Journal of Cleaner Production 406 (2023) 136856

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Towards sustainable environment in Somalia: The role of conflicts, urbanization, and globalization on environmental degradation and emissions

Abdimalik Ali Warsame [a,b,*], Abdikafi Hassan Abdi [a,c], Amir Yahya Amir [a,d], W.N.W. Azman-Saini [d]

[a] Faculty of Economics, SIMAD University, Mogadishu, Somalia
[b] Garaad Institute for Social Research and Development Studies, Mogadishu, Somalia
[c] Institute of Climate and Environment, SIMAD University, Mogadishu, Somalia
[d] School of Business and Economics, Universiti Putra, Malaysia

ARTICLE INFO

Handling Editor: Giovanni Baiocchi

Keywords:
Deforestation
GHG emissions
Conflicts
Urbanization
Globalization
Somalia

ABSTRACT

Climate change is a global phenomenon in the 21st century. Hence, achieving environmental sustainability has become a global initiative to tackle the repercussions of climate change. Fossil fuel energy consumption and economic growth remain critical amidst environmental degradation and emissions. Contrary to the previous attempts, this study examines the impacts of conflicts – internal and external –, urbanization, and globalization on environmental degradation and emissions in Somalia. The autoregressive distributed lag (ARDL) model, kernelized regularized least squares (KRLS) machine learning method, and vector error correction modeling (VECM) method are utilized with annual time series data spanning 1985–2016. The empirical results show that external conflict, globalization, and urbanization increase environmental degradation in the long run but not in the short run, except globalization which has a constructive role in enhancing environmental quality in the short-run. Notably, internal conflict is inconsequential both in the short- and long-run. The results of the study are robust for various analysis methods and environmental pollution indicators. In contrast, the VECM results indicate that urbanization, economic growth, and internal and external conflicts Granger cause environmental degradation both in the short and long-run, whereas globalization causes environmental degradation in the short run only. Notably, there is bidirectional causality between urbanization and environmental degradation in the short run only. A striking result is that both internal and external conflicts are neither caused by environmental degradation nor other regressors in the short- and long-run. Hence, relevant policy implications are suggested based on the empirical findings of the study.

1. Introduction

Today's most critical concern of humanity is mitigating the adverse consequences of global environmental pollution. According to the IPCC (2014), carbon emissions from industrial activities and the combustion of fossil fuels are responsible for 78% of the overall increase in greenhouse gases (GHGs) between 1970 and 2010 worldwide. The expanding pollutant of GHGs because of manufacturing activities has contributed significantly to climate change and the deterioration of the atmosphere, which influenced the livelihoods of many societies (Abdi et al., 2022; Warsame and Abdi, 2023). The fluctuations in climatic conditions including the subsequent scarcity of water resources created the tendency of social instability (Hendrix &Salehyan, 2012; Hsiang and Burke, 2014). Currently, ecological issues are globalized concerning their ramifications and the factors that cause them. Dunlap and Jorgenson (2012) argue that industrialization and urbanization were responsible for the increasing adverse environmental circumstances. Hence, the mitigation of the adverse environmental consequences of economic growth, conflicts, and urbanization became a global concern. The policies aimed at attaining sustainable development facilitate the flow of effective technologies, climate-resilient practices, and research and development to support environmental sustainability.

* Corresponding author. Faculty of Economics, SIMAD University, Mogadishu, Somalia.
E-mail address: abdimalikali1995@gmail.com (A.A. Warsame).

https://doi.org/10.1016/j.jclepro.2023.136856
Received 24 December 2022; Received in revised form 7 March 2023; Accepted 17 March 2023
Available online 29 March 2023

The discussions about the connections between climate change and conflicts indicate that climatic conditions affect conflicts directly through competition over limited resources. For instance, Warsame et al. (2022b) and Hsiang et al. (2013) demonstrate that climatological changes may affect the availability of scarce resources and cause conflict over their distribution. According to McMichael (1993), climate change and resource shortage induce the outbreak of disputes, which worsen the environmental quality and lead to increased resource depletion. However, other studies indicate that conflict may result from climate change indirectly by reducing human welfare, agrarian livelihoods and pushing migration (Koubi, 2019; Sharifi et al., 2021). These studies present that climatic factors may only operate as motivating components of violent events under certain conditions. Sharifi et al. (2021) revealed that climate change is likely to threaten peace only in the presence of political instability, weak governance, poverty, homogenous livelihood arrangements, and ethnic fragmentation.

In addition, the environmental implications of globalization are an issue of concern among researchers. Globalization reinforces countries' comparative advantage by boosting economic growth through more significant trade and generating investment possibilities through enlarged foreign direct investment (Pata and Yilanci, 2020). There is a controversial empirical debate over the connections between globalization and environmental pollution. The effects of globalization on the environment are mainly driven by trade activities such as the consumption of imported commodities, the manufacturing of exported goods, and the transportation activities linked with them (Veen-Groot and Nijkamp, 1999).

Another huge challenge to the tremendous desire to cut GHGs emissions is the complicated effects of urbanization. Settlement patterns shift dramatically in developing countries, and urban economic activity increases due to the economic disparity between urban and rural areas (Wu et al., 2016). According to Wang et al. (2016), a substantial proportion of the labor force is moving from mainly agrarian to urban-based industrial activities due to the rapid acceleration of economic globalization and social development. Since the urban population is useful input for the production process, it is connected to the industrialization process and the mass production system (Ansari et al., 2021). Increased energy consumption and transportation due to increased industrialization and urbanization result in externalities like energy waste and pollution (Tahir et al., 2021). The urbanization in Somalia has tremendously risen during the last three decades. The urban population of the country was 47 percent of the total population in 2021. Since 1991, the urban population has grown by around 32.5 percent. In contrast, the urban population rose only 16 percent between 1970 and 1991 (Warsame, 2022).

