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Renewable energy and globalization influence: assessing environmental degradation in Somalia

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ABSTRACT

The pressing issue of environmental degradation underscores the urgent need for collective action to preserve and restore our planet's delicate balance. This study investigates the relationships between environmental degradation, globalization, renewable energy adoption, economic growth, and domestic investment in Somalia from 1990 to 2020. It utilizes various statistical techniques, such as descriptive analysis, unit root tests, cointegration tests, ARDL analysis, FMOLS, and CCR, to examine short-term fluctuations and long-term patterns among these variables. The empirical findings reveal several key insights. Renewable energy plays a significant role in promoting environmental well-being, both in the short and long term. On the other hand, economic growth contributes to environmental degradation. Globalization has mixed impacts across different time frames, suggesting its potential to support environmental preservation in the long run. Domestic investment also has a modest positive influence on environmental sustainability. Based on these findings, the study recommends investing in renewable energy infrastructure and implementing sustainable growth strategies to mitigate environmental degradation. It emphasizes the importance of strengthening regulations and promoting eco-friendly practices to minimize adverse environmental impacts. Lastly, the study highlights the need to integrate environmental considerations into policy making processes and foster global solutions.

IMPACT STATEMENT

Somalia is currently facing significant environmental and socio-economic challenges. Therefore, this study critically examines how renewable energy adaptation and globalization can mitigate the carbon dioxide emissions in Somalia. By applying advanced statistical techniques, this research revealed that renewable energy and globalization significantly enhance environmental sustainability while economic growth exacerbated environmental degradation in Somalia. The effects of the positive influence of domestic investment underscore the complexity of these dynamics, highlighting the significant role each individual and entity can play in shaping a sustainable future. The significance of this study lies in its actionable insights. It advocates for investment in renewable energy infrastructure in Somalia, implementing sustainable growth strategies, and integrating environmental considerations into policymaking in Somalia. This research highlights the need for strengthened regulations and eco-friendly practices and provides a vital roadmap for mitigating environmental degradation and fostering global environmental solutions. This study is of utmost importance in the current environmental and socio-economic context.

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1. Introduction

The escalating concern over environmental degradation has emerged as a critical global issue, primarily driven by extensive deforestation for activities such as logging and agriculture (Kok et al., 2018; Raihan, 2023). This trend is compounded by the extraction of substantial quantities of fossil fuels, minerals, metals, and biomass, totaling approximately 55 billion tons annually, exacerbating the effects of climate

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change on ecosystems worldwide (Rabbat et al., 2022). Recognizing these dire consequences has spurred heightened attention from scientists, researchers, and policymakers, although the efforts to mitigate these environmental challenges remain insufficient (Ernst, 2012; Radmehr et al., 2021). Globalization has significantly transformed the energy sector, reshaping its distribution, consumption, and production dynamics. These shifts carry profound implications for environmental degradation and the imperative transition toward renewable energy sources (Fuinhas et al., 2021; Sun et al., 2022).

The combustion of fossil fuels, including coal, oil, and natural gas, releases significant quantities of greenhouse gases such as carbon dioxide, methane, and nitrous oxide into the atmosphere, with profound implications for ecosystems, biodiversity, and human well-being (Loucks, 2021; Yoro & Daramola, 2020). Recognizing the adverse environmental impacts of fossil fuel consumption, there is a global shift towards renewable energy sources as a more sustainable alternative (Radmehr et al., 2021; Vanegas Cantarero, 2020; Zafar et al., 2020) Renewable energy offers notable synergies with the Sustainable Development Goals (SDGs). Primarily, it furnishes energy sources with minimal environmental ramifications. In regions like Africa, where energy access significantly constrains economic development and poverty alleviation efforts, adopting renewable energy holds substantial promise (Ofori et al., 2022).

Somalia is currently facing significant environmental and socio-economic challenges. It is at a crucial point where renewable energy and globalization can play a vital role in its development. Despite contributing relatively low amounts to global carbon emissions, Somalia is already suffering from the adverse effects of climate change, including frequent droughts, floods, and land degradation. These challenges particularly threaten the livelihoods of the population who rely on agriculture (Giller, 2020; Wegenast & Beck, 2020). The potential for renewable energy in Somalia is immense, especially considering the abundance of solar and wind resources (Levenda et al., 2021; Vanegas Cantarero, 2020). The United Nations Development Programme emphasizes that various studies highlight the significance of harnessing these renewable energy sources in effectively mitigating the impacts of global warming (UNDP, 2023). Furthermore, the adoption of renewable energy can address Somalia's energy access issues, which are currently hindering efforts towards economic development and poverty alleviation. By providing reliable and sustainable energy, renewable sources can support infrastructure development, improve health and education services, and stimulate economic activities, particularly in rural areas (Warsame et al., 2022).

