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Article

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International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Mohamud, Iqra Hassan/Mohamud, Ahmed Abdirashid (2023). The impact of renewable energy consumption and economic growth on environmental degradation in Somalia. In: International Journal of Energy Economics and Policy 13 (5), S. 533 - 543.
https://www.econjournals.com/index.php/ijeep/article/download/14488/7514/34439.
doi:10.32479/ijeep.14488.

This Version is available at:
http://hdl.handle.net/11159/631271

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), 533-543.

The Impact of Renewable Energy Consumption and Economic Growth on Environmental Degradation in Somalia

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Received: 15 April 2023 **Accepted:** 28 July 2023 **DOI:** https://doi.org/10.32479/ijeep.14488

ABSTRACT

This study investigates the impact of renewable energy consumption and economic growth on environmental degradation in Somalia between the period 1990 and 2020. Econometric tools ARDL and Pairwise Granger Causality Test were used. A stationarity test was first carried out to ascertain the stationarity and all variables are all integrated of order (0) and (I). Results from the short term demonstrate a positive, significant relationship between renewable energy usage, oil price, and environmental deterioration, and a negative, significant relationship between foreign direct investment (FDI), population, and environmental degradation. More so, in the short term, there is a positive and insignificant relationship between economic growth and environmental degradation. While the long-run result revealed a positive, significant relationship between FDI, population, oil price, and environmental degradation, as well as a negative, significant relationship between the use of renewable energy, economic growth, and environmental degradation. Results indicate that renewable energy consumption is a key contributor to environmental degradation in both short and long-run periods in Somalia. The result from the Granger causality test revealed that there is unidirectional causality from EG to ED, REC to ED, ED to FDI, and FDI to EG of Somalia.

Keywords: Renewable Energy, EG, Environmental Degradation, ARDL, Somalia
JEL Classifications: P28, Q56, O11

1. INTRODUCTION

Since the industrial revolution, there has been a dramatic reversal in the global rate of environmental degradation over the past two decades. Human activities have caused climate change and global warming and the detriment to the environment is attributable to fossil fuels usage for consumption of energy associated with these human activities. The world has suffered a dramatic temperature rise, heavy floods, tropical storms, and declining crop production, (Munir et al., 2020). Environmentalists is extremely concerned about the frightening influence that ecological distortions and environmental degradation are having on the geographical space of the globe. These concerns, which were formerly little more, have now led to environmental catastrophes such as extreme weather occurrences and sea level rise. As a result of this, countries are under pressure to simultaneously solve environmental crises while still attempting to maintain economic growth and emissions of carbon dioxide (CO_2) are well-recognized as a major factor in global warming and environmental deterioration, (Castellanos et al., 2020).

Since the 1990s, scholars have been closely analyzing the effects of global warming on the global economy. Many international groups, including the United Nations, have been working to establish legally binding treaties between nations in an effort to mitigate the worst effects of climate change, (Romero and Gramkow, 2021). The WHO says environmental improvements can prevent 25% of world deaths. A healthy environment gives clean air, water, and a safe house and environmental sustainability is crucial to long-term economic growth Reducing carbon dioxide (CO_2) emissions is widely recognized as a sign of enhancing environmental quality, as shown by several scientific studies. To comprehend and address global climate change necessitates greater knowledge of how CO_2 concentrations are related to economic activities (Dar et al., 2022), One SDG is to deliver low-cost, low-pollution energy by boosting the quantity of renewable energy (RE) in the energy mix. Capital investment in green energy projects could increase as a result of decreased emissions, the creation of new jobs, and possible increases in GDP, ultimately improving people's standard of living. Hydroelectricity, the sun, wind, biomass, tides, biofuels, and geothermal energy are all examples of clean, natural, and environmentally friendly resources. For the health of the local economy and the good of the community as a whole, this is an absolute must.

Even the most ardent climate-change skeptics now acknowledge that human-caused emissions of carbon dioxide and other greenhouse gases are a major contributor to the problem. The EKC hypothesis equates economic activity to environmental degradation. According to the Environmental Kuznets Curve (EKC), economic activity first degrades the environment, but as income levels grow, environmental quality improves (Grossman and Krueger, 1991). Environmental pollution will surge early in the economic expansion then reduce once the economy stabilizes (Antonakakis et al., 2017). The economy and carbon dioxide emissions have an inverted U-shaped relationship. As countries grow and invest in energy-efficient infrastructure and technology, some researchers believe the association between growing economy and pollution may eventually become negative (Esteve and Tamarit, 2012).

Somalia is facing energy insecurity since most urban and rural people still utilize firewood and charcoal, (Warsame et al., 2022). (Dawson, 2008) estimate that 82% of the nation's energy comes from biomass. Biomass has reduced forests, decertified land, and damaged grazing and agricultural land. Somalia's forest cover fell from 13% in 1990 to 9.5% in 2020 and 1990-2020 deforestation harmed 2.2 million hectares. Lightning and other industries use 95% fossil fuel energy. Somalia has not fully used its solar, wind, hydropower, and geothermal energy potential due to political, economic, and institutional barriers. Human well-being depends on nature on nature (Figure 1).

Sharma, (2011) examined the factors that led CO_2 emissions to rise or fall for a panel of sixty-nine nations and three income brackets. In the worldwide panel, urban growth and income per capita are two of the most important leading indicators of CO_2 emissions, while overall electric power and primary energy consumption per capita have a statistically minor effect and trade liberalization has no effect. A growth in GDP per capita reduces CO_2 emissions across all income categories, although only the low and middle-income panels are statistically significant. Experts from the past say that as industrialization advances, even primitive societies take and cultivate resources more intensively. CO_2 emissions are related to rubbish creation, hence resource depletion and waste generation are increasing. Due to technology, developed nations focus on the service sector and reduce their carbon emissions. (Menegaki, 2011) found evidence for the neutrality hypothesis in his study of renewable energy and economic growth in Europe and found that GDP, employment, CO_2 emissions, and renewable energy consumption have long-term correlations. Growing greenhouse gas emissions by 1% boosts GDP more than renewable energy sources by 1%. Renewable energy is less competitive for GDP growth due to its high cost. Supporting the neutrality hypothesis and claiming that renewable energy consumption has no impact on European GDP. Previous research used bivariate models and ignored other factors that may affect CO_2 emissions. Recent research has replaced bivariate models with multivariate models to account for extra variables that may affect CO_2 emissions.