Furthermore, conflict is considered to be a crucial factor that directly or indirectly influences environmental degradation. The violent events have led to energy catastrophes, loss of physical capital, as well as trade, productivity, and investment reductions that have hampered the economic growth of many conflict-affected countries (Usman et al., 2021). According to the World Bank (2022), it is anticipated that almost two-thirds of the world's poor people will inhabit nations experiencing conflicts by 2030. Somalia had frequent violent clashes that were raging since the civil war outbreak in 1991 (Maystadt and Ecker, 2014). The country faced different kinds of violent events during the past three decades, including clashes between clan and warlord militias to diverse other militant groups. Competition over scarce resource allocation and power struggle was identified as the primary causes of the Somali conflict (Dahir and Sheikh Ali, 2021; Elmi and Barise, 2006). The main argument for thinking that conflicts have an immediate impact on environmental quality is that conflicts weaken institutional quality, which led to excessive deforestation in Somalia. For instance, after the ousting of the military government in 1991, charcoal exports to the Gulf Cooperation Council (GCC) countries have become a lucrative business trade in Somalia which were illegal prior to that period (Warsame and Sarkodie., 2022).

Somalia is experiencing severe environmental conditions including inter alia; droughts, locust plagues, floods, and land degradation. The country's environmental degradation is mainly driven by deforestation that results from cutting trees for charcoal production for domestic consumption and exports (Warsame and Abdi, 2023). The majority of urban and dominant rural population households utilize traditional biomass energy namely firewood and charcoal which constitutes 82 percent of the total energy consumption (Warsame et al., 2022c). For instance, Somalia's forest area of the total land has decreased from 13 percent in 1990 to 9.5 percent by 2020 (Warsame et al., 2022c). Since the demise of the government in 1991, Somalia has been one of the most vulnerable countries to climate change in the world due to its weak adaptation capacity. Determining factors that affect environmental degradation and pollution is necessary to develop sustainable development policies targeting environmental degradation and emissions alleviation.

Even though few studies have examined determinants of environmental quality in Somalia using various indicators such as energy consumption and economic growth (Warsame et al., 2022c); agriculture and livestock productions (Warsame et al., 2022a); and renewable energy and institutional quality (Warsame et al., 2022c), but no study has examined the impact of urbanization, globalization, and conflicts on environmental degradation and emissions in Somalia. Moreover, most of the previous studies investigated the influence of environmental changes on leading conflict (Hendrix and Salehyan2012; Hsiang and Burke, 2014; and Mohamed and Nageye, 2019). Nevertheless, there is a growing concern about whether conflicts – internal and external – affect the environmental degradation of conflict-prone nations such as Somalia. Against this backdrop, this study aims to investigate the impact of conflicts, urbanization, and globalization on environmental degradation and pollution in Somalia where there are limited studies on this theme. Unlike previous attempts, this undertaking assesses the heterogeneous marginal effects of the parameters on environmental degradation using the KRLS machine learning methods. Further, this study implements the autoregressive distributed lag (ARDL) technique which can precisely predict the short- and long-term relationships between the study's variables and is effective for small samples.The study also uses GHG emissions as a measurement of environmental pollution indicator to find out robust results that are not sensitive to the environmental quality proxies employed. Some robust measurement approaches such as the multivariate cointegration approach and VECM are used to determine the long-run and short-run causal path among the variables.

The rest of the paper is structured as follows. The second section summarizes the relevant literature. The third section illustrates the variables and the econometric approaches utilized for the study. The fourth section presents the results and discussion, and the final section concludes the study, and suggests relevant policy implications.

2. Literature review

An expanding body of empirical studies assessed the nexus between conflicts and environmental degradation. For instance, Usman et al. (2021) explored the impact of internal and external conflicts on the ecological footprint in the Middle East and North African (MENA) nations between 1995 and 2016. They demonstrated that the escalation in conflicts stimulates environmental degradation. Moreover, Hsiang and Burke (2014) observed from a thorough analysis of the literature that an increase in conflict is connected to an increase in surface temperature in typically temperate or warm regions. There is a discrepancy in the empirical studies on whether conflicts have environmental consequences or adverse environmental conditions lead to conflicts. In addition, Mohamed and Nageye (2019) reported that adverse environmental conditions, the decline in arable land, and an increase in rural population increase civil conflicts in Somalia. Likewise, Hendrix and Salehyan (2012) investigated whether climatic alterations impact people's tendency to participate in internal conflicts. The findings show that

variations in rainfall have a considerable impact on both major and minor political conflicts. The study also pointed out that the relationship between violent events and climate change are higher in plentiful than scarce rainfall periods. According to Ge et al. (2022), temperature variations or extremes in precipitation are linked to a higher chance of armed conflict globally. Additionally, Elmi and Barise (2006) supported the evidence of the causal association between the occurrence of civil conflicts and extreme weather phenomena in the case of Somalia. They noted that this causality holds for both localized violent conflicts and droughts that occur over a brief period of time where the chance of violence increases by 62% for every standard deviation increase in drought intensity and duration. However, Sharifi et al. (2021) argued that only particular circumstances might lead to interactions between water stress, severe temperatures, and civil conflicts.

Globalization can be described as the process of increasing economic interdependence among nations in terms of free trade, the flow of information, international capital flows, and growing labor mobility (Fischer, 2003). Since this process is related to industrialization and expansion of cities, it has environmental effects in all regions of the world (Veen-Groot and Nijkamp, 1999). The empirical evidence regarding the globalization-environmental pollution nexus demonstrated blended results. Most studies identified that globalization enhances environmental quality in developing countries (Ansari et al., 2021; Awan et al., 2020; Tahir et al., 2021; Yuping et al., 2021). Moreover, Pata and &Yilanci (2020) inspected the impact of globalization on environmental pollution along with several regressors in G7 countries over the period 1980–2015. The long-run results indicated that globalization dramatically lowers ecological footprints. Similarly, Ahmad et al. (2021) concluded that financial globalization and eco-innovation minimize the ecological footprints of the G7 countries. Economic globalization is considered a crucial factor that lessens environmental degradation, while economic expansion significantly deteriorates environmental quality in MENA countries (Jahanger et al., 2022; Xiaoman et al., 2021). Additionally, Alam (2010) discovered that a rise in globalization reduces the rate of environmental degradation while it had a favorable impact on economic growth.

