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Towards Environmental Sustainability: The Impact of External Debt and Government Expenditure on Carbon Emissions in Somalia

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ABSTRACT

This study aims to assess the effect of external debt and government expenditure on carbon emissions in Somalia. To do so, the study employed a rigorous econometric approaches such as autoregressive distributed lag model (ARDL), fully modified least square (FMOLS), and Dynamic least square (DOLS). Findings demonstrated that external debt (LNED) positively and significantly affects carbon emissions. Results revealed that a 1%, or a point increase of external debt, rises 0.29% into the emitted emissions. Moreover, the study found that the long-run coefficient of government expenditure (LNGE) positively correlates with emissions. However, a 1% increase in total government expenditure significantly increases CO_2 emissions by 0.05% in the long run. So, regarding the positive correlation between external debt, government expenditure, and carbon emissions, the study suggests that the government should strategically use its expenditures and external debt to fund environmentally sustainable projects. This approach aims to reduce carbon emissions while promoting sustainable development and balancing economic growth with ecological conservation.

Keywords: External Debt, Heavily Indebted Poor Countries, Carbon Emissions, Environmental Sustainability, and Autoregressive Distributed Lag Model

JEL Classifications: Q2, Q3, P1, P3

1. INTRODUCTION

In today's global landscape, the intricate relationship between external financial mechanisms and environmental sustainability has emerged as a critical focal point of concern, particularly for developing nations. Heavily indebted poor countries (HIPCs), including East African ones, rely extensively on external debt and foreign aid to support economic growth and development. This reliance shapes their economic trajectories, environmental policies, and sustainability efforts. In East Africa, foreign debt remains the primary source of foreign capital, contributing to the region's external debt reaching $102.25 billion by the end of 2017. This surge led to a significant increase in the debt-to-GDP ratio for East African nations, rising from 40.1% in 2014 to 51.9% by 2018. In Somalia, the external public debt was estimated at US$2.8 billion in 2017, owing primarily to 27 creditors. These creditors are categorized into the Paris Club group (53.8%), the multilateral group (32.8%), and the non-Paris Club group (13.4%). Key creditors include the United States (22%), Italy (13%), and France (9%), along with multilateral institutions such as the International Monetary Fund (7%) and the World Bank (11%). Noteworthy debt rescheduling and cancellations occurred, with Saudi Arabia rescheduling US$106 million in 2016 and China completely annulling Somalia's debt (Omar and Ibrahim, 2021; Warsame and Mohamed, 2024).

Government expenditure and external debt are equally critical in influencing environmental outcomes. Public spending decisions, especially in energy-intensive sectors like infrastructure, industrial development, and transportation, significantly contribute to a country's carbon footprint. In Somalia, as in many developing countries, government expenditure is often directed towards stimulating economic growth. However, without adequate attention to environmental sustainability, this can result in heightened energy consumption and increased carbon dioxide (CO_2) emissions. Focusing on rapid economic development often leads to investments in energy-intensive sectors, which are the primary drivers of rising carbon emissions (Boly et al., 2022; Warsame et al., 2023; Nor et al., 2024).

The close link between government expenditure and environmental degradation stems from how increased public spending fuels economic expansion and energy demand. In Somalia, where much of the energy is sourced from fossil fuels, this directly contributes to higher CO_2 emissions. Aligning government spending with sustainability goals is crucial to ensuring that economic growth does not come at the cost of environmental degradation. For instance, while infrastructure investments may drive economic progress, they must be accompanied by sustainable energy practices to minimize ecological harm (Akam et al., 2021; Warsame et al., 2024).

The challenge of balancing immediate economic needs with long-term sustainability is further compounded by external debt. Somalia's heavy reliance on external borrowing limits the government's capacity to prioritize environmental protection. With significant portions of government resources directed toward servicing debt, less funding is available for sustainable development projects, renewable energy investments, or climate change mitigation efforts. As a result, the country remains trapped in a cycle where debt-driven economic growth exacerbates environmental degradation, making the transition to greener alternatives more difficult (Akam et al., 2021; Warsame and Abdi, 2024).

The Environmental Kuznets Curve (EKC) theory offers a theoretical framework for understanding the relationship between economic development and environmental degradation. The EKC posits that environmental damage increases during the early stages of economic development, but after reaching a certain income level, environmental quality improves as countries invest in cleaner technologies. However, in the case of Somalia, high levels of external debt and limited fiscal capacity hinder the ability to reach this turning point, suggesting that without targeted interventions, Somalia may continue to experience rising carbon emissions despite its efforts at economic growth (Carrera and de la Vega, 2022).

