Testing Environmental Kuznets Curve Hypothesis in Somalia: Empirical Evidence from ARDL Technique

Article *in* International Journal of Energy Economics and Policy · September 2023

DOI: 10.32479/ijeep.14590

2 authors:

Hassan Abdikadir Hussein
SIMAD University

Abdimalik Ali Warsame
SIMAD University

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(5), 678-684.

Testing Environmental Kuznets Curve Hypothesis in Somalia: Empirical Evidence from ARDL Technique

Hassan Abdikadir Hussein[1]*, Abdimalik Ali Warsame[2]

[1]Faculty of Management Science, SIMAD University, Mogadishu, Somalia, [2]Faculty of Economics, SIMAD University, Mogadishu, Somalia. *Email: amalow499@simad.edu.so

Received: 29 April 2023 **Accepted:** 13 August 2023 **DOI:** https://doi.org/10.32479/ijeep.14590

ABSTRACT

Economic growth is typically considered as the fundamental cause of environmental problems due to higher production which generates more pollution. The Environmental Kuznets Curve (EKC) hypothesis is used to test the link between economic growth and environmental pollution. In this regard, this study aims to ascertain the validity of the EKC hypothesis in Somalia using time series data spanning 1989-2020 in Somalia. The autoregressive distributed lag (ARDL) technique is applied to verify the presence of EKC and cointegrations between the sampled variables. According to the empirical result, it was revealed that all the regressors are statistically significant except trade openness. Agriculture production and squared economic growth are negatively related to environmental pollution whereas economic growth significantly impedes environmental quality in Somalia. Hence, an inverted U-shaped relation between growth and pollution has been found confirming the EKC hypothesis. In contrast, both economic growth and squared growth Granger cause environmental pollution but not vice versa. Policymakers should develop environmental policies to help reduce emissions by promoting and investing in cleaner energy resources to improve Somalia's economy's overall energy efficiency to achieve economic and environmental/sustainability.

Keywords: EKC Hypothesis, Carbon Dioxide Emissions, Economic Growth, ARDL, Somalia
JEL Classifications: C32, O44, O55, Q53

1. INTRODUCTION

Environmental degradation is currently one of the major concerns facing worldwide. It adversely affects the economy, labor productivity, air quality, and natural resources. The driving force of environmental harm is the global rising trend in CO_2 emissions, which is linked to rising energy consumption. In addition, economic development and environmental protection are the two most pressing concerns facing humanity. However, due to the impacts of climate change which is primarily brought on by greenhouse gas emissions (GHG), the environment has recently been a key concern for both developed and developing countries (Aye and Edoja, 2017). Environmental deterioration is a vital sign of industrialization, which is the fundamental force behind economic growth.

Moreover, the rate of economic development in every country is influenced by a wide range of factors such as energy consumption and industrialization (Warsame, 2022a). To stimulate a rapid rate of growth, several economies have used development strategies based on the distinctive traits of each country and its natural resources which are available. Economic growth may harm the environment in several ways, such as pollution, overuse of natural resources, habitat destruction, degradation, and climate change (Warsame et al., 2022). These are the key issues that many countries have been coping with.

Apart from the global, Africa is a sensitive continent that climate change is affecting in all aspects with a rise in temperature of 1.5°C. Moreover, Africa has historically and currently contributed <3% of global emissions. Since the negligible contribution to global emissions, Africa is experiencing severe climatic consequences which are posing risks to its economies, agriculture, infrastructure projects, public health, water and food systems, and livelihoods (African Development Bank, 2021). Furthermore, understanding climate change is one of the main issues that African countries are currently dealing with. A thorough understanding of the situation in Africa is significant because it has been claimed that severe conflicts are a direct result of climate change (Warsame et al., 2023).

Somalia is very susceptible to climate change in its agricultural, terrestrial, and coastal areas. From 2019 to 2021, on average 6 million Somalis experienced flooding and drought which hampered GDP growth and made poverty and income inequality worse (Warsame, 2022b; Warsame et al., 2023). In addition, Somalia still faces challenges connected to a poor political structure, conflict, extreme poverty, and shocks from climate change. The country is disproportionately impacted by climate change while having little history or current culpability for it (African Development Bank, 2021).

The country now emits <0.03% of the world's GHGs. Agriculture, forest, and land use are the three sectors that contribute most to its emissions (Warsame et al., 2023). Somalia is dedicated to following a path toward sustainable development consequently. In line with the updated nationally determined contributions (NDC) report, Somalia has established the objectives of reducing emissions by 30% by 2030 compared to the 107.39 $MtCO_2$ equivalent. The country's low emissions development pathway is reflected in the carbon reduction goals through the implementation of policies, programs, and technology. The implementation of the mitigation aim will need international private and public backing, particularly financial and investment support, technological development and transfer, and capacity building (Coban et al., 2022). Therefore, accounting for the impact of economic growth on environmental sustainability is very significant (The Federal Republic of Somalia, 2021).