2. LITERATURE REVIEW

After the collapse of the Somali government in 1991, the thriving private sector stepped in to take over the provision of power. About 106 MW of generators are currently in use and 106 MW generators are in use. Hybrid systems that employ solar and wind power to create electricity are gaining interest and financing, even though most companies still use diesel power plants, (USAID, 2018). Somalia possesses Africa's greatest onshore wind power resource, with an estimated generation capacity of 30,000-45,000 MW, according to a recent African Development Bank assessment. Solar panels produce over 2,000 kWh/m^2. Only 16% of the community has power lines. Somalia's tariffs are higher than Kenya and Ethiopia. Some economic activity can directly affect the environment, but international trade can indirectly. According to (Sobrinho, 2005), some economists argue that free trade boosts wealth and reduces environmental degradation. However, some worry that free commerce may deplete the planet's natural resources. Pollution may slow economic growth. Research, academics, and policymakers are increasingly focused on the challenge of accelerating and sustaining economic growth without harming the environment. Thus, the empirical studies investigating the impact of economic growth and renewable energy consumption in lessening the environmental degradation.

2.1. The Impact of EG on CO_2

Although EG is undoubtedly a contributor to environment, the literature is divided on whether or not EG helps to mitigate environmental degradation. In the field of literature, there are essentially two different schools of thought. Some believe that there is an inverted U-shaped relationship between income and pollution, as demonstrated by (Al-Mulali et al., 2015) investigation of the EKC theory in 93 low, moderate, and high income nations. Ecological footprints explain environmental impacts and EKC theory may operate only for high-income nations. Low-income economies are still developing and have not yet attained their full potential. Thus, as economies grow, environmental degradation usually worsens, but after a country reaches a certain degree of economic growth, the U-shaped relationship between GDP and environmental degradation turns negative. Low-income countries cannot profit from that relationship. Thus, the EKC hypothesis is most likely to hold in high-income countries. Economic growth doesn't alter low-income countries' ecological footprints since they lack financial development. Economic expansion benefits the environment in high-income countries. (Sirag et al., 2018) assessed EKC using the dynamic panel threshold estimator. GDP and energy use are non-linear. Only high-income countries have a U-shaped relationship between income and environment.

Modern researchers like (Ali et al., 2019) have studied a number of environmental threats. Urbanization has been a major source of carbon emissions, threatening the global ecosystem. Pakistan, a developing nation, is urbanizing rapidly. Urbanization in Pakistan increases CO_2 emissions immediately and long time. These findings support the claim that Pakistan's urbanization is increasing its carbon footprint. (Hassan et al., 2020) investigated energy use and CO_2 emissions in light of economic growth and institution quality structural changes. High-quality institutions reduce carbon dioxide emissions. Economic growth reduces CO_2 emissions, validating the CO_2 EKC. Pakistan's institutions drive the reverse U-shaped GDP-pollution relationship. CO_2 emissions are inevitable, and energy use is a key contribution.

Therefore (Salman et al., 2019) examined the impact of institutional and bank profitability quality on nexus growth-emissions in three East Asian economies. Finding revealed that Regional institutions improve economic growth, this also lent credence to the idea that strong, impartial domestic institutions also boost economic growth and CO_2 reduction. The time series analysis emphasizes the impact of strong institutions on GDP and carbon emissions in the three countries. Consumption of energy and the extent to which markets are allowed to run freely have significant effects on the rate of economic growth in both South Korea and Thailand. However, studies have shown that freer trade actually slows down Indonesia's GDP.

Despite the above, (Haug and Ucal, 2019) found that exports, imports, and FDI strongly asymmetrically affected CO_2 emissions per capita in Turkey. Turkey has passed the environmental Kuznets curve tipping point, with rising real net GDP per capita and decreasing CO_2 emissions per capita in the long term. Exports, imports, and FDI affect long-term CO_2 emissions per capita. Commerce, immigration, and urbanization affect power and heating plant CO_2 emissions. Building and manufacturing emissions are solely connected to GDP and GDP per capita. (Demissew Beyene and Kotosz, 2020) tested EKC theory in 12 East African nations using GDP per capita, GDP per capita squared, globalization, FDI, political variables, and population density. Long-term carbon dioxide emissions and economic growth are bell-shaped, unlike Kuznets' inverted U-shaped hypothesis. Eastern African economies can cut CO_2 emissions using environmental protection laws, industry modernization, and long-term pollution reduction technology. Globalization, air pollution, climate change, FDI, and trade openness harm the economy. Danish et al. (2020) discovered that BRICS countries have an inverted U-shaped relationship between income and ecological footprint. Innate capital rent, renewable energy expansion, and urbanization lower ECF, with a heterogeneous panel causality test to establish the research variables' robustness.

Despite some conflicting findings about EKC in Somalia (Warsame et al., 2022; Warsame, 2022), Warsame, (2022) study validates the presence of EKC in Somalia. In addition, this finding contradict those of Warsame et al. (2022), who found no evidence to support the EKC hypothesis in Somalia.

2.2. The Impact of REC on CO_2

As a result of the fast growth of renewable energy, an increasingly large body of studies has investigated the impact of renewable energy consumption on environmental degradation. (Salahuddin et al., 2018) found a favorable relationship between power consumption and CO_2 emissions and reveals that renewable energy and energy security can promote sustainable development and prevent environmental degradation.