On the other hand, ample studies affirmed the adverse effects of globalization on environmental quality (Destek, 2020; Jahanger et al., 2022). For instance, Pata (2021) ascertained the impact of globalization on ecological footprint and carbon dioxide (CO_2) emissions in BRIC nations. The findings of the Fourier ARDL long-term elasticities indicate that globalization raises pollution indicators. Similarly, Rehman et al. (2021) found from the ARDL approach that globalization impedes environmental quality in Pakistan by increasing the ecological footprint in the long run. Moreover, Adebayo and Acheampong (2022) evaluated the effects of economic globalization on carbon emissions in Australia between 1970 and 2018. The quantile-on-quantile results showed a positive feedback relationship between globalization and carbon emissions. In addition, economic growth and carbon emissions are positively correlated at most quantiles. Khan et al. (2022) concluded that globalization significantly increases environmental degradation in the South Asian region. By applying a similar technique, Wen et al. (2021) found that globalization has a positive relationship with CO_2 emissions. It is remarkable to present that globalization affects countries differently due to discrepancies in the kinds of products traded. The majority of developing countries export less sophisticated items that are environmentally unfriendly (Doğan et al., 2019). The third strand of the literature assesses the nexus between urbanization and environmental pollution. Urbanization – environmental pollution nexus produced inconsistent findings due to the countries' income levels. Studies focusing on developing countries reported that urban expansion adversely affects environmental quality (Ansari et al., 2021; Y. Wang et al., 2016). For example, Doğan et al. (2019) observed that the rate of urbanization deteriorates the environment in lower and higher-middle-income nations. Moreover, Hanif (2018) provided evidence that the expansion of urban areas significantly contributes to carbon dioxide emissions. Besides, Wu et al. (2016) asserted the impact of urbanization on CO_2 emissions along with several regressors. The results indicated that an increase in urbanization leads to increased carbon emissions. By the same token, Musah et al. (2021) found that urbanization and economic growth had a significant positive influence on CO_2emissions in West Africa. A recent study by Abdi (2023) observed from 41 Sub-Saharan African countries that urbanization exacerbates the repercussions of environmental degradation. Similar findings are remarked by Sun et al. (2022) in China. On the contrary, Shaheen et al. (2019) verified that urban expansion in Pakistan was found to have insignificant effects on environmental pollution.

Indeed, most of the findings from advanced economies revealed that urbanization does not harm environmental quality. For instance, Ali et al. (2017) stated that urbanization enhances environmental quality in Singapore by reducing carbon emissions. Additionally, Wang et al. (2021) inspected the effects of urbanization on carbon emissions in OECD countries. The findings pointed out that urbanization tends to decrease CO_2 emissions in developed countries. However, Rafique et al. (2022) observed from the top 10 sophisticated countries that urbanization increases the ecological footprint. Notably, the effects of urbanization in some countries are U-shaped (Khan &Su, 2021; Sun and Huang, 2020; Zhang et al., 2017). During the initial stages of urbanization, carbon emissions increase, but once urbanization reaches a specific threshold value, the environmental quality improves due to urban agglomeration and technological progress.

In light of the literature above, it could be noticed that the impact of urbanization and globalization are extensively examined in the literature, but this theme is absent in the context of Somalia. Moreover, previous studies on urbanization-globalization-environmental quality have produced blended results. This could be attributed to the fact that globalization affects countries differently due to discrepancies in the kinds of products traded. The majority of developing countries export less sophisticated items that are environmentally unfriendly (Doğan et al., 2019). In the same vein, the empirical studies on urbanization and environmental quality nexus are inconclusive and subject to the economic development stage of sampled countries. However, this sheds the light on that further studies are needed on this theme in other countries. Further, the impact of conflicts on environmental quality is scanty in the literature. Hence, this study contributes to the literature by investigating the impact of urbanization, globalization, and conflicts on environmental degradation and emissions in Somalia. Contrary to the previous attempts, the study utilizes the KRLS machine learning methods, which assess the heterogeneous marginal effects of the parameters on environmental degradation.

3. Methodology

3.1. Data

In the case of Somalia, this study employs annual time series data spanning 1985–2016. Environmental degradation, internal conflict, external conflict, economic growth, globalization, and urbanization are among the variables. The data were obtained from the World Bank, International country guide risk (ICRG) published by the political risk group (PRS), the Organization of Islamic Cooperation countries (OIC) database SESRIC, and the KOF Swiss Economic Institute. All the data for

Table 1
Variables' descriptions.

Parameters	Code	Measurement	Source
Environmental Degradation	ED	Deforestation (Percent of arable land) is measured for environmental degradation	World Bank
Internal conflict	IC	It is assessment rating contains three components: (a) civil war/ coup threat, (b) terrorism/political violence, (c) civil disorder	ICRG published by PRS
External conflict	EC	It is assessment rating contains three components: (a) war (b) cross-border conflict, (c) foreign pressures	ICRG published by PRS
Globalization	Glo	KOF Globalisation Index	KOF
Economic growth	EG	Real Gross Domestic Product (Constant, 2010)	SESRIC
Urbanization	UR	Percent of urban population to the total population	World Bank

the variables used in this study, except for internal conflict and external conflict, were transformed into natural logarithms for smoothness and variance reduction. The time frame was determined based on the availability of data on all variables. Table 1 presents the descriptions and details of the data source. We have selected these variables based on sustainable development goals (SDGs) 13 (climate action), 8 (decent work and economic growth), 11 (sustainable cities and communities), and 12 (partnerships for the goals). In 2015, the United Nations (UN) launched 17 SDGs to be reached in 2030. Among these goals, countries were urged for reducing environmental pollution and degradation to combat climate change. Moreover, recent studies have underscored that conflicts undermine the efforts for mitigating climate change via increasing environmental degradation and pollution (Usman et al., 2021). Hence, this study also tries to quantify the impact of conflicts on environmental degradation and pollution in Somalia.

