Journal of Environmental Science and Economics
https://doi.org/10.56556/jescae.v5i1.1514
ISSN: 2832-6032

RESEARCH ARTICLE

Income Inequality, Financial Development, and Carbon Emissions: Does Institutional Quality Matter in Belt and Road Economies?

Majbaul Alam Akash[1], Alaeldeen Ibrahim Elhaj[2*]

[1]Department of Public Administration, National Research University Higher School of Economics, Russia
2Applied Research Center for Environment and Marine Studies, King Fahd University of Petroleum & Minerals, Saudi Arabia

Corresponding author: Alaeldeen Ibrahim Elhaj, Email: aladin.elhaj@kfupm.edu.sa
Received: 08 February, 2026, Accepted: 15 April, 2026, Published: 25 June, 2026

Abstract
Addressing income inequality and environmental degradation is essential for achieving sustainable development. This study examines the effects of income inequality, economic growth, financial development, renewable energy consumption, and institutional quality on carbon dioxide (CO_2) emissions in 37 Belt and Road Initiative (BRI) countries over the period 2002–2020. Employing a two-step system generalized method of moments (GMM) estimator, the study investigates the influence of socioeconomic and institutional factors on environmental sustainability. The findings reveal that income inequality and renewable energy consumption significantly reduce CO_2 emissions, whereas economic growth and financial development contribute to environmental degradation. Industrialization increases emissions in certain model specifications, while urbanization generally exhibits a positive association with emissions. Regarding institutional quality, control of corruption, voice and accountability, and political stability are positively associated with CO_2 emissions, whereas government effectiveness and the rule of law exhibit negative effects in selected models. Furthermore, the legal system, political system, and overall institutional quality indices are positively associated with emissions. The positive coefficient of squared economic growth provides no support for the Environmental Kuznets Curve (EKC) hypothesis. These findings highlight the importance of expanding renewable energy adoption, strengthening environmentally effective governance, and redirecting financial resources toward green investments. The study offers policy insights for promoting low-carbon economic development and environmental sustainability across BRI economies.

Keywords: Income inequality; Financial development; Carbon emissions; Institutional quality; Renewable energy

1. Introduction

Climate change and environmental degradation remain major challenges to sustainable development, particularly in emerging and developing economies experiencing rapid economic expansion, industrialization, and urbanization. Rising CO_2 emissions have intensified concerns regarding the environmental consequences of economic growth and the effectiveness of existing policy frameworks. Addressing these challenges requires a

comprehensive understanding of the socioeconomic, financial, and institutional factors influencing environmental sustainability. Income inequality, economic growth, financial development, renewable energy consumption, and institutional quality are particularly important because they shape production activities, consumption patterns, resource allocation, and environmental governance (Yang et al., 2022; Khalfaoui et al., 2023; Rachid et al., 2025). Recent evidence further suggests that the environmental consequences of economic and financial development depend considerably on institutional arrangements and country-specific characteristics (Rehman et al., 2025; Bhatti et al., 2025).

Income inequality represents an important socioeconomic determinant of environmental quality, although its relationship with carbon emissions remains theoretically and empirically ambiguous. According to Boyce (1994), unequal income distribution can contribute to environmental degradation by concentrating political and economic power among wealthier groups, potentially weakening environmental regulations. Conversely, higher income inequality may reduce aggregate emissions when lower-income households have limited purchasing power and consume fewer carbon-intensive goods and services. Empirical findings support these contrasting perspectives. Grunewald et al. (2017) demonstrated that the relationship between income inequality and carbon emissions varies across income groups, while Yang et al. (2022) highlighted the importance of institutional quality in shaping this association. More recently, Ghazouani and Hamdi (2025) reported that income inequality increases CO_2 emissions in OECD countries, with financial technology influencing this relationship. These findings indicate that the environmental implications of income inequality are context-dependent and warrant further investigation, particularly in economically diverse developing regions.

Economic growth and financial development are also central to the relationship between socioeconomic progress and environmental sustainability. Economic expansion generally increases energy demand, industrial production, transportation activities, and natural resource consumption, potentially intensifying carbon emissions. However, sustained development may facilitate technological innovation, cleaner production processes, and improvements in energy efficiency. This relationship is commonly examined through the EKC hypothesis, which proposes an inverted U-shaped relationship between economic development and environmental degradation (Grossman & Krueger, 1991; Kaika & Zervas, 2013). Similarly, financial development may either support environmental improvements by financing cleaner technologies or contribute to environmental degradation by encouraging investment in carbon-intensive industries. Recent studies confirm these contrasting possibilities. Rachid et al. (2025) identified heterogeneous environmental effects of financial development across Middle Eastern and North African economies, while Rehman et al. (2025) emphasized the importance of institutional quality in determining whether financial development supports environmental sustainability. These findings highlight the need to examine economic growth and financial development alongside governance characteristics. Recent studies have examined the interconnected roles of economic growth, financial development, energy consumption, and natural resources in shaping carbon emissions in developing economies, highlighting the importance of considering these factors within an integrated environmental framework (Raihan et al., 2024; Raihan et al., 2023).

Renewable energy consumption has emerged as a crucial component of sustainable development strategies because it offers opportunities to reduce dependence on fossil fuels and mitigate greenhouse gas emissions. Expanding renewable energy use can support cleaner industrial production, improve energy security, and facilitate the transition toward low-carbon economies. Nevertheless, its environmental effectiveness depends on energy infrastructure, technological capabilities, financial accessibility, and supportive regulatory frameworks. Tan and Uprasen (2021) demonstrated that income inequality influences renewable energy consumption in ASEAN economies, suggesting important connections between socioeconomic conditions and energy transitions. The relationship between energy transitions and environmental sustainability has also been investigated through the roles of energy efficiency, technological innovation, and economic development, emphasizing the

multidimensional nature of decarbonization strategies (Raihan et al., 2025a). More recently, Almulhim et al. (2025) investigated the relationship between renewable energy, institutional quality, and consumption-based CO_2 emissions in BRICS countries, reinforcing the importance of considering energy and governance factors jointly. Therefore, understanding the contribution of renewable energy consumption to environmental sustainability requires accounting for broader economic and institutional conditions.

