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Environmental Degradation and Economic Growth Nexus in Liberia: Auto Regressive Distributive Lag Analysis (ARDL MODEL)

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Abstract

Economic growth has been said to degrade the environment. This study takes a long run analysis of the relationship between exploitation of the environment and economic performance in Liberia. The study used WDI data from 2001 to 2020 with the ARDL model in the Liberian economy. The study indicates long run analysis among population, environmental degradation, and economic growth in Liberia. Past economic performance positively affects economic growth while population of Liberia and exploitation of the environment negatively affect economic growth from the study. The study reports that population and environmental degradation were not statistically significant at 5% but the model was statistically significant with diagnostic and stability tests showing fitted good model. The study established a long run analysis. The recommendation from the study is that more environmentally friendly economic activities with huge attention on human capital development and management of the population of Liberia to optimally utilize human resources for economic development is pivotal.

Keywords: Environmental Degradation; Economic Growth; ARDL MODEL; Liberia.

1. Introduction

Liberia is a low-income country that is rich in natural resources which include iron ore, diamonds, gold, fertile soil, fishery, and forestry. However, the economic potential of these assets remains largely untapped [16]. Real GDP was estimated to contract by 3.1% in 2020, its third year of decline in the past five. The 2020 result reflects a pandemic-induced reduction in external demand for its major exports [1; 2].

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Despite this gloomy outlook, the country economic fundamentals remain robust, mainly due to inflow of direct remittances and donors, bi-lateral and multilateral assistances. Real GDP was forecasted to be 2.8% driven mainly from post covid-19 recovery of the global economy and the demand for Liberia's key exports namely gold, diamonds, rubber and iron ore [1; 2]. The population of Liberia is estimated at 5.06 million people in 2020 with a current population growth rate of 2.4% [17]. It is estimated that approximately 51.6% of the population currently live in urban areas and this is projected to increase to 57.3% and 68.2% of the population by 2030 and 2050, respectively [17]. According to the environmental protection agency (2008) report Liberia is highly vulnerable to adverse effects of climate change. This high vulnerability to environmental instability is due to its extreme poverty and high dependence on 'climate sensitive' sectors such as agriculture, forestry, fisheries, and energy and mining [9]. As the population grows, the pressure on the environment will eventually need to be managed.

2. Literature Review

There literature on environment degradation, caused by climate variation, population and economic activities continued to point light on the growing concerns of its devastating impact it has on both livelihood and economic growth. The study on the elements of environmental pollution and the mechanisms to mitigate it, has been a growing theoretical and empirical literature in recent years that verifies the relationship between economic growth, energy consumption and CO2 emissions [3; 13]. There is a wide empirical literature verifying the relationship between economic activity and environmental degradation, in particular the relationship between economic growth, energy consumption and carbon dioxide (CO2) emissions [5; 15; 4; 6; 10]. Although the empirical evidence is not conclusive, the results suggest a strong relationship between economic activity and environmental degradation, with greater emphasis during the process of development [3]. Countries with high industrialization are mostly susceptible to huge greenhouse gas emissions, especially carbon dioxide emission which inadvertently negatively impact the ecosystem because the increased manufacturing activity associated with development leads to increased CO2 emissions [7]. However, in countries like Liberia with low levels of industrialization and high levels of vegetal cover, a serious environmental problem is associated with growing deforestation, also known at the expansion of the agricultural frontier [8] and not with CO2 emissions. Others have argued that the relationship between the environment and economic growth, whether positive or negative, is not fixed along a country's development path [16; 14]. The 'Environmental Kuznets Curve' shows that at a low level of development, both the quantity and intensity of environmental degradation is limited on economic activities was hypothesized to explain this relationship [12]. There were others who argued that at a 'higher levels of development, structural change towards information-based industries and services, more efficient technologies, and increased demand for environmental quality result in levelling-off and a steady decline of environmental degradation' [14]. The question of the involvement of population on the environment has been a heated debate by Neo Malthusians who stressed the negative impact of population growth. In their argument, ignoring the presence of technology and the advancement of society, they posited that population growth has no limit and that at some stages, there will exist overpopulation while those who developed the anti-thesis of this argument tend to argue that population growth can have a positive effect by stimulating demand and encouraging technological innovation and permitting economies of scale in production [11].