One way for assessing the efficiency of environmental policy is the EKC test. The EKC hypothesis is frequently used to investigate the relationship between economic growth and environmental pollution (Grossman and Krueger, 1991). The EKC theory explores the connection between environmental deterioration and economic growth in a way of an inverted U-shape. This theory states that environmental pollution rises during the initial stages of economic growth. This is due to factors such as low levels of environmental awareness, insufficient financing for environmental protection, and a lack of modern technology to reduce environmental pollution. Nevertheless, after a certain level of growth, for a variety of factors, environmental degradation begins to decrease and environmental quality tends to improve simultaneously with economic growth because of the raising awareness of environmental issues, advancing production technologies, moving toward environmentally friendly technologies, and establishing and upholding environmental protection laws and regulations.

Regarding the importance of the effects of economic growth, trade openness, and agricultural production on the environment, the purpose of this study is to evaluate the existence of the EKC hypothesis in Somalia from 1989 to 2019. Moreover, the study incorporates agriculture production and trade openness as control variables. Even though these associations have been examined in a variety of time series and panel studies (Al-Mulali et al., 2015; Al-Mulali et al., 2016; Murshed et al., 2021; Salari et al., 2021; Warsame et al., 2022). As far as the authors' knowledge, no research has been done to ascertain these causal links in the context of Somalia, a nation that may be crucial for such an analysis. The present work tries to bridge this gap.

2. LITERATURE REVIEW

The consequences of environmental pollution and its economic implications are extensively debated in the literature. The link between economic growth and emissions is examined using the well-known EKC hypothesis. The EKC remains the most prominent hypothesis for explaining the connection between rapid economic growth and environmental pollution (Grossman and Krueger, 1991). According to this theory, a country's initial level of growth is characterized by a positive correlation among these variables; once a country has reached a certain level of growth and is equipped with efficient technology, emissions start to decline along with GDP growth. This implies an inverted U-shaped connection between economic growth and environmental pollution.

Table 1 provides an overview of the selected literature. The validity of the EKC theory has been investigated in several studies, which state that environmental pollution gradually declines as a country's economic growth rises. Some studies that supported the validity of the EKC hypothesis include (Liu et al., 2019; Olale et al., 2018; Salari et al., 2021, Murshed et al., 2021; Sarkodie and Ozturk, 2020) in the China, Canada, U.S, Bangladesh, and Kenya respectively. In contrast, Al-Mulali et al., (2015), Al-Mulali et al., (2016); and Warsame et al., (2022) in Vietnam, Kenya, and Somalia respectively have rejected the validity of EKC. The blended findings between growth and pollution could be explained by the various data applied, and econometric approaches to analyze various nations and regions. Furthermore, a variety of factors were utilized as environmental degradation measures, such as ecological footprint, CO_2, and deforestation.

To the best of our knowledge, so far there is only one study conducted in Somalia (Warsame et al., 2022) that has tested the existence of the EKC test in Somalia using deforestation as a measurement for environmental degradation. They reported no evidence for the EKC existence in Somalia. This study adds to the body of literature by investigating the EKC hypothesis' validity in Somalia using CO_2 emissions as a measure of environmental degradation. In addition, this paper enhances the global discussion on climate change and its implications in the Somalia context and serves as a policy document for upcoming national planning and policies on mitigating climate change. Several studies within the existing literature provide inconsistent findings of the validity of the EKC hypothesis. This indicates the need for more research on this subject in other countries. Therefore, this research explores the existence of the validity of the EKC hypothesis in Somalia where no study has been done on this theme using CO_2 emissions as an environmental quality proxy.