To support these theoretical claims, Usman et al. (2020) examined the dynamic interactions between the US environmental degradation and different variables such as the use of renewable energy, economic growth, biocapacity, and trade policies from the first quarter of 1985 to the fourth quarter of 2014. They were using an autoregressive distributed lag (ARDL) model. The findings demonstrated a clear correlation between the uptake of renewable energy sources and a reduction in environmental degradation, highlighting the significance of promoting research and development as well as investments in renewable energy sources such as biomass, solar, hydropower, wind, and wave energy (Tariq Majeed & Luni, 2019) used various methods to estimate the effectiveness of renewable energy deployment in reducing environmental impacts. These methods include Pooled OLS, Random Effects, Fixed Effects, and Two Stage Least Square. The analysis was based on panel data from 166 countries between 1990 and 2017. The results showed that renewable energy is an effective way to mitigate environmental impacts. Similarly, Adebayo and Kirikkaleli (2021) utilized various wavelet techniques on data from 1990 to 2015 in Japan, indicating that using renewable energy sources effectively reduces carbon dioxide emissions. Furthermore, the study has proven that the allocation of funds towards sustainable resources has increased, further reinforcing the case for its widespread implementation. Given this evidence, Japan should prioritize bolstering the expansion of renewable energy and cultivate a more conducive investment environment in the sector. (Ibrahiem, 2020) also underscored similar results in Egypt, indicating environmental improvement as alternative energy sources increase.

On the other hand, Adams and Nsiah (2019) examined the relationship between carbon dioxide emissions and the adoption of renewable energy across 28 Sub-Saharan African nations between 1980 and 2014; their findings were inconsistent with some initial hypotheses and yielded results that were both insignificant and positive for the countries studied because of issues like outdated storage technology and recurrent power outages in the area. Additionally, Hasnisah et al. (2019) examine the connections between renewable and non-renewable energy use, economic development, and environmental health in thirteen developing Asian nations. using the FMOLS and DOLS estimators from 1980 to 2014 as a

long-term sample. Nonetheless, the empirical data indicates that the contribution of renewable energy consumption to reducing CO2 emissions is still negligible because developing countries continue to rely heavily on conventional energy sources like fossil fuels.

The existing literature exhibits a lack of consistency, and some reasonable explanations might be that studies may vary in terms of methodology, data sources, periods analyzed, statistical techniques employed, and impact of regional and income variations.

Globalization, driven by technological advancements, trade and investment policy reforms, and economic interconnectedness, has had both positive and negative effects on the environment (Sethi et al., 2020). On one hand, it has led to increased resource extraction and environmental degradation, particularly in developing countries (Adebayo et al., 2022). On the other hand, it has fostered closer integration between developing and developed countries, creating opportunities for a more sustainable future (Sethi et al., 2020). One potential benefit of globalization is its ability to accelerate the adoption of renewable energy in countries like Somalia (Chien et al., 2021).

Globalization promotes international cooperation, allowing Somalia to access advanced technologies and expertise from developed countries that are leaders in renewable energy, waste management, and pollution control. By transferring these technologies, Somalia can bypass traditional, more polluting energy sources and transition directly to cleaner alternatives (Warsame et al., 2022). Trade and investment policy reforms driven by globalization can attract foreign direct investment (FDI) into Somalia's renewable energy sector. This investment can finance large-scale renewable energy projects, create jobs, and stimulate local economies. Multilateral agreements and international NGOs can also provide funding and technical support to ensure the successful implementation of renewable energy initiatives (Hickmann & Elsässer, 2020). Furthermore, globalization enhances economic interconnectedness, which can lead to better integration of Somalia into the global market. This integration can open up new markets for Somali products, increasing export revenues that can be reinvested into sustainable development projects, including renewable energy. The resulting economic growth can further stabilize the country and provide a foundation for long-term development (Warsame et al., 2022).

