

The Impact of Democracy and Globalisation on Environmental Degradation Modeling: A Multidimensional Analysis in Arab Countries Using the STIRPAT Model

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Abstract:

This paper examines the impact of democracy and globalisation on Environmental Degradation in Arab countries from 1990 to 2023. This study adopts two widely used measures of democracy and evaluates environmental degradation using both CO₂ emissions and Greenhouse Gas emissions. The empirical findings of Pooled Mean Group panel model indicate that economic growth and energy use have a positive impact on environmental degradation. Democracy contributes to degradation when measured as a proxy for freedom and equality; however, when democracy reflects societal engagement and political participation, it may reduce carbon emissions in Arab countries. For globalization, the results indicate that an increase in political globalization mitigates environmental degradation, whereas both economic and cultural globalization exhibit fluctuating effects.

Key Words: democracy; globalization; environmental degradation; panel data; Arab countries

JEL Classification : Q56, F64, C30

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Introduction:

Globally, economics, environmental specialists, and policymakers are increasingly concerned about the environmental difficulties linked to climate change (Usman, Olanipekun, Iorember, & Abu-Goodman, 2020). The over-dependence on fossil fuels (gas and oil) as the primary energy sources to power economic development and growth has contributed importantly to worldwide warming and environmental degradation (Wang, & Azam, 2024). Reducing human reliance on natural resources and promoting sustainable development are crucial in addressing environmental deterioration and the depletion of natural resources. Scarcity of natural resources, energy use from fossil fuels, and total greenhouse gas emissions are important challenges that require immediate attention. According to Jahanger, Usman, and Balsalobre-Lorente (2022), there is a persistent rise in carbon emissions around the globe, which poses challenges to meeting the environmental targets set forth in the Paris Agreement. Understanding the problems that impact carbon emissions is crucial for developing mitigation methods. The most crucial element included in greenhouse gases is emissions of carbon dioxide (CO₂), which state

around 0.72 percent of produced emissions of greenhouse gases (Usman, Kousar, Yaseen, & Makhdum, 2020). According to Jiang Ye, and Liu, (2019), developing countries account for approximately 63.4% of global CO₂ emissions. Over the past 20 years, globalisation on all fronts economic, social, and political has had both beneficial and detrimental effects on the environment. Every country has grown more international as a result of globalisation, but political conditions remain national, increasing the likelihood that certain poor political democracy decisions will result in higher CO₂ emissions (Jahanger et al. 2022). The relationship in the literature between globalisation, autocracy, democracy, and CO₂ emissions has received a lot of attention. Moreover, research demonstrates that globalisation is a major driver of carbon emissions. Despite the fact that several academics like Shahbaz et al. (2018), Hussain et al. (2020), and Sethi et al. (2020) have studied the impact of globalisation on carbon emissions extensively, they have not been able to agree on the precise role that globalisation plays in CO₂ emissions. Theoretically, democracy and globalisation have a significant impact on carbon emissions. But there is still controversy about the impact of democracy and globalisation on the environment. For example, Usman et al. (2020) pointed out that the impact of democracy on CO₂ emissions is controversial. Democracy may contribute to the mitigation of environmental damage, but critics may argue that it may even be the cause of environmental devastation (Tiwari, & Sunny, 2024). According to some scholars, democratic countries typically see improvements in environmental quality as a result of appropriate and successful policy implementation. Democracy is a necessary component for altering the economic climate in a country that has ratified environmental laws and regulations and participates in international environmental agreements (Bättig & Bernauer 2009). Environmental matters are significantly impacted by a number of political decisions made in democracies for business benefits. A study done by Jahanger et al. (2022) found that democracy could degrade environmental quality. The primary cause of autocracies in developing countries is their emphasis on short-term objectives (such as political victories, which frequently highlight the requirement of temporarily visible results) as opposed to long-term planning, such as environmental modification mitigation (Keefer, 2007). Therefore, there is a conflict in the results and discussions about the impact of democracy and globalisation on the CO₂ emissions. Accordingly, the main research question of this study can be formulated as follows: Is there an impact of democracy and globalisation on carbon dioxide (CO₂) emissions in Arab countries?