Despite extensive studies on the relationship between external debt and carbon emissions (Bese et al., 2021a; Bese et al., 2021b; Warsame et al., 2023; Zhao and Liu, 2022; Xu et al., 2022; Boly et al., 2022; Carrera and de la Vega, 2022; Kartal, 2022), existing research remains inconclusive and lacks clear policy recommendations for addressing the environmental challenges posed by external debt. Many studies adopt a collective, cross-country approach, overlooking individual nations' specific economic and environmental dynamics. Furthermore, there is a lack of studies using time-series data to explore how external debt and government expenditure influence carbon emissions in particular countries like Somalia. This study aims to fill that gap by providing a country-specific analysis of Somalia's external debt, government expenditure, and their impacts on environmental sustainability, offering actionable policy recommendations to mitigate these environmental risks.

In light of these complexities, this study explores the dual impact of external debt and government expenditure on carbon emissions in Somalia. This research will analyze the interplay between these financial factors and their environmental effects using advanced econometric techniques such as ARDL, Granger causality, and FMOLS. The study aims to provide new insights into how fiscal policies, particularly in a developing country context, can either support or hinder efforts toward environmental sustainability.

The rest of this study is structured as follows: Section 2 summarizes the relevant literature, Section 3 outlines the materials and methods and the data used in our study, Section 4 offers findings and discussion, and finally, Section 5 portrays the conclusions and suggests policy implications.

2. LITERATURE REVIEW

As far as we know, the empirical studies on debt emissions are limited. This section will first present some recent findings about the impact of debt on emissions. Next, we will cite some relevant studies that investigated the effect of renewable energy on carbon emissions.

2.1. External Debt and Carbon Emissions

Carrera and de la Vega (2022) Found that external debt positively correlates to greenhouse gas emissions (GHG). Results showed that a 1% increase in external debt causes a 0.7% increase in greenhouse gas emissions. Similarly, Boly et al. (2022) investigated the nexuses of environmental debt. The findings revealed that public debt increases carbon emissions by 0.74% because of a 1% increase in public debt in the long run. Bese et al. (2021) examined the symmetric and asymmetric relationship between China's external debt and carbon emissions. Findings confirm that external debt and energy consumption positively and significantly affect economic growth. In addition, results demonstrated a positive linkage between growth and emissions. Akam et al. (2021) revealed that external debt increases the carbon emissions of heavily indebted poor countries, and economic growth mitigates environmental quality. An ARDL approach study by (Bese et al., 2021a) demonstrated a positive and significant effect of external emissions in India, such as emissions from carbon dioxide, methane emissions, and emissions from liquid and solid fuel consumption. They also confirmed an inverted U-relationship between methane emissions and economic development.

Beşe and Friday (2022a) found that external debt has a negative and insignificant effect on emissions from coal consumption in Turkey by employing an autoregressive distributed lag model (ARDL). Xu et al. (2022) applied bootstrap ARDL to measure the dynamic effect of external energy consumption and income on Turkey's environmental sustainability. The findings proved that external debt has both short- and long-term impacts on environmental quality. Nonetheless, it has been discovered that actual income and energy utilization have reduced environmental quality in both the short and long run. Beşe and Friday (2022b) found an inverted U-shaped relationship between external debt and carbon dioxide emissions using an autoregressive distributed lag model. Bachegour and Qafas (2023) analyzed the impact of external debt on the environment utilizing the ARDL model with a time series data span between 1984 and 2018. The findings revealed a significant negative effect of external debt on environmental pollution. In addition, results demonstrated the existence of a U-shaped Kuznets curve in Morocco.

2.2. Energy Consumption and Carbon Emissions

Nathaniel and Iheonu (2019) investigated the role of renewable and non-renewable energy consumption on carbon dioxide abatement in Africa. Findings revealed that the consumption of renewables reduces carbon emissions while the usage of non-renewables increases the amount of carbon emissions. Similarly, utilizing panel data between 1980 and 2012 in European Union (Dogan and Seker, 2016) found that renewable energy and trade improve environmental sustainability in terms of mitigating carbon emissions while fossil fuel energy consumption mitigates environmental quality. A study by Awodumi and Adewuyi (2020) showed that, apart from Algeria, the per capita consumption of natural gas and petroleum causes an unbalanced impact on economic growth and carbon emissions in oil-producing African countries.

Shafiei and Salim (2014) employed the STIRPAT model with a data span between 1980 and 2011 in OECD countries. Results showed that non-renewable energy consumption increases carbon emissions compared to renewable energy. Hadj (2021) examined the impact of biomass energy consumption on ecological footprint by utilizing NARDL. The findings demonstrated that an advantageous change in biomass utilization for energy can bring about a long-term and short-term decrease in the ecological footprint. Abbasi et al. (2022) used ARDL and Frequency Domain causality (FDC) to investigate the role of fossil fuel energy and renewable energy in China between 1980 and 2018. The findings conclude that renewable energy sources encourage reaching a sustainable environment and mitigating carbon emissions, and vice versa, for non-renewables.