The existing literature has delved into this phenomenon, including Jun et al. (2021) employ the Environmental Kuznets Curve (EKC) framework to investigate the impact of globalization, non-renewable energy consumption, and economic growth on CO2 emissions across select South Asian economies spanning from 1985 to 2018. Their empirical findings reveal a positive association between CO2 emissions and globalization. Similarly, Nathaniel et al. (2020) examine the interplay among natural resources, globalization, urbanization, and environmental degradation in nations within Latin America and the Caribbean (LACC) from 1990 to 2017. Their analysis indicates that globalization contributes to higher CO2 emissions in LACC countries. On the other hand, Shahbaz et al. (2019) empirically examine the dynamic nexus between globalization and CO2 emissions across 87 countries with diverse income levels. Results revealed that globalization predominantly enhances environmental quality by reducing carbon emissions. Therefore, by increasing income through more trade and creating investment opportunities to improve environmental wellbeing. Others, such as Saint Akadiri et al. (2020), scrutinize the influence of real income, globalization, and tourism on environmental sustainability goals in Turkey. They employ the Vector Error Correction Model (VECM) and Autoregressive Distributed Lag (ARDL), which spans from 1970 to 2014. Their findings indicate that globalization does not significantly affect CO2 emissions in Turkey across various significance levels. This outcome underscores the importance of considering specific country characteristics such as industrial structure, energy sources, and environmental policies, which may vary and thus influence the impact of globalization on CO2 emissions.

Although Somalia possesses ample renewable energy resources, such as solar and wind energy, the country has not been adequately studied in terms of harnessing these resources for sustainable development (Newell & Bulkeley, 2017). A closer examination of Somalia's renewable energy potential can provide valuable insights into how other regions with similar resources can transition to low-carbon economies.

Despite previous research, no studies have yet explored the relationship between globalization, the adoption of renewable energy, and environmental degradation in Somalia. This study aims to address this gap by investigating how globalization impacts carbon emissions and how adopting renewable energy can help mitigate them in Somalia. The main objective is to analyze the effects of globalization and renewable energy adoption on carbon emissions in Somalia, while also considering patterns of

economic growth and domestic investment. Our research is driven by the need to understand the factors contributing to environmental degradation in Somalia and to develop strategies for sustainable growth. This topic is of great importance due to the urgent need for effective climate change policies, particularly in developing regions like Somalia that possess abundant renewable resources (Newell & Bulkeley, 2017). We utilize advanced econometric techniques such as the Autoregressive Distributed Lag (ARDL), Canonical Cointegration Regression (CCR), and Fully Modified Least Square (FMOLS) models. These methodologies enable us to accurately assess the short- and long-term relationships between variables. This study provides a comprehensive analysis of how globalization and the adoption of renewable energy interact to influence carbon emissions in Somalia. Additionally, we examine the dynamics of economic growth and domestic investment, emphasizing the importance of sustainable growth strategies that prioritize clean energy and green investments. Our research underscores the significance of directing investments towards renewable energy projects and sustainable development initiatives, offering valuable insights for policymakers and stakeholders in Somalia.

2. Methodology

2.1. Data

The study's annual time series data spanned from 1990 to 2020, with sample observations determined by data availability. Data were sourced from the World Bank, the Organization of Islamic Cooperation (OIC), and the KOF Swiss Economic Institute. The dataset comprised Environmental degradation, Globalization, Renewable energy, Economic growth, and Domestic investment (see Table 1 for more details).

2.2. Econometric modeling

In this study, we utilized several steps to empirically investigate the impact of renewable energy and globalization on environmental degradation. By employing EViews 12, our study utilizes the Augmented Dickey-Fuller (ADF) test to assess the stationarity properties of the data. Stationarity is a crucial assumption in time series analysis, as it ensures that the statistical properties of the data remain consistent over time. In addition, the study utilized the ARDL model, FMOLS, and CCR approaches to accomplish our research objectives. The ARDL method demonstrates superior performance in situations with limited sample sizes, making it particularly suitable for small-scale observations (Nkoro & Uko, 2016). Moreover, it can accommodate series that exhibit different levels of integration, whether at level, first-difference, or a combination of both. Finally, the ARDL method allows for the simultaneous estimation of short- and long-run cointegration without compromising the accuracy of long-term results (Chandio et al., 2018). This methodological framework enables the investigation of the interconnectedness among environmental degradation, globalization, renewable energy, economic growth, and domestic investment. The trends of the interested variables are depicted in Figures 1.

$$LnED_t = \beta_0 + \beta_1 LnGI_t + \beta_2 LnREC_t + \beta_3 LnEG_t + \beta_4 LnDI_t + \varepsilon_t \quad (1)$$

The equation incorporates several independent variables and one dependent variable, each transformed using the natural logarithm, representing different aspects of the economic context under study. These include LnED_t (Environmental Degradation), LnGI_t (Globalization), LnREC_t (Renewable Energy), LnEG_t (Economic Growth), and LnDI_t (Domestic Investment) These transformations facilitate a more explicit interpretation of the relationship between variables, especially when the relationship is multiplicative rather than additive.