Institutional quality plays a fundamental role in determining environmental outcomes by influencing policy formulation, regulatory enforcement, public accountability, and the allocation of financial resources. Institutional economics emphasizes that effective institutions establish the rules and incentives governing economic activities (North, 1990). Strong governance may improve environmental protection through regulatory compliance, transparency, and efficient implementation of sustainability policies. Conversely, weak institutions may facilitate corruption, regulatory inefficiencies, and environmentally harmful investments. However, institutional improvements do not necessarily produce uniform environmental benefits, particularly when governance reforms prioritize economic expansion over environmental protection. Bergougui et al. (2024) demonstrated that institutional quality influences carbon emissions inequality across major emitting economies, while Bhatti et al. (2025) identified the importance of governance and regulatory quality for environmental outcomes in Next-11 economies. These findings suggest that individual institutional dimensions may influence environmental performance differently, highlighting the importance of examining governance indicators separately rather than relying exclusively on an aggregate institutional quality index.

The BRI countries provide a particularly relevant setting for investigating these relationships because they exhibit considerable diversity in economic development, income distribution, financial systems, energy structures, and institutional arrangements. Economic expansion and infrastructure development across these economies may increase energy consumption and carbon emissions, while renewable energy investment and institutional reforms offer opportunities for more sustainable development. Previous research has examined income inequality, carbon emissions, and institutional characteristics in BRI countries (You et al., 2020), alongside broader evidence concerning the environmental implications of inequality and governance in developing economies (Yang et al., 2022). Nevertheless, the combined relationships among income inequality, economic growth, financial development, renewable energy consumption, and multiple institutional quality dimensions remain insufficiently understood within a unified dynamic panel framework. In particular, distinguishing between individual governance indicators and composite institutional indices may provide additional insights into their differing associations with carbon emissions.

Against this background, the present study investigates the effects of income inequality, economic growth, financial development, renewable energy consumption, industrialization, urbanization, and institutional quality on CO_2 emissions in 37 BRI countries over the period 2002–2020. The study employs a two-step system GMM estimator to account for the dynamic structure of the panel and address potential endogeneity under the estimator's identifying assumptions. Its contribution lies in integrating socioeconomic, financial, energy, and institutional determinants within a common empirical framework; examining individual institutional indicators alongside legal, political, and overall institutional quality indices; and reassessing the EKC hypothesis within the sampled economies. By providing evidence on the heterogeneous associations between institutional characteristics and environmental outcomes, the study seeks to inform policies aimed at promoting inclusive economic development, green financial investment, renewable energy adoption, and effective environmental governance.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature and theoretical foundations. Section 3 describes the data, variables, and econometric methodology. Section 4 presents and discusses the empirical findings, while Section 5 concludes with policy implications, study limitations, and directions for future research.

2. Literature review and theoretical framework

2.1. Income inequality and carbon emissions

The relationship between income inequality and environmental degradation has attracted considerable attention in environmental economics, although empirical findings remain inconclusive. Theoretically, income inequality may influence CO_2 emissions through consumption patterns, political influence, and resource allocation. Boyce (1994) argued that unequal income distribution can weaken environmental protection by concentrating political and economic power among wealthier groups. Conversely, greater inequality may reduce aggregate emissions when lower-income households have limited purchasing power and consequently consume fewer energy-intensive goods and services. Grunewald et al. (2017) demonstrated that the relationship between income inequality and CO_2 emissions varies across income groups, with negative associations in lower-income economies and positive associations in wealthier countries. Similarly, Baloch et al. (2020) reported that income inequality contributes to environmental degradation in sub-Saharan Africa, whereas Rojas-Vallejos and Lastuka (2020) identified income-dependent variations in this relationship.

Recent studies have further emphasized the importance of socioeconomic and institutional conditions. Yang et al. (2022) found that income inequality increases CO_2 emissions in developing economies, while institutional quality influences this relationship. Bergougui et al. (2024) demonstrated that institutional quality and income exhibit heterogeneous relationships with carbon emissions inequality across major emitting economies. More recently, Zeb et al. (2025) examined poverty, inequality, and green growth in BRI countries, highlighting regional differences in environmental sustainability outcomes. These findings suggest that the environmental consequences of income inequality depend on economic development, institutional arrangements, and country-specific characteristics, underscoring the importance of further empirical investigation.

2.2. Economic growth, financial development, and carbon emissions

Economic growth is a major determinant of environmental quality because expanding production, industrialization, and urbanization generally increase energy consumption and demand for natural resources. The EKC hypothesis proposes an inverted U-shaped relationship between economic development and environmental degradation, suggesting that emissions initially increase with economic growth but eventually decline as economies adopt cleaner technologies and strengthen environmental regulations (Grossman & Krueger, 1991; Kaika & Zervas, 2013). However, empirical evidence remains mixed, particularly in developing economies where economic expansion frequently depends on fossil fuels and energy-intensive industries. Cho (2021) demonstrated that the relationship between economic development and environmental degradation varies across high-income countries, highlighting the relevance of income inequality and institutional arrangements. More recently, Gu et al. (2025) examined carbon emission drivers across BRI countries and identified differences associated with national income levels, suggesting that economic development pathways shape environmental outcomes.

Financial development may also exert contrasting effects on carbon emissions. On the one hand, improved financial accessibility can stimulate industrial expansion, private consumption, and investment in carbon-intensive activities. On the other hand, financial development can facilitate renewable energy investment, technological innovation, and cleaner production processes. Ntow-Gyamfi et al. (2020) emphasized the importance of institutional quality in shaping the relationship between financial development and environmental sustainability in Africa. Similarly, Rachid et al. (2025) found that the environmental effects of financial development differ between oil-producing and non-oil-producing economies in the Middle East and North Africa.

Rehman et al. (2025) further demonstrated that financial development does not necessarily reduce CO_2 emissions without improvements in institutional quality. The environmental implications of financial development have been investigated in emerging Asian economies. Raihan and Voumik (2022) examined the relationships among financial development, renewable energy utilization, technological innovation, economic growth, urbanization, and carbon emissions in India, while Raihan et al. (2023) investigated the interconnected roles of financial development, globalization, economic growth, and renewable energy uptake in Indonesia. These findings indicate that financial development alone may be insufficient to achieve environmental sustainability unless accompanied by effective governance and environmentally responsible investment policies.

2.3. Renewable energy consumption and environmental sustainability

Renewable energy consumption is widely recognized as an important mechanism for reducing carbon emissions and promoting sustainable economic development. Increasing the contribution of renewable energy to the energy mix can reduce dependence on fossil fuels, improve energy efficiency, and support cleaner industrial activities. However, the effectiveness of renewable energy adoption depends on financial resources, technological development, regulatory support, and institutional capacity. Tan and Uprasen (2021) found that income inequality influences renewable energy consumption in ASEAN economies, highlighting the interconnectedness of socioeconomic conditions and energy transitions. Similarly, Khan et al. (2021) demonstrated that renewable energy consumption contributes to environmental improvements across countries with different income levels. Raihan and Bari (2024) investigated the energy–economy–environment nexus in China, focusing on the role of renewable energy in achieving carbon neutrality. Similarly, Raihan et al. (2025b) examined renewable energy and energy efficiency as components of China's carbon neutrality transition.

