other factors are held constant. However, changes in these other factors may be sufficient to reduce pollution.

Proponents of the EKC hypothesis argue that "at higher levels of development, structural change towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology and higher environmental expenditures, result in levelling off and gradual decline of environmental degradation." (Panayotou, 1993)

Therefore, the EKC can be explained by the following 'proximate factors': *Scale of production* implies expanding production with the mix of products produced, the mix of production inputs used, and the state of technology all held constant. Different industries have different pollution intensities and typically, over the course of economic development the output mix changes. This is often referred to as the *composition effect*. Whereas, Changes in *input mix* involve the substitution of less environmentally damaging inputs to production for more damaging inputs and vice versa Stern, (2015).

Production efficiency in terms of using less, ceteris paribus of the polluting inputs per unit of output and emissions specific changes in process result in less pollutant being emitted per unit of input, both involves changes in the improvement in the state of technology Stern, (2015).

3. Methodology

For the purpose of this research, a secondary panel data was obtained from World Development Indicators

(WDI) of the World Bank data base for a period of 30 years from the year 1990-2020, the selected countries for the panel sample include Benin, Cote d'Ivoire, Ghana, Niger, Nigeria, Senegal and Togo. CO_2 emissions, GDP growth, Electric power consumption were considered as variable for this research, the variables were measured in metric tons per capita, growth annual percentage, and kilowatt per capita for CO_2 emissions, GDP growth and Electric power consumption respectively.

ARDLs are standard least squares regressions which include lags of both the dependent variable and explanatory variables as regressors (Greene, 2008). Although ARDL models have been used in econometrics for decades, they have gained popularity in recent years as a method of examining long-run and cointegrating relationships between variables (Pesaran and Shin, 1999).

3.1 Estimation Procedure

The analysis procedure of this paper was carried out in three phases. The process began by pre-estimation test, conducting the panel unit root test using Im, Pesaran and Shin W-stat and Breitung T-stat, this becomes expedient to avoid spurious regression and ensure that none of the data series becomes integrated of order 2. In addition, Johansen cointegration test was conducted to show cointegrating relationships. Lastly, a Panel ARDL model was use to analyse the long and short run coefficients of the variables.

3.2 Model Specification

An ARDL is a least squares regression containing lags of the dependent and explanatory variables. ARDLs are usually denoted with the notation ARDL $(p, q_1, \ \dots, q_k)$, where p is the number of lags of the dependent variable, q_1, is the number of lags of the first explanatory variable, and q_k is the number of lags of the k-th explanatory variable.

An ARDL model can be written as:

$$y_t = \alpha + \sum_{i=1}^{p} \gamma_i y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q_j} X_{j,t-1}{}' \beta_{j,i} + \epsilon_t$$

To specify an ARDL model, you must determine how many lags of each variable should be included that is specify p and $q_1, \ \dots, q_k$. Fortunately, simple model selection procedures are available for determining these lag lengths. For the purpose of this study an ARDL model can be estimated via least squares regression, standard Akaike, Schwarz and Hannan-Quinn information criteria was used for model selection.

4. Results and Discussion

Table 1 present the unit root testing of the variables GDP, CO2 and ELEC at level and at first difference, Im, Pesaran and Shin W-stat and Breitung t-stat panel unit root testing at level and at first difference were conducted and are presented in panel A and B of Table 1 respectively.

Table 1: Panel Unit Root Test

Panel A				Panel B			
AT LEVEL				AT FITST DIFFRENCE			
	IPS W-STAT	BREITUNG T-TEST	STATUS		IPS W-STAT	BREITUNG T-TEST	STATUS
GDP	-3.17***	-1.75*	I(0)	D(GDP)	-	-	-
CO2	-2.17**	-2.29**	I(0)	D(CO2)	-	-	-
ELEC	1.25	1.78	-	D(ELEC)	-4.88***	-3.89***	I(1)

*Source; Author's computation using EViews 9, ***, ** and * significance at 1%, 5% and 10%*

For the purpose of robustness, Im, Pesaran and Shin W-stat that assumes individual unit root process and Breitung t-stat which also assumes common unit root process unit root testing was conducted the variable GDP and CO_2 were found to be stationary at level as presented in panel a of table one. However, ELEC was

found to be stationary only at first difference. Therefore, the order of integration of the variables was a mixture of order of integration at level I (0) and at first difference I(1).

