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Asymmetric Effects of Human Rights on Renewable Energy Consumption

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Abstract

As the transition to renewable energy has become increasingly important for achieving environmental sustainability, understanding the institutional factors that influence renewable energy consumption (REC) is crucial. This study examines the relationship between human rights and REC using a panel dataset covering five world regions (Africa, Asia, Europe, North America, and South America) from 1990 to 2024. Employing an asymmetric panel ARDL and the Dumitrescu–Hurlin panel causality test, the results reveal a significant long-run nonlinear relationship in which improvements in human rights increase REC, while deteriorations in human rights reduce REC. Short-run effects vary across regions, reflecting differences in institutional and developmental conditions. The causality analysis indicates a bidirectional relationship between human rights and renewable energy consumption. These findings suggest that strengthening human rights institutions can promote renewable energy adoption, support environmental sustainability, and facilitate the transition toward a cleaner energy system.

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1. Introduction

The transition toward renewable energy has become a central pillar of sustainable development, particularly in the context of global commitments to climate mitigation and energy security [1]. Renewable energy adoption is increasingly recognized not only for its environmental benefits but also for its role in promoting long-term economic resilience and reducing dependence on fossil fuels [2]. Renewable energy consumption is a key mechanism for reducing greenhouse gas emissions, lowering carbon intensity, and mitigating environmental degradation [3, 4]. By replacing fossil fuel-based energy sources, greater renewable energy utilization contributes to improvements in environmental quality and supports long-term climate objectives [5]. Therefore, identifying the institutional factors that facilitate renewable energy consumption has become increasingly important for achieving long-term sustainability objectives.

Among the institutional factors that may shape renewable energy adoption, human rights have attracted growing attention because of their implications for governance quality and broader developmental outcomes [6]. A key causal mechanism linking human rights to renewable energy adoption lies in the role of civil liberties in strengthening institutional quality and governance processes. Greater protection of civil liberties enhances access to information, public participation, transparency, and government accountability, which can improve the design, implementation, and monitoring of renewable energy policies [7]. Beyond the energy sector,

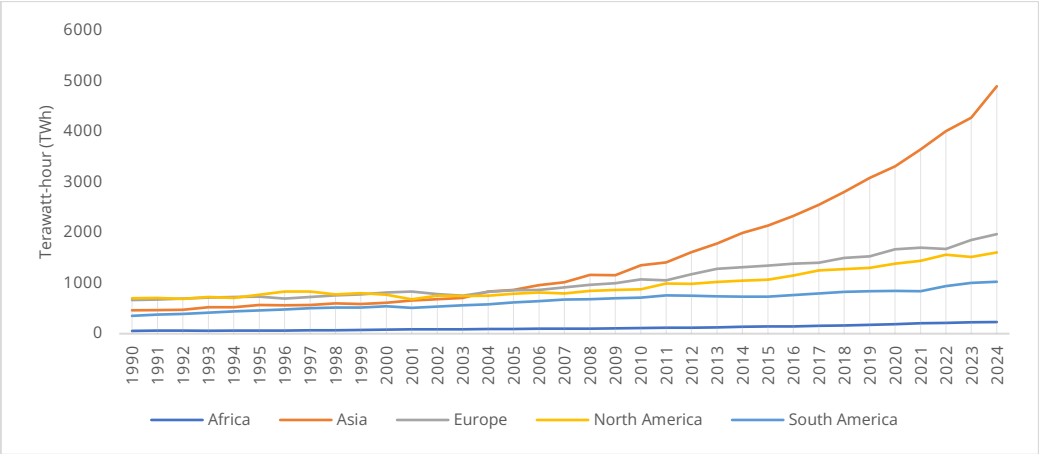


Figure 1. Trends in renewable energy consumption across regions, 1990–2024. Source: Our World In Data [8].

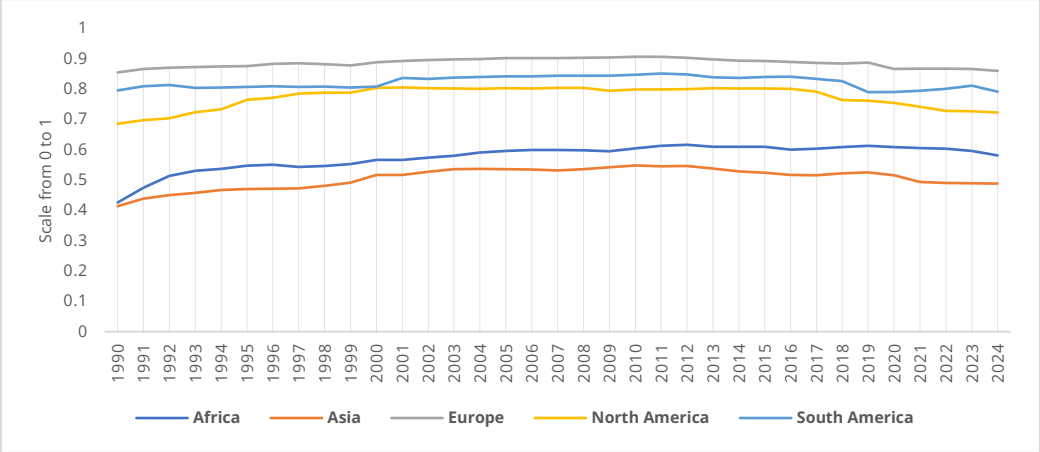


Figure 2. Evolution of human rights index based on V-Dem civil liberties across regions, 1990–2024. Source: Varieties of Democracy Institute [9].

human rights play an important role in environmental governance by facilitating access to environmental information, strengthening public oversight of environmental decision-making, and enhancing accountability for environmental degradation [10]. Stronger protection of civil liberties can improve the enforcement of environmental regulations and encourage broader societal participation in environmental protection efforts [11]. Consequently, human rights may influence renewable energy adoption through multiple channels, including improved transparency, stronger policy accountability, greater public engagement in environmental decision-making, and a more predictable institutional environment for renewable energy development. These governance mechanisms may also generate broader environmental benefits by strengthening environmental stewardship and regulatory effectiveness [12].