3. MATERIALS AND METHODS

3.1. Econometric Methodology

Following the studies of (Bese et al., 2021; Zhao and Liu, 2022), this study employs an auto-regressive distributed lag model (ARDL), which was first proposed by Pesaran et al. (2001) to investigate the short-run and long-run association between association between external debt and carbon emissions in Somalis. ARDL is suitable for several reasons. First, due to the small sample size, it's the most appropriate technique to mobilize the dynamic relationship between the explained and explanatory indicators. Second, by nature, the ARDL approach provides consistent estimation methods and minimizes the serial correlation to the model. Without lagging long-run information, the system for error correction (ECM) can be generated by using a simple linear modification and utilized to integrate short-term adjustments with long-term equilibrium. Nevertheless, since the variables under discussion in this research characterized both I (1) and I (0), this study adopts the linear ARDL method. Thus, the original form of the study model will be as follows:

We specified the empirical model in the following functional form based on the current literature.

$$CO2= F\,(ED, REC, EG, GE) \tag{1}$$

Adding natural logarithm to the equation (1):

$$lnCO2_t = \beta_0 + \beta_1\, lnED_t + \beta_2\, lnREC_t + \beta_3\, lnRGDP_t + \beta_4\, lnGE_t + \varepsilon_t \tag{2}$$

Where 1, 2,…. 5 refer coefficients, and it is the residual, while CO_2 emissions mean CO_2, ED represents external Debt, REC stands for renewable energy consumption, RGDP shows economic growth, and GE means government expenditure.

Therefore, the RDL model is specified as follows:

$$\Delta lnCO2_t = \alpha_0 + \beta_1 lnCO2_T + \beta_2 lnED_t + \beta_3 lnREC_t + \beta_4 lnRGDP_t + \beta_5 lnGE_t + \sum_t^q \Delta\alpha_1 + lnCO2_t \sum_t^\rho \Delta\alpha_2 lnED_t + \sum_t^\rho \Delta\alpha_3 lnREC_t + \sum_t^\rho \Delta\alpha_4 lnRGDP_t + \sum_t^\rho \Delta\alpha_5 lnGE_t + \varepsilon_t \tag{3}$$

The Δ refers to the difference operator, β1-β5 are the long-run coefficients, and α are the short-run coefficients. P stands for the optimal lag of the independent variables, while q demonstrates the explained variable's optimal lag. Then, to investigate the long relationship between the variables, we employ the ARDL bund test. The ARDL bound test is based on two assumptions:

The null hypothesis: H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$, which states that all variables have no long-run relationship. Null hypothesis: H_0: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_5 \neq 0$, indicates that all variables have cointegrated in the long run. If the calculated F-statistics exceeds the upper bound with the critical value of 5%, we reject the null hypothesis; otherwise, we do not. If the computed F-statistics are below the upper bound with the essential value of 5%, we accept the null hypothesis; otherwise, we do not. Moreover, after establishing the long-run cointegration, the ECM model equation was generated as follows:

$$\Delta lnCO2_t = \sum_t^q \Delta\beta_1 lnC02_t + \sum_t^\rho \Delta\beta_2 lnED_t + \sum_t^\rho \Delta\beta_3 lnENC_t + \sum_t^\rho \Delta\beta_4 lnRGDP_t + \sum_t^\rho \Delta\beta_5 lnGE_t + \varphi ECT_t + \varepsilon_t \tag{4}$$

Φ measures the speed of adjustment that short-run estimations revert to the long-run equilibrium. Meanwhile, ECT refers to the error correction term.

3.2. Data Description

To analyze the impact of external debt and government expenditure on carbon emissions in Somalia, the study employed CO_2 emissions as the dependent variable, with external debt and government expenditure as independent variables, while renewable energy consumption (REC) and real GDP (RGDP) served as control variables. The data spans from 1990 to 2019, and details on the variables, acronyms, measurement units, and data sources can be found in Table 1 below.

4. EMPIRICAL RESULTS AND DISCUSSION

4.1. Descriptive Analysis

A detailed explanation of the primary variables is traced out. Table 2 depicts the summary statistics of variables, which shows that all mean values of variables are higher than their dispersion except CO_2. The mean value and standard deviation of $LNCO_2$ emission are −2.800411 and 0.274249, respectively. The maximum and minimum values of LNED are 15.54208 and 14.62404. REC has 4.527952 average values, whereas the mean value of LNRGDP is 21.77692. The standard deviation of LNRGDP is 0.452924, whereas the central value for LNGE is 18.93595, with a standard deviation of 0.52571.

Moreover, the correlation results in Table 2 also reveal that all explanatory variables are negatively correlated to carbon emissions.

Table 1: Description of the variables

Variables	Acronyms	Measurement unit	Sources
Carbon dioxide emissions	CO_2	Metric tons per capita	WDI
External debt stocks	ED	DOD, current US dollar	SESRIC
Renewable energy	REC	% total energy consumption	WDI
Economic growth	RGDP	constant, 2015 US$	WDI
Government expenditure	GE	Constant 2015 Prices	SESRIC

4.2. Lag Criteria Selection

selection of an appropriate lag length is a vital step in econometric analysis. Concerning that, we utilized Akaike information criteria (AIC) to select an appropriate lag length that could help measure the dynamic relationships between the interested indicators (Figure 1).