I. Literature Review

1. Democracies and Responsibility of Environment Degradation

Tiwari and Sunny (2024) concluded that action is necessary to improve political leaders' accountability and make environmental information more accessible to the public, given the significance democratic processes play in the creation of environmental policy. With an emphasis on improving democratic transparency and increasing public understanding of environmental issues, the study offers a number of recommendations on how to accomplish this goal. Democracy and sustainable development are negatively correlated, although this correlation is not statistically significant across the majority of quantiles. Sustainable development is hampered by gross fixed capital formation (Ahmed, 2020). Usman et al. (2020) investigated how democracy, globalization, and energy use affect environmental degradation. Environmental Kuznets curve (EKC) statistics for South Africa from 1971 to 2014. Additionally, the data demonstrate a clear correlation between energy consumption and globalization, economic progress, democracy, and CO₂ emissions. It is found that energy use and CO₂ emissions, as well as globalization and CO₂ emissions, have a short-term causal link. Furthermore, it is asserted that economic growth Granger-causes democracy, whereas democracy Granger-causes CO₂ emissions. Ergun et al. (2019) used panel data gathered between 1990 and 2013 to shed light on the factors driving renewable energy use in Africa. According to the Freedom House Political Rights and Civil Literacy Ratings, one of their findings is that there is no relationship between the quantity of renewable energy sources and democracy. Research by Ursavaş and Apaydın (2024) showed a positive relationship between ecological footprint and democracy. In other words, the surroundings of developing nations worsen as democracy expands. Additionally, The findings show that while the ecological footprint increases as GDP per capita rises, it falls as renewable energy use rises. The results thus show how crucial democracy is to the sustainability of the environment in emerging nations.

2. Globalisation and Responsibility for Environmental Degradation

Globalization can either positively or negatively affect environmental deterioration, according to empirical study (Löschel et al. 2013; Paramati et al. 2017; and Shahbaz et al. 2017). According to Shahbaz et al. (2018), if there is a positive shock to globalization that increases energy demand and promotes ecologically unfavorable energy use, which in turn boosts CO₂ emissions, there will be a positive correlation between globalization and environmental degradation. Globalization enhances environmental quality by reducing CO₂ emissions through improved technology, claim Shahbaz et al. (2015). Society gains from this. An increase in productive activity and income, rapid exploration of domestic resources and raw materials, economic openness, and improvements in living standards such as housing, effective transportation, and enhanced communication are all outcomes of globalization. Opponents of globalization contend that it cannot lead to sustainable development since it simply fosters economic activity at the expense of future generations' well-being, compromising environmental quality in the sake of greater economic activity. Rafindadi and Usman (2019) have also examined the dynamic

effects of globalization and energy consumption on environmental degradation. They illustrated how globalization helps to slow down environmental degradation, at least momentarily. According to Ahmed (2024), there is a significant gain in sustainable development for every percentage point increase in political globalization, with increments ranging from 0.015 to 0.017% between the 10th and 90th quantiles. The study by Idroes et al. (2024) looks at how labor, capital creation, globalization, manufacturing, tourism, renewable energy, and military spending changed North African countries' CO2 emissions between 1995 and 2021. The long-term results of the ARDL model indicate that globalization, renewable energy, and capital formation have a negative impact on CO2 emissions, whereas economic expansion, manufacturing, and tourism have a favorable impact. Pairwise Granger causality statistics show a unidirectional causative relationship between CO2 emissions and economic growth, globalization, military spending, manufacturing, tourism, and capital formation.

II. Data and Methodology

Algeria, Comoros, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, and the United Arab Emirates are among the 17 Arab nations whose annual panel data are included in the study. Some nations in the region, like Yemen, Djibouti, and Somalia, were eliminated due to data unavailability. The World Bank Development Indicators (WDI), GlobalData (GD), Varieties for Democracy (V-DEM), Freedom House Index (FHI), and the KOF Swiss Economic Institution were among the sources from which the variables' data were gathered. The study used a quantitative methodology (STochastic Impacts by Regression on Population, Affluence, and Technology) to examine how globalization and democracy affect CO2 emissions. The STIRPAT model, which has been extensively utilized in the body of current literature (Xing et al., 2023; Pattak et al., 2023; Shu et al., 2024), enables a more accurate characterization of the sensitivity of environmental consequences to the factors driving them, as noted by York et al., 2003.

$$I_{it} = \alpha p_{it}^b A_{it}^c T_{it}^d \mu_{it}$$

where P stands for population, A for wealth, T for technology, and I for the components of environmental pressure. The explanatory variables' exponential powers are denoted by the terms b, c, and d; the model's intercept is denoted by α ; time is denoted by t, nations by i, and the error term is denoted by μ .

For every variable in the investigation, the natural logarithm was used. We have transformed every variable—aside from globalization and democracy—into a natural logarithm in order to overcome the likelihood of heteroscedasticity and data sharpness. The following is the presentation of the log-linear specification:

$$\ln I_{it} = \alpha_i + b(\ln p_{it}) + c(\ln A_{it}) + d(\ln T_{it}) + \mu_{it}$$

The study employs urban populations for P, GDP per capita for A, and fossil fuel energy consumption for T. We have defined our empirical model in the following format based on the earlier research:

$$\ln I_{it} = \beta_0 + \beta_1 \ln DEMOC_{it} + \beta_2 \ln POLTGI_{it} + \beta_3 \ln CULTGI_{it} + \beta_4 \ln ECOGI_{it} + \beta_5 \ln GDP_{it} + \beta_6 \ln URP_{it} + \beta_7 \ln GCF_{it} + \beta_8 \ln ENG_{it} + \mu_{it}$$

Stochastic error terms are represented by μ_{it} , time is represented by t , and nations are indexed by i . The constant is represented by the term β_0 , and the expected parameters are $\beta_1 \dots \beta_8$. The sources and definitions of the variables are shown in Table 1.