3. Research Method

The study was conducted using a quantitative research method with secondary data from various WDI websites. It is being implemented to get an in-depth understanding how economic growth relates with population and environmental degradation in Liberia from 2002 to 2020. The model specification below depicts the analogy;

y = a + bx

Where:

y = economic growth (GDP_GROWTH)

a = constant variable

b = coefficient of population and environmental degradation

x = population and environmental degradation (CO2_FUEL)

$$GDP\_GROWTH_t = C + POPULATION_t + B2CO2\_FUEL_t + e_t$$

Where t represent the years of the time series analysis that made up data analysis technique.

Above is a model formulated from the dependent and independent variables of the topic under study and is used to run the regression analysis.

Since the unit root test indicated some variables are stationary at levels and others were stationary at first difference, the ARDL model is applied in this study. The final model specification is thus;

$$Y_t = C + \sum_{i=0}^{p} \alpha Y_{t-i} + \sum_{i=0}^{p} biX_{t-i}\, B + e_t$$

Where Y is the dependent variable and X is the independent variables, α is the coefficient of the lagged dependent variables as a regressor in the model, bi is the coefficient of the other independent variables, and the e is the error term

4. Presentation Of Result And Discussion

Table 1: Variable Discription

Carbon dioxide emissions from liquid fuel consumption refer mainly to emissions from use of petroleum-derived fuels as an energy source.	1	CO2_fuel
Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.	1	population
Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.	0	GDP_GROWTH

Table 2: Unit Root Test Result

s/n		levels	First difference	remark
1	GDP	-3.507009(-3.040391)		I(0)
2	Co2		-3.798485(-3.040391)	I(1)
3	pop		-26.2526(-3.052169)	I(1)
4				

Source: Author's computation with Eviews 10 (2022

Using the cointegration of Bounds test proposed by Pesaran, Shin and Smith (2001), the ARDL estimates are presented below

The lag length selection from table 3 indicates one lag. Hence, one lag is the appropriate lag length used in the ARDL model

Table 3: VAR Lag Order Selection Criteria

Endogenous variables: GDP_GROWTH POPULATION CO2_FUEL						
Exogenous variables: C						
Date: 02/11/22 Time: 17:38						
Sample: 2001 2020						
Included observations: 17						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-414.6794	NA	4.40e+17	49.13876	49.28579	49.15337
1	-339.9808	114.2450	1.99e+14	41.40950	41.99765	41.46797
2	-318.2014	25.62281*	5.03e+13*	39.90604*	40.93531*	40.00836*
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

Source: Author's computation with Eviews 10 (2022)

Table 4: VAR Lag Order Selection Criteria

Endogenous variables: GDP_GROWTH
Exogenous variables: C CO2_FUEL POPULATION
Date: 03/01/22 Time: 07:05
Sample: 2001 2020
Included observations: 15

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-35.20490	NA*	9.598191	5.093987	5.235597	5.092478
1	-33.10102	3.085686	8.348954*	4.946803*	5.135616*	4.944792*
2	-32.90748	0.258058	9.420931	5.054330	5.290347	5.051816
3	-32.83273	0.089700	10.88209	5.177697	5.460917	5.174680
4	-32.82413	0.009170	12.81062	5.309884	5.640308	5.306364

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's computation with Eviews 10 (2022)

The ARDL bounds test reveals the presence of cointegration as the f statistics is greater than the I(1) series bound. This is as a result of rejecting the null hypothesis of no cointegration

Table 5: ARDL Long Run Form and Bounds Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	**5.910007**	10%	2.63	3.35
k	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
			Finite Sample: n=35	
Actual Sample Size	18			
		10%	2.845	3.623
		5%	3.478	4.335
		1%	4.948	6.028
			Finite Sample: n=30	
		10%	2.915	3.695
		5%	3.538	4.428
		1%	5.155	6.265

Source: Author's computation with Eviews 10 (2022)

Having found a long run relationship among environmental pollution, population and economic growth in the Liberian economy, table 5 present both the short run and long run estimates of the ARDL below. Table 5 indicates that lag economic growth after the war positively supports economic progress in Liberia at a statistically significant rate in the short run term. Population and environmental pollution were not significant at 5% level of significance in the short run analysis. However, the long run variable indicates a negative and significant estimate. This shows that the model adjusts from any discrepancy to model between the short run and long run analysis I the Liberian economy.