Table 2: Johansen Cointegration test

	Trace Test				Maximum Eigenvalue			
Hypothesized		Trace	0.05			Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.209498	45.34993	29.79707	0.0004	0.209498	33.85253	21.13162	0.0005
At most 1	0.074401	11.49740	15.49471	0.1827	0.074401	11.13330	14.26460	0.1477
At most 2	0.002525	0.364100	3.841466	0.5462	0.002525	0.364100	3.841466	0.5462

Source; Author's computation using EViews 9.

The outcome of Johansen cointegration the trace test and maximum eigenvalues indicates a cointegrating equation at the 0.05 level as shown in table 2 and a mixture of stationarity of variables at level and first difference of the IPS and Breitung panel unit root testing justifies the use of Panel Auto Regressive Distributive Lag (ARDL) model for the purpose of this research.

Table 3: Analysis of short run relationship between Carbon Emission and Economic Growth of Individual Countries.

	Short run coefficient	
	D(GDP)	D(ELEC)
CIV	0.001347***	-0.000740***
GHANA	-0.004209***	-0.000153***
NIGERIA	-0.001259***	-0.001283***
BENIN	-0.001293***	0.002975***
NIGER	-0.000507***	0.001493***
SENEGAL	-0.006876***	0.000308***
TOGO	0.001149***	0.003991***

*Source; Author's computation using EViews 9, ***, ** and * significance at 1%, 5% and 10%*

According to the cross-country analysis, short run estimates for Cote d'ivoire posits a positive impact of economic growth and a negative impact of electricity consumption on CO_2 emission. A unit increase in GDP exerts a positive impact of about 0.001347 whereas ELEC exerts a negative impact of about 0.000720 units on CO2 emission at the 1% statistical significance level.

For Ghana and Nigeria, a negative relationship is evidenced from both economic growth and electricity consumption on CO_2 emission. A unit increase in GDP reduces $C0_2$ emission by about 0.004209 and 0.001259 unit. Similarly, a unit increase in electricity consumption decelerates $C0_2$ emission by about 0.000153 and 0.001283 units in Ghana and Nigeria at 1% statistical significance level respectively. Estimates for Benin, Niger and Senegal portends a negative impact of economic growth accompanied by a positive impact of electricity consumption on CO_2 emission. Accordingly, a unit increase in GDP reduces $C0_2$ emission by about 0.001293, 0.000507 and 0.006876 units. However, a unit increase in ELEC increase the volume of $C0_2$ emission by

about 0.002975, 0.001493 and 0.000308 units respectively at 1% statistical significance level.

The economy of Togo saw a positive impact from both Economic growth and electricity consumption on CO_2 emission. Estimate puts a unit increase in GDP & ELEC to result in about 0.001149 and 0.003991 units increase in C02 emission at the significance level of 1%. The short run result is at variance with the findings of Olubusoye & Musa (2020) who reports that $C0_2$ emission increase as economic growth increase in 79% of the countries while economic growth lead to lower carbon emission in only a few countries (21%). According to this study, in five countries representing 71%, economic growth has a negative relation with $C0_2$ emission whereas two countries representing 29%, economic growth has a positive association with $C0_2$ emission.

Table 4: Analysis of the Long Run Relationship Between Carbon Emission and Economic Growth.

Long Run Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDP	0.044911	0.014592	3.0778	0.0025
ELEC	0.002069	0.000319	6.488024	0

*Source; Author's computation using EViews 9, ***, ** and * significance at 1%, 5% and 10%*

In

the long run, economic growth and electricity consumption has a positive significant impact on $C0_2$ emission across the panel of selected economies. According to the estimates, a unit increase in economic growth and electricity consumption accelerate $C0_2$ emission by about 0.044911 and 0.002069 units respectively. This finding is in contrast with Musa *et-al*., (2020) that economic growth has no vital influence on $C0_2$ emission.