Table 1. Variables descriptions.

Variables	Code	Measurement	Sources
Environmental Degradation	ED	Carbon emissions (kt)	World Bank
Globalization	GI	Globalization Index	KOF
Renewable Energy	REC	Renewable Energy Consumption	SESRIC
Economic Growth	EG	Gross Domestic Product Per Capita (Constant, 2015)	SESRIC
Domestic Investment	DI	Gross fixed capital formation (Constant, 2015)	SESRIC

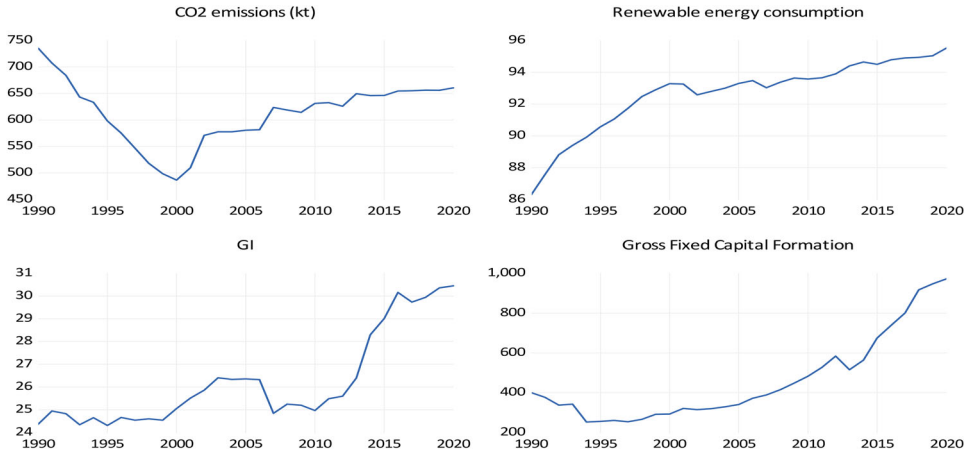

Figure 1. Trends of interested variables.

Table 2. Descriptive statistics and correlation matrix.

Descriptive information	LnED	LnREC	LnGI	LnEG	LnDI
Mean	−0.511	4.529	3.264	21.909	6.045
Median	−0.494	4.536	3.238	21.831	5.932
Maximum	−0.315	4.559	3.416	22.925	6.880
Minimum	−0.733	4.458	3.191	21.146	5.531
Std. Dev.	0.097	0.025	0.075	0.579	0.415
Skewness	−0.574	−1.282	1.031	0.445	0.657
Kurtosis	3.439	4.021	2.595	1.917	2.301
Jarque-Bera	1.953	9.840	5.702	2.536	2.862
Probability	0.377	0.007	0.058	0.281	0.239
Correlations					
LnED	1				
LnREC	−0.344	1			
LnGI	0.227	0.670	1		
LnEG	0.263	0.769	0.892	1	
LnDI	0.415	0.582	0.864	0.959	1

The coefficients β_1, β_2, β_3, and β_4 quantify the estimated effects of these independent variables on the dependent variable, which measures the effects of a one percent change in Globalization, Renewable Energy, Economic Growth, and Domestic Investment on Environmental Degradation. The error term ε_t represents the disturbance at time t, encompassing factors not explicitly captured in the model that influence Economic Degradation. Once stationarity is confirmed, the ARDL model will analyze the relationships between the variables. Thus, Equation 2 can be formulated accordingly.

$$\Delta LnED_t = \beta_0 + \beta_1 \Delta LnED_{t-1} + \beta_2 \Delta LnGI_{t-1} + \beta_3 \Delta LnREC_{t-1} + \beta_4 \Delta LnEG_{t-1} + \beta_5 \Delta LnDI_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta \mathrm{LnED}_{t-1} + \sum_{i=1}^{q} \gamma_i \Delta \mathrm{LnGI}_{t-1} + \sum_{i=1}^{r} \delta_i \Delta \mathrm{LnREC}_{t-1} + \sum_{i=1}^{s} \theta_i \Delta \mathrm{LnEG}_{t-1} + \sum_{i=1}^{t} \rho_i \Delta \mathrm{LnDI} + \mu ECT_{t-1} \quad (2)$$

where Δ is the first difference operator; p, q, r, s, and t are the lag lengths for each variable, which you can determine empirically or through model selection criteria; β0 is the intercept; ECTt-1 is the error correction term; β_1, β_2, β_3, β_4 and β_5 and α_i, γ_i, δ_i, θ_i, and ρ_i are the long-run and short-run coefficients of the model, respectively.

