

# Is Democracy Environmentally Friendly? An Empirical Investigation into How Institutional Quality affects Environmental Deterioration in Indonesia

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**Abstract:** *This study investigates the impact of democracy on environmental degradation in Indonesia using the autoregressive distributed lag (ARDL) model over the period of 1971 to 2018. The analysis employs the STIRPAT framework to assess how institutional quality, energy structure, and other factors affect carbon dioxide emissions. The results show that institutional quality has a significant effect on environmental degradation in the short term, but becomes statistically insignificant in the long term. Meanwhile, energy structure – measured by the share of fossil fuels in total energy consumption – positively and significantly affects environmental degradation in both time horizons. These findings highlight the critical role of transitioning to renewable energy and improving governance quality. Although democracy has the potential to foster better environmental outcomes through transparency and citizen participation, the study reveals that in Indonesia, democratic institutions may also enable environmentally harmful practices due to weak enforcement and short-term political incentives. Therefore, effective environmental governance requires not only democratic mechanisms but also strong, transparent institutions. Policy recommendations include strengthening institutional accountability, increasing public access to environmental information, and promoting energy diversification to ensure sustainable development.*

**Keywords:** Institutional quality; Democracy; Environmental degradation; STIRPAT; ARDL

**JEL Classification:** C32, D02, F64, O44

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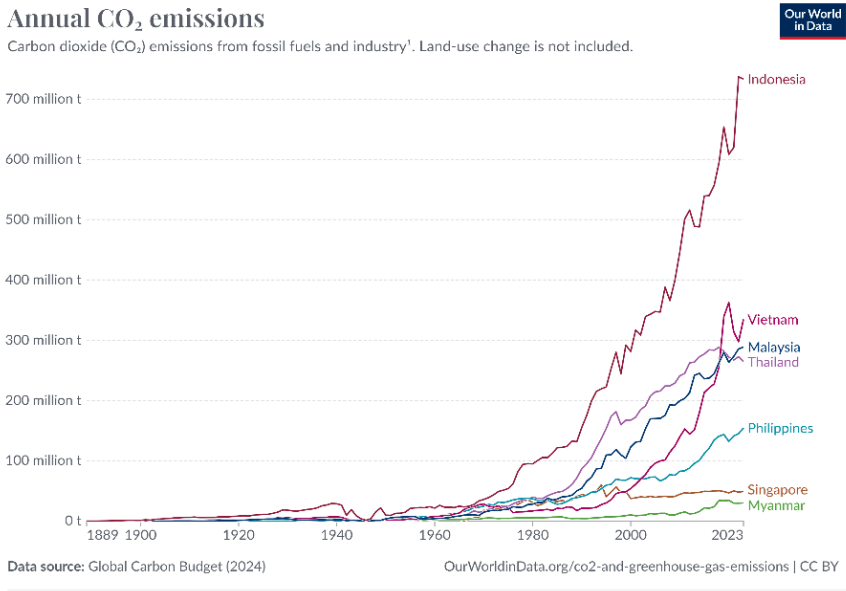
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## 1. Introduction

This study aims to analyse the role of democracy in environmental degradation in Indonesia. The phenomenon of global warming is primarily the result of an increase in greenhouse gas emissions in the atmosphere. The accumulation of greenhouse gases traps heat from the sun, leading to an increase in air temperature on the Earth's surface. (Armeanu et al., 2018). According to the Intergovernmental Panel on Climate Change (IPCC, 2018), the Earth's surface temperature rose by approximately 0.87 °C from 2006 to 2015, compared to an increase of only 0.85 °C from 1880 to 2015. Anthropogenic emissions over the past two decades contributed approximately 0.5 °C to this increase. Global climate models project that average global surface temperatures will continue to rise by approximately 0.2 °C per decade over the next 30 years, assuming current emission trajectories are maintained (IPCC, 2023). This estimate aligns with previous findings and reflects the consequences of cumulative greenhouse gas emissions, particularly from energy production, land use changes, and industrial activities. This warming trend is caused by the greenhouse effect, which results from rising emissions of gases such as carbon dioxide, CH<sub>4</sub>methane, nitrous oxide, and CFCs (Triani et al., 2023).

Global warming has led to various environmental changes, including rising sea levels, extreme weather events, and shifts in rainfall patterns. This aligns with earlier warnings by environmental economists who emphasise the limits to growth and ecological thresholds (Daly & Farley, 2004; Meadows et al., 2004). As a member of the global community, Indonesia is actively engaged in the Asean region, having initiated the development of the Asean Socio-Cultural Community (ASCC) and Asean Cooperation on Climate Change (ACCC). In Indonesia, climate change regulations are governed by Law No. 17 of 2004 on the ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change, and Law No. 16 of 2016 on the ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change.

**Figure 1:** CO<sub>2</sub> emissions trend of Indonesia compared to Asean countries



1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO<sub>2</sub>) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO<sub>2</sub> includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Figure 1 illustrates the trend of CO<sub>2</sub> emissions in Indonesia compared to other Asean countries, underscoring Indonesia's position as a major emitter in the region. Indonesia, as one of the world's top greenhouse gas polluters, faces significant challenges in mitigating climate change. According to its nationally determined contributions (NDC), the Indonesian government has committed to reducing emissions by 29% without international assistance by 2030, and by 41% with such assistance. This ambitious goal requires a multifaceted approach that includes increasing carbon sequestration, transitioning to renewable energy sources, and implementing sustainable agricultural practices. One key factor contributing to a country's environmental degradation is its economic activities. Lestari et al. (2020) state that while emerging markets play a significant role in global economic growth, they also face tremendous environmental challenges due to rising industrial activity. The connection between economic activity and environmental degradation is an important area of study, particularly as global economies strive for expansion while grappling with the impacts of environmental harm.