This shows that past economic performance positively affects economic growth in Liberia. The speed of adjusting long run differences in the model has the required negative sign and significant hence the model would adjust any discrepancies to equilibrium. But clearly though not statistically significant, the management of the population as well as environmental issues have not been efficient in supporting economic growth in Liberia.

Table 6: ARDL Short run and Long Run Estimates

Dependent Variable: GDP_GROWTH				
Method: ARDL				
Date: 03/01/22 Time: 07:17				
Sample (adjusted): 2004 2020				
Included observations: 17 after adjustments				
Maximum dependent lags: 1 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (1 lag, automatic): CO2_FUEL POPULATION ECM(-1)				
Fixed regressors: C				
Number of models evalulated: 8				
Selected Model: ARDL(1, 1, 0, 0)				
Note: final equation sample is larger than selection sample				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDP_GROWTH(-1)	1.329299	0.391034	3.399451	0.0059
CO2_FUEL	0.017649	0.018627	0.947474	0.3637
CO2_FUEL(-1)	-3.26E-05	0.017025	-0.001914	0.9985
POPULATION	-8.29E-06	1.06E-05	-0.782838	0.4502
ECM(-1)	-1.804971	0.440969	-4.093193	0.0018
C	18.00935	25.15203	0.716020	0.4889
R-squared	0.650144	Mean dependent var		2.311428
Adjusted R-squared	0.491119	S.D. dependent var		9.176708
S.E. of regression	6.546287	Akaike info criterion		6.866237
Sum squared resid	471.3926	Schwarz criterion		7.160313
Log likelihood	-52.36302	Hannan-Quinn criter.		6.895469
F-statistic	4.088308	Durbin-Watson stat		1.020066
Prob(F-statistic)	0.024154			
*Note: p-values and any subsequent tests do not account for model selection.				

Source: Author’s computation with Eviews 10 (2022)

5. Conclusion

The study concludes that management of people’s activities and environmental protections are not efficient in supporting economic growth. However, past economic growth gains positively account for economic growth in the long run.

6. Policy recommendation from the study

This paper recommends that production activities should meet standards and population management and human capital development should be prioritized.

APPENDIX

cos_fuel

stationary at first diff

Table 7

Null Hypothesis: D(CO2_FUEL) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.277803	0.0006
Test critical values:	1% level	-3.857386	
	5% level	-3.040391	
	10% level	-2.660551	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 18

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CO2_FUEL,2)
Method: Least Squares
Date: 02/11/22 Time: 16:05
Sample (adjusted): 2003 2020
Included observations: 18 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CO2_FUEL(-1))	-1.274752	0.241531	-5.277803	0.0001
C	53.58533	28.86933	1.856134	0.0819

R-squared	0.635163	Mean dependent var	-0.950704
Adjusted R-squared	0.612361	S.D. dependent var	183.6917
S.E. of regression	114.3677	Akaike info criterion	12.42115
Sum squared resid	209279.6	Schwarz criterion	12.52008
Log likelihood	-109.7904	Hannan-Quinn criter.	12.43480
F-statistic	27.85521	Durbin-Watson stat	1.932573
Prob(F-statistic)	0.000075		

population total

stationary at first diff

Table 8

Null Hypothesis: D(POPULATION) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		**-26.25265**	0.0000
Test critical values:	1% level	**-3.886751**	
	5% level	**-3.052169**	
	10% level	-2.666593	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 17

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(POPULATION,2)
Method: Least Squares
Date: 02/11/22 Time: 16:55
Sample (adjusted): 2004 2020
Included observations: 17 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(POPULATION(-1))	-0.303339	0.011555	-26.25265	0.0000
D(POPULATION(-1),2)	0.708867	0.023802	29.78144	0.0000
C	36142.04	1327.945	27.21652	0.0000