Table 1: Environmental Kuznets curve literature table

Author (s)	Country (ies)	Period	Method	Results
Olale et al. (2018)	Canada	1990-2014	Pooled regression and fixed-effects regression	Supported the EKC hypothesis
Salari et al. (2021)	U. S	1997-2016	Static (OLS and fixed effect) and dynamic (GMM) estimation model	Supported the EKC hypothesis.
Liu et al. (2019)	China	1996-2015	Fixed effects panel data partially linear additive model,	Supported the EKC hypothesis
Boubellouta and Kusch-Brandt, (2020)	30European countries (EU28+2)	2000-2016	GMM	Supported the EKC hypothesis
Ozatac et al. (2017)	Turkey	1960-2013	ARDL	Supported the EKC hypothesis
Egbetokun et al. (2020)	Nigeria	1970-2017	ARDL	Supported the EKC hypothesis
Adzawla et al. (2019)	Sub-Saharan Africa	1970-2012	Vector Autoregressive and an Ordinary Least Square regression	Supported the EKC hypothesis
Al-Mulali et al. (2016)	Kenya	1980-2012	ARDL	Not supported the EKC hypothesis
Yilanci and Pata (2020)	China	1965-2016	ARDL	Not supported the EKC hypothesis
Murshed et al. (2021)	South Asian countries	1990-2016	panel regression analysis	Validated EKC hypothesis for Bangladesh, India, and Sri Lanka but not for Pakistan
Murshed et al. (2021)	Bangladesh	1980-2015	ARDL	supported the EKC hypothesis
Sarkodie and Ozturk (2020)	Kenya	1971-2013	ARDL and Utest estimation	Supported the EKC hypothesis
Baek (2015)	Nuclear generating countries	1980-2009	Pedroni and Kao cointegration, FMOLS, dynamic OLS (DOLS)	Not supported the EKC hypothesis
Al-Mulali et al. (2015)	Vietnam	1981-2011	ARDL bounds testing and vector error correction model (VECM) Granger causality	Not supported the EKC hypothesis
Warsame et al. (2022)	Somalia	1990-2017	ARDL	Not supported the EKC hypothesis

3. MATERIALS AND METHODS

3.1. Data Sources and Descriptions

Economic growth is typically attributed as the fundamental cause of environmental issues due to higher production which generates more pollution. The relationship between economic growth and CO_2 emissions is examined using the EKC theory. Ample studies have investigated these connections. However, this study aims to ascertain the validity of the EKC hypothesis in Somalia using time series data spanning 1989-2020. The sample period of the data is determined by the data's availability. All data are sourced from the World Bank and SESRIC. Environmental pollution, economic growth, trade openness, and agricultural production are the sampled variables of the study. To remove heteroskedasticity, natural logarithm transformations were conducted for all variables. So far, several variables have been employed to measure environmental degradation such as GHG, deforestation, and other indicators. In this study, environmental quality is measured using Somalia's CO_2 emission levels. The environmental quality is seen to be negatively impacted by an increase in CO_2 emissions, whereas the environmental quality is found to be positively impacted by a decrease in CO_2 emissions.

Trade openness and agricultural production are considered a significant role in rising CO_2 emissions (Hussein et al., 2023; Balsalobre-Lorente et al., 2018) Therefore, trade openness and agricultural production are used as control variables to consider their impacts on environmental pollution. All variables were used to construct natural logarithms. Table 2 provides the data and its sources while Figure 1 shows the trends of the sampled variables.

Table 2: Data sources and description

Variable	Code	Description	Source
Carbon dioxide emissions	CO_2	Carbon dioxide emission kilotons	World Bank
Gross Domestic Product	EC	Real gross domestic product	SESRIC
Trade openness	TO	Import plus export divided by GDP	SESRIC
Agricultural Production	AVCON	Agricultural Production Constant	SESRIC

3.2. Econometric Methodology

To achieve the objective of the study, the ARDL approach is used to check the existence of long-run cointegration among the sampled variables. The ARDL method is preferred over other cointegration methods in a variety of ways. Firstly, The ARDL can be used for small sample sizes and is not compulsory for having long time-series data. Secondly, The ARDL could regress variables if they are not integrated at the second difference I (2). Thirdly, in contrast to prior methods it simultaneously regresses long-run and short-run cointegration between the variables (Pesaran et al., 2001).

By following the efforts of Warsame et al. (2022), Sarkodie and Ozturk, (2020), and Yilanci and Pata, (2020), we specify the equation model of our study as follows:

$$lnCO_{2t} = \beta_0 + \beta_1 lnGDP_t + \beta_2 lnTO_t + \beta_3 lnAVCON_t + \beta_4 lnGDP2_t + \varepsilon_t \quad (1)$$

$lnCO_{2t}$ is the log of carbon dioxide emission in year t, $lnGDP_t$ is the log of Gross domestic product in year t, $lnTO_t$ is the log