Economic activities, especially in developing nations, often lead to severe environmental degradation. Ashraf and Rehman (2022) highlight that increased economic activity contributes to environmental deterioration over time. To understand the complex and multifaceted relationship between democracy and environmental degradation, it is essential to examine the interactions between a country's public policy decision-making process and its political system. As a democratic nation, Indonesia's political framework should ideally serve as the best choice for addressing these issues. Economic growth is indeed a double-edged sword; it can enhance living standards, but may also lead to environmental degradation if not managed sustainably. Therefore, the interplay between economic growth, democracy, and environmental degradation presents a compelling area for further study.

Studies on the relationship between economic performance and political systems have been conducted and show different results. It is therefore appropriate to investigate the institutional choice of governing the country through the democratic system with environmental degradation in Indonesia. The implications of these findings are profound, suggesting that policymakers must strike a balance between promoting economic growth and ensuring environmental sustainability. While economic growth can lead to environmental degradation, it can also generate resources and technologies necessary for environmental protection and restoration, particularly with effective governance and regulatory frameworks.

Several studies have investigated how democratic governance affects economic performance and vice versa, demonstrating a dynamic interaction between these two realms. One prominent viewpoint holds that the maturation of democratic institutions is favourably correlated with economic progress. Heo and Hahm (2015) argue that as democracies deepen, their economic performance tends to improve; economic prosperity, in turn, supports the resilience and further consolidation of democratic institutions. Barro (1996) and Knutsen (2012) also highlight that the democracy-growth relationship is complex and non-linear, indicating that democratic transitions do not uniformly produce economic gains, especially in countries with weak institutional foundations. Consistent with this perspective, Gerring et al. (2005) and Heo and Hahm (2015) emphasise the notion of democracy not merely as a quantifiable outcome, but as a normative reference point that shapes institutional development over time.

This demonstrates that long-term democratic governance can lead to greater economic outcomes. Acemoglu et al. (2019) find that democracy boosts economic growth by promoting investment and enhancing public services, which is crucial for long-term economic stability. The opposite is expressed by Okoronkwo et al. (2023), who argue that it is precisely economic development that will lead a country to become democratic. This perspective is supported by Tang (2012), who argues that while economic development is a strong predictor of democracy, the relationship is indirect and may vary based on contextual factors. If there is a strong relationship between economic growth and democratisation, then this is essentially the same as the belief of the neoclassical view on how improvements in environmental quality can occur with high economic growth (Simon, 1998). This means that economic growth will automatically lead to improvements in environmental quality. Clearly, the economic growth of a society will increase income and welfare levels, which will also enable its members to participate in politics effectively. Similarly, through high economic growth, income and welfare levels will increase, which will then enable the government to provide a clean environment for citizens (Bruyn, 2000). The rationale for the defence of economic growth is that the invisible hand of the market mechanism will automatically adjust the demand and supply of natural resources. High economic growth will encourage innovation in technology and generate funding through finance-based environmental policies. Beckerman (1992) even suggests that the surest way to improve environmental quality is to become rich.

In the regional context, the relationship between democracy and economic growth remains a subject of significant debate. According to Bruyn (2000), even among proponents of democracy who are not inherently opposed to economic development, there is growing recognition that in the long run, economic growth tends to have detrimental effects on the environment. This view aligns with the perspective of so-called 'strong antagonists', who argue that unchecked economic expansion often leads to environmental degradation, despite potential democratic gains. Environmental policies can only mitigate it temporarily, but they will still harm the environment, so one of the radical measures that can be taken is to reduce economic growth (Daly & Farley, 2004; Meadows et al., 2004). Those who are more moderate in their support for economic growth will have a positive impact on environmental quality, such as Grossman and

Krueger (1991). This group is often known as conditional supporters, who still believe that economic growth has a positive effect on improving environmental quality, but also see the potential dangers of implementing economic growth policies that do not consider environmental aspects, so there is still a need for environmental policies to be made by the government. Slightly different from other moderate groups are weak antagonists, who are sceptical of economic growth having a positive influence on improving environmental quality. This group sees the need for state policy instruments to address the long-term impacts of environmental degradation, for example (Arrow et al., 1995).

In terms of democratic institutions, some state that institutional quality has a positive influence on environmental degradation. This view was initiated by Congleton (1992), who argues that a democratic country will have a good quality of democracy with openness to access public government information and allow any government policy to be accessed by the public. At the same time, in a country that has a good quality of democracy, freedom of expression, and freedom of association are constitutionally recognised so that government policies, especially those related to environmental issues, can be widely known by the public and questioned through constitutional forums (e.g., parliament) or through civil liberties forums (e.g., demonstrations). Meanwhile, the second opinion is that the quality of democracy will provide improvements to environmental issues, related to democratic countries providing a better response than autocratic countries. This argumentation can occur through electoral accountability, where public interest groups can easily mobilise public opinion to influence public policy through state institutions (Demissew Beyene & Kotosz, 2020). A third perspective emphasises the ideational dimension of democracy, particularly the role of democratic norms and ideals in shaping the 'rules of the game' within domestic and international governance structures. According to this view, democratic systems are more likely to establish and adhere to environmental agreements and norms, thus improving environmental outcomes over time (Simmons, 1998; Weiss & Jacobson, 1999). The emphasis on transparency, legal accountability, and participatory processes inherent in democratic governance fosters institutional environments conducive to sustainable development and ecological cooperation.