R-squared	0.990371	Mean dependent var	3998.529
Adjusted R-squared	0.988996	S.D. dependent var	11496.43
S.E. of regression	1205.992	Akaike info criterion	17.18678
Sum squared resid	20361821	Schwarz criterion	17.33381
Log likelihood	-143.0876	Hannan-Quinn criter.	17.20139
F-statistic	719.9881	Durbin-Watson stat	2.071612
Prob(F-statistic)	0.000000		

GDP_GROWTH

STATIONARY AT LEVELS

Table 9

Null Hypothesis: GDP_GROWTH has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.507009	0.0202
Test critical values:	1% level	-3.857386	
	5% level	-3.040391	
	10% level	-2.660551	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 18

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP_GROWTH)
Method: Least Squares
Date: 02/11/22 Time: 17:18
Sample (adjusted): 2003 2020
Included observations: 18 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP_GROWTH(-1)	-0.877821	0.250305	-3.507009	0.0029
C	2.064524	2.250976	0.917168	0.3727

R-squared	0.434611	Mean dependent var	-0.288807
Adjusted R-squared	0.399274	S.D. dependent var	11.76141
S.E. of regression	9.115859	Akaike info criterion	7.362348
Sum squared resid	1329.582	Schwarz criterion	7.461278
Log likelihood	-64.26113	Hannan-Quinn criter.	7.375989
F-statistic	12.29911	Durbin-Watson stat	1.987922
Prob(F-statistic)	0.002920		

Diagnostic test

Correlation

Table 10

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	3.558008	Prob. F(5,6)	0.0770
Obs*R-squared	12.71249	Prob. Chi-Square(5)	0.0262

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 03/01/22 Time: 08:15
Sample: 2004 2020
Included observations: 17
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP_GROWTH(-1)	0.119095	0.305414	0.389946	0.7100
CO2_FUEL	0.010044	0.013953	0.719886	0.4987
CO2_FUEL(-1)	0.000376	0.011998	0.031304	0.9760
POPULATION	-3.13E-06	7.82E-06	-0.400109	0.7029
ECM(-1)	-0.561758	0.330661	-1.698893	0.1403
C	4.066151	18.32674	0.221870	0.8318
RESID(-1)	0.633139	0.494891	1.279350	0.2480
RESID(-2)	-0.629687	0.335170	-1.878712	0.1094
RESID(-3)	-0.427960	0.308808	-1.385845	0.2151
RESID(-4)	-0.143377	0.350171	-0.409448	0.6964
RESID(-5)	-0.404943	0.407589	-0.993508	0.3588

R-squared	0.747794	Mean dependent var	4.66E-15
Adjusted R-squared	0.327450	S.D. dependent var	5.427894
S.E. of regression	4.451371	Akaike info criterion	6.076965
Sum squared resid	118.8882	Schwarz criterion	6.616103
Log likelihood	-40.65420	Hannan-Quinn criter.	6.130556
F-statistic	1.779004	Durbin-Watson stat	1.368255
Prob(F-statistic)	0.248186		