Figure 1: Trend of sampled variables

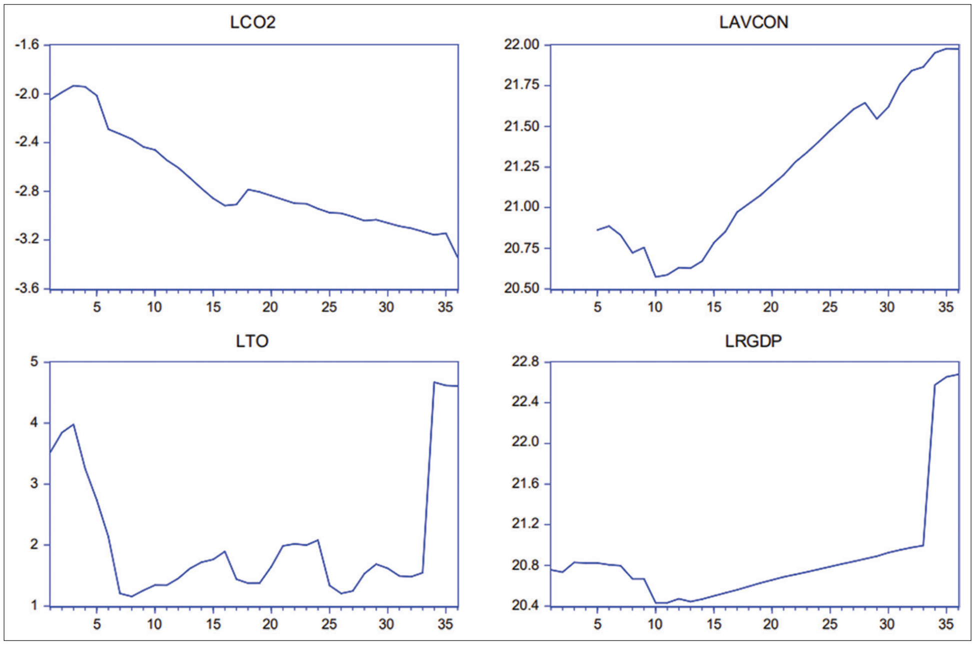
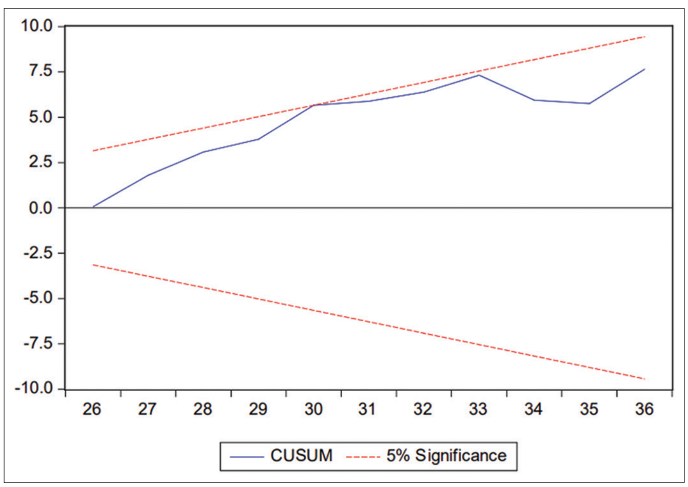


Figure 2: Cusum test



of Trade openness in year t, $lnAVCON_t$ is the log of agricultural production constant in year t, $lnGDP_t^2$ is a log of the square of Gross domestic product and $\mathcal{E}_t$ is the disturbance term in time t. We express equation 1 as a long- and short-run ARDL cointegration, which is denoted by:

$$\begin{aligned}\Delta lnCO_{2t} &= +\alpha_0 + \sum\nolimits_{i=0}^{p} \Delta\alpha_1 lnCO_{2t-k} + \sum\nolimits_{i=0}^{p} \Delta\alpha_2 lnRGDP_{t-k} \\ &+ \sum\nolimits_{i=0}^{p} \Delta\alpha_3 lnTO_{t-k} + \sum\nolimits_{i=0}^{p} \Delta\alpha_4 lnAVCON_{t-k} \\ &+ \sum\nolimits_{i=0}^{p} \Delta\alpha_2 lnRGDP\wedge 2_{t-k} + \beta_1 lnCO_{2t-1} \\ &+ \beta_2 lnRGDP_{t-1} + \beta_3 lnTO_{t-1} + \beta_4 lnAVCON_{t-1} \\ &+ \beta_5 LnRGDP\wedge 2_{t-1} + \varnothing ECT_{t-1} + \varepsilon_t \end{aligned} \quad (2)$$

Whereas $\alpha_{1\text{-}4}$ is the coefficient of short-tun, and α_0 is the intercept $\beta_{1\text{-}4}$ denotes the coefficient of long-run variables, Δ is the operator of the first difference, p represents the number of lags and the ECT is the error correction term and $\mathcal{E}_t$ is the error term. To ascertain the long-term cointegration between the dependent and independent variables, we regress equation (2) using the ordinary least square (OLS) method. The Wald F-statistic is used to compare the alternative hypothesis, which states that there is cointegration between the variables, to the null hypothesis that there is no cointegration among the variables in Somalia. The hypothesis is formulated as follows:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ |The null hypothesis (H_0): The indicators are not cointegrated.