Recent empirical evidence further supports the importance of renewable energy and institutional arrangements. Almulhim et al. (2025) examined renewable energy consumption, institutional quality, and consumption-based CO_2 emissions in BRICS economies, emphasizing the importance of integrating clean energy policies with effective governance. Rehman et al. (2025) also identified renewable energy consumption as an important contributor to environmental improvements across different regions. These studies suggest that renewable energy expansion can facilitate environmental sustainability, although its effectiveness may vary according to institutional quality, financial development, and national energy structures.

2.4. Institutional quality and carbon emissions

Institutional quality is an important determinant of environmental sustainability because governance structures influence regulatory enforcement, public accountability, investment decisions, and environmental policy implementation. Institutional theory emphasizes that effective institutions establish rules and incentives that shape economic behavior and resource allocation (North, 1990). Strong institutions may promote environmental protection through transparent governance, regulatory compliance, and efficient resource management. Conversely, weak institutions may encourage corruption, ineffective environmental regulations, and environmentally harmful economic activities. Azam et al. (2021) demonstrated that institutional quality influences environmental outcomes and energy consumption in developing countries. Yang et al. (2022) further highlighted the role of institutional quality in shaping the relationship between income inequality and CO_2 emissions. Recent studies have reinforced the importance of governance while revealing heterogeneous environmental effects. Bergougui et al. (2024) found that improvements in institutional quality generally reduce carbon emissions inequality, although the magnitude of this relationship varies across institutional conditions.

Rachid et al. (2025) demonstrated that institutional quality influences the environmental consequences of financial development, while Rehman et al. (2025) emphasized its role in promoting environmentally sustainable financial activities. Furthermore, Zou et al. (2025) reported that institutional quality, digital finance, industrialization, and energy efficiency exhibit complex relationships with environmental degradation in BRI economies.

The relationship between governance and environmental sustainability has also been investigated in emerging economies. Ghosh et al. (2023) examined the spillover effects of democracy and renewable energy consumption on environmental quality in BRICS countries, while Hossain et al. (2026) investigated the roles of policy stringency, globalization, eco-innovation, and democratic institutions in environmental sustainability transitions. These findings indicate that institutional quality does not necessarily produce uniform environmental improvements, particularly when governance reforms primarily facilitate economic expansion rather than environmental protection. Therefore, examining individual institutional dimensions, including control of corruption, government effectiveness, regulatory quality, political stability, rule of law, and voice and accountability, may provide a more comprehensive understanding of their environmental implications.

2.5. Research gap and theoretical framework

The reviewed literature demonstrates that income inequality, economic growth, financial development, renewable energy consumption, and institutional quality are closely associated with environmental outcomes. Nevertheless, the direction and magnitude of these relationships remain inconsistent across countries and empirical approaches. Existing studies frequently examine selected socioeconomic or institutional determinants independently, while fewer studies integrate these factors within a unified dynamic panel framework. Although previous research has investigated income inequality and institutional quality in BRI economies (You et al., 2020; Yang et al., 2022), recent evidence concerning green growth, financial development, and governance suggests that their combined environmental implications require further examination (Zeb et al., 2025; Zou et al., 2025). In particular, distinguishing between individual governance indicators and composite institutional indices may help explain why institutional improvements are associated with different environmental outcomes.

The theoretical framework of this study draws on the political economy of environmental inequality, the EKC hypothesis, and institutional economics. The political economy perspective suggests that income distribution influences environmental outcomes through consumption behavior and unequal political influence (Boyce, 1994). The EKC hypothesis explains how environmental degradation may change with economic development, while institutional theory emphasizes the importance of governance structures in regulating economic activities and environmental protection (North, 1990). Financial development and renewable energy consumption provide additional channels through which economic and institutional conditions may influence emissions. Accordingly, this study examines the associations between income inequality, economic growth, financial development, renewable energy consumption, industrialization, urbanization, and CO_2 emissions, while explicitly considering different dimensions of institutional quality. Using panel data for 37 BRI countries from 2002 to 2020 and a two-step system generalized method of moments estimator, the analysis seeks to provide further evidence on these relationships and assess the applicability of the EKC hypothesis in the sampled economies.

3. Methodology

3.1. Data and variable description

This study investigates the effects of income inequality, economic growth, financial development, renewable energy consumption, and institutional quality on CO_2 emissions in 37 BRI countries over the period 2002–2020. The analysis also incorporates industrialization and urbanization as control variables to account for their potential environmental implications. Data are obtained from the World Development Indicators (WDI), while institutional quality is measured using six governance indicators from the Worldwide Governance Indicators (WGI) database. CO_2 emissions, measured in metric tons per capita, serve as the dependent variable. The explanatory variables include income inequality, measured by the Gini index; economic growth, represented by the economic growth indicator; financial development, proxied by domestic credit to the private sector as a percentage of GDP; and renewable energy consumption, measured as a percentage of total final energy consumption. Industrialization and urbanization are represented by industry value added and the urban population as a percentage of the total population, respectively.

Institutional quality is assessed using six indicators: control of corruption, voice and accountability, political stability, rule of law, regulatory quality, and government effectiveness. In addition to examining these indicators individually, the study considers composite indices representing legal institutions, political institutions, and overall institutional quality. Table 1 summarizes the variables, their measurements, and data sources.

Table 1. Description of variables

Variable	Symbol	Measurement	Data Source
Carbon dioxide emissions	CO_2	Metric tons per capita	WDI
Income inequality	INIY	Gini index	WDI
Economic growth	ECG	Economic growth indicator	WDI
Financial development	FID	Domestic credit to private sector (% of GDP)	WDI
Renewable energy consumption	REU	Renewable energy consumption (% of total final energy consumption)	WDI
Industrialization	IND	Industry value added	WDI
Urbanization	URBN	Urban population (% of total population)	WDI
Control of corruption	COC	Governance estimate	WGI
Voice and accountability	VOA	Governance estimate	WGI
Political stability	PS	Governance estimate	WGI
Rule of law	ROL	Governance estimate	WGI
Regulatory quality	RQ	Governance estimate	WGI
Government effectiveness	GOV	Governance estimate	WGI
Institutional quality	InstQ	Composite institutional quality index	WGI

3.2. Model specification

To examine the relationships between socioeconomic factors, institutional quality, and environmental degradation, the study specifies the following baseline panel regression model:

$$CO2_{it} = \beta_0 + \beta_1 INIY_{it} + \beta_2 ECG_{it} + \beta_3 FID_{it} + \beta_4 REU_{it} + \beta_5 IND_{it} + \beta_6 URBN_{it} + \beta_7 InstQ + \varepsilon_{it} \quad (1)$$

where i and t represent countries and years, while ε_{it} denotes the error term.