Despite this conceptual linkage, two interrelated challenges remain. First, at the global level, many countries continue to face constraints on civil liberties, weak institutional enforcement, and limited public participation, particularly in developing economies [13]. These shortcomings can weaken environmental governance and hinder the effective implementation of renewable energy policies. Second, considerable regional heterogeneity exists in renewable energy development. While some regions have achieved substantial progress through strong institutions, technological advancement, and investment capacity, others continue to struggle with limited infrastructure, regulatory uncertainty, and socio-political instability [14–16]. As a result, the influence of human rights on renewable energy consumption is unlikely to be uniform across regions, but instead varies according to institutional quality, governance effectiveness, and regional development conditions.

This conditional and region-specific nature of the relationship is clearly reflected in the empirical patterns presented in Figures 1 and 2. Based on data from Our World in Data [8] and the Varieties of Democracy Institute [9], the figures show that renewable energy consumption (REC) generally exhibits a sustained upward trend across

all regions despite short-term fluctuations in human rights conditions. This pattern suggests that the relationship between REC and the Human Rights Index (HRI) is neither uniform nor contemporaneous across regions. In Africa, REC rises almost monotonically, while HRI shows only modest improvements followed by recent declines, suggesting that REC expansion is driven more by structural energy needs and resource endowments than by institutional quality in the short run, with human rights playing a more consistent long-run enabling role. In Asia, REC increases exponentially, whereas HRI stagnates and declines after the mid-2010s, reflecting a development pattern in which state-led industrial policy, energy security concerns, and scale effects dominate over civil liberties in shaping renewable deployment. In Europe, both indicators remain at persistently high levels, with continued REC growth despite a slight downward trend in HRI, suggesting mature institutional environments in which established rights-based frameworks and regulatory stability sustain renewable expansion independently of short-term institutional fluctuations. In North America, steady REC growth occurs alongside a gradual deterioration in HRI after the mid-2010s, indicating a short-run decoupling likely driven by market-based energy transitions and technological change. In South America, the two indicators are comparatively more aligned, with increases in HRI generally coinciding with rising REC, while reversals in HRI correspond to weaker or less stable REC growth, indicating greater sensitivity to institutional conditions. Overall, the figures suggest that human rights serve primarily as a long-run institutional enabler of renewable energy development, whereas short-run REC dynamics are shaped by region-specific political, economic, and energy-sector factors, leading to the observed asymmetries across regions.

Given these overlapping challenges, it becomes important to systematically examine the relationship between human rights and renewable energy consumption. Understanding this relationship is critical for two reasons. First, it provides insight into whether strengthening human rights institutions can function as a driver of the energy transition through improved transparency, policy credibility, and investor confidence [17]. Second, it helps identify potential trade-offs and transitional frictions that may emerge when institutional reforms interact with energy policy dynamics, particularly in contexts with evolving governance structures [18]. Moreover, based on evidence in the literature, the relationship is unlikely to be uniform across time and space, as short-run adjustment costs, stakeholder contestation, and coordination failures may offset potential long-run gains, while regional differences in institutional capacity and economic development further condition outcomes [19–21]. Without explicitly accounting for these temporal and regional heterogeneities, policy conclusions risk being overly generalized and insufficiently grounded in the institutional realities that shape renewable energy adoption.

The relationship between human rights and renewable energy consumption can be theoretically grounded in several established frameworks. Institutional theory suggests that stronger institutions, reflected in the protection of civil liberties and rule-based governance, enhance policy credibility, reduce regulatory uncertainty, and strengthen investor confidence, thereby encouraging investment in renewable energy projects and increasing renewable energy consumption [22, 23]. Modernization theory further posits that as societies develop and expand civil rights, they become more receptive to technological innovation, environmental awareness, and sustainable development practices, creating conditions that facilitate the adoption and diffusion of renewable energy technologies [24]. In addition, the political economy of energy transition emphasizes the role of governance structures and stakeholder participation in shaping energy policy outcomes. Through channels such as public engagement, policy accountability, and broader societal support for environmental initiatives, greater respect for human rights can facilitate collective action and strengthen the implementation of renewable energy policies [7]. Therefore, institutional theory predicts an investment and policy-certainty channel, modernization theory predicts a technology-adoption and social-development channel, and the political economy perspective predicts a governance and stakeholder-participation channel linking human rights to renewable energy consumption. Together, these theoretical perspectives provide a coherent foundation for expecting a systematic relationship between human rights and renewable energy consumption.