Others, however, doubt whether democracy will significantly benefit environmental quality. Hardin (1968) warns of the moral hazard posed by the uncontrolled exploitation of natural resources by individuals or groups. He argues that unclearly defined property rights will lead to individual free riders and interest groups that overexploit resources within a country. Meanwhile, Dryzek (2021) suggests that democracy tends to favour a market economy, where business activities play a crucial role in economic development. This profit-oriented motive can jeopardise a nation's natural resources (Barro, 1996; Knutsen, 2012). In the context of improving environmental quality, a democratic state is expected to enhance environmental protection through citizens participation and local wisdom (Mina, 2016).

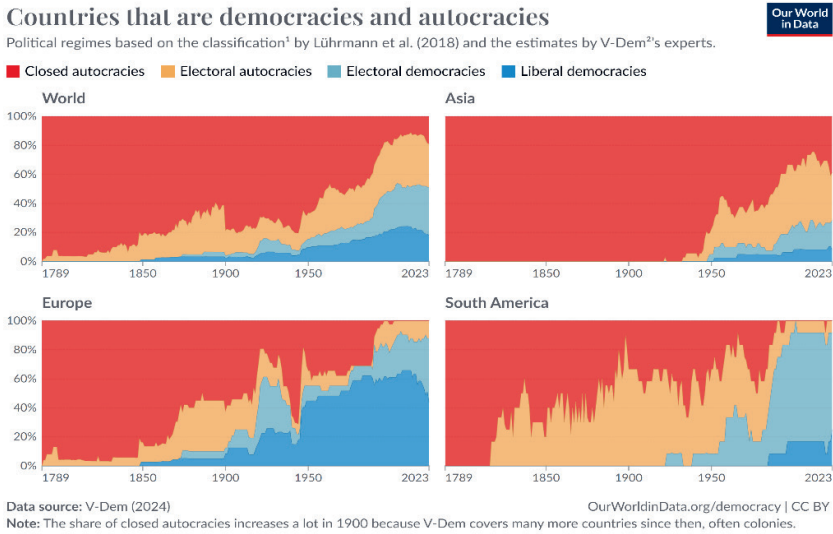
In Indonesia, however, challenges persist in enforcing environmental laws. Although the legal system aims to guarantee a healthy environment as a constitutional right, implementation remains weak due to limited oversight and community involvement in environmental policymaking (Pawestri, 2019). The Indonesian government has established administrative sanctions for environmental offenses and has implemented pro-environmental policies to uphold citizens' rights to a healthy environment (Thahira, 2020). Nonetheless, more effective enforcement of environmental laws and increased public participation are essential to address ongoing environmental degradation.

Figure 2 shows a comparison of democratic countries at the continental levels. There is an increase of electoral democracies and liberal democracies, which continue to increase, especially in Europe and South America after World War 2. The study of the relationship between a democratic system and environmental quality remains interesting to pursue, considering that almost the majority of countries in the world are officially democratic. It follows that the process of making policies, including environmental policy, is carried out using democratic mechanisms.

Furthermore, the phenomenon of democratic recession poses additional challenges to environmental governance. As noted by Hussein (2022), the decline of democratic norms globally can lead to weakened environmental protections, exacerbating degradation and undermining sustainable development efforts. This underscores the importance of not only fostering democratic institutions, but also ensuring their resilience and capability to address environmental issues effectively. In summary, while democracy can

provide a framework for better environmental outcomes, its effectiveness is influenced by a range of factors, including economic conditions, institutional integrity, and the specific environmental challenges faced by different countries. The interplay between these elements highlights the need for tailored approaches to environmental governance that consider the unique contexts of both developed and developing nations.

**Figure 2:** Comparison of democratic and autocratic countries (1789–2023)



1. **Regimes of the World's regime classification:** Closed autocracy: citizens do not have the right to choose either the chief executive of the government or the legislature through multi-party elections. Electoral autocracy: citizens have the right to choose the chief executive and the legislature through multi-party elections; but they lack some freedoms, such as the freedoms of association or expression that make the elections meaningful, free, and fair. Electoral democracy: citizens have the right to choose the chief executive and the legislature in meaningful, free and fair, and multi-party elections. Liberal democracy: electoral democracy and citizens enjoy individual and minority rights, are equal before the law, and the actions of the executive are constrained by the legislative and the courts. [Read more in our article: The 'Regimes of the World' data: how do researchers measure democracy?](#)

2. **V-Dem:** The Varieties of Democracy (V-Dem) project publishes data and research on democracy and human rights. It relies on evaluations by around 3,500 country experts and supplementary work by its own researchers to assess political institutions and the protection of rights. The project is managed by the V-Dem Institute, based at the University of Gothenburg in Sweden. [Learn more: Democracy data: how do researchers measure democracy? The 'Varieties of Democracy' data: how do researchers measure democracy? The 'Varieties of Democracy' data: how do researchers measure human rights?](#)