The empirical analysis considers eight model specifications to evaluate the robustness of the estimated relationships across alternative institutional measures. Model 1 presents the baseline specification without institutional quality. Model 2 incorporates all six institutional indicators, while Models 3 and 4 separately examine political and legal institutional indicators. Models 5 and 6 employ composite legal and political institutional indices, respectively. Model 7 includes the overall institutional quality index, and Model 8 introduces the squared economic growth term to examine the EKC hypothesis.

The EKC specification extends the baseline model by incorporating a quadratic economic growth term:

$$CO2_{it} = \beta_0 + \beta_1 CO2_{it-1} + \beta_1 INIY_{it} + \beta_2 ECG_{it} + \beta_8 ECG_{it}^2 + \beta_4 FID_{it} + \beta_5 REU_{it} + \beta_6 IND_{it} + \beta_7 URBN_{it} + \beta_8 InstQ + \varepsilon_{it} \quad (2)$$

An inverted U-shaped EKC relationship requires a positive coefficient on economic growth and a negative coefficient on its squared term, with an economically meaningful turning point within the observed data range. Conversely, positive coefficients on both terms do not support the conventional EKC hypothesis.

3.3. Econometric estimation strategy

The study employs a two-step system generalized method of moments (system GMM) estimator to investigate the dynamic relationships between the explanatory variables and CO_2 emissions. This approach is appropriate for dynamic panel models with potential endogeneity, unobserved country-specific heterogeneity, and persistence in the dependent variable. System GMM combines equations in first differences and levels, using appropriate lagged variables as instruments to address endogeneity and improve estimation efficiency under the required moment conditions.

For comparison, the study also considers ordinary least squares (OLS), fixed-effects, and two-step difference GMM estimators. The validity of the GMM specifications is evaluated using the Sargan and Hansen overidentification tests and the Arellano–Bond serial correlation tests. The Hansen test assesses the joint validity of the instruments, while the Arellano–Bond AR(2) test examines second-order serial correlation in the differenced residuals. Reliable inference requires appropriate instrument selection, absence of problematic second-order serial correlation, and avoidance of excessive instrument proliferation.

3.4. Preliminary diagnostic tests

Before estimating the empirical models, the study conducts preliminary statistical and diagnostic analyses. Descriptive statistics summarize the distribution and variability of the study variables, while correlation analysis provides an initial assessment of their pairwise relationships. Panel unit root tests are subsequently employed to examine the stationarity properties of the variables. Specifically, the study applies the Im–Pesaran–Shin (IPS), Fisher augmented Dickey–Fuller (Fisher-ADF), cross-sectionally augmented IPS (CIPS), and cross-sectionally augmented Dickey–Fuller (CADF) tests. The latter two procedures account for potential cross-sectional dependence among countries.

The study also employs the Pedroni and Kao panel cointegration tests to investigate possible long-run equilibrium relationships among the variables. These diagnostic procedures provide supplementary information about the time-series properties of the panel and the suitability of alternative econometric specifications. Following these preliminary assessments, the empirical analysis focuses on the two-step system GMM estimates, with particular attention to coefficient signs, statistical significance, institutional heterogeneity, and the EKC hypothesis.

4. Results and discussion

4.1. Descriptive statistics and correlation analysis

The descriptive statistics presented in Table 2 provide an overview of the socioeconomic, environmental, and institutional characteristics of the sampled BRI countries. The average CO_2 emissions are 4.482 metric tons per capita, with a standard deviation of 3.422, indicating substantial variation in environmental performance. The mean Gini index is 33.762, reflecting differences in income distribution across the sample. Financial development averages 45.394% of GDP, while renewable energy accounts for approximately 24.217% of total final energy consumption. Industrialization and urbanization also exhibit considerable variation, reflecting differences in economic structures and development patterns. The institutional indicators display heterogeneous mean values, suggesting differences in governance effectiveness across the sampled economies.

Table 2. Descriptive statistics

Variable	Mean	Std. dev.	Minimum	Maximum
CO_2	4.482	3.422	0.000	15.047
INIY	33.762	5.446	23.700	47.200
ECG	3.980	3.813	1.464	17.031
FID	45.394	29.772	0.186	165.390
REU	24.217	22.157	0.000	93.456
IND	29.904	8.171	14.303	58.884
URBN	55.253	16.887	18.196	92.501
COC	−0.232	0.643	−1.415	1.646
VOA	−0.200	0.862	−1.829	1.213
PS	−0.181	0.874	−2.810	1.302
ROL	−0.123	0.670	−1.371	1.372
RQ	0.045	0.752	−1.720	1.698
GOV	0.037	0.644	−1.230	1.391

The correlation matrix in Table 3 indicates that CO_2 emissions are positively correlated with income inequality, financial development, renewable energy consumption, industrialization, urbanization, and all six institutional indicators. The strongest reported correlations with emissions are observed for urbanization (0.618) and renewable energy consumption (0.610). Several institutional indicators are also highly correlated, particularly control of corruption and rule of law (0.934), and rule of law and government effectiveness (0.930).