4.3. Unit Root Test

In time series analysis, the first step is determining the series' properties by defining their degree of integration. The ARDL model requires that the variable have mixed integration I (0) and I (1). Specifically, the dependent variable should be I (1), while the other can be both. Moreover, ARDL estimation is no longer applicable if a variable integrates I (2). For this purpose, we employed the Augmented Dickey Fuller (ADF) and Philip Pearson (PP) unit root tests. The ADF and PP tests declared that some variables are stationary at I (0) while others are stationary at I (1) (Table 3). Moreover, none of the study variables have integrated I (2). So, ARDL is the most suitable model in our study.

4.5. Cointegration Analysis

The study performed a bound test cointegration to test the long-run cointegration of the selected variables and make a decision about continuing the ARDL model and emphasizing its applicability. To do that, we compared the obtained F-statistics value to the upper bound I (1) and lower bound I (0) results with critical value adjusted a variety of selected significance levels. The finding in the Table 4 confirmed a long-run cointegration since the calculated F-statistics (34.13562) exceeds its corresponding upper bound value (4.01) within a critical value of 5%

4.6. ARDL Short Run and Long Run Analysis

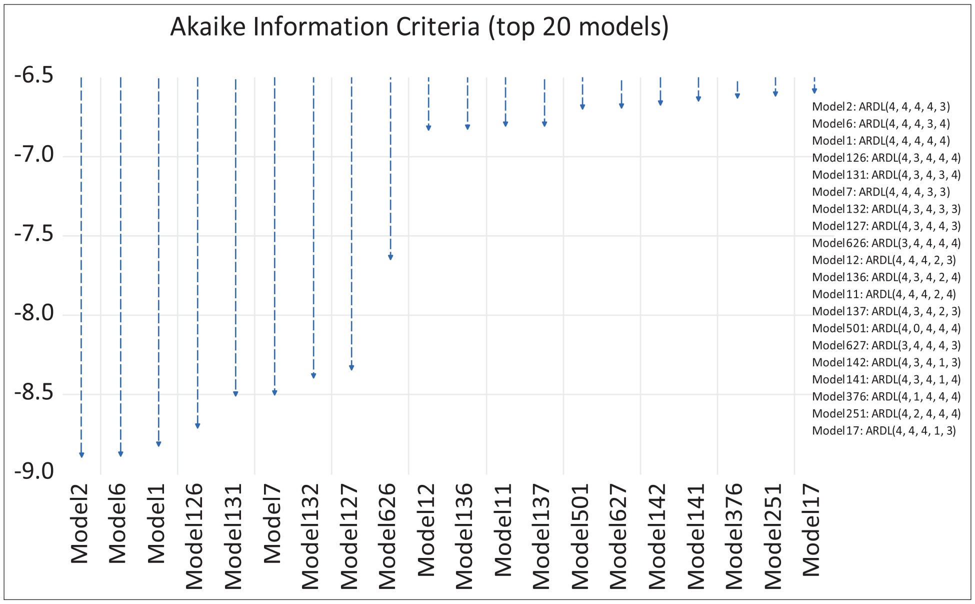
The study performed a bound test cointegration to test the long-run cointegration of the selected variables and make a decision about continuing the ARDL model and emphasizing its applicability. To do that, we compared the obtained F-statistics value to the upper bound I (1) and lower bound I (0) results with critical value adjusted a variety of selected significance levels. The finding confirmed a long-run cointegration since the calculated F-statistics (34.13562) exceeds its corresponding upper bound value (4.01) within a critical value of 5%.

Table 2: Descriptive analysis

Variables	Mean	Median	Maximum	Minimum	Std.Dev.
$LNCO_2$	−2.800411	−2.882873	−2.246348	−3.150603	0.274249
LNED	14.84088	14.82840	15.54208	14.62404	0.205157
LNREC	4.527952	4.535499	4.554193	4.468241	0.023374
LNRGDP	21.77692	21.72747	22.58962	21.14602	0.452924
LNGE	18.93595	18.72332	20.13133	18.44792	0.52571
Correlation matrix					
Variables	**LNCO2**	**LNED**	**LNREC**	**LNRGDP**	**LNTO**
$LNCO_2$	1				
LNED	−0.623245	1			
LNREC	−0.985269	0.582419	1		
LNRGDP	−0.813946	0.709623	0.764034	1	
LNTO	−0.606118	0.70940	0.551354	0.873774	1

Source: Author's calculations, 2023. REC: Renewable energy consumption, ED: External debt, RGDP: Real gross domestic product, SD: Standard deviation