3. Empirical results

3.1. Descriptive statistics

Table 2 provides a comprehensive overview of the variability and distributional characteristics of the variables under consideration. For instance, the variable environmental degradation demonstrates moderate

variability. This suggests that environmental degradation values vary moderately around their average, indicating potential fluctuations in the phenomenon it represents. Conversely, renewable energy exhibits less variability with a mean and standard deviation, implying a more stable trend in renewable energy consumption. Additionally, measures like kurtosis and skewness offer insights into the shape of the distributions. Positive skewness for globalization and domestic investment suggests right-skewed distributions, while environmental degradation displays a left-skewed distribution.

The Jarque-Bera test was used to evaluate the normality of the variables. Environmental degradation globalization, economic growth, and domestic investment showed p-values greater than the critical value, suggesting potential normal distribution. At the same time, renewable energy had p-values below a critical value, indicating non-normal characteristics. Correlation analysis revealed significant relationships among the variables. Environmental degradation negatively correlated with renewable energy, indicating a moderate negative relationship. Conversely, environmental degradation positively correlated with globalization, economic growth, and domestic investment, suggesting moderate positive relationships with the globalization index, economic growth, and domestic investment. Renewable energy showed strong positive correlations with globalization, economic growth, and domestic investment, highlighting robust positive associations with the globalization index, economic growth, and domestic investment. Additionally, globalization, economic growth, and domestic investment exhibited strong positive correlations, indicating substantial relationships between globalization, economic growth, and domestic investment.

3.2. Unit root test

To ascertain non-stationarity, a prerequisite for accurate time series analysis, the Augmented Dickey-Fuller (ADF) unit root test scrutinizes whether time series variables demonstrate a unit root (Ajewole et al., 2020). As presented in Table 3, variables such as renewable energy and domestic investment evince evidence against a unit root at the level, whereas environmental degradation, globalization, and economic growth do not. Nonetheless, all variables demonstrate evidence against a unit root after the first difference, signifying post-differencing stationarity. This transformation is paramount in estimating long-run relationships among variables, ensuring stable statistical properties over time, and adhering to the principles of Autoregressive Distributed Lag (ADRL) models. Once unit root tests corroborate stationarity or integration properties, F-bound cointegration tests evaluate whether a linear combination of the variables is stationary, thereby indicating a long-term relationship.

As per Table 4, the F-statistic of (7.83) surpasses critical values at the 1% significance level, leading to the rejection of the null hypothesis. The outcome indicates the presence of cointegration among the variables, implying a stable long-run equilibrium. By actively identifying underlying relationships among economic indicators, this test aids in accurate forecasting, enhancing our understanding of economic trends.

3.3. Autoregressive distributed lag model (ARDL)

The analysis presented in Table 5 provides valuable insights into the temporal dynamics of the relationships between variables, as illustrated by the Long-run and Short-run tests. In the long term, the study

Table 3. ADF unit root test.

At Level		
Variables	With constant	With constant and trend
LnED	−2.477	−2.639
LnREC	−5.950***	−3.369*
LnGI	0.285	−1.208
LnDI	1.262	−3.671**
LnEG	0.642	−2.192
At Fist Difference		
D(LnED)	−3.261**	−3.609**
D(LnREC)	−3.525**	−3.439*
D(LnGI)	−4.521***	−4.787***
D(LnDI)	−4.472***	−3.788**
D(LnEG)	−3.784***	−4.148**

Note. Significance levels are denoted by *, **, and ***, indicating increasing significance levels at 10%, 5%, and 1%, respectively.

Table 4. F-bound cointegration test.

F-bounds test		Null hypothesis: no levels of relationship		
Test statistic	Value	Significant	I(0)	I(1)
F-statistic	7.832***	1%	3.74	5.06
K	4	5%	2.86	4.01
		10%	2.45	3.52

*Note.*** denotes levels of significance at 1%.

Table 5. Long run and short run effects.