The study explores the effects of democracy and globalization on economic growth using two models, using V-Dem measurements for democracy in the first model and the FHI indicators in the second model, because there is no agreement among studies regarding the best measure for democracy in the empirical studies (Knutson et al., 2024). Additionally, CO2 emissions (CO2) and greenhouse gas emissions (GHG) were used as two independent variables to quantify environmental degradation. The four models are shown as follows:

The first model:

In this model, CO2 emissions are used to measure environmental pressure and V-Dem is used to measure democracy.

$$\ln CO2_{it} = \beta_0 + \beta_1 (\ln LIBR_{it}) + \beta_2 (\ln PARTIP_{it}) + \beta_3 (\ln DELIB_{it}) + \beta_4 (\ln EGALT_{it}) + \beta_5 (\ln POLTGI_{it}) + \beta_6 (\ln CULTGI_{it}) + \beta_7 (\ln GDP_{it}) + \beta_8 (\ln ECOGI_{it}) + \beta_9 (\ln ENG_{it}) + \mu_{it}$$

The second model:

In this model, CO2 emissions are used to quantify environmental pressure, and FHI is used to measure democracy.

$$\ln CO2_{it} = \beta_0 + \beta_1 (\ln CLR_{it}) + \beta_2 (\ln HRP_{it}) + \beta_3 (\ln POLTGI_{it}) + \beta_4 (\ln CULTGI_{it}) + \beta_5 (\ln ECOGI_{it}) + \beta_6 (\ln GDP_{it}) + \beta_7 (\ln ENG_{it}) + \mu_{it}$$

The third model:

GHG emissions are used in this model to quantify environmental pressure, and V-Dem is used to measure democracy.

$$\ln GHG_{it} = \beta_0 + \beta_1 (\ln LIBR_{it}) + \beta_2 (\ln PARTIP_{it}) + \beta_3 (\ln DELIB_{it}) + \beta_4 (\ln EGALT_{it}) + \beta_5 (\ln POLTGI_{it}) + \beta_6 (\ln CULTGI_{it}) + \beta_7 (\ln GDP_{it}) + \beta_8 (\ln ECOGI_{it}) + \beta_9 (\ln ENG_{it}) + \mu_{it}$$

The fourth model:

GHG emissions are used in this model to quantify environmental pressure, while FHI is used to measure democracy.

$$\ln GHG_{it} = \beta_0 + \beta_1 (\ln CLR_{it}) + \beta_2 (\ln HRP_{it}) + \beta_3 (\ln POLTGI_{it}) + \beta_4 (\ln CULTGI_{it}) + \beta_5 (\ln ECOGI_{it}) + \beta_6 (\ln GDP_{it}) + \beta_7 (\ln ENG_{it}) + \mu_{it}$$

Table 1. Variables description and sources

Variables	Acro.		Definition	Source
Modeling of Environmental Degradation	CO2 emissions	LCO2	The burning of fossil fuels and the manufacturing of cement are the main sources of carbon dioxide emissions.	WDI
	Green Gas House emissions	LGHG	Carbon dioxide, methane, and nitrous oxide are all included in total greenhouse gas emissions, which come from all sources, including changes in land use.	Global Data
Democracy (FHI)	Civil Liberties	LCLR	Obtaining civil liberties	Freedom House Index
	Human Right Protection	LHRP	Obtaining political rights	
Democracy (FHI)	Liberal Democracy	LLIBR	the scope of civil liberties, associational and expressive freedoms, voting rights, electoral justice and freedom, and restrictions on executive power.	V-DEM
	Participatory Democracy	LPARTIP	participation of citizens in both electoral and non-electoral procedures.	
	Deliberative Democracy	LDELIB	focuses on the decision-making process in society.	
	Egalitarian Democracy	LEGALT	the extent to which social groupings have equal access to resources, power, and rights and liberties.	
Economic Globalisation		ECOGI	depicts real economic flows as well as the limitations placed on them.	KOF
Political Globalisation		POLGI	shows how much a nation participates in international politics.	
Cultural Globalisation		CULTGI	evaluates how open a nation is to the outside world.	
Economic Growth		GDP	GDP (constant 2015 US\$)	WDI
Energy Use		ENG	The consumption of primary energy prior to its transformation into other end-use fuels is referred to as energy utilization.	