Figure 1: Akaike information criteria



Source: Authors' calculations, 2023

Table 3: Unit root test

Variable	ADF unit root test			
	Intercept		Intercept+Trend	
	Level	1st difference	Level	1st difference
$LNCO_2$	−2.21912	−2.1599	−4.1546**	−2.4440
LED	0.0653	−5.0343***	−3.3052*	−5.2937***
LNEC	−4.6965***	−3.1205**	−3.4186*	−3.8252**
LNRGDP	1.2184	−2.8635*	−2.3998	−3.4344*
LNGE	−1.6133	−2.4564	−0.4554	−3.3213*
Variable	**PP unit root test**			
	Intercept		Intercept+Trend	
	Level	1st difference	Level	1st difference
$LNCO_2$	−1.9006	−3.0933**	−1.3495	−3.5475*
LED	0.1216	−5.0313***	−1.4573	−5.2944***
LNEC	−4.4833***	−2.9930**	−2.9176	−3.8387**
LNRGDP	1.1744	−4.7675***	−2.4214	−5.3026***
LNGE	−1.6025	−2.4562	−1.4266	−38603**

***, **, and * refer to the significance level at 1%, 5% and 10% respectively. Source: Author's calculations, 2023. ADF: Augmented Dickey Fuller, PP: Philip Pearson, REC: Renewable energy consumption, ED: External debt, RGDP: Real gross domestic product

Table 4: Bound F-test for cointegration

Dependent variable: $LNCO_2$		
Independent variables: LNED, LNREC, LNGDP, LNGE		
F-statistics calculated: 34.13562		
Critical value	Lower bound value I (0)	Upper bound value I (1)
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Source: Author's calculations, 2023. REC: Renewable energy consumption, ED: External debt, RGDP: Real gross domestic product

The most imperative results of the study are in Tables 5 and 6. To begin with, the long-run estimations in Table 6. Show that external debt (LNED) has a positive and significant effect on

Table 5: Autoregressive distributed lag short run results

Variable	Coefficient	SE	T-statistics	P-value
D (LNED)	0.001432	0.007431	0.192726	0.8650
D (LNREC)	−22.46655***	0.631045	−35.60213	0.0008
D (LNRGDP)	−0.965739***	0.053630	−18.00749	0.0031
D (LNGE)	1.511581***	0.060646	24.92478	0.0016
ECT (t−1)	−7.230374***	0.319528	−22.62833	0.0019

***, **, and * indicate to the significance level at 1%, 5% and 10% respectively. Source: Authors' calculations, 2023. SE: Standard error, REC: Renewable energy consumption, ED: External debt, RGDP: Real gross domestic product

Table 6: Autoregressive distributed lag long run estimations

Variable	Coefficient	SE	T-statistics	P-value
LNED	0.292143**	0.040117	7.282256	0.0183
LNREC	−13.12917***	0.304317	−43.14309	0.0005
LNRGDP	−0.186869***	0.012210	−15.30453	0.0042
LNGE	0.058833**	0.007949	7.401474	0.0178

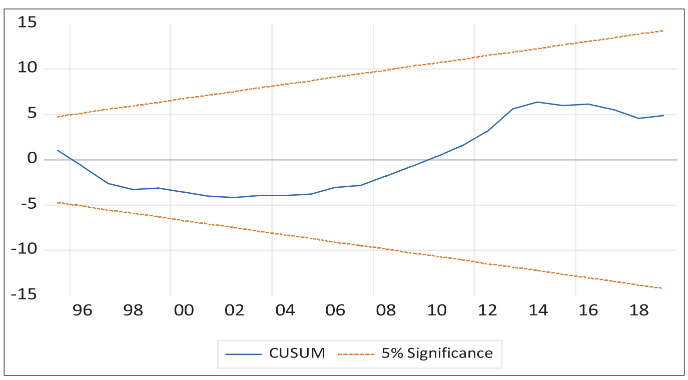
***, **, and * denote the significance level at 1%, 5%, and 10% respectively. Source: Author's calculations, 2023. SE: Standard error, REC: Renewable energy consumption, ED: External debt, RGDP: Real gross domestic product

carbon emissions. Results revealed that a 1%, a point increase of external debt rises 0.29% into the emitted emissions in Somalia. This finding aligns with the conclusions of (Bese et al., 2021b; Bese et al., 2021a; Zhao and Liu, 2022; Xu et al., 2022; Boly et al., 2022; and Carrera and de la Vega, 2022). In contrast, the estimation of renewable energy consumption shows that it has a negative linkage to carbon emissions. Findings demonstrated that a 1% increase in the utilization of renewable energy sources improves the environment by declining −13.12% of the emissions released into the ecology. This finding in line with results of (Asongu et al., 2019; Adams and Acheampong, 2019; Zafar et al., 2020; Zheng et al., 2021; Abbasi et al., 2022; Shafiei and Salim, 2014; Awodumi and Adewuyi, 2020; Nathaniel and Iheonu, 2019), and (Dogan and Seker, 2016). Moreover, consistent with the findings of (Warsame, 2022), economic growth brings positive environmental sustainability in the long run. A 1% increase in economic growth

(LNRGDP) reduces 0.96% of carbon emissions in the long run. This confirms the assumption of EKC theory, which believes that income growth leads environmental pollution at the first stage. After reaching a high point of income growth, the extra income will be used to re-innovate environmental initiatives in the long term. Moreover, disagreeing (Jin et al., 2022; Adewuyi, 2016 and Halkos and Paizanos, 2013), we also noted that the long-run coefficient of government expenditure (LNGE) has a positive correlation to the emissions. However, a 1% increase in total government expenditure significantly increases CO_2 emissions by 0.05% in the long run.