H_a: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$|The alternative hypothesis (H_a): The indicators are cointegrated.

4. EMPIRICAL ANALYSIS AND DISCUSSION

4.1. Descriptive Statistics

Summary statistics of the variables are presented in Table 3. It reveals mean values of environmental pollution (−2.8), agriculture production (21), economic growth (20), and trade openness (1.89). Agriculture production and economic growth are recorded to have the highest maximum values of 21 and 20 respectively; whereas environmental pollution has the lowest value of −2.8. Trade openness is observed to have the highest standard deviation value of 0.95 which implies that its value is scattered compared to other variables. Besides, the correlations of the interested variables are also presented in Table 3. It shows that agriculture production, economic growth, and trade openness are adversely related to environmental pollution. On the contrary, economic growth and trade openness are positively associated with environmental pollution. Finally, there is a positive relationship between trade openness and economic growth.

4.2. Unit Root

It is a prerequisite confirming that the time series data are stationary due to the possibility that the variables may have a unit root issue, which might lead to biased findings. Augmented Dickey-fuller (ADF) and Philips Perron (PP) tests are carried out to detect whether the variables could have this problem. A unit root issue is confirmed by the null hypothesis of the ADF and PP, Yet, the alternative hypothesis argues the absence of a unit root issue. When the variable's t-statistic exceeds the critical t-value specified to it, we fail to reject the alternative hypothesis that the data are stationary and reject the null hypothesis that they are non-stationary. The findings of the tests shown in Table 4 indicate that all variables investigated are stationary at the first difference level (I (1). Nonetheless, the key variables are stationary at the first difference according to the results of both unit root tests (PP and ADF), rejecting the null hypothesis that they are nonstationary while failing to reject the alternative hypothesis. The lack of unit root problems in our data, as demonstrated by ADF and PP, shows that the ARDL bound test is suitable for the features of the data.

The ARDL bound test is estimated after confirming the unit root test. Its result is reported in Table 5. It underscores the presence of long-run cointegration between environmental pollution and the independent variables-economic growth, squared economic growth, agriculture production, and trade openness. Because the F-statistics (7.8) is above the upper bound critical value (4.37) at a 1% significance level.

We subsequently examine the long- and short-run coefficient elasticities of the explanatory variables. Its result presented in Table 6 revealed that all the regressors are statistically significant except trade openness. Notably, agriculture production and squared economic growth are negatively related to environmental pollution in Somalia in the long run; whereas economic growth significantly impedes environmental quality in the long run. A 1% increase in agriculture production will lead to environmental pollution by about 0.94% in the long run. On the contrary, economic growth tends to increase environmental pollution by about 34% for a 1% increase in economic growth. However, squared economic growth improves environmental quality. A 1% increase in squared growth tends to decrease environmental pollution by about 0.75% in the long run.

Further, the short-run result with ECT is also reported in Table 3. Previous year environmental pollution leads to an increase in current environmental pollution. However, agriculture production and trade openness improve environmental quality. A 1% in agriculture production and trade openness results in environmental pollution decrease by about 0.43% and 0.043% in the short run respectively. Both economic growth and squared economic growth are statistically insignificant in the short run. The coefficient of the ECT is negative and significant; hence, the model makes a convergence. Any deviation shock that occurs in environmental pollution is corrected by 28% in the long run by the interested parameters annually.

According to the ARDL result, economic growth and CO_2 emissions have an inverse U-shaped relation, which confirms the EKC hypothesis. This indicates that environmental pollution typically rises as economic growth accelerates for a while, but once Somalia's income level approaches a tipping point, it starts to fall as income levels rise. This finding is in line with the studies of Egbetokun et al. (2020), Sarkodie and Ozturk (2020), Murshed et al. (2021), Liu et al. (2019), and Salari et al. (2021) in Nigeria, Kenya, Bangladesh, China and U.S respectively. However, the results are inconsistent with the studies of Al-Mulali et al. (2016), and Warsame et al. (2022), in Kenya and Somalia respectively.