5. Conclusion and Recommendation

This existing evidence has portrayed developing economies cannot do away with carbon emissions in other to grow and develop their economies in both short and long run. This result implies that carbon emission decreases economic growth in a significant number of economies in across the panel in the short run. However, in the long run, evidences show acceleration in carbon emission exacerbates economic growth. Per capita emission of developing countries is relatively very low compared to that of developed counties. With existing positive relationship between economic growth and carbon emission, developing countries may be finding it difficult to make decision between reductions of carbon emission and growing their economies. The consequences of higher carbon emission globally are very clear and understood. However, failing to grow an economy is yet another catastrophe that cannot be over emphasised. As a result, this study is strongly recommending a need for an average carbon emission per country so that while developed countries are reducing their carbon emission drastically by switching to more alternative carbon free energy, developing countries on the other hand are setting up industries and further growing their economies in a sustainable manner.

References

African Development Bank. (2023). *Macro Economic Performance and Outlook.*

Alege, P. O., Adediran, O. S., & Ogundipe, A. A. (2016). Pollutant Emissions , Energy Consumption and Economic Growth in Nigeria. *International Journal of Energy Economics and Policy*, *6*(2), 202–207. www.econjournals.com International

Chindo, S. (2014). The Causality between Energy

Consumption , CO2 Emissions and Economic Growth in Nigeria : An Application of Toda and Yamamoto Procedure. *Advances in Natural and Applied Sciences*, *8*, 75–81. www.aensiweb.com/ANAS

Greene, W. H. (2008). *Econometric Analysis* (6th Editio).

Insights Spherical. (2022). *Global Cocoa and Chocolate Market Size To Worth USD 68.2 Billion By 2030 | CAGR of 4.37%*. https://www.globenewswire.com/en/news-release/2023/03/29/2637062/0/en/Global-Cocoa-and-Chocolate-Market-Size-To-Worth-USD-68-2-Billion-By-2030-CAGR-of-4-37.html

Musa, M., Kong, Y., Mensah, I. A., Antwi, S. K., & Donkor, M. (2020). The link between carbon emissions, renewable energy consumption, and economic growth: a heterogeneous panel evidence from West Africa. *Environmental Science and Pollution Research*, *27*(23), 28867–28889. https://doi.org/10.1007/s11356-020-08488-8

OEC. (2023). https://oec.world/en/profile/bilateral-product/cocoa-beans/reporter/gha

Olubusoye, O. E., & Musa, D. (2020). Carbon Emissions And Economic Growth In Africa: Are They Related ? Carbon Emissions And Economic Growth In Africa : Are They Related? *Cogent Economics and Finance*, *8*. https://doi.org/10.1080/23322039.2020.1850400

Omojolaibi, J. A. (2010). Environmental quality and economic growth in some selected West African countries: A panel data assessment of the environmental Kuznets curve. *Journal of Sustainable Development in Africa*, *12*(8), 35–48. https://www.researchgate.net/profile/Joseph-Omojolaibi-2/publication/266459886

Orubu, C. O., & Omotor, D. G. (2011). Environmental quality and economic growth: Searching for environmental Kuznets curves for air and water pollutants in Africa. *Energy Policy*, *39*(7), 4178–4188. https://doi.org/10.1016/j.enpol.2011.04.025

Osadume, R., & Edih, U. O. (2021). Impact of economic growth on carbon emissions in selected West African countries, 1980–2019. *Journal of Money and Business*, *1*(1), 8–23. https://doi.org/10.1108/jmb-03-2021-0002

Paris Agreement. (2015).

Stern, D. I. (2015). The Environmental Kuznets Curve. In *Earth Systems and Environmental Sciences*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-409548-9.09278-2

UNFCCC. (2023). https://unfccc.int/process-and-meetings/what-is-the-united-nations-framework-convention-on-climate-change

World Bank. (2023). *Ghana Begins Receiving Payments for Reducing Carbon Emissions in Forest Landscapes*. https://www.worldbank.org/en/news/press-release/2023/01/24/ghana-begins-receiving-payments-for-reducing-carbon-emissions-in-forest-landscapes

World Development Indicators | DataBank. (2023). https://databank.worldbank.org/country/USA/556d8fa6/Popular_countries#