III. Results and Discussion

1. Descriptive statistics

The first dependent variable, LCO2, has a mean value of 16.95 with a standard deviation of 2, according to the descriptive statistical analysis shown in Table 2. LCO2 has a minimum of 11.09 and a maximum of 20.01. LGHG, the second indicator of environmental deterioration, has a mean of 17.92 and a standard deviation of 1.47. According to V-Dem definitions, the target variables measuring democracy have mean values of -2.13, -1.86, -2.13, and -2.49 for LDELIB, LEGALT, LLIBR, and LPARTIP, respectively. with comparable 0.93, 0.47, 0.71, and 0.82 standard deviations. The LCLR and LHRP Freedom House indicators have mean values of 1.66 and 1.73, respectively, with standard deviations of 0.20 and 0.25. The mean globalization metrics for LPOLGI, LCULTGI, and LECOGI are 3.86, 3.43, and 3.86, respectively, with standard deviations of 0.50, 0.85, and 0.48. Table 2 also includes the descriptive statistics for the other control variables.

Table 2. Descriptive Statistics

Variable	Mean	Median	Max	Min	Std	Obs
LCO2	16.9526	17.7226	20.0157	11.0966	2.00736	544
LGHG	17.9284	18.1909	20.5266	13.1672	1.47187	544
LCLR	1.66633	1.60943	1.94591	0.69314	0.20813	544
LHRP	1.73614	1.79175	1.94591	0.00000	0.25157	544
LPOLGI	3.86672	3.92540	4.48925	1.89571	0.50607	544
LCULTGI	3.43996	3.51439	4.56557	0.79027	0.85167	544
LECOGI	3.86987	4.01457	4.59840	2.10897	0.48837	544
LDELIB	-2.13179	-1.88387	-0.36961	-4.82831	0.93203	544
LEGALT	-1.86561	-1.82325	-0.45728	-3.10109	0.47866	544
LLIBR	-2.13745	-2.02495	-0.43695	-4.42284	0.71643	544
LPARTIP	-2.49565	-2.35387	-0.70522	-4.19970	0.82946	544
LGDP	24.5679	24.6762	27.3129	20.0311	1.52638	544
LENG	9.54498	9.42595	12.6684	6.23298	1.45735	544

2. Estimation results of static panel models

The static panel regression findings employing Pooled, Fixed, and Random effects are shown in Tables 3 and 4. With R-squared values of 0.98, 0.97, 0.97, and 0.97 in models 1, 3, 2, and 4, respectively, the Fixed Effect model exhibits the best statistical performance.

Table 3. Estimation results of static panel for model 1 and model 3

Independent Variables	Estimation of models of total homogeneity, fixed effect, and random effect					
	Model 1			Model 3		
	FEM	Pooled	REM	FEM	Pooled	REM
LLIBR	-0.014	1.600***	0.003	-0.392***	0.085	-0.309***
LPARTIP	0.271***	0.638***	0.263***	0.335***	0.007	0.245***
LDELIB	-0.136***	-1.013***	-0.14***	0.038	-0.167***	0.052
LEGALT	0.378***	-0.303	0.359***	0.387***	-0.077	0.222***
LPOLGI	0.143*	1.345***	0.176**	0.428***	0.503***	0.577***
LCULTGI	0.333***	0.028	0.326***	0.160***	-0.170***	0.110***
LGDP	0.066***	0.265***	0.072***	0.191***	0.737***	0.253***
LENG	0.556***	0.872***	0.569***	0.199***	0.176***	0.568***
LECOGI	0.097	-0.541***	0.097	-0.094	-0.387***	0.2834***
C	8.997***	1.196	8.600***	10.28***	-2.033***	-0.1134**
Durbin-Watson	0.6733	0.1424	0.660	0.6830	0.3436	0.5984
R_squared	0.9820	0.7534	0.5269	0.9760	0.8903	0.5379
Sum squared resid	39.201	539.37	1096.8	28.186	129.02	430
F-statistic	1135.7	181.35	66.089	844.03	481.61	69.074
Prob (F-statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Estimation method	OLS	OLS	GLS	OLS	OLS	GLS

(***) : significant at 1%, (**) : significant at 5%, (*) : significant at 10%.

Table 4. Estimation results of static panel for model 2 and model 4

Independent Variables	Estimation of models of total homogeneity, fixed effect, and random effect					
	Model 2			Model 4		
	FEM	Pooled	REM	FEM	Pooled	REM
LCLR	0.176	-0.540	0.176	-0.026	1.468***	0.143
LHRP	-0.137	-0.392	-0.137	-0.027	-0.172	-0.021
LPOLGI	0.181**	1.359***	0.196**	0.530***	0.522***	0.642***
LCULTGI	0.378***	0.123	0.375***	0.150***	0.073*	0.101***
LGDP	0.108***	0.227***	0.110***	0.238***	0.673***	0.288***
LENG	0.625***	0.667***	0.625***	0.207***	0.138***	0.239***
LECOGI	0.186***	-0.344**	0.182***	0.009	-0.243***	-0.038
C	5.5324***	2.227*	5.4528***	7.576***	-2.927***	5.666***
Durbin-Watson	0.5668	0.0417	0.5984	0.5431	0.4108	0.5607
R_squared	0.9791	0.6263	0.4528	0.9715	0.9041	0.5037
Sum squared resid	45.59	817.53	1083.01	33.4922	112.77	348.3
F-statistic	1062.24	128.36	63.37	771.490	722.13	77.71
Prob (F-statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Estimation method	OLS	OLS	GLS	OLS	OLS	GLS

(***) : significant at 1%, (**) : significant at 5%, (*) : significant at 10%.