Each subcomponent of internal and external conflicts is assigned a maximum value of "4" and a minimum value of "0". The value of "4" represents very low risk, whereas the value of "0" indicates very high risk. Hence, we rescaled these values using the inverse of the ICRG index to make sure of a robust interpretation of the results. The high value represents a high risk of conflicts and the low value represents a low risk of conflicts.

3.2. Method

This study employs the ARDL bound test developed by Pesaran et., (2001) to examine the cointegration between the estimated variables. The ARDL method has several advantages over previous cointegration techniques. First, the ARDL method can be applied to underlying regressors regardless of their order of integration, i.e. [I (0)], [I (1)], or a combination of both. However, it must be confirmed that none of the variables is [I (2)]. Second, it is appropriate for small sample size data. Thirdly, it simultaneously estimates long-run and short-run coefficients. This feature makes it easier to distinguish between the long-run and short-run effects of independent variables on the dependent variable.

To investigate the role of conflicts, urbanization, and globalization in environmental degradation in Somalia, we specify the following model – by utilizing the previous empirical works of Shahbaz et al., (2016) and Usman et al. (2021) – as follows:

$$\ln EDt = \beta_0 + \beta_1 \ln EG_t + \beta_2 IC_t + \beta_3 EC_t + \beta_4 \ln GLO_t + \beta_5 \ln UR_t + \varepsilon_t \quad (1)$$

Where β_0 is the constant, ln represents the natural logarithm. lnED, lnEG, IC, EC, and lnGLO represent environmental degradation, economic growth, internal conflict, external conflict, globalization, and urbanization. t and Ɛ represent time and the error term, respectively. The parameters β_1, β_2, β_3, β_4, and β_5 are the long-term elasticity of environmental degradation for economic growth, internal conflict, external conflict, globalization, and urbanization, respectively.

This study's main objective is to analyze the short- and long-run association of environmental degradation with conflicts – both internal and external conflicts –, urbanization, economic growth, and globalization. Hence, we express the ARDL long- and short-run model of the variables as follows:

$$\begin{aligned}\Delta lnED_t = {} & + \delta_0 + \delta_1 IC_{t-1} + \delta_2 EC_{t-1} + \delta_3 lnGlo_{t-1} + \delta_4 lnUR_{t-1} + \delta_5 lnEG_{t-1} \\ & + \sum_{i=0}^{q} \Delta\gamma_1 lnED_{t-k} + \sum_{i=0}^{p} \Delta\gamma_2 IC_{t-k} + \sum_{i=0}^{p} \Delta\gamma_3 EC_{t-k} \\ & + \sum_{i=0}^{p} \Delta\gamma_4 lnGlo_{t-k} + \sum_{i=0}^{p} \Delta\gamma_5 lnUR_{t-k} + \sum_{i=0}^{p} \Delta\gamma_6 lnUR_{t-k} \\ & + \varnothing \mathrm{ECT}_{t-1} \quad (2)\end{aligned}$$

Where δ_0 is the constant, $\delta_1 - \delta_5$ stand for the long-run coefficient parameters, $\gamma_1 - \gamma_6$ are the short-run coefficients of the variables, p indicates the optimal lag length of the explanatory variables, q is the optimal lag length of the dependent variable, Δ is the first difference sign that indicates short-run parameters, and ∅ stands for the coefficient of the error correction term (ECT).

To determine the presence of cointegration among the selected variables, the bounds test compares the null hypothesis (H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$) of no cointegration for the explanatory variables to dependent variable to the alternative hypothesis (H_1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$) indicating the cointegration among the variables. Pesaran et al. (2001) proposed that if the calculated F-test value exceeds the upper bound critical value, the null hypothesis of no cointegration will be rejected, indicating a long-term relationship. In contrast, if the estimated value of the F-test is less than the critical value, the null hypothesis cannot be rejected, indicating that there is no long-term relationship. If the estimated F-test value falls between the upper and lower critical values, the result remains inconclusive (Pesaran et al., 2001).

4. Empirical analysis and discussion

4.1. Unit root test

Time series often encompasses trending that violates the assumption of stationary. To address the unit root test, we employ several unit root tests such as, Augmented Dickey-fuller (ADF), Philips Perron (PP), and

Table 2
Unit root tests.

Variable	ADF	PP	KPPSS
LnEP	−2.9883	−2.1945	0.1033***
ΔLnEP	−4.3079***	−5.9454***	0.2420
IC	−2.1092	−2.1662	0.075***
ΔIC	−4.4439***	−5.2044***	0.0758***
EC	−2.0699	−2.1921	0.0746***
ΔEC	−5.0865***	−5.0855***	0.0607***
LnEG	−3.4285*	−1.1226	0.1752
ΔLnEG	−2.5019	−5.3589***	0.0756***
LnGLO	−4.9112***	−1.2705***	0.1023***
ΔLnGLO	−5.7379***	−5.7384***	0.1091***
LnUR	−2.1983	−2.1834	0.1647
ΔLnUR	−5.6746***	−8.3603***	0.2398

Δ stands for the first difference variables. *, **, and *** exhibit the significance level of 10%, 5%, and 1% respectively. The t-statistics reported are trend and intercept only.

Kwiatkowski-Phillips-Schmidt-Shin (KPSS). The interpretations of ADF and PP tests are similar, whereas the KPSS is the opposite of ADF and PP. The unit root result of the study is reported in Table 2. Some variables – globalization, internal and external conflicts – are integrated both at level I (0) and the first difference I (1), while the rest of the variables are stationary at the first difference. It has shown that the scrutinized variables of the study are mixed order of integration. Thus, the ARDL bound test is appropriate for the characteristics of our data, and we could proceed to estimate the presence of long-run Cointegration among the variables.

Table 3
Long and Short-run analysis.