(Shittu et al., 2021) found that energy security was adversely connected with ecological footprint in resource-rich Asian states. Ecological footprint adversely affects inherent capital rent. Economic growth and ecological effect are non-linear, opposing EKC theory. Environmental performance index rises with ecological footprint, while population declines sustainability. To reduce public environmental impact, spend natural resource earnings in productive activities. Eco-friendly resource management and high extraction rates replenish resources for rents. The Hartwick-Solow rule allows non-renewable resource rents to be reinvested into other sectors to offset capital loss from depletion. (Fan and Hao, 2020) analyzed Pakistan's energy consumption, CO_2 emissions, and GDP growth dynamics and determined that Pakistan lacks energy to maintain long-term economic growth. Energy shortage slows economic growth and produces CO_2; hence the government should favor shared renewable energy. Growth emits CO_2 and may hurt environmental. (Danish et al., 2020) researched the factors that determined the ecological footprint of BRICS. The results show an inverted U-shaped relationship between ECF and income for all BRICS countries. Renewable energy, rent from intrinsic capital, and urbanization lower ECF. Global commerce has shifted countries' economies, societies, and environments' accessibility to external effects like capital flow, export growth, and industrialization, according to (Munir and Ameer, 2020). FDI reduces CO_2 emissions but capital flow overseas raises them, these findings support (Acharyya, 2009). Economic growth boosts Pakistan's CO_2 emissions, Industrialization increases CO_2 emissions but decreases it marginally. These findings imply that FDI, consumption, and urbanization are harming Pakistan's ecology. A Granger causality test showed that investment, industrialization, and economic growth all increased carbon dioxide emissions, whereas economic growth decreased them.

A study carried out by (Dar et al., 2022) reported that consumption of natural gas is related to the growth of the economy and the emissions of carbon dioxide given the close relationship between natural gas and the economy, government officials would be wise to fund energy infrastructure projects and craft long- and short-term energy policies that put the private sector ahead. (Al-mulali and Binti Che Sab, 2012) studied the 30 Sub-Saharan African economies and found Economic growth over the long term is strongly related to total primary energy consumption and carbon dioxide emissions across all of the investigated countries. Energy consumption increased financial growth and GDP, these countries should boost their strategy and invest more in energy productivity by conserving energy, saving energy, and outsourcing energy infrastructure maintenance. In view of structural changes associated with economic growth and institution quality, Hassan et al. (2020) examine CO_2 emissions and energy usage. The results show that high-quality institutions can significantly lower their carbon impact. The EKC for CO_2 emissions is confirmed by economic growth reducing emissions. The study gives Pakistan new knowledge by focusing on institution function. Pakistan's institutions help explain the reverse U-shaped relationship between GDP and pollution. It's well known that fossil fuels emit greenhouse gases.

(Chien et al., 2022) analyzed Asian greenhouse gas emissions over time, taking into consideration economic growth, city growth, and renewable energy use. They studied 30 years of environmental degradation and found that renewable energy networks and GDP squares temporarily reduced greenhouse gases, while urbanization and GDP boosted natural environment emissions. Asian economies polluted more as their economies and urbanization grew. (Warsame et al., 2022) researched Somalia to see how renewable energy and financial institutions affected environmental degradation and found that renewable energy reduces deforestation, which slows environmental degradation, and Somalia's governance structures improve environmental quality. The domestic investment raises population and economic expansion degrades the environment and Institutional quality is negatively associated with environmental degradation.

2.3. The Impact of FDI on CO_2

Because environmental pollution affects economic growth and human health, researchers and policymakers have paid a lot of attention to it in recent years. Thus, determining the cause of environmental degradation is crucial. Recent studies on FDI and environmental pollution scarcely consider regional considerations. (Bakhsh et al., 2017) found that physical capital stock and labor positively affect GDP and pollution negatively affects it. FDI negatively impacts CO_2 emissions and recyclable trash. CO_2 emissions have a positive composition impact on road length and capital stock, while GDP per capita is negatively associated. FDI in Pakistan is positively correlated with pollution output, supporting the pollution haven hypothesis. FDI enhances manufacturing capacity, employment, and technological know-how, which benefits countries in many ways. (Oxelheim and Ghauri, 2008), increased innovative activities (Ito et al., 2012), and improved managerial skills (Lin et al., 2009), FDI's environmental impact is growing because to climate change. The relationship between carbon emissions and FDI are questioned. Some studies discovered a positive relationship, others a negative relationship. (Shao, 2018) found that FDI negatively impacts host nation carbon intensity. FDI reduces carbon intensity despite fossil fuel use, industrial sector size, urban density, and trade openness. Fossil fuels and industrial activity raise carbon emissions, but cities grow and trade reduces carbon intensity. High-income, middle-income, and low-income economies' carbon intensity is negatively affected by FDI. (Nasir et al., 2019) found a statistically significant relationship between CO_2 emissions, FDI, GDP, and long-term economic growth. Only international debt was unrelated to CO_2 emissions. Domestic credit creation created longer-term environmental devastation. ASEAN economic expansion and FDI will hurt the environment and support to Pollution Heaven Hypothesis Studies reveal that ASEAN banks create more credit than bank deposits, damaging the environment. (Waqih et al., 2019) examined how FDI degrades the environment. This could attract affluent foreign investors to boost these countries' economies. These foreign investors will bring their dirt. ARDL statistics show the EKC's presence. FMOLS robustness check confirms economic growth increases energy usage. Solar, nuclear, wind, and hydropower can power the world's booming economy with cheap, redundant energy.