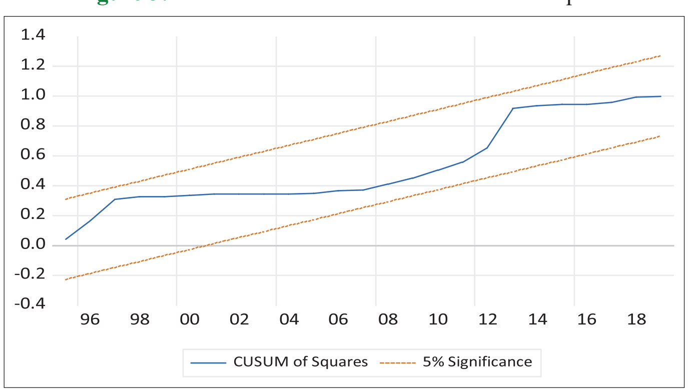
The short-term results show that CO_2 emissions are positively influenced by external debt (ED) and government expenditure (GE). However, CO_2 emissions are negatively affected by renewable energy consumption (REC) and real gross domestic product (RGDP), with both being statistically significant at the 1% level between 1990 and 2019. While ED shows a positive relationship with CO_2 emissions, its impact is not statistically significant in the short term during this period.

Figure 2: Cumulative sum of recursive residuals



Source: Authors' calculations, 2023

Figure 3: Cumulative sum of recursive residuals square



Source: Authors' calculations, 2023

Table 7: Parameter stability

Diagnostic test	F-statistics	P-value
Breusch-Godfrey serial correlation	8.026497	0.879601
Heteroskedasticity	0.796828	0.6961
Jarque-Bera normality test	0.082937	0.959379

Source: Author's calculations, 2023

Table 8: Dynamic least square

Variable	Coefficient
LNED	0.064515 (0.430437)*
LNREC	−13.12564 (−15.11598) ***
LNRGDP	−0.102810 (−2.512725) **
LNGE	0.032892 (1.281794)
C	5.30405 (17.94770) ***

***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. Source: Author's calculations, 2023. REC: Renewable energy consumption, ED: External debt, RGDP: Real gross domestic product

Table 9: Fully modified least square

Variable	Coefficient
LNED	0.037763 (−4.187504) ***
LNREC	−10.43346 (29.25801) ***
LNRGDP	−0.073007 (−2.656943) **
LNGE	0.008260 (0.426748)
C	46.43692 (34.99248) ***

***, **, and * indicate the significance level at 1%, 5%, and 10% respectively. Source: Author's calculations, 2023. REC: Renewable energy consumption, ED: External debt, RGDP: Real gross domestic product

Table 10: Granger causality

Null hypothesis	Observation	F-statistic	P-value
LNED does not granger cause $LNCO_2$	28	0.00132	0.2973
$LNCO_2$ does not granger cause LNED		1.86058	0.1783
LNREC does not granger cause $LNCO_2$	28	3.29765	0.0551
$LNCO_2$ does not granger cause LNREC		0.54235	0.5886
LNRGDP does not granger cause $LNCO_2$	28	0.30088	0.7430
$LNCO_2$ does not granger cause LNRGDP		5.97151	0.0082
LNGE does not granger cause $LNCO_2$	28	0.86691	0.4335
$LNCO_2$ does not granger cause LNGE		2.35559	0.1173
LNREC does not granger cause LNED	28	1.46944	0.2509
LNED does not granger cause LNREC		1.92146	0.1692
LNRGDP does not granger cause LNED	28	5.07589	0.0149
LNED does not granger cause LNRGDP		1.14898	0.3345
LNGE does not granger cause LNED	28	5.51911	0.0110
LNED does not granger cause LNGE		6.78052	0.0048
LNRGDP does not granger cause LNREC	28	1.05745	0.3636
LNREC does not granger cause LNRGDP		5.33129	0.0125
LNGE does not granger cause LNREC	28	0.88603	0.4259
LNREC does not granger cause LNGE		3.86769	0.0356
LNGE does not granger cause LNRGDP	28	1.99736	0.1585
LNRGDP does not granger cause LNGE		3.73932	0.0393

Source: Author's calculations, 2023. REC: Renewable energy consumption, ED: External debt, RGDP: Real gross domestic product

Furthermore, the error correction term (ECT) is negative (−7.230374) and statistically significant at 1% level. Which ensures a mechanism of error correction and return of CO_2 to the equilibrium in the long term and long run cointegration between the variables. This vital significance underscores the credibility and applicability of the policy suggestions proposed in this study.