Source: Our World in Data

In this study, the researchers aim to analyse the impact of institutional quality on environmental degradation in Indonesia, with significant implications for state policies aimed at improving environmental quality. The concept of institutional quality is inherently tied to the provision of environmental quality as a public good. In this context, effective institutions are crucial for ensuring the delivery of non-excludable and

non-rivalrous goods such as clean air, water, and climate stability—public goods that market mechanisms alone cannot efficiently provide. Strong institutions facilitate environmental regulation, enforcement, and long-term sustainability planning. In contrast, neoclassical economists, particularly those emphasising the environmental Kuznets curve (EKC) hypothesis, argue that environmental quality will improve naturally as income levels rise, assuming that societies will eventually demand cleaner environments once basic economic needs are fulfilled (Beckerman, 1992; Grossman & Krueger, 1991). Consequently, this study focuses on the relationship between institutional quality and environmental degradation in Indonesia, specifically investigating whether democracy influences the enhancement of environmental quality. The inclusion of the democracy variable stems from the belief that institutional factors are vital in the economic policy-making process. While some studies suggest that the relationship between democracy and environmental quality is not straightforward, others argue that the benefits of democracy can vary based on specific environmental indicators and the context of each country (Gill et al., 2019). Thus, this study emphasises the importance of institutional factors in shaping economic policies that affect environmental outcomes.

## **2. Literature Review**

This study employs the structural human ecology (SHE) theory, a framework that examines the dynamic interrelations between human populations, social institutions, and the natural environment. Originally rooted in the ecological thought of Ernst Haeckel and further developed in sociological and environmental studies, SHE emphasises how social structures—such as governance systems, economic arrangements, and demographic patterns—mediate human interaction with ecosystems. It offers a lens to understand how institutional arrangements and population pressures contribute to environmental outcomes, particularly in the context of resource degradation and climate change (Haeckel, 1974). According to the SHE framework, population growth and increased levels of consumption exert mounting pressure on natural resources and ecological systems. This study adopts SHE to analyse the structural forces that shape human-environment interactions, particularly focusing on how social and economic systems mediate ecological outcomes.

A commonly used analytical tool within this framework is the IPAT identity, which posits that environmental impact (I) is the product of population (P), affluence (A)—often measured as income per capita—and technology (T). This relationship highlights that environmental degradation results from the combined effects of demographic trends, consumption levels, and technological intensity (Dietz & York, 2021). The model has its roots in Malthusian population theory (Malthus, 1798), refined by Ehrlich and Holdren (1971) in population-environment models. It provides a foundational structure for assessing environmental stress, especially in developing nations like Indonesia. According to the SHE perspective, population growth and consumption increase pressure on ecosystems, while social structures and power distribution shape resource use—often to the detriment of marginalised groups (Dietz et al., 2003). This approach aligns with the neo-Malthusian perspective, which expands beyond population growth to include institutional failures and technological inefficiencies as drivers of environmental degradation (Hussen, 2004). Building on IPAT, Dietz and York (2003) developed the STIRPAT (stochastic impacts by regression on population, affluence, and technology) model to enable empirical analysis. York et al. (2003) emphasise STIRPAT's utility for evaluating environmental pressures in emerging economies. While population and affluence are straightforward to quantify, technology remains more difficult to measure, as it often interacts with both (York et al., 2003).

Several studies have shown that democracy positively influences environmental protection. In democratic systems, people have access to political participation mechanisms that enable them to demand better environmental policies. Several studies have demonstrated that democracy promotes environmental conservation. People in democratic systems can use political involvement tools to demand better environmental policy (Congleton, 1992). Democracy is also frequently connected with increased openness, government accountability, and press freedom, which can raise public understanding of environmental issues (Li & Reuveny, 2006). However, the impact of democracy on the environment is not always beneficial. Some studies argue that democracy may inadvertently accelerate the exploitation of natural resources, particularly in developing countries where political pressures incentivise short-term economic gains over long-term environmental sustainability (Ward, 2008). This dynamic is often driven by electoral cycles and the political imperative to deliver immediate

economic benefits to constituencies. Moreover, in democratic regimes with weak institutional frameworks, there is a tendency to implement populist policies that prioritise political popularity over environmental responsibility. These measures often disregard long-term ecological consequences in favour of short-term political capital (McGuire & Olson, 1996). In developing countries, democratic transitions may enable environmental activism, but can also open up new political risks, especially where institutional checks and balances remain weak (Akalin & Erdogan, 2021).

Recent empirical studies have revisited the democracy–environment nexus using both panel data and country-specific approaches. For instance, Mukhtarov (2024) highlights the importance of civic engagement and participatory institutions in shaping effective environmental policy outcomes in Central Asia. Similarly, Rehman and Gill (2023) investigate the role of populist political narratives in influencing carbon emissions and regulatory rollback in South Asia. In the context of Southeast Asia, Xaisongkham and Liu (2022) provide evidence that electoral accountability moderately enhances environmental performance, though its effectiveness is contingent on broader governance structures. Building on these regional insights, this study focuses on Indonesia, specifically examining how institutional quality—as a reflection of democratic consolidation and governance effectiveness—shapes the trajectory of ecological degradation.

Institutional quality is a key factor in determining the extent to which democracy can contribute to environmental protection. Strong institutions—such as the rule of law, good governance, and evidence-based policies—can reduce corruption and improve natural resource management (Ostrom, 1990). Acemoglu et al. (2019) show that poor institutional quality often serves as a barrier to effective environmental policy implementation. For instance, corruption can facilitate the illegal exploitation of natural resources, including deforestation and overfishing. In contrast, responsive and transparent institutions can enhance community involvement in environmental protection (Meadowcroft, 2002). Some studies combine analyses of democracy and institutional quality to understand their impact on the environment. Farzin and Bond (2006) find that the effect of democracy on the environment is highly dependent on the quality of institutions in a country. In nations with strong institutions, democracy tends to promote sustainable environmental policies. Conversely, in countries with weak institutions, democracy can exacerbate environmental degradation due to

insufficient enforcement of laws and regulations. Additionally, Boyce (1994) argues that the distribution of political power plays an important role. In unequal democracies, powerful groups can dominate decision-making, often sacrificing environmental interests for economic gain.