Thus, (Liu et al., 2018) investigate the influence of FDI on environmental pollution. FDI has quite distinct impacts on various pollutants. Researchers discovered that the inflow of FDI into China had ameliorated the amount of waste ash and dust pollution, and at the same time, it has intensified the amount of pollution caused by sulfur dioxide and wastewater. The findings provide credence to both the Pollution Halo hypotheses and Pollution Heaven. Further support for the EKC Hypothesis shows that economic expansion has an inverted U-shaped relationship with environmental degradation. Waste soot, dust, and sewage were statistically unaffected by industrial structure but greatly affected sulfur dioxide levels.

(Bildirici and Gokmenoglu, 2020) examined conservational smog, tourism, FDI, economic development, and renewable energy and found that modern terrorists, GDP expansion, and FDI raised CO_2 emissions. Global cooperation vanquished terrorism and high-carbon business-biased FDI boosts greenhouse gas emissions. Public ignorance of polluting industries, regulatory delay, and legislative inactivity have raised emissions. FDI, economic expansion, energy consumption, and terrorism pollute the world. (Omri and Bel Hadj, 2020) found that good governance and technology reduce CO_2 emissions in emerging economies. We found that technical innovation and good governance reduce CO_2 emissions in emerging nations. FDI-governance quality connections reduce CO_2 and benefit the environment. Technology, carbon emissions, FDI, and economic growth are inversely related. To promote cleaner technology throughout regions, sectors, and the country, emerging economies require more FDI in high-tech, environmentally friendly domains. This shields developing nations against foreign direct investment. Increase absorptive capacity control systems for efficiency. (Wang, 2021) explored how financial development, the Human Capital Index, renewable energy use, and globalization affect ecological and carbon footprints. Long-term and short-term ARDL modeling reveals that human capital improves environmental degradation. Globalization and renewable energy reduce environmental degradation, whereas financial expansion considerably improves it. To lower their ecological and carbon footprints, the BRICS nations must prioritize renewable energy and globalization. Companies should invest in research, renewable energy, and education to maximize human and financial capital. FDI's environmental impact is questioned. FDI improves host country ecosystems (Liang, 2017). FDI supports economic growth but degrades host countries' environments (Tang and Tan, 2015). (Kivyiro and Arminen, 2014) identified long-term Sub-Saharan Africa CO_2, economic development, energy use, and FDI trends. (Omri et al., 2014) demonstrated bidirectional causality between CO_2, FDI, and economic growth and found that FDI may affect the recipient's economy.

(Djellouli et al., 2022) examined how renewable energy, economic growth, non-renewable energy consumption, and FDI affect environmental deterioration in 20 African countries. Our most important finding is that all independent factors except renewable energy have a strong and beneficial effect on CO_2 emission. All independent factors affect CO_2 emissions in both the short and long term, except for FDI, which only affects long-term emissions. The sample countries have not verified the EKC hypothesis, unlike the PHH hypothesis. Polluting companies will move to countries with more FDI since it cuts CO_2 emissions. (Khan and Rana, 2021) examined pollutant emissions, economic growth, trade openness, energy use, foreign direct investment, financial sector development, government expense, and institution quality in 41 Asian economies. Our dynamic ordinal logistic regression model shows that FDI and economic progress increase pollution. To attract business and international direct investment, regional governments must meet tough environmental criteria. These governments can employ domestic and foreign company charges and trade subsidies for quality environmental infringement without compromising trade liberalization. Laws may boost FDI in energy-saving and consumption technology. Institutional quality indicators demonstrate that strong political institutions in target nations can offset environmental degradation induced by income, trade openness, and foreign direct investment. Policymakers must regulate environmental norms set by powerful institutions. Strong political frameworks enable environmental regulation.

(Xie et al., 2020) studies CO_2 emissions and foreign investment from 11 emerging nations. Nonparametric kernel density estimation and non-linear marginal analysis show the threshold effect of FDI imports on greenhouse gas emissions and population diversity. Non-linear FDI reduces CO_2 emissions more than linear FDI, supporting the PH hypothesis. Investment overproduction reduces CO_2 emissions, supporting the pollution halo theory. FDI gradually shift between two emission discharge regimes and FDI's inverted "S-shape" concentration impact supports the pollution haven and pollution halo hypotheses. After a threshold, FDI reduces CO_2 emissions and the inverted "U" pattern between GDP growth and CO_2 emissions confirms EKC theory. Energy use, global trade, and population have boosted CO_2 emissions. High-GDP FDI-receiving countries have a pollution halo, while low-GDP countries have a pollution haven. (Jiang et al., 2018) tested the pollution haven hypothesis using city-level data from 150 Chinese cities. They modeled FDI variables, GDP per capita, academic benefits to the population density, particulate matter 2.5 ability to focus, and sulfur dioxide emissions. Our research reveals that environmental quality declines even as per capita GDP rises. Millions of Chinese people live a modern lifestyle, thus, there is a significant demand for items that use a lot of power, such as air conditioning, vehicles, and central heating, Because of this, an enormous amount of waste and pollution is produced during the generation of electricity, the exponential rise in the number of Private automobile warrants unique attention According to the findings, FDI has the potential to substantially improve both the environmental quality and the spatial flash floods.

3. MATERIALS AND METHODS

3.1. Data

This study analyzes the effects of economic growth and renewable energy use on environmental emissions using secondary data, specifically time series data. The five explanatory variables of this analysis comprise World Development indicators and SESRIC data from 1990 to 2020. These variables are as follows in Table 1.