Table 3. Correlation matrix

Variable	CO_2	INIY	ECG	FID	REU	IND	URBN	COC	VOA	PS	ROL	RQ	GOV
CO_2	1.000	—	—	—	—	—	—	—	—	—	—	—	—
INIY	0.195	1.000	—	—	—	—	—	—	—	—	—	—	—
ECG	0.051	0.161	1.000	—	—	—	—	—	—	—	—	—	—
FID	0.271	0.221	0.177	1.000	—	—	—	—	—	—	—	—	—
REU	0.610	0.164	0.032	0.150	1.000	—	—	—	—	—	—	—	—
IND	0.146	0.141	0.178	0.231	0.161	1.000	—	—	—	—	—	—	—
URBN	0.618	0.023	0.088	0.137	0.613	0.053	1.000	—	—	—	—	—	—
COC	0.352	0.086	0.147	0.377	0.039	0.165	0.372	1.000	—	—	—	—	—
VOA	0.230	0.234	0.236	0.114	0.011	0.346	0.301	0.772	1.000	—	—	—	—
PS	0.435	0.456	0.033	0.212	0.281	0.043	0.313	0.583	0.555	1.000	—	—	—
ROL	0.352	0.119	0.219	0.399	0.056	0.185	0.319	0.934	0.848	0.605	1.000	—	—
RQ	0.341	0.077	0.212	0.341	0.077	0.292	0.315	0.838	0.871	0.545	0.916	1.000	—
GOV	0.358	0.005	0.222	0.497	0.049	0.110	0.338	0.898	0.758	0.496	0.930	0.894	1.000

4.2. Panel unit root tests

The stationarity properties of the variables are examined using the Im–Pesaran–Shin (IPS), Fisher augmented Dickey–Fuller (Fisher-ADF), cross-sectionally augmented IPS (CIPS), and cross-sectionally augmented Dickey–Fuller (CADF) tests. As reported in Table 4, the results indicate that several variables are stationary at levels, whereas others become stationary after first differencing. In particular, CO_2 emissions, financial development, and renewable energy consumption generally exhibits stronger evidence of stationarity after first differencing. The results therefore suggest a mixture of level-stationary and first-difference-stationary variables, although the conclusions vary across tests. These findings support further investigation of the dynamic relationships among the variables while highlighting the need to consider their integration properties when specifying the econometric models.

4.3. Panel cointegration tests

The study employs Pedroni and Kao panel cointegration tests to assess whether long-run equilibrium relationships exist among the variables. Table 5 presents the Pedroni test results, which provide mixed evidence. The panel PP and group PP statistics reject the null hypothesis of no cointegration at the 1% significance level, while the panel rho, group rho, and panel v statistics do not. The panel ADF statistic also rejects the null hypothesis, whereas the group ADF statistic does not. These differences suggest that evidence of cointegration is sensitive to the test statistic employed.

The Kao test results in Table 6 provide additional evidence of cointegration, with an ADF statistic of −2.8502 and a p-value of 0.0022, rejecting the null hypothesis at the 1% significance level. Taken together, the Pedroni and Kao tests suggest some evidence of long-run relationships, although the results are not uniform.

Table 4. Panel unit root test results

Variable	IPS		Fisher-ADF		CIPS		CADF	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
CO_2	−0.34	−6.99***	93.94	262.65***	−1.66	−3.57***	−0.28	−3.83***
INIY	−2.21***	−3.23***	104.94	146.82***	−2.78***	−4.06***	−2.48***	−4.25***
ECG	−3.47**	−12.24***	139.72***	422.41***	−3.64***	−5.16***	−3.06***	−4.29***
FID	0.47	−2.15*	65.29	125.77***	−0.32	−4.29***	−0.71	−3.38***
REU	0.08	−6.51***	88.14	234.04***	−0.47	−5.34***	−0.60	−4.00***
IND	−1.02	−6.66***	102.97	217.54***	−2.87***	−5.36***	−2.44***	−4.22***
URBN	−2.59**	−7.73***	224.89***	232.64***	−1.62	−2.40***	−2.54***	−2.11**
COC	−1.95	−4.95***	120.03***	194.11***	−2.19	−3.77***	−2.48***	−2.83***
VOA	−1.65	−8.16***	107.73	288.24***	−1.83	−3.53***	−1.87	−2.80***
PS	−4.07**	−10.86***	186.26***	385.89***	−1.73	−3.81***	−1.88	−3.10***
ROL	−1.49	−7.94***	101.40	264.59***	−2.25***	−4.01***	−2.08	−3.00***
RQ	0.25	−5.34***	83.70	194.38***	−2.29**	−4.24***	−1.72	−2.43***
GOV	−1.36	−8.18***	109.88	271.91***	−2.48***	−3.88***	−2.24**	−2.73***

Note: I(0) and I(1) denote levels and first differences, respectively. *, **, and *** indicate significance at the 10%, 5%, and 1% levels.

Table 5. Pedroni panel cointegration test results

Test statistic	Statistic	p-value	Weighted statistic	p-value
Within-dimension				
Panel v	−5.5574	1.0000	−4.5979	1.0000
Panel rho	7.3452	1.0000	6.8588	1.0000
Panel PP	−8.6098	0.0000	−6.1797	0.0000
Panel ADF	−3.7029	0.0001	−1.5494	0.0606
Between-dimension				
Group rho	9.4819	1.0000	—	—
Group PP	−10.7385	0.0000	—	—
Group ADF	−0.3994	0.3448	—	—

Table 6. Kao panel cointegration test results

Statistic	Value	p-value
ADF statistic	−2.8502	0.0022
Residual variance	0.1992	—
HAC variance	0.1763	—

Note: HAC = heteroskedasticity and autocorrelation consistent. The null hypothesis is no cointegration.

4.4. Dynamic panel estimation results

The main empirical findings are obtained using the two-step system GMM estimator. Table 7 reports eight specifications incorporating alternative institutional quality measures. Model 1 excludes institutional quality, Model 2 includes all six governance indicators, Models 3 and 4 examine political and legal institutional dimensions, respectively, Models 5 and 6 employ composite legal and political indices, Model 7 includes the

overall institutional quality index, and Model 8 incorporates the squared economic growth term to assess the EKC hypothesis.

Table 7. Two-step system GMM estimation results

Variable	M1	M2	M3	M4	M5	M6	M7	M8
INIY	−0.149	−0.018**	0.112	−0.145	−0.205	−0.053	−0.226*	−0.236*
ECG	0.008***	0.006***	0.006***	0.010***	0.010***	0.008***	0.006***	0.004***
FID	0.150***	0.176***	0.154***	0.153***	0.145***	0.162***	0.111***	0.098**
REU	−0.012***	−0.014***	−0.013***	−0.011**	−0.015***	−0.016***	−0.015***	−0.014***
IND	0.137	−0.055	−0.055	0.152	0.188	0.035	0.109*	0.134*
URBN	0.013***	0.004	0.007**	0.010***	0.012***	0.009***	0.010***	0.010***
COC	—	0.192***	0.156***	—	—	—	—	—
VOA	—	0.036	—	0.137*	—	—	—	—
PS	—	0.151***	0.163***	—	—	—	—	—
ROL	—	−0.160**	—	0.073	—	—	—	—
RQ	—	0.085	—	−0.065	—	—	—	—
GOV	—	−0.158**	−0.133***	—	—	—	—	—
Legal index	—	—	—	—	0.057*	—	—	—
Political index	—	—	—	—	—	0.042**	—	—
InstQ	—	—	—	—	—	—	0.116***	0.095***
ECG^2	—	—	—	—	—	—	—	0.000*
Constant	−0.648	0.060	−0.0912	−0.465	0.228	−0.321	0.347	−0.0142
N	280	280	280	280	280	280	280	280
Countries	37	37	37	37	37	37	37	37