Variable	Model I (ED)	Model II (GHG)
Long-run coefficient		
Constant	8.1623***	5.5736***
	(7.5675)	(4.7873)
IC	−0.000214	0.0031
	(-0.0575)	(0.7211
EC	0.0127***	0.0061***
	(3.8118)	(3.1875)
lnGLO	0.1503*	0.0603*
	(1.7843)	(1.9735)
lnEG	−0.1359***	−0.0529
	(-3.1551)	(-0.8430)
lnUR	0.1565**	0.1234
	(2.7286)	(1.2911)
Short-run coefficients		
Constant	5.1707***	4.7421***
	(4.2596)	(6.8973)
Δ(lnEP (−1))	0.78006***	
	(3.5203)	
Δ(lnGHG(-1))		0.9336***
		(7.4287)
Δ(IC)	−0.0035	
	(-0.4021)	
Δ(IC(-1))	0.0049	−0.0066
	(0.7539)	(-1.1611)
Δ(EC (−1))	−0.0233**	−0.0053
	(-2.7864)	(-1.5264)
Δ(lnGLO)	−0.4724*	−0.0839
	(-1.8497)	(-0.8181)
Δ(lnGLO(-1))		0.0613
		(0.7252)
Δ(lnUR)	0.6492	0.1004
	(1.2789)	(0.4335)
Δ(lnUR (−1))	−1.4505***	−0.4151*
	(-3.2494)	(-1.9076)
Δ(lnEG)	0.1099	0.6032***
	(0.6614)	(5.4531)
Δ(lnEG (−1))	0.5903**	0.5303***
	(2.6504)	(3.5099)
ECT (−1)	−0.6816***	−0.9317***
	(-4.2473)	(-6.8821)
F-Bound Statistics	4.5166**	9.3837***
Critical value at 5%	(4.143)	(6.32)
Diagnostic tests		
LM Test	0.8926	0.8901
	(0.1833)	(0.1269)
Heteroskedasticity	1.7372	0.5014
	(0.1750)	(0.7498)
Normality Test	1.0711	3.6284
	(0.5853)	(0.1629)
Reset Test	1.5553	0.2342
	(0.2315)	(0.6388)
Adjusted R2	0.546	0.7626

Note: *** and ** indicates significance at 1% and 5% levels, respectively. T-statistic is reported in parenthesis. Δ = differencing.

4.2. Long- and short-run results of the bound test

The study assesses the presence of long-run Cointegration between environmental degradation, internal conflict, external conflict, economic growth, globalization, and urbanization in Somalia. The F-bound statistics are reported in Table 3. The F-bound test statistics (4.5) fall above the upper bound critical values (4.12) at a 5% significance level. Furthermore, the long and short-run coefficients of the regressors are simultaneously presented in Table 3. It indicated that all the regressors are statistically significant except internal conflict. External conflict, globalization, and urbanization increase environmental degradation in the long run, whereas economic growth has a constructive role in reducing environmental degradation in the long run. A 1 unit increase in external conflict contributes to the environmental degradation increase by about 0.012% in the long run. Similarly, globalization and urbanization increase environmental degradation by about 0.15% and 0.156% respectively in the long run, if they are increased by1%. On the contrary, economic growth – which represents income – has a constructive role in stimulating environmental quality in the long run. A 1% increase in economic growth reduces environmental degradation by ~0.135% in the long run.

Furthermore, the short-run dynamic effect is also presented in Table 3. Previous year environmental degradation significantly increases current environmental degradation in the short run. It is noteworthy that both internal and external conflicts are statistically insignificant in the short run; this implies that they are not an issue in the short run. Globalization has a constructive role in reducing environmental degradation in the short run. A 1% increase in globalization leads the environmental degradation decrease by 0.473% in the short run. Urbanization is not different from zero in the short run which means that it is statistically insignificant in the short run. Moreover, current and previous values of economic growth induce the environmental quality to deteriorate in the short run; even though the current value of economic growth is statistically insignificant. More importantly, the ECT is significant and has a negative coefficient which implies that any shock deviation that occurs in the short run is adjusted 68% by the scrutinized variables in the long run annually.

It is widely agreed that the determinants of environmental pollution indicators – deforestation, ecological footprint, and GHGs emissions –are heterogeneous across countries (Warsame et al., 2022a; Warsame et al., 2022). To find out robust results which are free from environmental pollution indicator sensitivity, we incorporate GHGs emissions as a dependent variable in the study. Its result – reported in Table 3 (Model II) – revealed that there is a long run Cointegration between GHGs emissions and the regressors in the long run since the F-bound statistics (9.3837) falls above the upper bound critical value (6.32) at a 1% significance level. Furthermore, it is observed that external conflict and globalization are statistically significant at 1% and 10% significance levels respectively, whereas others are statistically insignificant in the long run. A one-unit increase in external conflict induces the GHGs emissions to increase by about 0.006% in the long run, while globalization enhances GHGs emissions by about 0.06% in the long run if it is increased by 1%. The dynamic effect of the short-run result indicated that economic growth is the only significant regressor. A 1% increase in economic growth stimulates emissions by about 0.6032% in the short run. More importantly, the ECT is statistically significant and has a negative coefficient, hence, showing a convergence of the model. Any deviation shocks that occur in the short run in GHGs emissions are corrected by the sampled explanatory variables by about 93% annually in the long run.

To find out unbiased results, we have performed several diagnostic tests including, inter alia, serial correlation, normality test, model misspecification, and heteroskedasticity. The result reported in Table 4

Table 4
Pointwise derivatives using KRLS.

	Avg.	SE	T-statistics	P-value	P25	P50	P75
lnUR	.105104	.036417	2.886	0.008	−.044885	.089982	.29469
lnRGDP −.026397	.02795	−0.944	0.353	−.136359	−.043427	.030957	
lnGLO	.142616	.061605	2.315	0.028	−.064133	.078188	.252088
IC	−.007289	.003652	−1.996	0.056	−.012418	−.007162	−.00132
EC	.008989	.002874	3.128	0.004	−.000305	.006079	.017362
Lambda	= .2691						
Tolerance	= .032						
Sigma	= 5						
Eff. df	= 12.13						
R2	= .8309						
Looloss	= .8878						
Robust							
Pr(Skewness)	0.6556						
Pr(Kurtosis)	0.2619						
Adj chi^2(2)	1.56						

revealed that the results of the study are free from serial correlation and heteroskedasticity. Moreover, the data is independently and identically distributed as shown by the normality test. The model specifications are correctly specified. The adjusted R-squared of the two models (I&II) is 0.54 and 0.76, respectively, which imply that 54% and 76% of the variations in environmental degradation and emissions are responsible by the sampled regressors – internal conflict, external conflict, globalization, urbanization, and economic growth. The models of the study are stable as there is no structural break in the data as shown Figs. 1 and 2 of Cusum and Cusum squares respectively.