3.2. Econometric Methodology

ARDL, a popular time series data model, was employed. This model outperformed Johansen co-integration and other time series models for many reasons. This model works for small time series data without reducing coefficient precision or validity. Second, this model evaluates short- and long-term impacts using one equation, while Johansen co-integration models require two models. Finally, the ARDL model can incorporate I (0) and I (1), making it the ideal model to investigate the relationship between explained and explanatory factors (Pesaran et al., 2001). Finally, the technique's unrestricted structure provides the finest data-generating process presentation lag order in the general-to-specific framework. Rearranging ARDL model parameters reduces indigeneity and residual serial correlation (Pesaran, 1999). Carbon dioxide emissions serve as the predictor variable, whereas economic growth, foreign direct investment, renewable energy use, population density, and crude price are independent variables. To observe both the long-term and short-term relationship between the factors impacting environmental emissions is expressed as follows:

$$InED_t = \beta_0 + \beta_1 InEG_t + \beta_2 InREC_t + \beta_3 InOP_t + \beta_4 InFDI_t + \beta_5 InPOP_t + \mu_t \quad (1)$$

Where ED is environmental degradation, EG is economic growth, FDI is foreign direct investment, OP is the oil price, POP is population growth, REC is renewable energy consumption, and μt is the error term. We turned all variables into natural logarithms. To evaluate the model's long-term association, equation (2) is rewritten in ARDL form.

$$\begin{aligned}\Delta InED_t = {} & \alpha_0 + \beta_1 InED_{t-1} + \beta_2 InEG_{t-1} + \beta_3 InREC_{t-1} \\ & + \beta_4 InOP_{t-1} + \beta_5 InFDI_{t-1} + \beta_6 InPOP_{t-1} \\ & + \sum_{i=0}^{q} \Delta\alpha_1 InED_{t-k} + \sum_{i=0}^{p} \Delta\alpha_2 InEG_{t-k} + \\ & \sum_{i=0}^{p} \Delta\alpha_3 InREC_{t-k} + \sum_{i=0}^{p} \Delta\alpha_4 InOP_{t-k} \\ & + \sum_{i=0}^{p} \Delta\alpha_5 InFDI_{t-k} + \sum_{i=0}^{p} \Delta\alpha_6 InPOP_{t-k} + \varepsilon_{t-k} \quad (2)\end{aligned}$$

Where α_0 is the constant, α_1-α_7 are the short-run coefficients of variables, β_1-β_7 are the elasticities of the long run of parameters, q expresses the explained optimal lags, p illustrates the optimal lags of the explanators, Δ is the sign of first difference showing short run variables and ε_t is the error term. The ARDL co-integration approach undertake with bound testing.

The null hypothesis (H_0): $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$ propose that in the long-run variables are not co-integrated while the alternative hypothesis (H_1): $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7$

Table 1: Variable description

Variable	Years	Unit measurement	Source
Environmental degradation	1990-2020	Metric tons per capita	World Development Indicator
Economic growth	1990-2020	GDP per capita US Dollars	SESRIC
Renewable energy consumption	1990-2020	% of total final energy consumption	World Development Indicator
Foreign direct investment	1990-2020	Net inflows (BOP, current US$	World Development Indicator
Population	1990-2020	Annual percentage change of population	World Development Indicator
Oil price	1990-2020	Crude oil, Brent	World Bank

Table 2: Descriptive statistics

Stats	InED	InEG	InREC	InOP	InFDI	InPOP
Mean	−0.2159	2.1516	1.9669	1.6352	7.0114	0.5047
Median	−0.2146	2.1341	1.9697	1.6536	7.3802	0.5575
Maximum	−0.3151	2.3689	1.9818	2.0070	8.6665	0.7092
Minimum	−0.3187	1.9028	1.9405	1.1896	4.6020	−0.2839
Std. Dev.	0.0534	0.1426	0.0103	0.2575	1.4019	0.1791
Skewness	0.8525	0.1464	−1.0867	−0.0905	−0.3205	−3.0416
Kurtosis	6.2744	1.9008	3.4185	1.6652	1.6141	13.4736
Jarque-Bera	17.604	1.6714	6.3285	2.3436	3.0117	189.4929
Probability	0.0001	0.4335	0.0422	0.3098	0.2218	0.0000

Source: Extract from E-views 12 students

Table 3: Unit root test

Variables	Augmented Dickey-Fuller (ADF)		Phillip-Perron (PP)	
	Level	Diff.	Level	Diff.
InED	0.5829	0.0000	0.0055	------
InEG	0.0844	0.0254	0.6829	0.0008
InREC	0.0636	------	0.1241	0.0944
InOP	0.8887	0.2247	0.8378	0.0140
InFDI	0.1151	0.0001	0.0666	------
InPOP	0.0000	-----	0.0000	------

Source: Extract from E-views 12 students and the significance levels are 10%, 5%, and 1%.

≠ 0 argue that in the long-run variables are co-integrated. The Critical values and Wald-F statistics were employed to assess the null hypothesis. If the Wald-F statistics exceed the upper bound critical values, the null hypothesis is rejected, indicating that the variables are linked in the long run and vice versa.

Given that co-integration tests seek out the long-run equilibrium, this also employed the ARDL model to conduct a Granger causality test to explore the direction and causal relationship between the variables of interest, Granger causality emphasizes near-term predictability (Ogutu, 2014).

$$X_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i y_{t-1} + \mu_t \quad (3)$$

$$Y_t = \alpha_0 + \sum_{i=1}^{n} \beta_i x_{t-1} + \varepsilon_t \quad (4)$$

4. RESULTS AND DISCUSSIONS

4.1. Descriptive Statistics

Descriptive statistics exhibit means, standard deviation, skewness, and normality to contextualize numerical data (Table 2). Findings shows that foreign investment averages 7.01% with a standard deviation of 1.40% while economic growth averages 2.15% with 0.14%. The average yearly rise in population density is 0.50, with a standard deviation of 0.17; the average price of oil is 1.64/barrel, with 0.26 standard deviation; the average quantity of renewable energy used is 1.97, with 0.01 standard deviation; and the environment degrades at 0.22, with 0.05 standard deviation. Skewness measures a real-valued random variable's probability distribution mean divergence from normality. All variables except LPOP are right-skewed. Kurtosis shapes data. LPOP, LREC, and LED are leptokurtic (higher peak, long tail) while others are bell-shaped (platykurtic, short-tailed, fat).