### 3. Data and Methods

The data period used in this study spans from 1967 to 2017, covering the structural transformations that occurred in Indonesia, including industrial policies and the post-New Order economic transition. Descriptive statistics and exploratory analysis use the broader dataset, but the model estimation is restricted to 1971 to 2018 to ensure methodological consistency. Autoregressive distributed lag (ARDL) estimation in this study covers the more politically stable period from 1971 to 2018, while certain preliminary transformations (e.g., semi-log transformations of GDP and CO<sub>2</sub>) are based on data available since 1967. ARDL is a regression model that includes variable values that explain either the present value or the past value (lag) of the independent variable in addition to the model that includes the lag value of the independent variable as one of the explanatory variables. ARDL models are very useful in empirical econometrics, as they make static economic theory dynamic by explicitly accounting for the role of time. This model can distinguish the short-term and long-term response of the independent variable to a unit change in the value of the explanatory variable (Gujarati, 2003). The research method used in this study is to analyse the correlation between factors that affect the production of CO<sub>2</sub> emissions from 1971 to 2018 using ARDL, allowing us to explore both the long-term and short-term relationships between the selected variables.

#### 3.1 Empirical approach

The general ARDL equation used in this study is as follows:

$$\begin{aligned} \Delta Y_t &= \alpha + \sum_{j=1}^p \beta \Delta(Y)_{t-j} + \sum_{j=0}^{q1} \varphi \Delta(X_{t-1}) + \sum_{j=0}^{q2} \gamma \Delta(X)_{2t-j} + \varepsilon_t \\ \ln \Delta I &= \beta_0 + \beta_1(A)_t + \beta_2(P)_t + \beta_3(T)_t + \beta_4(FDI)_t + \beta_5(IQ)_t + \varepsilon_t \\ \Delta I_t &= \alpha + \sum_{j=0}^{q1} \varphi \Delta(P_{t-1}) + \sum_{j=0}^{q2} \varphi \Delta(A_{2t-1}) + \sum_{j=0}^{q3} \gamma \Delta(X)_{3t-j} \\ &\quad + \sum_{j=0}^{q4} \gamma \Delta(X)_{4t-j} + \varepsilon_t \end{aligned}$$

The data analysis method used in this research is the ARDL error correction model (ARDL-ECM) method (Pesaran & Shin, 1995). There are several steps of analysis which include: stationarity test, cointegration bounds testing, the ARDL-ECM method, as well as classical assumption tests.

#### 4. Results and Discussion

This study uses annual data from CO<sub>2</sub> emissions per capita (CO<sub>2</sub>) and gross domestic product per capita (GDP) for the period from 1967 to 2017. The total number of observations was 51. In this study, the authors used semi-log transformation. In testing the stationarity of data in the ARDL model using the Augmented Dickey-Fuller (ADF) approach, the data is considered stationary if the time series does not contain unit roots. Conversely, the data is deemed non-stationary if its mean, variance, and covariance are not constant over time. In the ARDL framework, all variables must be stationary either at level I(0) or at I(1). If this condition is not met, attempting to use stationary data at I(2) will result in the invalid application of the ARDL method.

**Table 1:** Stationarity test results (intercept, intercept and trend)

Variables	Intercept		Intercept and trend	
	Level	1st difference	Level	1st difference
<i>Augmented Dickey-Fuller (ADF)</i>				
LOGCO <sub>2</sub>	0.7954	0.0000	0.1380	0.0000
POPST	0.0727	0.1369	0.9533	0.0274
GDP	0.9807	0.0004	0.8756	0.0014
ES	0.1165	0.0000	0.2050	0.0000
FDI	0.0138	0.0000	0.0575	0.0000
IQ	0.8828	0.0000	0.5273	0.0000

Note: POPST = population density, GDP = gross domestic product per capita, ES = energy structure, FDI = foreign direct investment, IQ = institutional quality

The next step is to determine the optimal lag length, which helps explain the duration of the influence one variable has on others. In this study, the researchers employed the Akaike information criterion (AIC) to identify the optimal lag. This was determined based on the lowest AIC value, which

resulted in ARDL (1, 3, 0, 5). Based on the unit root test results above, the next step is to analyse whether the variable data used in the model does not contain a unit root, so the next step is to analyse the data using ARDL.