Somalia's agriculture sector may be under threat since CO_2 emissions have a significant negative impact. That is a rise in carbon dioxide emissions in Somalia results in a decline in the long-term growth of the agricultural sector of the country. Over time, Rainfall has been a major factor in Somalia's agricultural sector. Unfortunately, a significant impact on agricultural activities is being seen as a result of the escalating consequences of climate change, which have led to unpredictable rainfall

Table 3: Summary statistics

	LCO_2	LAVCON	LRGDP	LTO
Mean	−2.821819	21.21931	20.88421	1.891916
Median	−2.900424	21.17016	20.74783	1.579431
Maximum	−2.013654	21.97891	22.67900	4.669913
Minimum	−3.341043	20.57265	20.43155	1.153732
SD	0.301332	0.465702	0.596317	0.957727
Skewness	0.830320	0.195183	2.401798	2.221033
Kurtosis	3.150896	1.668146	7.551384	6.786618
Jarque−Bera	3.707327	2.568294	58.38616	45.42723
Probability	0.156662	0.276887	0.000000	0.000000
Correlation LCO_2	1			
LAVCON	−0.803	1		
LRGDP	−0.499	0.709	1	
LTO	−0.337	0.485	0.907	1

Table 4: Unit root tests

Variable	ADF		PP	
	Level intercept	Intercept and trend	Level intercept	Intercept and trend
LCO2	−0.8031	−1.503	−0.8181	−1.6457
LAVCON	0.9514	−2.9415	0.5695	−2.9500
LRGDP	0.5468	−0.4817	0.6345	−0.3022
LTO	−1.2184	−1.0540	−1.4165	−1.0077
	First difference intercept	Intercept and trend	First difference intercept	Intercept and trend
LCO_2	−4.1275***	−4.1054***	−3.9978***	−3.7921***
LAVCON	−2.7846*	−2.8315	−4.1308***	−4.5819***
LRGDP	−5.5349***	−6.1022***	−5.5349***	−61880***
LTO	−5.0781***	−5.7434***	−5.0718***	−5.8889***

***, **, and * show significance level at 10%, 5%, and 1%, respectively

Table 5: Bound test

		Critical value bounds		
		Significance	Lower bound	Upper bound
		10%	2.2	3.09
		5%	2.56	3.49
K (4)		2.5%	2.88	3.87
F-statistic	7.823	1%	3.29	4.37

Table 6: Long- and short-run results

Variable coefficient	Std. error		T-statistic	Prob.
Long-run results				
LAVCON	−0.943	0.256	−3.684	0.002
LTO	−0.014	0.125	−0.113	0.911
LRGDP	34.272	11.356	3.018	0.008
LRGDP^2	−0.795	0.263	−3.022	0.008
Constant	−351.729	118.133	−2.978	0.009
Short−run results				
Δ (LCO2[−1])	0.326	0.088	3.688	0.002
Δ (LAVCON)	−0.436	0.114	−3.806	0.002
Δ (l LAVCON[−1])	0.343	0.127	2.692	0.017
Δ (LTO)	−0.043	0.023	−1.855	0.083
Δ (LTO[−1])	−0.033	0.020	−1.6244	0.125
Δ (LRGDP)	4.541	2.794	1.625	0.125
Δ (LRGDP[−1])	−8.632	3.278	−2.633	0.018
Δ (LRGDP^2)	−0.102	0.065	−1.579	0.135
Δ (LRGDP[−1]^2)	0.203	0.076	2.678	0.017
ECT (−1)	−0.286	0.036	−7.911	0.000

Table 7: Diagnostic test

Reset test	0.517 (0.484)
Adjusted R-square	0.98
Heteroskedasticity	1.769 (0.177)
Serial correlation	0.371 (0.445)
Normality	5.785 (0.056)

T-statistics values are in (.) parenthesis. P-values are in [.]

patterns, extremely high temperatures, and flooding in many parts of the country. According to Warsame et al. (2023), agriculture and livestock productions have a detrimental impact on Somalia's environmental quality by increasing deforestation. However, our study opined that agriculture production is insignificant in the long run which implies that it does not affect CO_2 emissions.

The diagnostic test result such as serial correlation, heteroskedasticity, misspecification test, and normality test is presented in Table 7. It implies that there are no diagnostic issues with the study's model. Moreover, the model of the study is reliable as shown in Figures 2 and 3-Cusum and Cusum square tests respectively.

4.3. Granger Causality

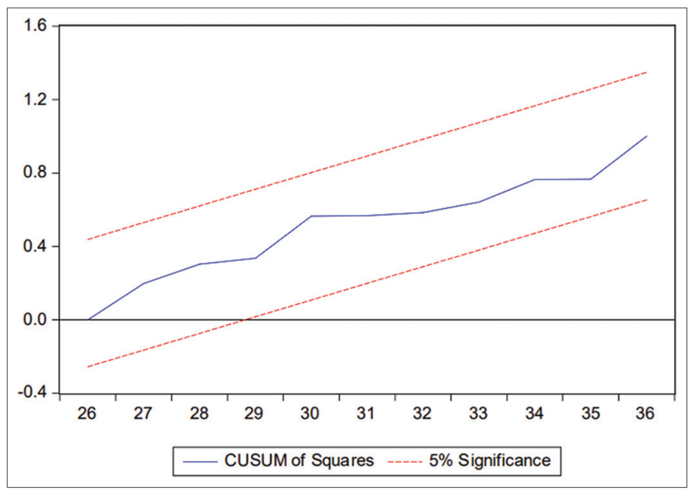
The result of causality among the sampled variables is displayed in Table 8. It is observed a unidirectional causality from environmental pollution to agriculture production. Similarly, a unidirectional causality is detected from economic growth and squared economic growth to environmental pollution but not vice versa. Hence, it could be noticed that economic growth drives environmental pollution which is a key determinant of environmental quality in Somalia.