Note: M1–M8 represent Models 1–8. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

The estimated coefficients of income inequality are negative and statistically significant in Models 2, 7, and 8, while the remaining specifications show insignificant associations. These results suggest that higher income inequality is associated with lower CO_2 emissions in selected specifications, although the relationship is not robust across all models. One possible explanation is that unequal income distribution constrains consumption among lower-income households, reducing aggregate demand for energy-intensive goods and services. However, this association should not be interpreted as evidence that increasing inequality is environmentally desirable, given its adverse socioeconomic consequences. The findings are consistent with Grunewald et al. (2017), who reported negative associations between inequality and emissions in lower-income economies, but contrast with Baloch et al. (2020), who identified an emissions-increasing effect of inequality in sub-Saharan Africa. Recent evidence from Bergougui et al. (2024) also highlights heterogeneous relationships between income inequality and climate inequality across major emitting economies, although their outcome variable differs from the CO_2 emissions examined here. Overall, the findings reinforce the importance of economic and institutional contexts in explaining the inequality–environment relationship.

Economic growth exhibits positive and statistically significant coefficients across all eight specifications, indicating a consistent association between economic expansion and increased CO_2 emissions. This finding suggests that growth in the sampled BRI economies remains closely linked to carbon-intensive production, industrial activity, and energy consumption. The results are consistent with the broader argument that economic expansion may intensify environmental pressures when cleaner technologies and energy transitions do not keep

pace with production growth. Financial development also exhibits positive and statistically significant coefficients in all specifications, suggesting that greater domestic credit availability is associated with higher emissions. This relationship may reflect the financing of energy-intensive production, industrial expansion, and carbon-intensive infrastructure. The findings are broadly consistent with Rehman et al. (2025), who reported that financial development increases emissions in several world regions unless supported by stronger institutional quality. Similarly, Rachid et al. (2025) demonstrated that the environmental implications of financial development differ across oil-producing and non-oil-producing MENA economies. Conversely, Bhatti et al. (2025) found that financial development reduces CO_2 emissions in Next-11 economies, illustrating the importance of differences in financial structures, institutional effectiveness, and investment composition.

Renewable energy consumption exhibits negative and statistically significant coefficients across all specifications, providing consistent evidence that greater renewable energy use is associated with lower CO_2 emissions. This finding underscores the potential contribution of clean energy transitions to environmental sustainability in BRI economies. It is consistent with Rehman et al. (2025), who identified renewable energy consumption as an important factor in improving environmental quality. The findings suggest that expanding renewable energy infrastructure and improving access to clean technologies may help reduce the environmental pressures associated with economic development.

Industrialization exhibits positive and weakly significant coefficients in Models 7 and 8, while its effects are statistically insignificant in the remaining specifications. This suggests that the environmental consequences of industrial activity depend on model specification and potentially on differences in production structures and technological capabilities. Urbanization, meanwhile, is positively and significantly associated with emissions in seven of the eight models. These results suggest that expanding urban populations may increase energy demand, transportation activity, infrastructure development, and associated emissions. These findings can be compared with previous research examining the relationships among economic growth, renewable energy consumption, industrialization, urbanization, and carbon emissions in Bangladesh and the Philippines (Raihan et al., 2022; Raihan, 2023). Voumik et al. (2023) also investigated the relationships between urbanization, industrialization, natural resource rents, and anthropogenic carbon emissions in South Asia. Recent evidence from Zou et al. (2025) similarly identifies industrial activity and energy consumption as important contributors to environmental degradation in BRI economies.

The institutional quality results reveal considerable heterogeneity across governance dimensions. Control of corruption and political stability exhibit positive and statistically significant coefficients in Models 2 and 3, while voice and accountability is positively significant only in Model 4. These findings suggest that improvements in certain institutional indicators are associated with increased emissions, potentially because more stable and predictable governance environments facilitate economic and industrial expansion without necessarily prioritizing environmental protection. However, the estimates do not directly establish these mechanisms.

Conversely, government effectiveness exhibits negative and statistically significant coefficients in Models 2 and 3, while the rule of law is negatively significant in Model 2. These findings suggest that effective public administration and legal enforcement may contribute to environmental improvements. Regulatory quality, however, does not exhibit a statistically significant association with emissions in the reported specifications. The contrasting institutional effects indicate that governance quality is multidimensional and that improvements in individual institutional indicators may have different environmental implications.

The composite legal, political, and overall institutional quality indices exhibit positive and statistically significant coefficients in their respective models. These results suggest that the aggregate institutional measures are associated with higher emissions in the sampled economies. Similar heterogeneity was reported by Zou et al. (2025), who identified mixed environmental effects of institutional quality in BRI economies. A broader study

by Saba et al. (2025) also found that governance indicators can be positively associated with emissions, with substantial regional variation. In contrast, Bergougui et al. (2024) reported that institutional improvements generally reduce carbon emissions inequality, although their study examined the distribution of emissions rather than aggregate per capita emissions. These comparisons indicate that institutional reforms must be accompanied by explicit environmental objectives to ensure that improved governance translates into lower carbon emissions.
Finally, Model 8 incorporates the squared economic growth term to examine the EKC hypothesis. The estimated coefficients of economic growth and its squared term are both positive, with the latter reported as statistically significant at the 10% level. This pattern does not support the conventional inverted U-shaped EKC hypothesis, which requires a positive linear coefficient and a negative quadratic coefficient. Instead, the results suggest that economic expansion has not been accompanied by a systematic reduction in emissions within the sampled economies. This finding may reflect continued dependence on fossil fuels, energy-intensive production, and insufficient adoption of cleaner technologies.
Overall, the empirical results indicate that economic growth, financial development, and urbanization are consistently associated with increased CO_2 emissions, whereas renewable energy consumption is associated with reduced emissions. Income inequality exhibits a negative but specification-dependent relationship, while institutional quality produces contrasting results across individual governance indicators and composite indices. These findings highlight the complexity of the relationships between economic development, governance, and environmental sustainability in BRI economies. Furthermore, the positive association between financial development and emissions suggests that expanding financial resources alone may not promote environmental sustainability unless investment is directed toward cleaner technologies and low-carbon activities. Similarly, the mixed institutional findings indicate that governance improvements do not automatically translate into environmental benefits. Effective environmental regulations, institutional accountability, and sustainable financial policies may therefore be necessary to align economic development with emissions reduction. The consistently negative renewable energy coefficients further highlight the importance of accelerating clean energy adoption. Taken together, the findings support an integrated policy approach combining renewable energy expansion, environmentally responsible financial development, and stronger environmental governance to promote sustainable economic growth across BRI countries.