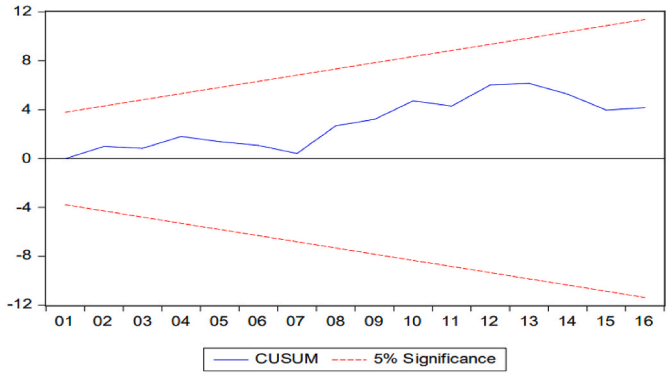

Figure a: Cusum test

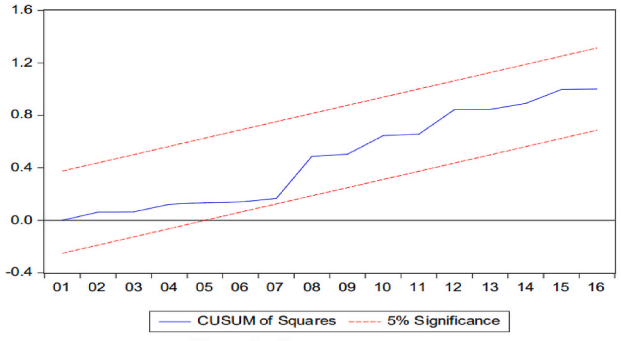

Figure b: Cusum square test

Fig. 1. Model I Stability test.

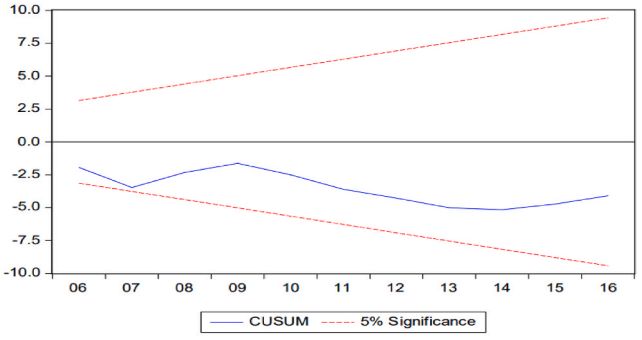

Figure a: CUSUM test

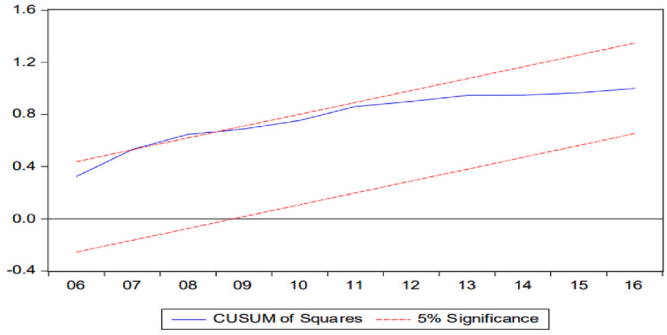

Figure b: CUSUM Square.

Fig. 2. Model II Stability test.

4.3. KRLS result

One of the shortfalls of the ARDL bound test is assuming constant marginal effects of the variables across time. Hence, to address the heterogeneous effects of the sampled parameters, we utilize the KRLS machine learning methods postulated by Hainmueller & Hazlett, (2014). The results of the KRLS method are presented in Table 4. It has a predictive power of 0.83. It implies that urbanization, conflicts, globalization, and economic growth explain 83% of the variations that occur in environmental degradation in Somalia. The heterogeneous marginal effects of the sampled variables are reported as 25th, 50th, and 75th percentiles (see Fig. 2).

Urbanization, globalization, and external conflicts significantly raise environmental degradation, whereas economic growth and internal conflict are statistically insignificant. The mean pointwise marginal

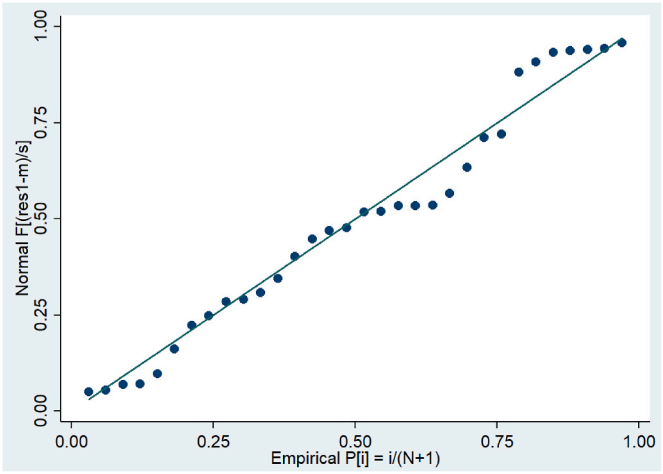

Fig. 3. Normal distribution of the estimated residuals.

effect of urbanization is 0.105%. An average increase in urbanization stimulates environmental degradation by about 0.105%. In the 25th percentile, urbanization reduces environmental degradation by 0.044%, whereas in the 50th and 75th percentiles, urbanization undermines environmental quality by about 0.089% and 0.29% respectively. Notably, urbanization has heterogeneous increasing marginal effects on environmental degradation in Somalia. Similarly, Globalization has heterogeneous marginal effects on environmental degradation. An average increase in globalization raises environmental degradation by about 0.14%. In the 25th percentile, globalization has a favorable effect on environmental quality. But in the 50th and 75th percentiles, globalization impedes environmental quality by about 0.078% and 0.25% respectively. It is noteworthy that globalization has heterogeneous increasing marginal effects on environmental degradation. Finally, external conflicts impede environmental quality by increasing deforestation in Somalia. A one-unit increase in external conflicts stimulates environmental degradation by about 0.008%. External conflict has a less significant effect on environmental degradation in the 25th percentile even though it has a favorable effect on environmental quality. In the 50th and 75th percentiles, the effects turn positive and has an increasing marginal effect on environmental degradation. Several diagnostic tests were performed including, inter alia, goodness-of-fit, lambda, looloss, and tolerance as reported in Table 4. Moreover, the estimated residuals of the data are normally and identically distributed as shown in Fig. 3.