Table 8: Pairwise granger causality tests

Null hypothesis	F-statistic	Prob.
LAVCON⇏lnCO_2	2.04596	0.1503
LCO2⇏lnAG	9.57851	0.0008
LRGDP⇏lnCO_2	5.10767	0.0126
LCO2⇏lnRGDP	0.90452	0.4159
LRGDP^2⇏lnCO	25.20062	0.0117
LCO2⇏lnRGDP^2	0.88917	0.4219
lnTO⇏lnCO2	1.49737	0.2405
LCO2⇏lnTO	1.41549	0.2591
LRGDP⇏lnAG	1.26604	0.2994
LAVCON⇏lnRGDP	2.45588	0.1062
LRGDP^2⇏lnAG	1.20915	0.3153
LAG⇏lnRGDP^2	2.42683	0.1088
lnTO⇏lnAG	0.18816	0.8296
LAVCON⇏lnTO	2.02016	0.1537
LRGDP^2⇏lnRGDP	0.87224	0.4287
LRGDP⇏lnRGDP^2	0.89313	0.4203
LTO⇏lnRGDP	0.46293	0.6340
LRGDP⇏lnTO	1.91755	0.1651
LTO⇏lnRGDP^2	0.45789	0.6371
LRGDP^2⇏lnTO	1.90782	0.1666

⇏ indicates that variables do not Granger cause

Figure 3: Cusum square test



5. CONCLUSIONS AND POLICY IMPLICATIONS

Economic growth is typically attributed as the fundamental cause of environmental issues due to higher production which generates more pollution. The EKC hypothesis has been used to test the link between economic growth and CO_2 emissions. In this regard, this study aims to ascertain the validity of the EKC hypothesis in Somalia using time series data spanning 1989-2020. The ARDL technique is applied to test the presence of cointegration between the interested variables and the EKC hypothesis. According to the ARDL result, economic growth and CO_2 emissions in Somalia have an inverse U-shaped relation, which confirms the EKC hypothesis. Moreover, all the regressors are statistically significant apart from trade openness. Notably, agriculture production and squared economic growth are negatively related to environmental pollution whereas economic growth significantly impedes environmental quality in Somalia.

Somali Government should develop environmental policies aimed at reducing environmental pollution to achieve economic sustainability in the country. In addition, policymakers should promote investing in clean energy resources to improve Somalia's economy's overall energy efficiency which would mitigate emissions. Furthermore, the country should encourage trade openness since it has a significant impact and enhances environmental quality. Lowering the tax rates on products that are environmentally friendly is also necessary.

REFERENCES

Adzawla, W., Sawaneh, M., Yusuf, A.M. (2019), Greenhouse gasses emission and economic growth nexus of Sub-Saharan Africa. Scientific African, 3, e00065.

African Development Bank. (2021), African Economic Outlook 2021 African Development Bank-building Today, a Better Africa Tomorrow. African Development Bank. Available from: https://www.afdb.org/en/countries-west-africa-nigeria/nigeria-economic-outlook%0A; https://www.afdb.org/en/countries/west-africa/ghana/ghana-economic-outlook%0A; https://www.afdb.org/en/knowledge/publications/african-economic-outlook

Al-Mulali, U., Saboori, B., Ozturk, I. (2015), Investigating the environmental Kuznets curve hypothesis in Vietnam. Energy Policy, 76, 123-131.

Al-Mulali, U., Solarin, S.A., Ozturk, I. (2016), Investigating the presence of the environmental Kuznets curve (EKC) hypothesis in Kenya: An autoregressive distributed lag (ARDL) approach. Natural Hazards, 80(3), 1729-1747.

Aye, G.C., Edoja, P.E. (2017), Effect of economic growth on CO_2 emission in developing countries : Evidence from a dynamic panel threshold model. Cogent Economics and Finance, 90(1), 1-22.

Baek, J. (2015), A panel cointegration analysis of CO_2 emissions, nuclear energy and income in major nuclear generating countries. Applied Energy, 145, 133-138.