Long run impact		
Variable	Coefficient	Prob
LnREC	−10.401***	0.000
LnGI	−0.492*	0.086
LnEG	0.758***	0.000
LnDI	−0.501***	0.003
Short run impact		
D(LnREC)	−11.352***	0.000
D(LnGI)	0.383**	0.026
D(LnDI)	−0.377***	0.000
ECM (-1)	−0.462***	0.000
Diagnostic check	Value	Probability
Jarque-Bera Normality test	0.849	0.653
Breusch-Godfrey Serial Correlation Test	0.003	0.9529
Breusch-Pagan Heteroskedasticity Test	6.475	0.594
R2	0.889	

Note. *, **, and *** represent significance at 10%, 5%, and 1% within statistical analysis.

reveals that renewable energy and domestic investment play crucial roles in mitigating environmental degradation, as evidenced by their discernible negative impact. The efficacy of renewable energy in reducing environmental harm is particularly noteworthy, with a substantial coefficient indicating that a 1% increase in renewable energy leads to a significant decrease of -10.4% in environmental degradation. Similarly, a 1% increase in domestic investment results in a substantial decrease of -0.5% in environmental degradation. Conversely, the study finds that economic growth has a robust positive impact on environmental degradation, implying that a 1% increase in economic growth contributes 0.76% to environmental deterioration. However, globalization's impact on environmental degradation is insignificant in the long run, as indicated by a coefficient with a p-value of 0.08.

Short-term dynamics are elucidated by the initial disparities in renewable energy and domestic investment, manifested by significant negative coefficients in the short run. This indicates that a 1% increase in renewable energy and domestic investment leads to substantial decreases in environmental degradation, approximately -11.35% and -0.37%, respectively. On the other hand, globalization is depicted as contributing to environmental degradation in the short term, indicating a 0.38% impact on environmental degradation. Furthermore, the Error Correction Model (ECM) coefficient from the antecedent period, characterized by a substantial negative coefficient of -0.462 and a probability value of 0.000, elucidates the swiftness with which the system returns to long-run equilibrium following a disturbance.

The analysis also highlights remarkable relationships between renewable energy consumption, economic growth, and domestic investment in the short and long run. The model's elevated R-squared value of 0.889 indicates that the independent variables can explain a substantial proportion of the variability in the dependent variable. These findings are of great value, as they uncover transient dynamics and enduring equilibrium relationships among variables, which are essential for effective policymaking and accurate economic prognostication.

Furthermore, the diagnostic checks conducted on the model indicate that it satisfies the assumptions of normality, absence of autocorrelation, and heteroskedasticity problems; these findings confirm the model's suitability. Stability analysis, particularly crucial for time-series data, assesses data consistency over time. It demonstrates the variations in data that occur within a specified timeframe. The CUSUM and CUSUMSQR tests of Figure 2 and 3 are valuable tools for determining variance and showcasing data

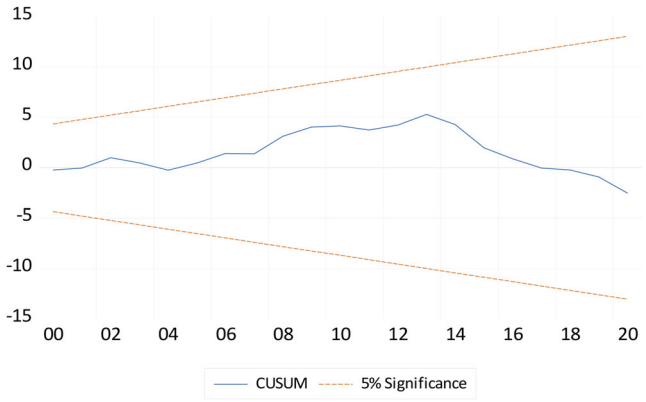

Figure 2. CUSUM test.

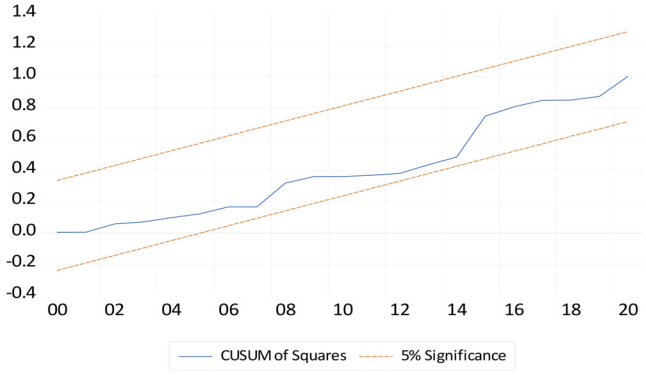

Figure 3. CUSUMSQR test.

Table 6. FMOLS and CCR tests.