4.4. Discussion of the result

Our results highlighted that external conflicts exert an adverse influence on environmental degradation and pollution in Somalia, whereas internal conflicts are inconsequential. In the ARDL result, a 1 unit increase in external conflict increases environmental degradation and emissions by about 0.012% and 0.006%, respectively, in the long run in Somalia. Somalia is a protracted crisis country that has been encountering several kinds of conflicts. It is argued that these conflicts hamper environmental quality in the country. Hence, our result supports that argument. But one of the most striking results is that internal conflict does not hamper environmental quality significantly, while external conflict does. An increase in conflicts induces deforestation to increase in the long run. Further, conflicts increase environmental pollution by raising air and water pollution. Burning cities and agriculture residues which increase GHGs emissions into the atmosphere are some of the main drivers that conflicts undermine environmental quality. Conflicts undermine the quality of government institutions which in turn hampers environmental quality. Notably, Somali charcoal exports to Gulf Cooperation Countries (GCC) is a key driver for deforestation in Somalia. These foreign countries' pressure and demand for Somalia charcoal lead to environmental degradation and pollution in Somalia as evidenced by our results. This result is in line with Usman et al. (2021) who found that internal and external conflicts hamper the ecological footprint in MENA countries. They observed that internal conflict has a more pronounced impact on environmental quality than external conflict. It also corroborates the findings of Al-Mulali & Ozturk, (2015) who discovered that conflicts and political turmoil inhibit environmental quality in MENA countries. In the same vein, Fredriksson & Svensson, (2003) also established that political instability hampers environmental regulations which in turn increases environmental pollution in panel countries.

Further, globalization significantly increases environmental degradation and emissions in the long run in Somalia. In the ARDL result, a 1% increase in globalization results in environmental degradation and emissions to increase by about 0.1503% and 0.0603%, respectively, in the long run. It also has increasing marginal effects on environmental degradation in Somalia as shown in the KRLS results. This result is in line with Deng et al. (2022) who found that social globalization enhances environmental pollution in panel countries. Similarly, Yurtkuran, (2021) has observed that economic globalization stimulates environmental pollution in Turkey. Ample studies found the positive effect of globalization on environmental quality such as Sabir & Gorus (2019) for South Asian countries, and Destek (2019) for Central and Eastern European Countries. On the contrary, Taiwo Onifade et al. (2021) underscored that economic globalization has a constructive role in reducing environmental degradation and ecological footprint in emerging seven countries (E7). Moreover, Zafar et al. (2019) detected that globalization enhances environmental quality by reducing CO_2emissions in OECD countries.

We have also observed that urbanization exerts a positive effect on environmental degradation only in the long run. In the ARDL result, a 1% increase in urbanization leads to environmental degradation by about 0.1565% in the long run, but urbanization does not significantly impact emissions in the long run. Urbanization leads to rapid industrialization which increases GHGs emissions. Moreover, the consumption patterns in urban cities are more carbon-intensive compared to rural dwelling. The urban population in Somalia is increasing at an unprecedented rate in the last three decades (Warsame, 2022). An increase in the urban population leads to environmental degradation in Somalia even though it has a diminishing effect on environmental degradation. This finding agrees with ample previous studies that concluded urbanization hampers environmental quality. For instance, Deng & Mendelsohn, (2021) reported that urbanization impedes air quality in the United States of America. A similar finding was established in Pakistan by Ali et al. (2019) who concluded that urbanization increases CO_2 emissions in Pakistan. Our results also agree with the findings of Adebayo et al. (2022) for Turkey and Luo et al. (2021) for China who reported that urbanization increases environmental pollution.

Table 5
Results of Johansen cointegration.

No. of CE(s)	Eigenvalue	T-Statistic	Critical Value	Probability
Trace Test				
None *	0.829625	126.1427	95.75366	0.0001
At most 1 *	0.672622	73.05012	69.81889	0.0270
At most 2	0.439281	39.55091	47.85613	0.2390
At most 3	0.332472	22.19487	29.79707	0.2878
At most 4	0.233106	10.06963	15.49471	0.2754
At most 5	0.067837	2.107439	3.841466	0.1466
Maximum Eigenvalue				
None *	0.829625	53.09258	40.07757	0.0010
At most 1	0.672622	33.49921	33.87687	0.0554
At most 2	0.439281	17.35604	27.58434	0.5495
At most 3	0.332472	12.12524	21.13162	0.5353
At most 4	0.233106	7.962192	14.26460	0.3825
At most 5	0.067837	2.107439	3.841466	0.1466

Table 6
Result of Granger Causality based on VECM.