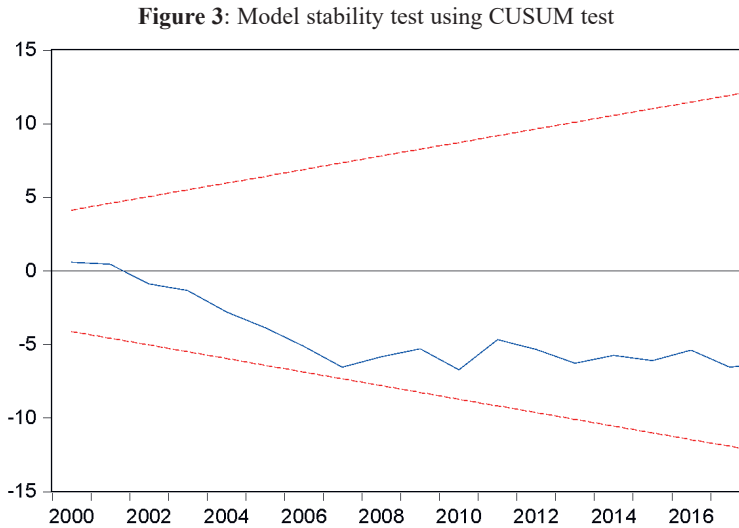
**Table 2:** ARDL model estimation (dependent variable: LOGCO<sub>2</sub>)

Variable	Coefficient	Standard error	t-statistic	Probability
LOGCO2(-1)	0.562390	0.121508	4.628431	0.0001
GDP	7.88E-06	7.15E-05	0.110147	0.9131
GDP(-1)	0.000333	0.000120	2.780044	0.0098
GDP(-2)	-0.000290	0.000109	-2.668246	0.0127
GDP(-3)	-0.000120	8.45E-05	-1.424653	0.1657
ES	0.013912	0.007938	1.752637	0.0910
FDI	0.030110	0.019145	1.572718	0.1274
FDI(-1)	0.014454	0.018023	0.801933	0.4296
FDI(-2)	0.018883	0.012759	1.479956	0.1505
FDI(-3)	-0.004583	0.012516	-0.366128	0.7171
FDI(-4)	0.019720	0.012795	1.541187	0.1349
FDI(-5)	0.019606	0.013295	1.474722	0.1519
POPDNS	0.147775	0.058093	2.543762	0.0170
IQ	0.058068	0.021191	2.740193	0.0108
C	-10.52482	3.847000	-2.735851	0.0109
@TREND	-0.267192	0.109136	-2.448255	0.0211
R <sup>2</sup>	0.985141	Mean dependent variable		0.134063
Adjusted R <sup>2</sup>	0.976886	SD dependent variable		0.442263
Std. error of regression	0.067239	Akaike info criterion		-2.282309
Sum squared resid	0.122069	Schwarz criterion		-1.626979
Log likelihood	65.06965	Hannan-Quinn criterion		-2.040644
F-statistic	119.3376	Durbin-Watson statistic		2.027362
Probability (F-statistic)	0.000000			

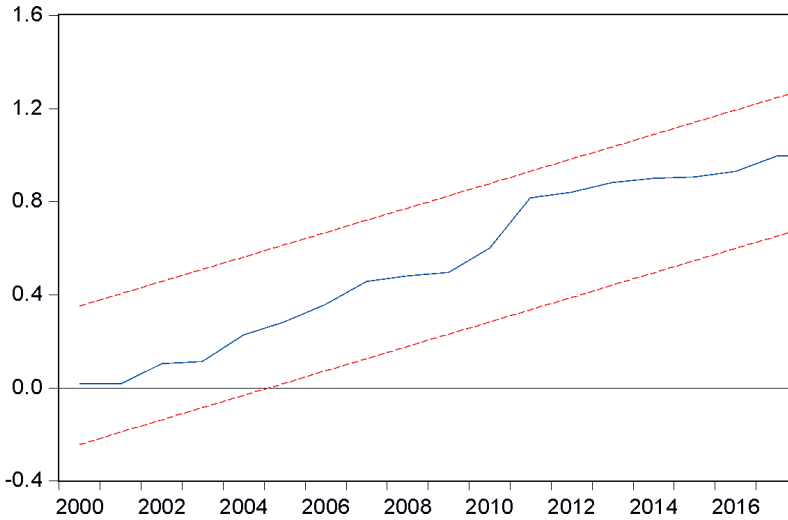
Note: Note: POPDST = population density, GDP = gross domestic product per capita, ES = energy structure, FDI = foreign direct investment, IQ = institutional quality. p-values and any subsequent tests do not account for the model

Based on ARDL testing, the selected model is ARDL (1, 3, 0, 5). The suitability of this model is tested to ensure that the research model does not violate standard econometric rules. This testing involves checking for autocorrelation and assessing model stability. The results of the autocorrelation test indicate a probability value of  $\chi^2$  at 0.4136, which is greater than  $\alpha$  at the 1%, 5%, and 10% levels. Therefore, the regression model in this study is free from autocorrelation problems.

Based on the cumulative sum control chart (CUSUM) test with a confidence level of 95%. So as the CUSUM and CUSUM square test images of model stability are determined the blue line is right between the red line which is the 5% significance line. This proves that the ARDL (1, 3, 0, 5) model is stable.



**Figure 4:** Model stability test using CUSUM of squares test



**4.1 Cointegration and bounds testing**

Based on the results of the ARDL diagnosis test, the selected ARDL (1, 3, 0, 5) model was identified. To determine the suitability and effectiveness of this model, bounds testing is required. The results of the bounds testing indicate an *F*-statistic value of 6.312609, which exceeds both the *I*(0) bounds and *I*(1) bounds at all levels of significance. This suggests that the ARDL model is valid at a significance level of 2.5%. Additionally, at the 1% level, the *F*-statistic is greater than the *I*(1) bounds and also exceeds the *I*(0) bounds. This finding indicates a long-term relationship between the variables.