Finally, we conducted various tests to validate the accuracy of the model's outcomes. According to Table 7, the suggested model doesn't exhibit serial correlation, normality concerns, or heteroscedasticity effects in disturbances. Additionally, to ensure the reliability of our findings and assess the stability of short- and long-term parameters in the cointegrating equation, we employed cumulative sum of recursive residuals (CUSUM) and CUSUM of squares tests (depicted in Figures 2 and 3). These figures indicate that the curve remains within the critical range at a 5% significance level, signifying the stability of the ARDL model utilized in this study.

4.7. Robustness Check

To make sure our predictions about the long-term effects were right, we used other ways to test them. These methods, like fully modified least square (FMOLS) and Dynamic least square (DLS), showed that LNRE and LNRGDP significantly and positively impact $LNCO_2$ over the long run (Tables 8 and 9). Similar to the previous long-run estimations, LNED positively related to carbon emissions. On the other hand, LNGE was linked to more carbon emissions. All in all, these findings support what our ARDL model predicted for the long term.

4.8. Causality Test

We performed the Granger causality test to ascertain the direction of the causality between the models. The findings of (Table 10) first revealed that none of the variables have bi-directional causes except LNED and LNGE. In addition, a unidirectional correlation from LNED to $LNCO_2$, LNREC to $LNCO_2$, $LNCO_2$ to LNRGDP, LNRGDP to LNED, LNREC to LNRGDP, LNREC to LNGE, and LNRGDP to LNGE.

5. CONCLUSIONS AND POLICY IMPLICATIONS

Many countries in Sub-Saharan Africa, known as heavily indebted poor countries (HIPC), rely on funds they borrow from other countries and assistance from outside to keep their economies going. They owe a lot of money to other countries. At the same time, they also get different kinds of financial help from one country to another, like loans, gifts, and specific support from various groups, including governments and organizations that aren't part of the government (Dritsakis et al., 2006).

This paper examines the impact of external debt and government expenditure on carbon emissions in Somalia. The study employed an autoregressive distributed lag model (ARDL) with time series data between 1990 and 2019. Findings revealed that external and government expenditure elevate carbon emissions in the long run. On the other hand, renewable energy has a long-term negative linkage to CO_2 emissions at a 1% significance level respectively. Moreover, empirical evidence presents a bidirectional causality between external debt and government expenditure. Meanwhile, unidirectional associations range from renewable energy consumption and external debt to CO_2 emissions in Somalia.

Following our empirical findings, the study presents the following policy implications: Regarding the positive correlation between external debt and carbon emissions, it's important to strategically manage borrowed funds by exploring alternative funding sources that have a lower environmental impact, which would make sure to align with sustainable development objectives. Moreover, exploring innovative mechanisms enabling debt restructuring in exchange for investments in eco-friendly initiatives can significantly mitigate carbon emissions, fostering a more sustainable financial landscape.

Additionally, the research proposes that Somalia should promote increased utilization of renewable energy sources. Policymakers should pivot the growth paradigm and ecological strategies to embrace the concept of decoupling, aiming to reduce carbon emissions without adversely affecting economic growth.

REFERENCES

Abbasi, K.R., Shahbaz, M., Zhang, J., Irfan, M., Alvarado, R. (2022), Analyze the environmental sustainability factors of China: The role of fossil fuel and renewable energy. Renewable Energy, 187, 390-402.

Adams, S., Acheampong, A.O. (2019), Reducing carbon emissions: The role of renewable energy and democracy. Journal of Cleaner Production, 240, 118245.

Adewuyi, A.O. (2016), Effects of public and private expenditures on environmental pollution: A dynamic heterogeneous panel data analysis. Renewable and Sustainable Energy Reviews, 65, 489-506.

Akam, D., Owolabi, O., Nathaniel, S.P. (2021), Linking external debt and renewable energy to environmental sustainability in heavily indebted poor countries: New insights from advanced panel estimators. Environmental Science and Pollution Research, 28(46), 65300-65312.

Asongu, S.A., Iheonu, C.O., Odo, K.O. (2019), The conditional relationship between renewable energy and environmental quality in sub-Saharan Africa. Environmental Science and Pollution Research, 26(36), 36993-37000.

Awodumi, O.B., Adewuyi, A.O. (2020), The role of non-renewable energy consumption in economic growth and carbon emission: Evidence from oil producing economies in Africa. Energy Strategy Reviews, 27, 100434.

Bachegour, H., Qafas, A. (2023), Does external debt Worsen environmental pollution? Evidence from Morocco. International Journal of Energy Economics and Policy, 13(2), 68-76.

Beşe, E., Friday, H.S. (2022a), The effect of external debt on emissions from coal consumption: Evidence from Turkey. International Journal of Energy Economics and Policy, 12(5), 515-518.