Previous studies demonstrate that the relationship between human rights and renewable energy is not merely theoretical but empirically grounded and context-dependent. Misra & Agbaitoro [25] show that renewable energy expansion in India can generate human rights infringements, particularly in relation to community land and corporate practices, potentially undermining local support for the energy transition. Similarly, Schwab De La O & Jones [26] find that rights-based claims, through social mobilization and legal contestation, can delay or halt renewable energy projects, reflecting the conflict-driven nature of such transitions. From a broader

perspective, Levenda et al. [27] highlight that renewable energy technologies often entail environmental justice risks, including adverse impacts on vulnerable communities, which may exacerbate distributional and procedural inequalities if not properly addressed. In contrast, Basil & Heffron [28] emphasize that embedding human rights principles such as accountability, inclusivity, and equity into energy governance can enhance policy legitimacy and support more sustainable energy transitions. Taken together, these findings indicate that the effect of human rights on renewable energy is substantial yet heterogeneous and context-dependent, conditioned by governance quality, institutional safeguards, and the broader socio-political environment.

However, despite the growing recognition of the importance of both human rights and renewable energy in the development agenda, empirical studies that directly examine their interaction remain limited and methodologically constrained. The existing literature has largely focused on broader economic dimensions, as in Maniruzzaman & Al-Saleem [29], O'Neill et al. [30], and Villavicencio Calzadilla & Mauger [31], and on the social implications of human rights, as in Buhmann et al. [32], Fagan [33], Finley-Brook & Thomas [34], Schwab De La O & Jones [26], and Vermeylen [35], often relying on limited proxies and paying relatively little attention to broader measurement scope and dynamic specification. In particular, many studies rely on aggregate or less comprehensive proxies of institutional quality, which may not adequately capture the multidimensional nature of human rights. This limitation is addressed in the present study by employing the V-Dem civil liberties index [9], which provides a more granular and conceptually grounded measure of human rights. Unlike conventional indices, V-Dem captures multiple dimensions of civil liberties, including freedom of expression, association, and access to information, using a disaggregated, expert-coded approach with extensive country and temporal coverage. This allows for a more precise representation of institutional conditions that are directly relevant to transparency, accountability, and public participation, all of which are critical channels through which human rights may influence renewable energy outcomes. Moreover, the potential for asymmetric and nonlinear effects, where improvements and deteriorations in human rights exert differing impacts on renewable energy dynamics, remains largely unexplored, especially in a comparative, multi-regional context.

Against this backdrop, this study aims to investigate the relationship between human rights and renewable energy consumption across five major regions over the period 1990–2024. To address these gaps, the analysis employs an asymmetric panel ARDL framework that captures differential effects of positive and negative changes in human rights, alongside the Dumitrescu-Hurlin panel causality test to examine directional linkages. Accordingly, this study addresses the following research questions: (1) Do positive and negative shocks to human rights exert asymmetric effects on renewable energy consumption in the short run and long run? and (2) Is there a causal relationship between human rights and renewable energy consumption across regions? Based on the theoretical arguments presented earlier, the study hypothesizes that improvements in human rights positively affect renewable energy consumption, while deteriorations in human rights negatively affect renewable energy consumption, with the magnitude of these effects differing across positive and negative shocks. Furthermore, it is hypothesized that a causal linkage exists between human rights and renewable energy consumption, reflecting the mutually reinforcing interaction between institutional quality and sustainable energy development.

The contribution of this study is threefold. First, it utilizes a more comprehensive and multidimensional measure of human rights based on the V-Dem framework, thereby improving measurement accuracy. Second, it incorporates an asymmetric modeling approach to uncover nonlinear dynamics that are often overlooked in the existing literature. Third, it provides region-specific policy insights into how variations in human rights conditions shape the trajectory of renewable energy adoption. Collectively, this study provides a more nuanced and empirically robust understanding of how different shocks in human rights conditions influence renewable energy dynamics in the long run at the global level and in the short run across diverse regional contexts.

2. Materials and Methods

2.1. Data and Variable

The panel data cover the period 1990-2024 across five regions (Africa, Asia, Europe, North America, and South America), with each region constituting a cross-sectional unit in the panel dataset rather than an aggregation of country-level observations. This period was selected based on the availability of Human Rights Index data, which have more limited coverage than the other variables included in the analysis. The model employs five variables in total. Renewable Energy Consumption (REC) as the dependent variable, while the Human Rights Index (HRI), proxied by the V-Dem civil liberties measure, as the

Table 1. Variable synopsis.

Status	Name	Symbol	Unit Measurement	Source
Dependent	Renewable Energy Consumption	REC	Terawatt-hour (TWh)	Our World In Data
Main Independent	Human Right Index	HRI	Scale from 0 to 1	Varieties of Democracy (V-Dem) Institute
Control Independent	Gross Domestic Product (GDP) per Capita	GDPC	Constant 2015 US Dollar	World Bank's World Development Indicators
	Population Growth	POPG	Percent	World Bank's World Development Indicators
	Urbanization Rate	URB	Percent	World Bank's World Development Indicators