The Hausman test model selection findings, which are used to determine the best estimating technique, are shown in Table 5. Results show that, with the exception of the third model, the fixed effect estimation is more suitable for all models. A 1% increase in LPARTIP and LDELIB in model 1 lowers CO₂ emissions by 0.27% and 0.13%, respectively, according to the fixed effect results. On the other hand, environmental deterioration is observed to increase by 0.27% under egalitarian democracy (LEGALT). Furthermore, CO₂ emissions increase by 0.14% and 0.33%, respectively, with every 1% increase in LPOLGI and LCULTGI. In the second model, environmental degradation is positively impacted by all globalization indices, but democracy proxies have no discernible effect on LCO₂. Results in the third model, which uses LGHG as a proxy for environmental degradation, are quite similar to those in the second model. Results for the third model's random impact estimation show that while LPARTIP raises LGHG by 0.24%, a 1% increase in LLIBR decreases LGHG by 0.30%. Overall, while the impact of democracy varies, globalization consistently adds to environmental degradation across all regimes.

Table 5. Husman test results

Model	P-Value	selected model
Model 1	0.013	Fixed Effect
Model 3	0.000	Fixed Effect
Model 2	0.808	Random Effect
Model 4	0.000	Fixed Effect

(***): significant at 1%, (**): significant at 5%, (*): significant at 10%.

3. Panel unit root test & Homogeneity:

In order to find any dynamic or cointegration links, the stationarity levels of the variables were analyzed in this section. Five unit root tests were used in the analysis, as shown in Table 6.

Table 6. Unit Root Test results

Results of panel unit root tests for model variables at level I(0)					
Test statistic Variables	Levin, Lin & Chu t*	Breitung t-stat	Im, Pesaran and Shin W-stat	ADF – Fisher Chi-square	PP -Fisher Chis-quare
LLIBR	-17.203***	1.522	-7.534***	297.01***	297.75***
LPARTIP	-6.679***	-0.336	-4.021***	300.79***	63.11***
LDELIB	-3.684***	1.014	-3.406***	87.95***	39.93
LEGALT	-1.241	0.751	-1.470*	51.898**	25.122
LPOLGI	-1.783**	-1.066	-3.227***	72.017***	214.59***
LCULTGI	-2.639***	-1.954**	-2.889***	63.836***	123.27***
LGDP	5.638			27.347	12.45
LENG	-1.065		0.229	38.835	42.283
LECOGI	-1.814**	0.8652	1.259	26.830	29.304

LCLR	-2.893***	-3.301***	-3.729***	78.59***	74.96***
LHRP	-8.519***	-1.221	-8.358***	419.45***	170.73***
LGHG	-7.782***	-0.554	-4.697***	301.58***	82.481***
LCO2	-7.036***	0.1782	-3.388***	290.95***	72.354***
Results of panel unit root tests for model variables at the 1st difference I(1)					
D(LEGALT)	-6.592***	-1.540*	-8.077***	127.241***	209.42***
D(LECOGI)	-8.285***	-4.756***	-10.905***	169.94***	1146.5***
D(LENG)	-9.283***		-10.875***	181.81***	341.79***
D(LDELIB)	-7.182***	-1.873**	-9.806***	153.69***	249.58***
D(LGDP)	-3.821***			75.02***	355.95***

(***): significant at 1%, (**): significant at 5%, (*): significant at 10%.

The variables LLIBR, LPARTIP, LPOLGI, LCULTGI, LCLR, LHRP, LGHG, and LCO2 are stationary at level (I(0)) at a 5% significance level, according to the table, but the other variables are integrated at the first difference (I(1)). The Pooled Mean Group (PMG) model, the Mean Group (MG) model, and the Dynamic Fixed Effects (DFE) model are the three estimating methods that are used in the PARDL (Panel Autoregressive Distributed Lag) methodology.

The results of the homogeneity test, which are shown in Table 7, show that general homogeneity among the sample countries was rejected. The computed Fisher value, which is higher than the tabular value ($F_c > F_t$), supports this conclusion. The computed Fisher value is likewise higher than the tabular value ($F_c > F_t$), according to the results of the second test. This outcome confirms that the parameters are not homogeneous by rejecting the null hypothesis H2 at a 5% significance level. The Blomquist and Westerlund (2013) test must be used to confirm the homogeneity of regression parameters across all of the nations shown in Table 8 because there are differences between the countries in terms of slope and intercept.