4.2. Unit Root Test

It is necessary to investigate the time series properties of the relevant variables; the ADF and PP tests assist us in avoiding erroneous outcome. Test results show that the InEG, InREC, and InPOP series are stationary at level (I [0]). The environmental degradation, along with the oil price and foreign direct investment, was unable to attain stationarity when tested at a level. Stationarity is achieved after the variable has been successfully processed through the first difference (Table 3).

A bounds test is presented to investigate whether environmental degradation and regressors are co-integrated over time. However, at 10% significance level, Wald F-statistics (10.549825) was greater than the absolute lowest and absolute maximum. With this information at hand, we can draw the conclusion that there is a long-term relationship between the variables. In the short future, shock is possible, but convergence is assured.

4.3. ARDL Long-run and Short-run Results

Tables 4 and 5 summarizes our findings and demonstrates that all regressors has a considerable bearing on ED. The other explanatory variables positively affected ED, but economic growth and renewable energy usage negatively affected it. However, the computed coefficient of the long-run relationship suggests that InEG negatively impacts Somalia's environmental degradation over time. As a result, Somalia's impact on the environment will decrease as its economy grows, that is to say, if economic growth increased by 1%, environmental deterioration would decrease by 8.5638% points. Of relevance, the t-statistics show that the variable is statistically significant at the 5% level (P = 0.05). Our statistics show that there is a statistically significant correlation between economic growth and an increase in pollution levels at the 5% level, and we can make this claim with 95% certainty. My findings corroborate those of other researchers, including (Ridzuan et al., 2020), they've concluded that increasing the economy, particularly through renewable energy, is the best long-term solution to environmental issues. (Demissew Beyene and Kotosz, 2020) found a negative relationship between GDP per capita and CO_2 emissions,

Table 4: F-bound test

Test statistic	Value	Significance	I (0)	I (1)
F-Statistic	10.549825		Asymptotic: n=1000	
K		10%	2.08	3
		5%	2.39	3.38
		2.5%	2.7	3,73
		1%	3.06	4.15

Table 5: Long-run results

Variables	Coefficient
C	4.4353
	(4.4599)***
InEG	−0.0856
	(−4.4849)***
InREC	−9.9783
	(−5.6255)***
InOP	0.0673
	(3.6595)***
InFDI	0.0164
	(3.2779)***
InPOP	0.0698
	(3.3288)***
Reset test	3.9578 (0.0666)
Serial correlation	0.6072 (0.5533)
Heteroskedasticity	1.2556 (0.3137)
Normality	1.9086 (0.3850)

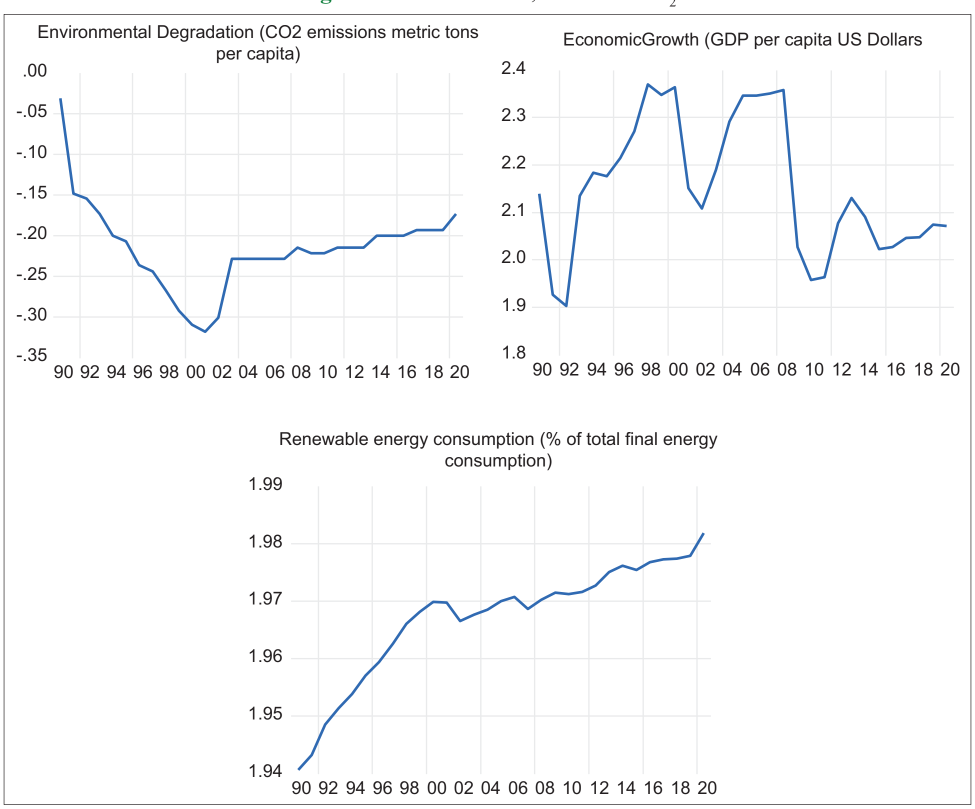
*,**,*** donate at 10%, 5%, and 1% significance levels. The T-statistics are cited in (…)

suggesting that economic growth and CO_2 emissions are more like a bell curve than the Kuznets hypothesis predicted.