**Table 3:** Bounds testing (F-statistic and critical values)

Test statistic	Value	k
<i>F</i> -statistic	6.312609	3
<b>Critical value bounds</b>		
Significance	I(0) bounds	I(1) bounds
10%	3.47	4.45
5%	4.01	5.07
2.5%	4.52	5.62
1%	5.17	6.36

## 4.2 Discussion

According to the bounds testing results, the variables utilised in this study exhibit long-term cointegration. The long run coefficient is derived from the ARDL (1, 3, 0, 5) model. The subsequent test incorporates the error correction coefficient value (CointEq(-1)) within the ECM short-term model; this value reflects the speed of adjustment, or the extent to which the error will be corrected in each time period. For eligibility, the coefficient value must be negative and statistically significant. The cointegration value is -0.437610, with a probability value of 0.0013, indicating that the coefficient is both negative and significant. This suggests that the model will converge towards the equilibrium point at a rate of 43.76%.

**Table 4:** Short-term estimation (ECM cointegrating form)

Variable	Coefficient	Standard error	t-statistic	Probability
D(GDP)	0.000008	0.000072	0.110147	0.9131
D(GDP(-1))	0.000290	0.000109	2.668246	0.0127
D(GDP(-2))	0.000120	0.000085	1.424653	0.1657
D(ES)	0.013912	0.007938	1.752637	0.0910
D(FDI)	0.030110	0.019145	1.572718	0.1274
D(FDI(-1))	-0.018883	0.012759	-1.479956	0.1505
D(FDI(-2))	0.004583	0.012516	0.366128	0.7171
D(FDI(-3))	-0.019720	0.012795	-1.541187	0.1349
D(FDI(-4))	-0.019606	0.013295	-1.474722	0.1519
D(POPDNS)	0.147775	0.058093	2.543762	0.0170
D(IQ)	0.058068	0.021191	2.740193	0.0108
D(@TREND())	-0.267192	0.109136	-2.448255	0.0211
CointEq(-1)	-0.437610	0.121508	-3.601499	0.0013

Note: CointEq =  $\text{LOG}(\text{CO}_2) - (-0.0002*\text{GDP} + 0.0318*\text{ES} + 0.2244*\text{FDI} + 0.3377*\text{POPDNS} + 0.1327*\text{IQ} - 24.0507 - 0.6106*\text{@TREND})$

The first variable is population density (POPST), as determined by the short-term estimation of variables based on data processing outcomes. Short-term analyses show that changes in population density significantly increase CO<sub>2</sub> emissions in Indonesia. While the affluence variable produced GDP per capita results on Lag 1, increases in affluence demonstrated a substantial rise in the concentration of CO<sub>2</sub> emissions in Indonesia. In the short run, changes

in technology (e.g., energy structure) and foreign direct investment have a positive but minor effect on rising CO<sub>2</sub> emissions.

Institutional quality (IQ) has a coefficient value of +0.058068 and a probability value of 0.0108, indicating that a one-point change in the democracy index raises the concentration of CO<sub>2</sub> in Indonesia by 0.058068 points. This finding contradicts the study's hypothesis, which states that an increase in Indonesia's democracy index will reduce CO<sub>2</sub> concentrations. In other words, changes in institutional quality should positively impact environmental improvement in Indonesia. However, the Indonesian context demonstrates how democracy can be detrimental to the environment. Dryzek (2021) argues that democracy often fosters pro-market and liberal governance, creating institutional conditions favourable to economic liberalisation and individual freedoms. However, this perspective is challenged by Hardin (1982), who contends that democracy can be detrimental to environmental sustainability. He argues that in democratic systems—particularly where property rights are poorly defined—the risk of moral hazard and the prevalence of free rider behaviour becomes significant. This leads to the overexploitation of common-pool resources, as individuals or interest groups exploit natural assets without bearing the full environmental costs. In the Indonesian context, such dynamics are often supported by political actors or coalitions that advocate for regime change or reform, but may simultaneously enable environmentally harmful practices under the guise of economic development or political inclusion.

**Table 5:** Long-term coefficients (long run coefficients)

Variable	Coefficient	Standard error	t-statistic	Probability
GDP	-0.000160	0.000080	-1.996826	0.0560
ES	0.031790	0.019633	1.619221	0.1170
FDI	0.224380	0.107186	2.093383	0.0458
POPDNS	0.337686	0.184484	1.830441	0.0782
IQ	0.132693	0.069590	1.906773	0.0672
C	-24.050684	12.392764	-1.940704	0.0628
@TREND	-0.610572	0.345692	-1.766231	0.0887

Note: POPDST = population density, GDP = gross domestic product per capita, ES = energy structure, FDI = foreign direct investment, IQ = institutional quality

The population density variable, related to the topic of population, has drawn attention since Malthus (1798), who posited that population growth is a primary cause of poverty and human suffering. The relationship between population growth and environmental degradation began to emerge, with Allen and Barnes (1985) concluding that high population growth was one of the causes of environmental degradation. In the long-term cointegration analysis, population density variable exhibited a coefficient value of 0.337686, substantially higher than that of other explanatory variables such as income (0.009799). However, the probability (*p*-value) of 0.1069 exceeds the conventional significance threshold of 0.05. This indicates that, while the estimated coefficient suggests a positive relationship between population density and CO<sub>2</sub> concentration growth in Indonesia, the effect is statistically insignificant in the long run. Therefore, it can be concluded that population density, although potentially associated with increased CO<sub>2</sub> emissions, does not exert a significant long-term influence within the model specification used in this study.