Table 7. Homogeneity test results

test value Homogeneity type	Fisher Calculated F_c	Fisher tabular F_t	Fisher's probability	Decision
Model 1				
Total homogeneity	$F1 = 294.87874$	$F_{(160.374)}=1.23$	$Pval F1 = 0$	Reject H1
Total heterogeneity	$F2 = 21.40449$	$F_{(144.374)}=1.25$	$Pval F2 = 3.68e-1$	Reject H2
Total homogeneity	$F3 = 413.07357$	$F_{(16.518)}=1.66$	$Pval F3 = 1.30e-2$	Reject H3
Model 3				
Total homogeneity	$F1 = 87.12555$	$F_{(160.357)}=1.24$	$Pval F1 = 1.25e-2$	Reject H1
Total heterogeneity	$F2 = 19.117596$	$F_{(144.357)}=1.25$	$Pval F2 = 2.01e-1$	Reject H2

Total homogeneity	F3 = 115.82724	$F_{(16,501)}=1.66$	Pval F3 = 2.42e-1	Reject H3
Model 2				
Total homogeneity	F1 = 398.93385	$F_{(128,408)}=1.25$	Pval F1 = 0	Reject H1
Total heterogeneity	F2 = 21.990258	$F_{(112,408)}=1.27$	Pval F2 = 2.75e-1	Reject H2
Total homogeneity	F3 = 550.18126	$F_{(16,520)}=1.66$	Pval F3 = 1.42e-3	Reject H3
Model 4				
Total homogeneity	F1 = 82.977767	$F_{(128,408)}=1.25$	Pval F1 = 9.65e-2	Reject H1
Total heterogeneity	F2 = 25.601634	$F_{(112,408)}=1.27$	Pval F2 = 1.75e-1	Reject H2
Total homogeneity	F3 = 76.936821	$F_{(16,520)}=1.66$	Pval F3 = 1.23e-1	Reject H3

Table 8. Slope homogeneity test

Model 1			Model 3	
Test	T-Statistic	p-value	T-Statistic	p-value
Δ_{HAC}	9.691	0.000	14.703	0.000
$(\Delta_{HAC})_{adj}$	11.963	0.000	18.150	0.000
Model 2			Model 4	
Test	T-Statistic	p-value	T-Statistic	p-value
Δ_{HAC}	27.158	0.000	29.171	0.000
$(\Delta_{HAC})_{adj}$	32.033	0.000	34.409	0.000

Regression coefficients are not homogeneous, meaning that there is no homogeneity in the countries being studied, because the probability values for the two tests are less than 5%.

4. Panel Cointegration

This study employed several tests, such as Pedroni, Kao, and Westerlund, to ascertain the cointegration relationship between variables. Table 9 presents the results.

Table 9. Panel Cointegration test results

Test Value		Model 1		Model 3	
Type of Test		T-Statistic	P-Value	T-Statistic	P-Value
Pedroni	Modified Phillips-Perron t	1.7838	0.0372	1.7351	0.0414
	Phillips-Perron t	-7.5526	0.0000	-9.9463	0.0000
	Augmented Dickey-Fuller t	-6.3503	0.0000	-8.2628	0.0000
Kao	Modified Dickey-Fuller t	-0.9061	0.1824	-1.5031	0.0664
	Dickey-Fuller t	-3.5012	0.0002	-3.2060	0.0007

	Augmented Dickey-Fuller t	3.2597	0.0006	3.4987	0.0002
	Unadjusted modified Dickey-Fuller	-9.5488	0.0000	-9.0515	0.0000
	Unadjusted Dickey-Fuller t	-7.9324	0.0000	-6.7667	0.0000
Westerlund	Variance ratio	-2.6896	0.0036	-1.8343	0.0333

Test Value		Model 2		Model 4	
Type of Test		T-Statistic	P-Value	T-Statistic	P-Value
Pedroni	Modified Phillips-Perron t	3.6474	0.0001	1.6453	
	Phillips-Perron t	-5.6308	0.0000	-7.3887	0.0000
	Augmented Dickey-Fuller t	-6.6313	0.0000	-7.1328	0.0000
Kao	Modified Dickey-Fuller t	0.1925	0.4237	-3.3263	0.0004
	Dickey-Fuller t	-3.1096	0.0009	-5.2610	0.0000
	Augmented Dickey-Fuller t	4.2895	0.0000	1.9893	0.0233
	Unadjusted modified Dickey-Fuller	-10.6365	0.0000	-9.0613	0.0000
	Unadjusted Dickey-Fuller t	-9.4869	0.0000	-7.4926	0.0000
Westerlund	Variance ratio	-1.4866	0.0686	1.6381	0.0507

Because the probability values are less than 5%, the results indicate that all tests for Pedroni, Kao, and Westerlund support the absence of the null hypothesis. This demonstrates that environmental deterioration and measures of globalization and democracy in Arab nations have a long-term cointegration relationship. Therefore, short and long run coefficients are examined using the panel ARDL model.