We also find that the adoption of renewable energy sources is inversely associated with environmental degradation at the 1% level of significance. That is to say, just a 1% increase in the use of renewable energy might lead to a 10% reduction in long-term carbon dioxide emissions. This result is consistent with (Bilgili et al., 2016) found that using renewable energy sources reduces carbon dioxide emissions. (Inglesi-Lotz and Dogan, 2018) agreed. CO_2 elasticity is 0.34 for non-REC and −0.17 for REC. Renewable energy sources reduce environmental deterioration, while nonrenewable energy sources create pollutants. The top 10 Sub-Saharan African electricity producers urged to prioritize renewable energy over nonrenewable energy to lower their carbon footprints.

It is expected that the increase in the oil price (InOP) have a positive effect on pollution levels. This indicates that as the price of oil rises, so does the rate at which the ecosystem deteriorates. As shown by (Ali et al., 2022), positive oil price shocks have a significant impact on South Africa's short- and long-term carbon emissions. South Africa's carbon emissions are affected by oil prices through economic growth and energy use. Furthermore, I find that there is a statistically significant positive association between FDI and environmental degradation at the 1% level. This means that an increase in FDI of just 1% would have a multiplier effect on CO_2 emissions of 1.65% over the long term. This finding is consistent with the empirical literature, which has found varying impacts of FDI on various pollutants, see, for example, (Liu et

Figure 1: Somalia's EG, REC and CO_2



Source: SESRIC and WDI respectively.

al., 2018). They found that FDI had a small positive effect on wastewater and sulfur dioxide pollution while having a negative effect on waste soot and dust pollution in China.

Finally, population growth and environmental degradation are positively correlated. Thus, 1% population growth would raise carbon dioxide emissions by 6.98% over time. (Rahman and Alam, 2021) examined both immediate and underlying variables causing Bangladesh's pollution and population increase, supporting this finding. With the help of use of the ARDL limits test, we were able to determine that higher population densities are associated with higher levels of pollution in their respective habitats over the long run.

As a result of diagnostic checks, the ARDL model does not show heteroscedasticity, serial correlation, or normality problems and does not have any model misspecification. Additionally, CUSUM and CUSUM-square tests indicate that the coefficients of the ARDL model are stable over the sample period, as shown in Figures 2 and 3.

Based on the results of the short-term ARDL model are summarized in Table 6. ECT (−1), A statistically significant speed-up adjustment coefficient of −0.687417 indicates that less than a year of divergence between the long-run equilibrium value and the actual value of ED is adjusted throughout the year. Co-integration was further confirmed by the adjustment coefficient's negative sign and significant probability; it promotes the model's long-term co-integration. Our independent variables explain environmental degradation well, as evidenced by R-squared (0.919903). The model is robust since the F-statistics are statistically significant at the 1% level. Over the course of the years 1990-2020, Somalia have a weakly positive correlation between economic growth and environmental degradation, indicating that environmental harm was not caused by economic growth in the short term. Short-term and long-term results show that Somalia's increasing reliance on renewable energy sources is significantly improves environmental quality. Degradation of the environment has favorable effects in the areas of FDI and growth in the population, while short-term oil prices harm the environment.

Figure 2: CUSUM test

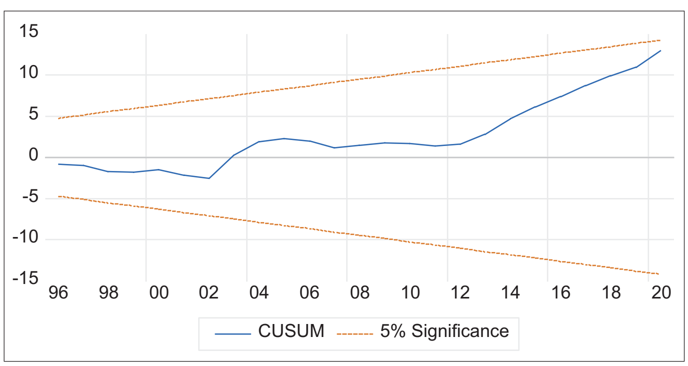
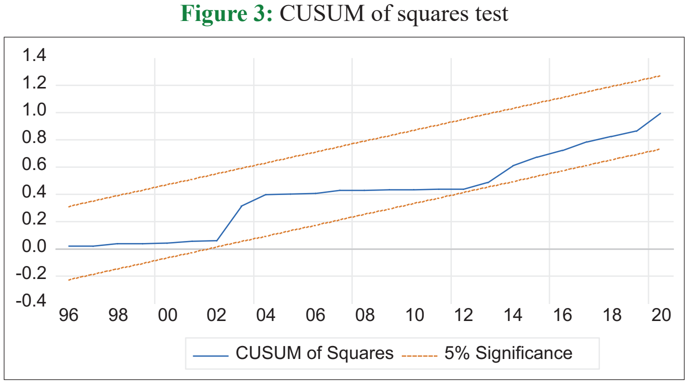


Figure 3: CUSUM of squares test



4.4. Robust Analysis

In table we used FMOLS to double-verify the ARDL long-run findings shown in Table 7. The use of REC, EG, FDI, and OIL

Table 6: Short-run and error correction results

Variables	Coefficient
ΔInEG	0.0175 (0.1961)
ΔInREC	−4.9100 (0.0001)***
ΔInOP	−0.0313 (0.0199)***
ΔInFDI	0.0095 (0.0067) ***
ΔInPOP	−0.0437 (0.0101)***
ECT_{t-1}	−0.6874 (0.0000)***

Table 7: FMOLS method

Variable	Coefficient	t-statistic
InEG	−0.0900***	−3.0090
InREC	−3.5686***	−5.1415
InOP	−0.0825***	−2.5613
InFDI	0.0389***	7.2225
InPOP	−0.0364	−0.7120
C	6.8780	5.2469