Beşe, E., Friday, H.S. (2022b), The relationship between external debt and emissions and ecological footprint through economic growth: Turkey. Cogent Economics and Finance, 10(1), 2063525.

Bese, E., Friday, H.S., Ozden, C. (2021a), Is India financing its emissions through external debt? International Journal of Energy Economics and Policy, 11(6), 170-179.

Bese, E., Friday, H.S., Ozden, C. (2021b), The effect of external debt on emissions: Evidence from China. International Journal of Energy Economics and Policy, 11(1), 440-447.

Boly, M., Combes, J.L., Menuet, M., Minea, A., Motel, P.C., Villieu, P. (2022), Can public debt mitigate environmental debt? Theory and empirical evidence. Energy Economics, 111, 105895.

Carrera, J., de la Vega, P. (2022), The Effect of External Debt on Greenhouse Gas Emissions. Available from: https://arxiv.org/abs/2206.01840

Dogan, E., Seker, F. (2016), Determinants of CO_2 emissions in the European Union: The role of renewable and non-renewable energy. Renewable Energy, 94, 429-439.

Hadj, T.B. (2021), Nonlinear impact of biomass energy consumption on ecological footprint in a fossil fuel-dependent economy. Environmental Science and Pollution Research, 28(48), 69329-69342.

Halkos, G.E., Paizanos, E.A. (2013), The effect of government expenditure on the environment: An empirical investigation. Ecological Economics, 91, 48-56.

Jin, Y., Tang, Y.M., Chau, K.Y., Abbas, M. (2022), How government expenditure Mitigates emissions: A step towards sustainable green economy in belt and road initiatives project. Journal of Environmental Management, 303, 113967.

Kartal, M.T. (2022), The role of consumption of energy, fossil sources, nuclear energy, and renewable energy on environmental degradation in top-five carbon producing countries. Renewable Energy, 184, 871-880.

Nathaniel, S.P., Iheonu, C.O. (2019), Carbon dioxide abatement in Africa: The role of renewable and non-renewable energy consumption. Science of the Total Environment, 679, 337-345.

Nor, B.A., Yusof, Y., Warsame, Z.A. (2024), Exploring the potential for renewable energy consumption in reducing environmental degradation in Somalia. International Journal of Energy Economics and Policy, 14(5), 643-650.

Omar, Z.M., Ibrahim, M.I. (2021), Determinants of external debt: The case of Somalia. Asian Development Policy Review, 9(1), 33-43.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics, 16(3), 289-326.

Shafiei, S., Salim, R.A. (2014), Non-renewable and renewable energy consumption and CO_2 emissions in OECD countries: A comparative analysis. Energy Policy, 66, 547-556.

Warsame, Z.A. (2022), The significance of FDI inflow and renewable energy consumption in mitigating environmental degradation in Somalia. International Journal of Energy Economics and Policy, 13(1), 443-453.

Warsame, Z.A., Ali Mohamed, I.S. (2024), On the determinants of unemployment in Somalia: What is the role of external debt? International Journal of Sustainable Development and Planning, 19(1), 190114.

Warsame, Z.A., Ali, M.M., Mohamed, L.B., Mohamed, F.H. (2023), The Causal relation between energy consumption, carbon dioxide emissions, and macroeconomic variables in Somalia. International Journal of Energy Economics and Policy, 13(3), 102-110.

Warsame, Z.A., Hassan, A.M., Hassan, A.Y. (2023), Determinants of inflation in Somalia: An ARDL approach. International Journal of Sustainable Development and Planning, 18(9), 2811-2817.

Warsame, Z.A., Mohamed, F.H., Hassan, M.G., Hassan, A.M., Mohamud, M.H., Nor, B.A. (2024), Evaluating the global research landscape on renewable energies in the context of climate change: A bibliometric analysis. International Journal of Design & Nature and Ecodynamics, 19(4), 1309-1316.

Warsame, Z.A., Abdi, A.O. (2024), Impact of external debt and energy consumption on environmental quality in Somalia. International Journal of Energy Economics and Policy, 14(5), 520-526.

Xu, W., Jahanger, A., Inuwa, N., Samour, A., Ibrahim, S.S. (2022), Testing the impact of external sovereign debt on Turkey's ecological footprint: New evidence from the bootstrap ARDL approach. Frontiers in Environmental Science, 10, 1010534.

Zafar, M.W., Shahbaz, M., Sinha, A., Sengupta, T., Qin, Q. (2020), How renewable energy consumption contribute to environmental quality? The role of education in OECD countries. Journal of Cleaner Production, 268, 122149.

Zhao, T., Liu, Z. (2022), Drivers of CO_2 emissions: A debt perspective. International Journal of Environmental Research and Public Health, 19(3), 9031847.

Zheng, H., Song, M., Shen, Z. (2021), The evolution of renewable energy and its impact on carbon reduction in China. Energy, 237, 121639.