Normality test

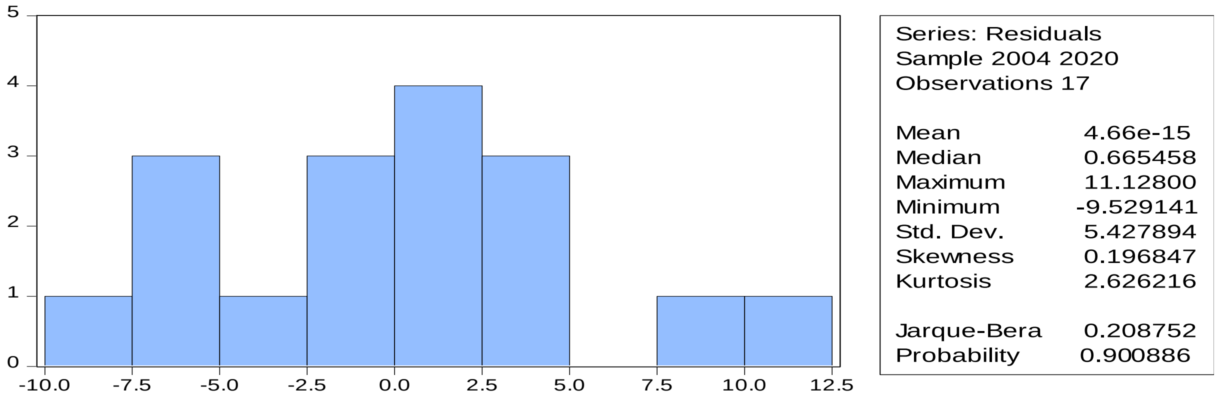

Figure 1

Heteros

Table 11

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.667477	Prob. F(5,11)	0.2227
Obs*R-squared	7.329613	Prob. Chi-Square(5)	0.1973
Scaled explained SS	2.495266	Prob. Chi-Square(5)	0.7772

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/01/22 Time: 08:16
Sample: 2004 2020
Included observations: 17

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.09720	127.3874	0.094964	0.9261
GDP_GROWTH(-1)	-2.180022	1.980467	-1.100762	0.2945
CO2_FUEL	0.066767	0.094341	0.707713	0.4938
CO2_FUEL(-1)	-0.100103	0.086225	-1.160954	0.2702
POPULATION	1.10E-05	5.36E-05	0.204252	0.8419
ECM(-1)	4.684982	2.233375	2.097714	0.0598

R-squared	0.431154	Mean dependent var	27.72898
Adjusted R-squared	0.172587	S.D. dependent var	36.44915
S.E. of regression	33.15496	Akaike info criterion	10.11083
Sum squared resid	12091.77	Schwarz criterion	10.40490
Log likelihood	-79.94202	Hannan-Quinn criter.	10.14006
F-statistic	1.667477	Durbin-Watson stat	2.125274
Prob(F-statistic)	0.222682		

Cusum

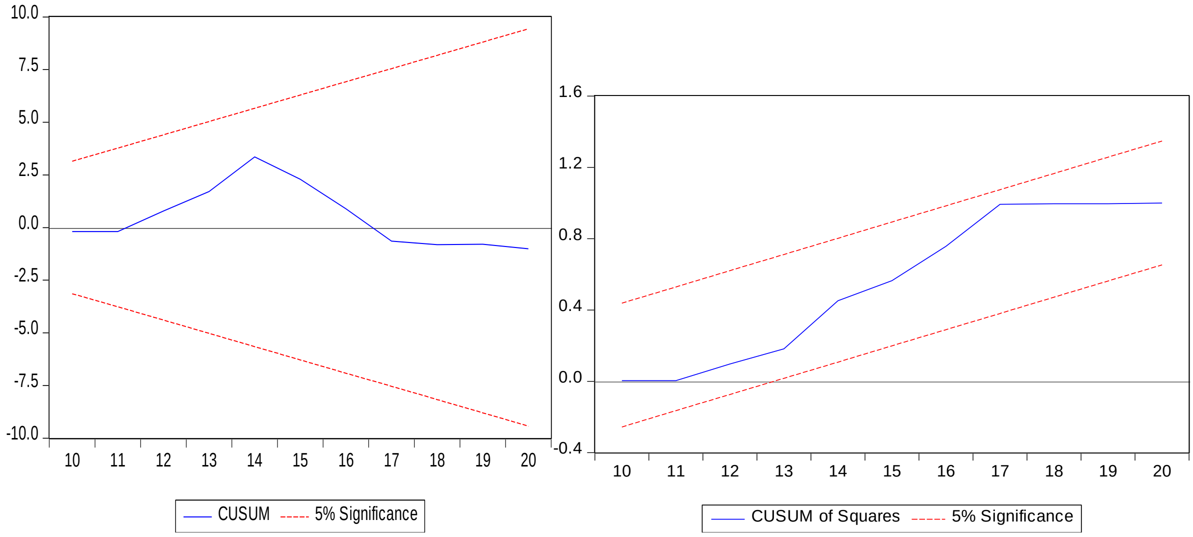

Figure 2

All the stability and diagnostic test shows that the model is stable

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