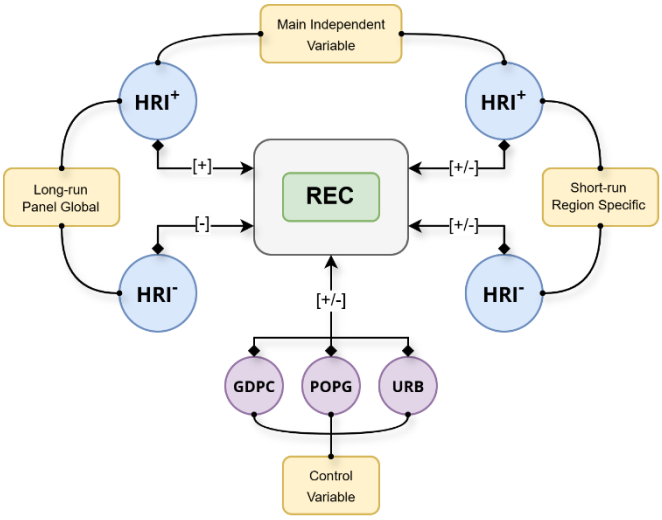


Figure 3. Overview of research framework. Note: The positive and negative signs in the brackets indicate the expected direction of each variable's impact.

main independent variable. GDP per capita (GDPC), population growth (POPG), and the urbanization rate (URB) as control variables. All data are sourced from reliable and trusted organizations: REC from Our World in Data [8], HRI from the Varieties of Democracy (V-Dem) Institute [9], and GDPC, POPG, and URB from the World Bank's World Development Indicators [36]. Table 1 presents the details of the variables employed.

2.2. Research Framework

The research framework, as shown in Figure 3, conceptualizes renewable energy consumption (REC) as the central outcome influenced by institutional dynamics, specifically human rights conditions, alongside key macroeconomic controls. Human rights are decomposed into positive (HRI^+) and negative (HRI^-) changes to capture potential asymmetry in their effects. In the long-run global panel setting, improvements in human rights (HRI^+) are expected to exert a positive influence on REC, while deteriorations (HRI^-) are expected to reduce it, reflecting the role of civil liberties in shaping transparent, stable, and investment-friendly environments for renewable energy development. This structure allows the model to distinguish not only the presence of an effect but also whether institutional improvements and declines operate differently in magnitude and direction over time.

In contrast, the short-run specification emphasizes regional heterogeneity, recognizing that the immediate impact of changes in human rights may vary across Africa, Asia, Europe, North America, and South America. Both positive and negative shocks to human rights (HRI^+ and HRI^-) are expected to have ambiguous effects on REC in the short term, capturing transitional frictions, policy adjustments, and differences in institutional capacity. In addition, the framework incorporates control variables, namely GDP per capita (GDPC), population growth (POPG), and urbanization (URB), to account for economic and demographic influences on renewable energy consumption [37–39]. Together, this research design enables a comprehensive assessment of how institutional quality, asymmetric shocks, and regional dynamics jointly shape renewable energy outcomes across different time horizons.

2.3. Model Specification

The mathematical function of this study's econometric estimation is shown in Equation (1).

$$REC = f(HRI, GDPC, POPG, URB) \quad (1)$$

Where *REC* denotes renewable energy consumption, *HRI* denotes the human rights index, *GDPC* represents gross domestic product per capita, *POPG* refers to population growth, and *URB* represents the urbanization rate.

Based on the functional form specified in Equation (1), the econometric models are formulated in Equation (2).

$$REC_{it} = \beta_0 + \beta_1 HRI_{it} + \beta_2 GDPC_{it} + \beta_3 POPG_{it} + \beta_4 URB_{it} + \varepsilon_{it} \quad (2)$$

Here, i represent regions, t represents the study period, β_0 represent the intercepts, $\beta_1 - \beta_4$ represent the coefficients, and ε is the error term.

Lastly, to help normalize the scale across variables and improve interpretability, variables not in percentage form, namely REC, HRI, and GDPC, are transformed into their natural logarithms (ln). The final form of this study's model is presented in Equation (3).

$$\ln(REC_{it}) = \beta_0 + \beta_1 \ln(HRI_{it}) + \beta_2 \ln(GDPC_{it}) + \beta_3 POPG_{it} + \beta_4 URB_{it} + \varepsilon_{it} \quad (3)$$

2.4. Methods

2.4.1. Asymmetric Panel Autoregressive Distributed Lag (Asymmetric Panel ARDL)

The asymmetric panel ARDL model provides a flexible framework to examine both long-run equilibrium relationships and short-run dynamic adjustments in panel data settings, particularly when variables are integrated of order I(0) and I(1) but not I(2) [40]. In this study, the panel ARDL approach is employed to estimate the long-run relationship between HRI and REC across countries, while allowing for heterogeneous short-run dynamics across regions. To capture potential nonlinearities, the model incorporates an asymmetric specification following the nonlinear ARDL (NARDL) framework [41], in which the HRI variable is decomposed into partial sum processes of positive and negative changes. This decomposition enables the estimation of distinct effects of improvements and deteriorations in human rights conditions on REC variable, thereby avoiding the restrictive assumption of symmetry embedded in conventional linear models.

In the empirical implementation, the long-run coefficients are estimated at the panel level, assuming a common equilibrium relationship across the full sample, while short-run dynamics are allowed to vary across regions to reflect structural and institutional heterogeneity. This specification is consistent with the pooled mean group (PMG) estimator, which imposes homogeneity in long-run parameters but permits heterogeneity in short-run adjustments, error variances, and speed of adjustment toward equilibrium. The error correction representation of the model further allows identification of the speed at which deviations from the long-run equilibrium are corrected following shocks [42]. By distinguishing between long-run panel effects and region-specific short-run responses, the asymmetric panel ARDL framework is particularly well suited to capture the transitional dynamics and heterogeneous adjustment processes that characterize the relationship between HRI and REC across different regions.