Fully modified ordinary least square (FMOLS)			Canonical cointegration regression (CCR)	
Variable	Coefficient	P. value	Coefficient	P. value
LnREC	−7.106***	0.000	−7.057***	0.000
LnGI	−0.477**	0.039	−0.458**	0.044
LnEG	0.542***	0.000	0.545***	0.000
LnDI	−0.253**	0.041	−0.261*	0.070
C	29.803***	0.000	29.502***	0.000
R2	0.87		0.86	

Note. *, **, and *** represent significance at 10%, 5%, and 1%, respectively, within the statistical analysis.

fluctuations at specific points. In this study, model stability is indicated by the cumulative total line remaining within the bounds of the two critical lines, signifying consistency in the data over time.

3.4. FMOLS and CCR test

In time series analysis, the CCR and FMOLS methods guarantee the consistency and efficiency of our estimates, especially when studying long-term relationships between variables (Pattak et al., 2023). This increases the reliability and validity of our findings, allowing us to draw more accurate conclusions about the underlying dynamics influencing environmental degradation in Somalia. Table 6 utilizes FMOLS and CCR analyses to explore the complex interplay of different factors related to environmental degradation in Somalia. The FMOLS regression analysis reveals that renewable energy consumption emerges as a critical determinant, exhibiting a significant negative relationship with environmental degradation. This implies that a 1% increase in renewable energy consumption results in an associated decrease of approximately -7.1% in environmental degradation, highlighting the pivotal role of renewable energy in fostering environmental sustainability. Additionally, globalization demonstrates a negative

association with environmental degradation, albeit with a relatively weaker impact of -0.47 compared to renewable energy. Furthermore, domestic investment exhibits a noteworthy negative influence, indicating that heightened levels of domestic investment correspond to a decrease of approximately -0.25 in environmental degradation. In contrast, economic growth emerges as a standout factor with a substantial positive impact, implying that a 1% increase in economic growth contributes to an increase of approximately 0.25% in environmental degradation.

Transitioning to the CCR, we observe consistent patterns, with renewable energy consumption and globalization maintaining significant impacts of approximately 0.70% and 0.45% on environmental degradation. These findings underscore renewable energy's and globalization's crucial roles in fostering environmental sustainability efforts. Moreover, economic growth continues to exert a substantial positive influence of 0.54% on environmental degradation. However, the influence of domestic investment appears insignificant in this model, suggesting that its role in mitigating environmental degradation may be less pronounced compared to other factors.

4. Discussion of the results

The study's empirical findings provide valuable insights into the relationship between globalization, renewable energy adoption, economic growth, and environmental degradation in Somalia. The analysis highlights the importance of renewable energy and domestic investment in mitigating environmental degradation, while also acknowledging the complex and sometimes negative effects of globalization and economic growth on the environment.

The results consistently show a significant negative correlation between renewable energy consumption and environmental degradation in Somalia. This aligns with previous research demonstrating that increased reliance on renewable energy sources can effectively reduce carbon emissions and other forms of environmental degradation (Tariq Majeed & Luni, 2019; Usman et al., 2020). Adebayo and Kirikkaleli (2021) found similar outcomes in Japan, where adopting renewable energy led to substantial reductions in carbon dioxide emissions. The strong negative coefficient observed in both the long-run and short-run ARDL models emphasizes the critical role of renewable energy in promoting environmental sustainability.

On the other hand, economic growth was found to have a significant positive impact on environmental degradation in Somalia. This supports the Environmental Kuznets Curve (EKC) hypothesis, which suggests that in the early stages of economic growth, environmental degradation increases until a certain level of income per capita is reached, after which it starts to decline (Jun et al., 2021). However, this study suggests that Somalia is still in the early stages of this curve, where economic growth is associated with higher environmental degradation. Similar findings have been observed in other developing regions (Nathaniel et al., 2020). The influence of globalization on environmental degradation in Somalia is more complex. While globalization has a significant positive impact on environmental degradation in the short run, its long-term impact is not statistically significant. This complexity is consistent with the existing literature, which shows that the effects of globalization on environmental outcomes vary depending on regional and contextual factors (Adebayo et al., 2022; Sethi et al., 2020). Some studies suggest that globalization can lead to higher carbon emissions due to increased industrial activity and resource extraction (Jun et al., 2021). while others argue that it can facilitate the adoption of cleaner technologies and promote environmental sustainability through international cooperation and the transfer of green technologies (Shahbaz et al., 2019). The study conducted reveals that domestic investment has a significant role in reducing environmental degradation in Somalia. This finding aligns with previous research that suggests investments in sustainable infrastructure and green technologies can help mitigate environmental impacts (Ibrahiem, 2020). By increasing domestic investment, it becomes possible to support the development of renewable energy projects and other sustainable initiatives, which in turn reduce reliance on fossil fuels and decrease carbon emissions.