5. Panel ARDL

The findings of the Panel ARDL analysis, which looked at how globalization and democracy affected environmental degradation in the fourth models described in the methodology section, are presented in this part. Furthermore, as the majority of the parameters in the MG and PMG models are significant but the majority of the parameters in the DFE model are not, the Hausman test for differentiation was used to compare the two models. The panel estimation outputs and Hausman for differentiation are shown in Tables 10 and 11, respectively.

Table 10. Panel ARDL Estimation results

Estimates	Variables	Estimation method					
		Model 1			Model 2		
		DFE	MG	PMG	DFE	MG	PMG
Long term estimates	LLIBR	-0.28***	-0.28***	0.09***	-0.57***	0.73*	0.11***
	LPARTIP	0.03	-0.19	-1.56***	0.16	0.04	-0.78***
	LDELIB	-0.07	0.08	-1.84***	0.15	-0.33	-0.07**
	LEGALT	0.48*	0.14	0.24	0.67***	-0.7	1.18***
	LPOLGI	0.27	0.35**	0.04	0.32*	0.27	-0.12***
	LCULTGI	0.20	0.18	2.50***	0.09	-0.03	-0.05***
	LGDP	0.08	0.31***	0.24***	0.21***	0.16***	0.31***
	LENG	0.63***	0.32**	-0.41***	0.20*	0.29*	-0.03
	LECOGI	0.25	-0.23	-0.06	-0.01	0.36	0.14***
Error correction factor	EC	-0.24***	-0.80***	-0.09**	-0.28***	-0.91***	-0.25**
Short term estimates	LLIBR D ₁	-0.32	0.01	0.15	0.02	-0.21	0.24
	LPARTIP D ₁	-0.36***	0.19*	0.13	-0.37***	-0.08	0.04
	LDELIB D ₁	0.05	-0.18	-0.11	0.03	-0.01	-0.72
	LEGALT D ₁	0.08	0.08	0.08	0.17	-0.15	0.02
	LPOLGI D ₁	0.05	-0.08	-0.01	0.08	0.12	0.15*
	LCULTGI D ₁	-0.04	-0.02	0.004	-0.05	0.02	0.06
	LGDP D ₁	0.02	-0.03	-0.03	-0.03	-0.04	-0.07
	LENG D ₁	0.02	0.11	0.32***	0.05	0.14	0.09
	LECOGI D ₁	0.0009	0.04	0.05	0.01	-0.04	0.10
	C	1.72***	5.22**	-0.01	2.84***	9.62***	2.83**

Estimates	Variables	Model 3			Model 4		
		DFE	MG	PMG	DFE	MG	PMG
Long term estimates	LCLR	0.58	-1.26*	-0.06	-0.13	-0.02	0.39***
	LHRP	-0.16	-0.05	0.0004	0.11	-0.08	-0.03
	LPOLGI	0.36	0.62**	-0.40***	0.44**	0.04	-0.04
	LCULTGI	0.23	0.13	0.15***	0.004	-0.03	-0.04
	LGDP	0.12	0.39***	0.53***	0.27***	0.19***	0.65***

	LENG	0.75***	0.19	0.61***	0.25**	0.33	0.41***
	LECOGI	0.31	-0.24	0.04	0.09	-0.12	-0.23***
Error correct ion factor	EC	-0.23***	-0.61***	-0.20***	-0.25***	-0.65***	-0.12***
Short term estima tes	LCLR D ₁	-0.31***	0.56	-0.12	-0.06	0.09	0.05
	LHRP D ₁	0.09	0.13*	0.04	-0.009	0.05	-0.0002
	LPOLGI D ₁	0.06	-0.12	0.23***	0.07	0.11	0.11
	LCULTGI D ₁	-0.06	-0.03	-0.23	-0.06	0.009	-0.18
	LGDP D ₁	0.02	0.02	-0.05	-0.02	0.03	-0.01
	LENG D ₁	0.01	0.04	0.08	0.04	0.10	0.07
	LECOGI D ₁	0.004	0.12*	0.006	-0.009	0.03	-0.01
	C	0.65	5.03	-0.005	1.74***	8.08***	-0.17***

(***): significant at 1%, (**): significant at 5%, (*): significant at 10%.

Table 11. Panel ARDL Estimation results Hausman test for differentiation between MG and PMG

Models	P-value
Model 1	0.0000***
Model 2	0.0000***
Model 3	0.0000***
Model 4	0.0000***

(***): significant at 1%, (**): significant at 5%, (*): significant at 10%.