The specific asymmetric panel ARDL model in this study is written in Equation (4).

$$\begin{aligned}\Delta \ln(REC_{it}) = {} & \alpha + \lambda[\ln(REC_{it-1}) - \beta_1^{+} \ln(HRI_{it-1}^{+}) - \\ & \beta_1^{-} \ln(HRI_{it-1}^{-}) - \gamma_1 \ln(GDPC_{it-1}) - \\ & \gamma_2 POPG_{it-1} - \gamma_3 URB_{it-1}] + \\ & \sum_{m=1}^{p-1} \delta_i \Delta \ln(REC_{it-m}) + \\ & \sum_{j=0}^{q-1} (\pi_{1j}^{+} \Delta \ln(HRI_{it-j}^{+}) + \\ & \pi_{1j}^{-} \Delta \ln(HRI_{it-j}^{-})) + \sum_{m=0}^{q_z-1} \kappa_m \Delta z_{it-m} + \\ & \mu_{it}\end{aligned} \quad (4)$$

Here, λ is the error-correction coefficient; β_1^{+} and β_1^{-} denote the long-run elasticities for positive or negative HRI; π_{1j}^{+} and π_{1j}^{-} represent the short-run asymmetric effects; HRI^{+} and HRI^{-} are the partial-sum series defined by cumulative positive and negative changes of the logged HRI series; z_{it} denotes $\{\ln(GDPC_{it}), POPG_{it}, \text{and } URB_{it}\}$; and μ_{it} is the error term.

2.4.2. Dumitrescu-Hurlin Panel Causality (DHPC)

The Dumitrescu–Hurlin panel causality (DHPC) test is employed to examine the direction of causal relationships between human rights and renewable energy consumption within a heterogeneous panel framework. Unlike conventional Granger causality tests, the DHPC approach allows for cross-sectional heterogeneity by permitting causal relationships to differ across units while still testing for the existence of causality at the panel level [43]. The method estimates individual regressions for each cross-section and then aggregates the test statistics to obtain a standardized Z-bar statistic, which is robust under both balanced and unbalanced panels and suitable when the time dimension is moderately large [44].

In this study, the DHPC test is used to identify whether causality runs unidirectionally or bidirectionally between the variables, thereby complementing the ARDL findings by providing evidence on dynamic interdependence rather than merely long-run association. This is particularly relevant given the potential feedback mechanisms between institutional quality and energy transition, where improvements in human rights may

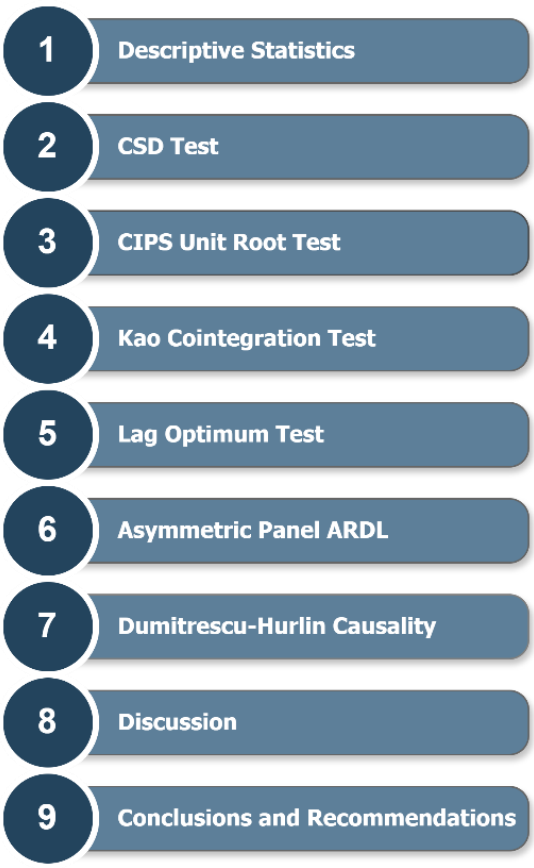


Figure 4. Overview of study flow analysis.

influence renewable energy adoption, while shifts in the energy structure may also affect institutional development over time.

2.5. Study Flow Analysis

The empirical strategy shown in Figure 4 follows a structured sequence to ensure the robustness and validity of the results. The analysis begins with descriptive statistics to provide an overview of the data, followed by the cross-sectional dependence (CSD) test to detect potential interdependencies across panel units. The CIPS unit root test is then applied to determine the stationarity properties of the variables under cross-sectional dependence. After establishing the order of integration, the Kao cointegration test is conducted to verify the existence of a long-run equilibrium relationship among the variables. The optimal lag length is subsequently selected to ensure appropriate model specification. Building on these preliminary steps, the asymmetric panel ARDL model is employed to estimate both long-run and short-run dynamics while capturing potential nonlinear effects. The Dumitrescu–Hurlin panel causality test is then used to assess directional relationships among the variables. Finally, the findings are interpreted in the discussion section, followed by conclusions and policy recommendations derived from the empirical results.

3. Results and Discussion

3.1. Descriptive Statistics

The descriptive statistics in Table 2 provide an overview of the distribution and variability of the variables across regions and over time. Renewable energy consumption (RE), measured in terawatt-hours, exhibits a high mean (877.68) and substantial dispersion (standard deviation of 771.76), indicating considerable heterogeneity in energy consumption levels. The large gap between the minimum (57.63) and maximum (4895.53), combined with strong positive skewness (2.38) and high kurtosis (10.69), suggests a highly right-skewed and leptokurtic distribution, likely driven by a few regions with exceptionally high renewable energy usage.