One of the most critical variables in this study is affluence, represented by GDP per capita (GDP). In the long-term cointegration estimation, this variable displays a negative coefficient of -0.00016 with a *p*-value of 0.05694. Although the probability value slightly exceeds the conventional 5% significance level, it falls within the commonly accepted 10% threshold, suggesting a weakly significant inverse relationship. This implies that, in the long run, rising GDP per capita in Indonesia is associated with a reduction in CO<sub>2</sub> concentration, potentially reflecting a decoupling effect between economic growth and environmental degradation as affluence increases. Specifically, a 1% increase in GDP per capita is associated with a 0.000160% decrease in CO<sub>2</sub> emissions in Indonesia, as indicated by the negative coefficient in the long-term cointegration analysis. These findings are consistent with the ultimate resource hypothesis (Simon, 1998), where innovation and human ingenuity can overcome environmental constraints through technological progress and institutional adaptation. Although the magnitude of this effect is modest, the direction of the relationship suggests that economic growth may contribute to improved environmental performance over time, potentially due to structural shifts toward cleaner technologies or enhanced regulatory enforcement. As noted above, Beckerman (1992) famously posited that “the best way to improve the environment is to become rich,” a view echoed in the EKC (Grossman

& Krueger, 1991), which suggests that after reaching a certain income threshold, environmental degradation begins to decline.

These findings are consistent with Wardhono et al. (2017), who observe that energy consumption remains the dominant factor influencing environmental degradation in Indonesia, while GDP per capita does not exhibit a substantial long-term impact on environmental quality. This convergence of results highlights the complex and potentially non-linear nature of the environment–growth relationship in emerging economies. Other contributing factors to the rise in CO<sub>2</sub> emissions include forest fires and illegal logging, which accelerate deforestation and land-use change. These activities often result in the conversion of forested areas into agricultural land, releasing substantial amounts of carbon stored in biomass and soil into the atmosphere. In countries like Indonesia, where tropical forests serve as major carbon sinks, such practices significantly undermine climate mitigation efforts and intensify environmental degradation, especially when regulatory enforcement is weak or inconsistently applied (Olivier & Peters, 2020).

In the long run, foreign direct investment (FDI) has a statistically significant positive influence on increasing CO<sub>2</sub> emissions, with a probability value of 0.7687 (greater than 0.05) and a negative coefficient value of -0.004213. This indicates that the FDI variable has a negative and minor effect on rising CO<sub>2</sub> emissions in Indonesia. Another variable that significantly impacts environmental quality is energy structure (ES), which reflects advancements in technology in Indonesia. This metric is calculated based on the fraction of fuel use derived from fossil fuels. The government, industrial, and transportation sectors consume the majority of fossil fuel-based energy. This study employs a long-term analysis to arrive at its conclusions. The technological change variable has a coefficient value of 0.021267 and a probability value of 0.0203, which is less than 0.05. This suggests that the Indonesian energy structure factor positively influences the concentration of CO<sub>2</sub> emissions and is a significant contributor to these emissions in Indonesia.

In this study, institutional quality, as measured by the Indonesian Democracy Index, has a positive coefficient value of 0.132693 with a probability value of 0.0672, which is greater than 0.05. This indicates that institutional quality has a positive and insignificant effect on increasing the concentration of CO<sub>2</sub> emissions, suggesting that in the long run, this supports the hypothesis of this study. Additionally, it can be concluded that

democracy in Indonesia aligns with the research conducted by Winslow (2005), which examines China and the United States, confirming that the more democratic a country is, the smaller the decline in environmental quality. Furthermore, the findings of this study reject the assumption that democracy leads to a market-oriented system, as suggested by Dryzek (2021), who posited that democratic systems tend toward market economic structures driven by profit motives, even though the long-term estimation results have not been proven significant. In contrast, research by Akalin and Erdogan (2021) which examines 26 Organisation for Economic Co-operation and Development (OECD) nations, finds that democracy had a detrimental impact on environmental quality.

## **5. Conclusion and Policy Implications**

Indonesia represents a compelling case of a democracy in transition, where institutional fragility and decentralised governance pose both opportunities and challenges for environmental sustainability. Strengthening democratic accountability at subnational levels remains crucial for ensuring consistent ecological outcomes. The relationship between democracy and environmental degradation is mediated by institutional quality, public awareness, and the consistency of political commitment. While democratic regimes have the potential to address environmental challenges—through accountability, public participation, and regulation—they may also fall into short-termism and interest group capture when institutions are weak. Findings from the ARDL model indicate that institutional quality significantly affects environmental degradation in the short term, although its long-term influence is statistically limited. This underscores the need for sustained institutional reform to secure lasting environmental benefits. To improve environmental outcomes under a democratic framework, Indonesia should strengthen institutional quality by enhancing transparency in environmental licensing, increasing public access to ecological information, and embedding participatory governance at the local level. Ostrom (1990) emphasises that institutional diversity and participatory governance are essential for managing common-pool resources, especially where central policies overlook local ecological dynamics. Meadowcroft (2002) also notes that environmental governance must align with appropriate scales, balancing vertical integration and local empowerment. Therefore, embedding

democracy within accountable, decentralised, and transparent institutions is vital to reducing emissions and ensuring long-term sustainability. One key recommendation is to improve transparency in licensing processes, for example, by enhancing e-government platforms to boost public oversight. The government should also accelerate the transition to cleaner energy sources, particularly renewables, to reduce reliance on fossil fuels.

### **CRediT author statement**

**Herman Cahyo Diartho:** Conceptualisation, Writing—Original draft preparation.

**M. Iqbal Fardian:** Methodology, Data curation, Formal analysis, Writing—Review and editing.

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