Balsalobre-Lorente, D., Shahbaz, M., Roubaud, D., Farhani, S. (2018), How economic growth, renewable electricity and natural resources contribute to CO_2 emissions? Energy Policy, 113, 356-367.

Boubellouta, B., Kusch-Brandt, S. (2020), Testing the environmental Kuznets curve hypothesis for E-waste in the EU28+2 countries. Journal of Cleaner Production, 277, 123371.

Coban, H.H., Rehman, A., Mohamed, A. (2022), Technical and economical investigation of a centralized and decentralized hybrid renewable energy system in Cadaado, Somalia. Processes, 10, 667.

Egbetokun, S., Osabuohien, E., Akinbobola, T., Onanuga, O.T., Gershon, O., Okafor, V. (2020), Environmental pollution, economic growth and institutional quality: Exploring the nexus in Nigeria. Management of Environmental Quality: An International Journal, 31(1), 18-31.

Grossman, G.M., Krueger, A.B. (1991), Environmental Impacts of a North American Free Trade Agreement. NBER Working Papers 3914. Cambridge: National Bureau of Economic Research, Inc.

Hussein, H.A., Khalif, M.A., Warsame, A.A., Barre, G.M. (2023), The impact of trade openness on economic growth in Somalia. International Journal of Sustainable Development and Planning, 18(1), 327-333.

Liu, J., Qu, J., Zhao, K. (2019), Is China's development conforms to the Environmental Kuznets Curve hypothesis and the pollution haven hypothesis? Journal of Cleaner Production, 234, 787-796.

Murshed, M., Alam, R., Ansarin, A. (2021), The environmental Kuznets curve hypothesis for Bangladesh: The importance of natural gas, liquefied petroleum gas, and hydropower consumption. Environmental Science and Pollution Research, 28(14), 17208-17227.

Murshed, M., Rahman, M.A., Alam, M.S., Ahmad, P., Dagar, V. (2021), The nexus between environmental regulations, economic growth, and environmental sustainability: Linking environmental patents to ecological footprint reduction in South Asia. Environmental Science and Pollution Research, 28(36), 49967-49988.

Olale, E., Ochuodho, T.O., Lantz, V., El Armali, J. (2018), The environmental Kuznets curve model for greenhouse gas emissions in Canada. Journal of Cleaner Production, 184, 859-868.

Ozatac, N., Gokmenoglu, K.K., Taspinar, N. (2017), Testing the EKC hypothesis by considering trade openness, urbanization, and financial development: The case of Turkey. Environmental Science and Pollution Research, 24(20), 16690-16701.

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

Salari, M., Javid, R.J., Noghanibehambari, H. (2021), The nexus between CO_2 emissions, energy consumption, and economic growth in the U.S. Economic Analysis and Policy, 69, 182-194.

Sarkodie, S.A., Ozturk, I. (2020), Investigating the environmental Kuznets curve hypothesis in Kenya: A multivariate analysis. Renewable and Sustainable Energy Reviews, 117, 109481.

Warsame, A., Sheik-Ali, I., Hussein, H., Barre, G. (2023), Assessing the long-and short-run effects of climate change and institutional quality on economic growth in Somalia. Environmental Research Communications, 5, 055010.

Warsame, A.A. (2022a), Does oil price affect the economic growth in Somalia asymmetrically ? International Journal of Energy Economics and Policy, 12(5), 47-54.

Warsame, A.A. (2022b), The impact of urbanization on energy demand: An empirical evidence from Somalia. International Journal of Energy Economics and Policy, 12(1), 383-389.

Warsame, A.A., Abdi, A.H., Amir, A.Y., Azman-Saini, W.N.W. (2023), Towards sustainable environment in Somalia: The role of conflicts, urbanization, and globalization on environmental degradation and emissions. Journal of Cleaner Production, 406, 136856.

Warsame, A.A., Mohamed, J., Ali, A. (2023), The relationship between environmental degradation, agricultural crops, and livestock production in Somalia. Environmental Science and Pollution Research International, 30, 7825-7835.

Warsame, A.A., Sheik-Ali, I.A., Hassan, A.A., Sarkodie, S.A. (2022), Extreme climatic effects hamper livestock production in Somalia. Environmental Science and Pollution Research, 29(27), 40755-40767.

Warsame, A.A., Sheik-Ali, I.A., Mohamed, J., Asumadu, S. (2022), Renewables and institutional quality mitigate environmental degradation in Somalia. Renewable Energy, 194, 1184-1191.

Yilanci, V., Pata, U.K. (2020), Investigating the EKC hypothesis for China: The role of economic complexity on ecological footprint. Environmental Science and Pollution Research, 27(26), 32683-32694.