The Human Rights Index (HRI), measured on a 0–1 scale, shows relatively low variability, with a mean of 0.71 and a standard deviation of 0.15. The median (0.79) exceeding the mean indicates slight left-skewness, which is consistent with the negative skewness value (-0.35). This suggests that most observations are concentrated at relatively higher levels of civil liberties, with fewer instances of low human rights performance. The kurtosis value (1.57) indicates a relatively flat (platykurtic) distribution compared to the normal distribution.

GDP per capita (GDPC), measured in US dollars, displays significant dispersion, with a high standard deviation (17,739.26) relative to its mean (17,976.78). The notable difference between the mean and median (8,610.67), along with positive skewness (1.22), indicates that income distribution is right-skewed, reflecting the presence of high-income economies within the sample. The kurtosis value (3.14) suggests a distribution close to normal but with slightly heavier tails.

Population growth (POPG), measured in percentages, shows moderate variability, with a mean of 1.26 and a standard deviation of 0.83. The positive skewness (0.62) implies that lower population growth rates are more common, with fewer observations experiencing high growth. The kurtosis value (2.25) indicates a relatively flatter distribution compared to normal, suggesting limited extreme values.

Urbanization (URB), also measured in percentages, has a mean of 60.69 and a standard deviation of 19.03, indicating moderate dispersion across regions. The negative skewness (-0.43) suggests that a larger proportion of observations are concentrated at higher levels of urbanization. With a kurtosis value of 1.45, the distribution appears relatively flat, implying fewer extreme deviations.

Table 2. Descriptive statistics of raw data.

Variable	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis
REC	877.68	748.43	4895.53	57.63	771.76	2.38	10.69
HRI	0.71	0.79	0.91	0.41	0.15	-0.35	1.57
GDPC	17976.78	8610.67	63990.60	2296.46	17739.26	1.22	3.14
POPG	1.26	1.06	2.77	-0.02	0.83	0.62	2.25
URB	60.69	69.97	81.27	28.98	19.03	-0.43	1.45

Note: RE is measured in terawatt-hours, HRI is measured on a 0–1 scale, GDPC is measured in US dollars, and POPG and URB are measured in percentages.

Table 3. Results of Breusch–Pagan LM and Pesaran scaled LM cross-sectional dependence test.

Variable	t-Stat.	
Breusch-Pagan LM	130.73***	0.0000
Pesaran Scaled LM	26.996***	0.0000

Note: *** denotes significance level at 1%.

Table 4. Results of CIPS unit root test.

Variable	t-Stat.	
	Level (I(0)	*1st. Diff. (I(1)*
REC	-2.6417***	n.e.
HRI	-2.6890***	n.e.
GDPC	-2.7021***	n.e.
POPG	-2.5863***	n.e.
URB	-1.5694	-2.5434**

Note: *** and ** denote statistical significance at the 1% and 5% levels, respectively. The CIPS critical values are -2.57 at the 1% level and -2.33 at the 5% level. "n.e." indicates that the variable was not estimated at first difference because it was already stationary at level.

Overall, the descriptive statistics indicate that while institutional and demographic variables such as HRI, POPG, and URB are relatively stable and less dispersed, economic and energy-related variables, particularly RE and GDPC, exhibit substantial heterogeneity and non-normality. These distributional characteristics justify the use of econometric techniques capable of handling skewness, heteroskedasticity, and cross-sectional differences.

3.2. Preliminary Test

3.2.1. Cross-Sectional Dependence (CSD) Test

The first preliminary test to be conducted is the cross-sectional dependence (CSD) test, which aims to identify dependence across panel units. Given the panel structure (T = 35, N = 5), the LM-based tests are particularly appropriate and reliable. As shown in Table 3, both the Breusch–Pagan LM and Pesaran scaled LM statistics are highly significant at the 1% level, with values of 130.73 and 26.996, respectively, and corresponding p-values of 0.0000. These findings lead to the rejection of the null hypothesis of cross-sectional independence, indicating that shocks affecting one region are likely to be correlated with others. From a practical perspective, this result suggests that developments in renewable energy markets, economic conditions, or institutional changes in one region may spill over to other regions through globalization, policy diffusion, trade linkages, and international investment flows. The presence of cross-sectional dependence justifies the use of second-generation panel techniques, such as the CIPS unit root test, to ensure robust and consistent estimation.

3.2.2. Cross-sectionally Augmented Im, Pesaran, and Shin (CIPS) Unit Root Test

Given the presence of cross-sectional dependence identified in earlier tests, the Cross-sectionally Augmented Im, Pesaran, and Shin (CIPS) approach is employed as it accounts for such dependence across panel units. The CIPS unit root test results, as shown in Table 4, indicate a mixed order of integration among the variables. Specifically, the test statistics for REC (-2.6417), HRI (-2.6890), GDPC (-2.7021), and POPG (-2.5863) are significant at the 1% level, exceeding the corresponding critical value of -2.57, indicating that these variables are stationary at level, I(0). In contrast, URB is not stationary at level, as its test statistic (-1.5694) fails to exceed the relevant critical value. However, after first differencing, the CIPS statistic for URB (-2.5434) becomes significant at the 5% level, exceeding the 5% critical value of -2.33, indicating that URB is stationary at first difference, I(1). These findings suggest that the variables are integrated of mixed orders, with none exceeding I(1), thereby satisfying the requirements for the application of the ARDL framework in the subsequent analysis.