However, it is important to note that not all literature supports these findings. Some studies suggest different relationships between the variables examined. In certain contexts, the adoption of renewable energy does not always lead to reduced environmental degradation. For example, Feng et al. (2023) found that the transition to renewable energy sources can result in increased environmental degradation due to inefficient technology and inadequate infrastructure in some developing countries. Premature adoption of

renewable technologies that are ill-suited to the local context can lead to higher lifecycle emissions associated with the construction, maintenance, and operation of renewable energy facilities. While the EKC hypothesis is widely accepted, some studies challenge its applicability. Sorrell (2015) argues that the relationship between economic growth and environmental degradation is not universally consistent and can be influenced by factors such as government policies, technological innovation, and public awareness. In certain cases, economic growth has been associated with improved environmental quality as a result of implementing strict environmental regulations and adopting cleaner technologies (Zhao et al., 2022).

5. Conclusion and policy implications

Environmental degradation is a pressing global concern, with ramifications spanning various regions. However, Sub-Saharan Africa faces heightened vulnerability due to its substantial arid and semi-arid areas, encompassing approximately two-thirds of the continent (Fenta et al., 2020). This vulnerability underscores the urgent need for comprehensive studies to understand the intricate dynamics shaping environmental sustainability in the region. The complex interplay between environmental degradation, globalization, renewable energy, economic growth, and domestic investment from 1990 to 2020 must be examined in Somalia. Employing advanced econometric techniques such as Autoregressive Distributed Lag (ARDL), Fully Modified Ordinary Least Squares (FMOLS), and Canonical Cointegrating Regression (CCR), the study sought to explain the nexus between environmental sustainability and key socio-economic factors. The empirical findings unveiled significant insights, with renewable energy emerging as a crucial driver of environmental well-being, exhibiting substantial positive effects both in the short and long run. While domestic investment also positively influenced the environment, its impact was comparatively modest relative to the pronounced effect of renewable energy. Conversely, economic growth was identified as a contributor to environmental degradation, highlighting the imperative of pursuing sustainable growth strategies. Moreover, globalization was found to exacerbate environmental degradation in the short run.

Interpretation of the findings revealed that an increase in renewable energy and domestic investment led to a reduction in environmental degradation in the long run, emphasizing the efficacy of these interventions. Conversely, economic growth exhibited a detrimental effect, contributing to environmental deterioration. FMOLS analysis further elucidated that globalization tended to mitigate environmental degradation in the long run, providing valuable insights for policy formulation. The robustness of the results was affirmed through additional analyses, including CCR, which corroborated the findings of FMOLS. Furthermore, stability analysis conducted via Cumulative Sum of Squares (CUSUMSQR) and Cumulative Sum (CUSUM) tests underscored the consistency of the data over time, bolstering confidence in the reliability of the findings for informing dependable time-series modeling.

Our findings are of great importance to policymakers in Somalia and around the world. It is crucial for policymakers to prioritize allocating resources towards the development of renewable energy infrastructure. This investment is essential for promoting environmental sustainability, as renewable energy sources offer a cleaner and more sustainable alternative to traditional fossil fuels. Specifically, our results indicate that increasing the adoption of renewable energy can have a significant impact on economic growth and domestic investment, providing both environmental protection and economic development. By giving priority to renewable energy projects, Somalia can reduce its dependence on fossil fuels, create job opportunities, attract foreign investment, and establish a sustainable development model in the region.

Although a comprehensive approach was used in this research, it is important to acknowledge certain limitations. The socio-political landscape of Somalia, which is marked by ongoing conflicts and instability, adds complexity to the analysis and may have an impact on the outcomes that are hard to quantify. These conditions introduce a considerable amount of variability that the econometric models employed in this study may not fully capture. As a result, the precision and generalizability of the findings may be affected.

Author's contributions

Omar Ahmedqani Hussein contributed significantly to the research process by providing valuable research methodology and data analysis, writing the literature review, data collection, interpreting the

findings, and drafting the initial manuscript. Khadija Shamsi Mohamed focused on developing the introduction, assisting in data collection, and making critical revisions.

Disclosure statement

Rest assured that the authors have no conflicts of interest to declare and are committed to upholding academic integrity and objectivity.

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Data availability statement

Data used in this study are publicly available from the following links: Indicators | Data (worldbank.org); OIC Statistics Database (OICStat) - Query - SESRIC; KOF Globalisation Index – KOF Swiss Economic Institute | ETH Zurich.

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