	Short-run causality						Long-run causality
	ΔlnED	ΔlnGLO	ΔlnUR	ΔlnEG	ΔIC	ΔEC	ECT_{t-1}
ΔlnED		0.0062	6.834***	3.421*	0.184	3.598*	−0.2706**
ΔlnGLO	14.726***		2.381	9.814***	2.467	6.783***	−0.1372
ΔlnUR	10.433***	3.634*		0.048	0.585	0.425	0.024
ΔlnEG	1.603	1.647	0.31		1.599	4.545**	0.5269***
ΔIC	0.562	0.127	0.032	0.552		0.115	2.9685
ΔEC	1.132	0.865	0.333	2.101	2.685		9.3257***

4.5. Multivariate Cointegration and VECM result

The study assesses the long and short-run causality among the variables using vector error correction modeling (VECM). However, the result of multivariate Cointegration presented in Table 5 indicated that environmental degradation and the interested explanatory variables make co-movement together in the long run. There is at least one cointegrating vector as shown by the results. After determining the existence of long-run Cointegration, we subsequently estimate the short and long-run causality of the variables via the VECM. Its results reported in Table 6 indicated that urbanization, economic growth, internal conflicts, and external conflicts granger cause environmental degradation both in the short- and longrun, whereas globalization causes environmental degradation in the short run only. Environmental degradation, economic growth, internal conflicts, and external conflicts cause globalization in the short run but not in the long run. Moreover, urbanization is caused by environmental degradation and globalization in the short run only. Notably, there is bidirectional causation between urbanization and environmental degradation. Urbanization leads to the release of more emissions and the clearing of forests for housing and other production activities. Economic growth is only caused by external conflict in the short run but not in the long run. A striking result is that both internal and external conflicts are neither caused by environmental degradation nor other regressors in short- and long-run. Hence, it could be concluded that the determinants of conflicts in Somalia are not environmental factors (see Table 6).

5. Conclusion and policy implications

Mitigating environmental degradation and emissions became a topical issue and policy discourse in the 21st century. Various determinants of environmental degradation and emissions have been discussed in the literature. Somalia is facing recurrent environmental harsh conditions which led to severe natural disasters – droughts, floods, extreme winds, etc. To derive sustainable environmental policies in Somalia – a conflict-prone country –, we assessed the impact of conflicts, urbanization, and globalization on environmental degradation and emissions in Somalia. This undertaking utilized the ARDL bound test, KRLS machine learning method, and VECM method with annual time series data spanning 1985–2017.

The empirical findings of the bound test revealed that all the regressors are statistically significant except internal conflict. External conflict, globalization, and urbanization increase environmental degradation in the long run but not in the short run, except globalization which enhances environmental quality in the short run; whereas economic growth has a constructive role in reducing environmental degradation in the long run but deteriorates it in the short run. To find out robust results which are free from environmental pollution indicator sensitivity, we incorporate GHGs emissions as a dependent variable. It was found that external conflict and globalization significantly increase environmental pollution, whereas others are statistically insignificant in the long run. Furthermore, the results of the KRLS method uncovered that urbanization, globalization, and external conflicts significantly raise environmental degradation, whereas economic growth and internal conflict are statistically insignificant. Notably, urbanization and globalization have heterogeneous increasing marginal effects on environmental degradation in Somalia. Finally, external conflicts exert a positive effect on environmental degradation in Somalia. It has heterogeneous marginal effects on environmental degradation. Besides, the VECM results revealed that urbanization, economic growth, and internal & external conflicts Granger cause environmental degradation both in the short and long-run, whereas globalization causes environmental degradation in the short run only. Environmental degradation, economic growth, internal conflict, and external conflict cause globalization in the short run but not in the long run. Moreover, urbanization is caused by environmental degradation and globalization in the short run only. Notably, there is bidirectional causality between urbanization and environmental degradation. A striking result is that both internal and external conflicts are neither caused by environmental degradation nor other regressors in the short- and long-run. Hence, it could be concluded that the determinants of conflicts in Somalia are not environmental factors.

In light of the empirical findings,the study recommends several policy implications. First, since Somalia mainly depends on traditional biomass energy (Warsame, 2022), the increasing rate of urban population is associated with the increasing demand for energy that hampers environmental quality. However, to achieve environmental quality, it is required effective urban planning, and urban-induced renewable energy. Somalia is endowed with various sources of renewable energy such as wind, hydropower, and solar. Investing in and extracting these sources could lead to reducing fossil fuel energy consumption without harming sustainable economic growth and environment. Developing effective urban planning is crucial for protecting and promoting terrestrial ecosystems, reducing deforestation, and managing forests. Urbanization impedes environmental quality in Somalia, policymakers should control urban population scales and make efficient utilization of land resources by selecting suitable schemes to effectively enhance the environmental quality and purify the air. The absence of proper urban plans in Somalia since 1991resulted in a lack of necessary infrastructure for the new neighborhoods and revives land conflicts that escalate violence and social instability. Devising proper urban plans are also critical for planting trees and reducing unnecessary forest degradation, and waste management in urban areas. Hence, this study strongly suggests to re-establish necessary government institutions for urban planning. Second, one of the striking results of the study is that internal conflict is inconsequential whereas external conflict significantly hampers environmental quality in Somalia. The study recommends that addressing and fixing all sorts of conflicts, both internal and external conflicts, are not only necessary for environmental quality but also for sustainable domestic production and consumption. The study, particularly, emphasizes the urgent need for de-escalating external conflicts such as cross-border conflicts and foreign pressures since it significantly undermines environmental quality in Somalia. For instance, foreign pressure from GCC to charcoal exports in Somalia is a prime example of external conflict. Somali policymakers should ban charcoal exports, and whoever is caught in charcoal export smuggling should face harsh punishments such as serving prison time or heavy fines. Third, adopting environment-friendly cleaner technologies, via Somali's integration

with the rest of the world, could contribute to the reduction of environmental degradation and emissions. This implies that the adverse effect of globalization on environmental degradation and emissions could be reduced.

Based on the empirical findings, we recommend for future studies consider the impact of conflicts on various environmental indicators and countries; since this study is limited to Somalia only, and employed deforestation and GHGs emissions as environmental indicators.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards.

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publish.

Not applicable.

Funding

This research is supported by SIMAD University, Somalia (Grant number: SU-PG-2023-015)

CRediT authorship contribution statement

Abdimalik Ali Warsame: Conceptualization, data collection and analyzing, improving the original draft. **Abdikafi Hassan Abdi:** Writing the introduction and the literature. **Amir Yahya Amir:** Writing the methodology. **W.N.W. Azman-Saini:** Reviewing and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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