The Pooled Mean Group (PMG) estimate is favored above the Mean Group (MG) estimator in all models, according to Table 10's results, indicating that the PMG estimator is more successful under the alternative hypothesis. The long-term research in Model 1 shows that while participatory democracy, deliberative democracy, and energy use function as mitigating factors, liberal democracy, cultural globalization, and economic expansion considerably contribute to CO₂ emissions. In the short term, however, a 1% increase in energy consumption results in a 0.32% increase in CO₂ emissions. Model 2 identifies economic expansion, economic globalization, egalitarian democracy, and liberal democracy as the main causes of greenhouse gas emissions. On the other hand, political globalization, deliberative democracy, participatory democracy, GHG emissions are adversely affected by cultural globalization. Results for Model 3 show that while political globalization has a detrimental impact on environmental degradation, cultural globalization, economic expansion, and energy consumption all lead to higher CO₂ emissions in Arab nations. Nonetheless, political globalization has a short-term beneficial effect on environmental deterioration. While economic globalization has a moderating effect, Model 4 identifies democracy, economic growth, and energy usage as long-

term predictors of CO₂ emissions. Across all PMG estimates, the error correction coefficient is shown to be substantial and negative, indicating that environmental degradation, democracy, and globalization have a long-term association. These findings are summarized in Table 12.

Table 12. Summary of results

Model	Positive Impact on CO ₂ /GHG Emissions	Negative Impact on CO ₂ /GHG Emissions
Model 1	Liberal democracy, Cultural globalization, Economic growth	Participatory democracy, Deliberative democracy,
Model 2	Liberal democracy, Egalitarian democracy, Economic growth, Economic globalization	Participatory democracy, Deliberative democracy, Political globalization, Cultural globalization
Model 3	Cultural globalization, Economic growth, Energy use	Political globalisation
Model 4	Civil liberties, Economic growth, Energy use	Economic globalization

Overall, the results support the conclusions of Erdogan (2024) and Nuňă et al. (2024) that CO₂ emissions are regularly caused by economic growth and energy use. In terms of democracy, civil liberties and liberal and egalitarian democracy are linked to higher CO₂ and GHG emissions. These three dimensions—freedom, civil liberties, and equality—indicate that democracy worsens environmental degradation when seen from the perspectives of freedom and equality. This result is comparable to that of Ursavaş and Apaydın (2024). However, democracy that prioritizes citizen participation and group decision-making—as exemplified by Participatory and Deliberative Democracy—generally lowers emissions, which is further backed by Political Globalization, especially over the long term. In line with Rasool et al. (2024), CO₂ emissions are positively impacted by economic globalization, whereas GHG emissions are negatively impacted.

Conclusion:

Given their significant CO₂ and GHG emissions, Arab nations are especially affected by the growing concern over identifying the causes of climate change and environmental degradation. This study examines how globalization and democracy affect environmental deterioration in a sample of Arab nations between 1990 and 2023. Given the existing conflicting views on how to best measure democracy in empirical research and which proxies best capture environmental degradation, this paper adopts two widely used measures of democracy and evaluates environmental degradation using both CO₂ emissions and Greenhouse Gas emissions. We use the Mean Group (MG) and Pooled Mean Group (PMG) estimators to do this. PMG's empirical results show that energy consumption and economic expansion have a beneficial effect on environmental deterioration. Democracy may lower carbon

emissions in Arab nations when it represents social engagement and political participation, but it also contributes to degradation when used as a stand-in for freedom and equality. The results also demonstrate that environmental degradation increases with GDP per capita and energy consumption. In terms of globalization, the findings show that while both economic and cultural globalization have varying consequences, an increase in political globalization reduces environmental degradation.

The contradictory results regarding the impact of democracy suggest that its effect in Arab countries is largely conditioned by institutional quality rather than democracy itself. When political participation is effective and translated into concrete environmental policies, democracy can contribute to reducing environmental degradation. However, in contexts characterized by weak governance, limited transparency, and ineffective enforcement of environmental regulations, democracy may fail to generate positive environmental outcomes and can even coincide with higher degradation due to the dominance of short-term economic interests, particularly in resource-dependent economies. Therefore, institutional quality emerges as the key factor determining the direction of democracy's impact on the environment in the Arab region.

Recommendations:

Based on the findings of the study, which indicate that economic growth and energy consumption contribute to environmental degradation, that the impact of democracy varies depending on how it is measured, and that globalization has mixed effects, a set of practical and actionable policy recommendations can be proposed for policymakers in Arab countries.

First, economic growth policies should be restructured to decouple growth from environmental degradation by adopting green growth models that integrate environmental efficiency into economic planning and promote low-emission sectors.

Second, energy policy reforms are necessary to gradually reduce dependence on fossil fuels, while expanding investment in renewable energy sources and enforcing strict energy efficiency standards in industrial and transport sectors.

Third, the positive role of democracy should be strengthened by enhancing effective political and social participation in environmental issues and by involving civil society in monitoring environmental policies, ensuring that democracy contributes to reducing environmental degradation rather than exacerbating it.

Fourth, political globalization should be strategically leveraged by strengthening commitment to international environmental agreements and benefiting from global cooperation in clean technology transfer and capacity building.

Fifth, economic and cultural globalization should be better regulated by attracting foreign direct investment in green sectors only, while imposing strict environmental standards on globalization-related economic activities to prevent pollution-intensive industries.

Finally, environmental governance systems in Arab countries should be strengthened by improving institutional coordination and developing effective

monitoring systems based on modern environmental data and indicators to support evidence-based policymaking.

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