3.2.3. Kao Cointegration Test

The results in Table 5 of the Kao panel cointegration test indicate the presence of a long-run equilibrium

Table 5. Results of Kao panel cointegration test.

Test	t-Stat.	Prob.
ADF	-2.7902***	0.0026

Note: *** denotes significance level at 1%.

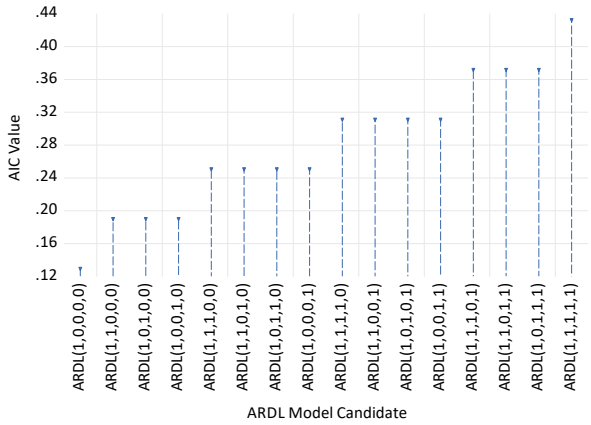


Figure 5. Results of Akaike Information Criterion (AIC).

relationship among the variables. Specifically, the ADF test statistic of -2.7902 is statistically significant at the 1% level, with a corresponding p-value of 0.0026. This leads to the rejection of the null hypothesis of no cointegration, confirming that the employed variables move together in the long run. The existence of cointegration implies that any short-run deviations from equilibrium are temporary and eventually converge back to the long-run path, which provides the econometric justification for estimating long-run relationships within the panel ARDL framework. Consequently, these findings support the appropriateness of employing a panel ARDL framework to estimate both long-run and short-run dynamics.

3.3. Lag Optimum Test

The Akaike Information Criterion (AIC) results in Figure 5 indicate that the optimal lag structure for the panel ARDL model is ARDL(1,0,0,0,0), as it yields the lowest AIC value among all candidate specifications. This suggests that including one lag of the dependent variable and no lags for the independent variables provides the best balance between model fit and parsimony. As higher lag orders are introduced, the AIC values increase, indicating that more complex specifications do not improve the model and may lead to overfitting. Therefore, the ARDL(1,0,0,0,0) specification is selected for subsequent analysis of both short-run and long-run dynamics.

3.4. Asymmetric Panel ARDL Estimation

The long-run results of the asymmetric panel ARDL model, as presented in Table 6, reveal a significant asymmetric effect of human rights on renewable energy consumption (REC). Positive changes in the Human Rights Index (HRI^+) have a positive and statistically significant impact on REC, with a coefficient of 5.7562 ($p < 0.01$), indicating that a 1% increase in HRI^+ is associated with a 5.76% increase in renewable energy consumption in the long run. Conversely, negative changes in human rights (HRI^-) exert a significant negative effect, with a coefficient of -4.4685 ($p < 0.01$), suggesting that a 1% increase in adverse human rights shocks reduces renewable energy consumption by approximately 4.47%. This confirms the presence of long-run asymmetry, where improvements and deteriorations in human rights have reinforcing but directionally opposite effects on renewable energy.

Among the control variables, GDP per capita (GDPC) shows a positive and highly significant effect (coefficient = 1.1526, $p < 0.01$), indicating that a 1% increase in GDP per capita increases renewable energy consumption by approximately 1.15% in the long run. This finding is consistent with the notion that wealthier economies have greater capacity to invest in cleaner energy technologies. In contrast, population growth (POPG) and urbanization (URB) do not exhibit statistically significant effects in the long run, as their p-values exceed conventional significance levels. Although POPG has a positive coefficient and URB a negative one, these effects are not robust enough to draw firm conclusions.

On the other hand, the short-run results of the asymmetric panel ARDL model reveal substantial regional heterogeneity in the impact of human rights on renewable energy consumption (Table 7). For positive changes in the Human Rights Index (HRI^+), the effects are negative and statistically significant in Africa (-1.0480, $p < 0.01$), Asia (-1.1700, $p < 0.10$), and South America (-2.3359, $p < 0.01$), indicating that a 1% increase in HRI^+ is associated with reductions in renewable energy

Table 6. Results of long-run asymmetric panel ARDL.

Dependent Variable: REC				
Independent Variable	**Coef.**	**Std. Er.**	**t-Stat.**	**Prob.**
HRI^+	5.7562	1.7336	3.3204***	0.0011
HRI^-	-4.4685	1.3604	-3.2846***	0.0013
GDPC	1.1526	0.1996	5.7751***	0.0000
POPG	0.3630	0.2308	1.5727	0.1178
URB	-0.0127	0.0083	-1.5255	0.1291

Note: *** denotes significance level at 1%.

Table 7. Results of short-run asymmetric panel ARDL.