5. Conclusions and policy implications

5.1. Conclusions

This study investigates the effects of income inequality, economic growth, financial development, renewable energy consumption, and institutional quality on CO_2 emissions in 37 BRI countries over the period 2002–2020. Employing a two-step system GMM estimator, the analysis provides empirical evidence on the relationships between socioeconomic development, institutional governance, and environmental sustainability. The findings reveal that economic growth and financial development are positively associated with CO_2 emissions, whereas renewable energy consumption consistently exhibits a negative association. Income inequality is negatively associated with emissions in selected specifications, although its statistical significance varies across models. Furthermore, industrialization increases emissions in certain specifications, while urbanization generally contributes to higher emissions.
The findings also reveal heterogeneous relationships between institutional quality and environmental performance. Control of corruption, political stability, and voice and accountability exhibit positive associations with emissions in selected models, whereas government effectiveness and the rule of law demonstrate negative

associations. The composite legal, political, and overall institutional quality indices are positively associated with CO_2 emissions, suggesting that institutional improvements do not necessarily translate into environmental benefits unless accompanied by effective environmental policies. Moreover, the positive coefficients of economic growth and its squared term provide no support for the conventional EKC hypothesis. Overall, the results highlight the importance of integrating economic development, financial reforms, renewable energy transitions, and environmental governance to promote sustainable development across BRI economies.

5.2. Policy implications

The findings offer several important policy implications. First, policymakers should prioritize the transition toward renewable energy by expanding clean energy infrastructure, encouraging technological innovation, and introducing financial incentives for renewable energy investment. Given the positive association between economic growth and emissions, BRI countries should promote low-carbon industrial development, improve energy efficiency, and gradually reduce dependence on fossil fuels. Sustainable urban planning, energy-efficient infrastructure, and environmentally friendly transportation systems are also essential for mitigating emissions associated with urbanization and industrial expansion.

Second, financial institutions should strengthen green financing mechanisms by directing credit toward renewable energy projects, cleaner production technologies, and environmentally sustainable businesses. Governments should encourage green investment through appropriate financial regulations, incentives, and environmental risk assessments. Third, institutional reforms should emphasize environmental accountability, transparent governance, and effective regulatory enforcement. The contrasting effects of individual governance indicators suggest that institutional improvements must be explicitly aligned with environmental objectives rather than economic expansion alone. Finally, although income inequality is negatively associated with emissions in certain specifications, reducing inequality remains essential for inclusive and sustainable development. Policymakers should therefore pursue equitable income distribution alongside cleaner consumption patterns, affordable renewable energy access, and environmentally responsible economic policies.

5.3. Limitations and future research directions

This study has certain limitations that provide opportunities for future research. First, the analysis focuses on 37 BRI countries over the period 2002–2020, which may limit the generalizability of the findings to other regions and more recent developments. Second, the study relies on aggregate country-level indicators that may not fully capture differences in economic structures, institutional effectiveness, and environmental policies. Third, although the system GMM approach addresses certain econometric concerns under appropriate identifying assumptions, potential limitations associated with instrument validity, omitted variables, and cross-country heterogeneity remain. Future studies could extend the sample period, incorporate additional determinants such as technological innovation, foreign direct investment, international trade, and green finance, and employ alternative econometric approaches to examine nonlinear relationships and heterogeneous effects across income groups. Further investigation of interactions between institutional quality, financial development, and renewable energy adoption could also provide deeper insights into the mechanisms influencing environmental sustainability in BRI economies.

Declaration

Acknowledgment: Not applicable.

Funding: This research received no funding.

Conflict of interest: The authors declare no conflict of interest.

Ethics approval/declaration: Not applicable.

Consent to participate: Not applicable.

Consent for publication: Not applicable.

Data availability: The data that support the findings of this study are available on request from the authors.

Authors contributions: Authors have equality contributed to the article

References

Almulhim, A. A., Inuwa, N., Chaouachi, M., & Samour, A. (2025). Testing the impact of renewable energy and institutional quality on Consumption-Based CO2 emissions: fresh insights from MMQR approach. Sustainability, 17(2), 704.

Azam, M., Liu, L., & Ahmad, N. (2021). Impact of institutional quality on environment and energy consumption: evidence from developing world. Environment, Development and Sustainability, 23(2), 1646-1667.

Baloch, M. A., Khan, S. U. D., Ulucak, Z. Ş., & Ahmad, A. (2020). Analyzing the relationship between poverty, income inequality, and CO2 emission in Sub-Saharan African countries. Science of the Total Environment, 740, 139867.

Bergougui, B., Boudjana, R. H., Mehibel, S., & Zambrano-Monserrate, M. A. (2024). How do institutional quality and income asymmetrically affect carbon emissions inequality? A quantile-on-quantile assessment for six major global emitters. Journal of Cleaner Production, 483, 144215.

Bhatti, M. K., Zhu, S., Hassan, A., Husnain, M. A., & Hussain, A. B. (2025). How do financial development and institutional quality influence greenhouse gases in the Next-11 economies?. Humanities and Social Sciences Communications, 12(1), 1656.

Boyce, J. K. (1994). Inequality as a cause of environmental degradation. Ecological Economics, 11(3), 169-178.

Cho, H. (2021). Determinants of the downward sloping segment of the EKC in high-income countries: The role of income inequality and institutional arrangement. Cogent Economics & Finance, 9(1), 1954358.

Ghazouani, T., & Hamdi, M. A. (2025). Income inequality, fintech innovation, and CO2 emissions: evidence from OECD countries. International Journal of Sustainable Development & World Ecology, 32(6), 650-670.

Ghosh, S., Hossain, M. S., Voumik, L. C., Raihan, A., Ridzuan, A. R., & Esquivias, M. A. (2023). Unveiling the spillover effects of democracy and renewable energy consumption on the environmental quality of BRICS countries: A new insight from different quantile regression approaches. Renewable Energy Focus, 46, 222-235.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement (NBER Working Paper No. 3914). National Bureau of Economic Research.