Table 8: Granger causality tests

InEG→InED	29	3.49877	0.0464
InED→InEG	29	0.35264	0.7064
InFDI→InED	29	0.98272	0.3889
InED→InFDI	29	5.26452	0.0127
InOP→InED	29	3.21022	0.0581
InED→InOP	29	0.72704	0.4937
InPOP→InED	29	2.91031	0.0738
InED→InPOP	29	0.53288	0.5937
InREC→InED	29	18.5254	1.E-05
InED→InREC	29	2.41870	0.1104
InFDI→InEG	29	4.86375	0.0169
InEG→InFDI	29	0.59544	0.5593
InOP→InEG	29	2.32283	0.1196
InEG→InOP	29	0.36165	0.7003
InPOP→InEG	29	0.68984	0.5211
InEG→InPOP	29	1.84931	0.1791
InREC→InEG	29	1.35648	0.2766
InEG→InREC	29	2.31522	0.1204
InOP→InFDI	29	2.62076	0.0934
InFDI→InOP	29	0.60543	0.5540
InPOP→InFDI	29	0.39014	0.6812
InFDI→InPOP	29	1.31035	0.2883
InREC→InFDI	29	0.41618	0.6642
InFDI→InREC	29	1.65815	0.2116
InPOP→InOP	29	0.45336	0.6408
InOP→InPOP	29	2.24571	0.1276
InREC→InOP	29	1.49306	0.2448
InOP→InREC	29	0.12317	0.8847
InREC→InPOP	29	0.21200	0.8105
InPOP→InREC	29	1.13463	0.3382

→ signifies that variable "X" does not granger cause variable "Y

PRICE were found to have statistically significant effects on environmental quality in Somalia, but growth in population was found to have no influence. We estimate that a 3.5% improvement in environmental quality can be expected for every 1% increase in the use of renewable energy.

4.5. Causality Test

Table 8 depicts the results of a Granger causality test showing that the following variable has four possible outcomes, all of which turn out to be unidirectional. There is a one-way causal relationship connecting GDP growth to environmental degradation ED, renewable energy consumption REC to environmental degradation ED, from foreign direct investment FDI to economic growth; environmental degradation ED to foreign direct investment FDI.

5. CONCLUSION AND RECOMMENDATION

Essentially, the study examined the rate of environmental degradation in Somalia from 1990 to 2020 and how that rate changed in tandem with the development of the Somali economy and the rising adoption of renewable energy sources. This research aimed to contribute to the conversation by doing empirical research in Somalia using recent time series data and an econometric model called ARDL. The correlation between economic development, renewable energy use, and environmental degradation have been the subject of conflicting empirical findings. While this debate is still going strong, our study aimed to contribute to it by collecting and analyzing new time series data in Somalia and doing novel empirical research in the country. Despite the fact that Somalia is one of the countries that receive foreign direct investment from donor nations, Somalia's GDP showed significant growth, and the majority of the population remains in extreme poverty. Thus, this study investigated the issue at hand.

Regarding the data, statistically, all of the regressors were found to have an effect on ED. Some explanatory variables were shown to have a substantial positive effect on ED, whereas others were found to have a significant negative effect. It was discovered that in the short run, the price of oil and the consumption of renewable energy have a substantial negative effect on ED, whereas all other variables, with the exception of the economy, have a major positive effect on ED. Growth in the economy has no immediate effect on environmental deterioration, and there is a weak positive correlation between the two. The findings reveal that renewable energy use in Somalia has a major impact on the country's environment, both immediately and over the long term. Thus, it follows that switching to renewable energy considerably enhances the environment fellow humans. Based on the estimated coefficient of the long-run relationship, it may be concluded that economic growth pertains negatively to environmental deterioration over the long term. This indicates that less environmental damage will occur in Somalia as the economy develops further. Additionally, we discover that making use of renewable energy sources has a negative correlation with environmental deterioration, suggesting that even though there would be a substantial effect on lowering carbon dioxide emissions with even a 1% rise in this sector's share of total energy use. Taking the price of oil into account has a beneficial effect on pollution. This suggests that as the price of oil rises, so does the which the ecosystem deteriorates. As a result of my study, I've come to the conclusion that FDI is bad for the environment and that encouraging even more FDI will only increase future carbon dioxide emissions. This indicates that a rise in the yearly percentage change in population would lead to higher emissions of carbon dioxide over time. Furthermore, the results of the Granger Causality Analysis show that there is a unidirectional causal relationship between economic growth and environmental degradation, the use of renewable energy and environmental degradation, as well as between environmental degradation and foreign direct investment, and finally, between foreign direct investment and economic growth.

Our findings, together with those of other researchers, show that renewable energy has the ability to mitigate environmental degradation. Based on our empirical research, this study makes several vital suggestions to the government and policymakers. First, despite the fact that our empirical results show a negative short- and long-term effect of renewable energy consumption on environmental degradation, the study argues that countries that are particularly vulnerable to climate change, such as Somalia, which is currently experiencing drought and erosion, should prioritize investing in renewable energy sources like wind, photovoltaic, and hydro energy. Environmentally sound economic growth may be sparked by the widespread adoption of renewable energy sources. Additionally, effective governmental institutions contribute positively to boosting environmental sustainability. The ability of agents to absorb externalities by engaging in the cooperative activity is made possible by high-quality institutions, which in turn encourages political opportunism and boosts environmental quality. To address the policy implications of our empirical findings, to that end, we push for a rapid shift to renewable energy sources like solar and wind. Renewables help the economy grow without negatively impacting environmental quality, as mentioned by Warsame et al. (2022). To preserve sustainable economic development and to reduce the harmful expect of CO_2 on the environment, Somalia requires efficient, innovative, and green technology to promote green energy consumption. This study concludes by proposing the addition of technological innovation, human capital, and research and development investment to this nexus in order to delve deeper into the significant insights and shifts related to oil prices, FDI, renewable and non-renewable energy consumption, economic growth, and environmental quality on a global scale. Another aspect restricting the breadth of this investigation is the inaccessibility of data accumulated before 1990.

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