Grunewald, N., Klasen, S., Martínez-Zarzoso, I., & Muris, C. (2017). The trade-off between income inequality and carbon dioxide emissions. Ecological Economics, 142, 249-256.

Gu, B., Liu, J., Sheng, Y., & Cui, R. (2025). Carbon emission drivers in the Belt and Road Initiative countries—An empirical analysis based on countries with different income levels. Energy and Climate Management, 1(3), 9400001.

Hossain, I., Ridwan, M., Raihan, A., Roshid, M. M., Esquivias, M. A., & Hossain, M. E. (2026). Determinants of Environmental Sustainability Transitions in BRICS Economies: Evidence from Policy Stringency, Globalization, Eco-Innovation and Democratic Institutions. World Development Sustainability, 9, 100330.

Kaika, D., & Zervas, E. (2013). The Environmental Kuznets Curve (EKC) theory—Part A: Concept, causes and the CO2 emissions case. Energy Policy, 62, 1392-1402.

Khalfaoui, R., Tiwari, A. K., Khalid, U., & Shahbaz, M. (2023). Nexus between carbon dioxide emissions and economic growth in G7 countries: Fresh insights via wavelet coherence analysis. Journal of Environmental Planning and Management, 66(1), 31-66.

Khan, I., Han, L., & Khan, H. (2022). Renewable energy consumption and local environmental effects for economic growth and carbon emission: evidence from global income countries. Environmental Science and Pollution Research, 29(9), 13071-13088.

North, D. C. (1990). Institutions, institutional change and economic performance. Cambridge University Press.

Ntow-Gyamfi, M., Bokpin, G. A., Aboagye, A. Q., & Ackah, C. G. (2020). Environmental sustainability and financial development in Africa; does institutional quality play any role?. Development Studies Research, 7(1), 93-118.

Rachid, S., Nasr, M., & Boukhatem, J. (2025). Dynamic interaction between financial development, institutional quality and environmental conditions: new insights from MENA region. Development and Sustainability in Economics and Finance, 6, 100050.

Raihan, A. (2023). The dynamic nexus between economic growth, renewable energy use, urbanization, industrialization, tourism, agricultural productivity, forest area, and carbon dioxide emissions in the Philippines. Energy Nexus, 9, 100180.

Raihan, A., & Bari, A. M. (2024). Energy-economy-environment nexus in China: The role of renewable energies toward carbon neutrality. Innovation and Green Development, 3(3), 100139.

Raihan, A., Muhtasim, D. A., Farhana, S., Pavel, M. I., Faruk, O., Rahman, M., & Mahmood, A. (2022). Nexus between carbon emissions, economic growth, renewable energy use, urbanization, industrialization, technological innovation, and forest area towards achieving environmental sustainability in Bangladesh. Energy and Climate Change, 3, 100080.

Raihan, A., Rahman, J., Tanchangya, T., Ridwan, M., & Bari, A. M. (2024). Influences of economy, energy, finance, and natural resources on carbon emissions in Bangladesh. Carbon Research, 3(1), 71.

Raihan, A., Rahman, S. M., Ridwan, M., Sarker, T., Ben-Salha, O., Rahman, M. M., ... & Munira, S. (2025a). Dynamic influences of different energy sources, energy efficiency, technological innovation, population, and economic growth toward achieving net zero emissions in the United Kingdom. Innovation and Green Development, 4(4), 100273.

Raihan, A., & Voumik, L. C. (2022). Carbon emission dynamics in India due to financial development, renewable energy utilization, technological innovation, economic growth, and urbanization. Journal of Environmental Science and Economics, 1(4), 36-50.

Raihan, A., Voumik, L. C., Rahman, M. H., & Esquivias, M. A. (2023). Unraveling the interplay between globalization, financial development, economic growth, greenhouse gases, human capital, and renewable energy uptake in Indonesia: multiple econometric approaches. Environmental Science and Pollution Research, 30(56), 119117-119133.

Raihan, A., Zimon, G., Ridwan, M., Rahman, M. M., & Salehi, M. (2025b). Role of mineral resource rents, renewable energy, and energy efficiency toward carbon neutrality in China. Energy nexus, 17, 100394.

Rehman, A., Luni, T., & Majeed, M. T. (2025). Financial Development and CO2 Emissions: A Global Analysis and Continent-level Comparisons of Institutional Quality's Mediating Role. The Lahore Journal of Economics, 30(2), 63-98.

Rojas-Vallejos, J., & Lastuka, A. (2020). The income inequality and carbon emissions trade-off revisited. Energy Policy, 139, 111302.

Saba, C. S., Alola, A. A., & Ngepah, N. (2025). Exploring the role of governance and institutional indicators in environmental degradation across global regions. Environmental Development, 54, 101152.

Tan, Y., & Uprasen, U. (2021). Carbon neutrality potential of the ASEAN-5 countries: Implications from asymmetric effects of income inequality on renewable energy consumption. Journal of Environmental Management, 299, 113635.

Voumik, L. C., Mimi, M. B., & Raihan, A. (2023). Nexus between urbanization, industrialization, natural resources rent, and anthropogenic carbon emissions in South Asia: CS-ARDL approach. Anthropocene Science, 2(1), 48-61.

Yang, B., Ali, M., Hashmi, S. H., & Jahanger, A. (2022). Do income inequality and institutional quality affect CO2 emissions in developing economies?. Environmental Science and Pollution Research, 29(28), 42720-42741.

You, W., Li, Y., Guo, P., & Guo, Y. (2020). Income inequality and CO2 emissions in belt and road initiative countries: the role of democracy. Environmental Science and Pollution Research, 27(6), 6278-6299.

Zeb, A., Ullah, O., & Zeb, A. (2025). Bridging equity and sustainability: A heterogeneous analysis of poverty, inequality, and green growth's impact on environmental sustainability in BRI economies. Journal of Environmental Management, 390, 126364.

Zou, X., Mehmood, U., & Wang, W. (2025). Do digital finance, governance, and energy efficiency mitigate or worsen environmental degradation? Evidence from belt and road economies. Finance Research Letters, 86, 108701.

Copyright: © 2026 by the author(s). Published by Global Scientific Research. This work is distributed under Creative Commons Attribution License (CC BY 4.0). visit https://creativecommons.org/licenses/by/4.0/.

How to cite this article:

Majbaul Alam Akash, & Alaeldeen Ibrahim Elhaj. (2026). Income Inequality, Financial Development, and Carbon Emissions: Does Institutional Quality Matter in Belt and Road Economies? Journal of Environmental Science and Economics, 5(1), 70-87. https://doi.org/10.56556/jescae.v5i1.1514