Dependent Variable: REC						
Independent Variable		*Africa*	*Asia*	*Europe*	*North America*	*South America*
HRI^+	**Coef.**	-1.0480	-1.1700	-2.4483	1.5485	-2.3359
	(t-Stat.)	(-3.0805)***	(-1.9901)*	(-0.9697)	(1.2831)	(-2.7914)***
HRI^-		0.9454	0.0780	-3.2032	-0.7994	1.5907
		(1.0790)	(0.1029)	(-2.0769)**	(-0.5952)	(2.4303)**
ECT-1		-0.0186	-0.1720	-0.0727	-0.0127	-0.2564
		(-0.9349)	(-6.0146)***	(-2.1672)**	(-2.0921)**	(-3.7787)***

Note: ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

consumption of approximately 1.05%, 1.17%, and 2.34%, respectively, in the short run. In contrast, the effect is positive but statistically insignificant in North America and negative but insignificant in Europe, suggesting weaker or delayed responses in these regions.

For negative changes in human rights (HRI^-), the results are more mixed. A significant negative effect is observed in Europe (-3.2032, $p < 0.05$), implying that a 1% increase in adverse human rights shocks reduces renewable energy consumption by approximately 3.20% in the short run. Conversely, South America exhibits a significant positive effect (1.5907, $p < 0.05$), suggesting that a 1% increase in adverse human rights shocks is associated with a 1.59% increase in renewable energy consumption. In Africa, Asia, and North America, the effects of negative shocks are statistically insignificant.

The error correction term (ECT_{-1}) is negative across all regions, as expected, but only statistically significant in Asia, Europe, North America, and South America, indicating the presence of a valid long-run equilibrium relationship and adjustment toward equilibrium in these regions. The speed of adjustment is highest in South America (-0.2564), followed by Asia (-0.1720), Europe (-0.0727), and North America (-0.0127), while Africa shows an insignificant adjustment coefficient, suggesting weak or absent short-run convergence to the long-run equilibrium. Overall, the findings highlight that short-run dynamics are asymmetric and region-specific, with transitional frictions and institutional differences shaping the immediate response of renewable energy consumption to changes in human rights.

3.5. Dumitrescu-Hurlin Panel Causality Estimation

The results of the Dumitrescu–Hurlin panel causality test, as reported in Table 8, reveal important directional relationships among the variables. There is strong evidence of bidirectional causality between human rights (HRI) and renewable energy consumption (RE), as both null hypotheses (HRI does not cause RE and RE does not cause HRI) are rejected at the 1% significance level. This indicates a mutually reinforcing relationship, where improvements in human rights promote renewable energy adoption, while increased renewable energy consumption may also contribute to better institutional and civil liberty outcomes.

Regarding the control variables, the results show unidirectional causality from GDP per capita (GDPC) to RE, as the null hypothesis that GDPC does not cause RE is rejected at the 5% level, while the reverse causality from RE to GDPC is not supported. Similarly, population growth (POPG) exhibits unidirectional causality toward RE, with strong significance at the 1% level, whereas RE does not Granger-cause POPG. These findings suggest that economic and demographic factors act as drivers of renewable energy consumption rather than being influenced by it.

In contrast, the relationship between urbanization (URB) and renewable energy consumption is characterized by bidirectional causality, as both null hypotheses are rejected at the 1% level. This implies a feedback mechanism where increasing urbanization influences renewable energy demand and development, while the expansion of renewable energy infrastructure may also

Table 8. Results of Dumitrescu-Hurlin panel causality test.

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
HRI does not homogeneously cause REC	5.9515***	3.6502***	0.0003
REC does not homogeneously cause HRI	7.3664***	5.0101***	0.0000
GDPC does not homogeneously cause REC	4.6464**	2.3957**	0.0166
REC does not homogeneously cause GDPC	2.4153	0.2513	0.8015
POPG does not homogeneously cause REC	6.4144***	4.0951***	0.0000
REC does not homogeneously cause POPG	3.2249	1.0295	0.3033
URB does not homogeneously cause REC	7.4466***	5.0872***	0.0000
REC does not homogeneously cause URB	8.6503***	6.2442***	0.0000

Note: *** and ** denote significance levels at 1% and 5%, respectively.

shape urban development patterns. Overall, the causality results highlight a complex interaction structure, with human rights and urbanization exhibiting mutual feedback with renewable energy, while economic and demographic factors primarily act as unidirectional determinants.

3.6. Discussion

The findings on human rights reveal a clear and consistent pattern in the long run. Improvements in human rights are associated with higher renewable energy consumption, while deteriorations lead to reductions in renewable energy use. This indicates that the relationship is not only significant but also asymmetric, as positive and negative changes reinforce outcomes in opposite directions. This result aligns with the broader literature suggesting that stronger human-rights-related institutions foster renewable energy development, with Chen et al. [45], Dong et al. [46], and Uzar [47] documenting positive contributions of freedom of expression, democratic institutions, and institutional quality to renewable energy adoption and consumption, respectively.

In practical terms, stronger civil liberties appear to create an enabling environment for renewable energy through better governance, higher transparency, and increased public participation, all of which support more stable and credible energy policies [48]. From an environmental justice perspective, stronger human rights protections also promote procedural justice by enabling communities to participate more effectively in energy-related decision-making processes, while greater transparency and accountability help ensure that the benefits and costs of renewable energy development are distributed more equitably across society [27]. Conversely, weakening human rights undermines these conditions, reducing the capacity and willingness to invest in and expand renewable energy systems [25]. This long-run consistency suggests that institutional quality, as reflected in human rights, is a foundational driver of sustainable energy transitions. Moreover, given that renewable energy consumption reduces dependence on fossil fuels and lowers greenhouse gas emissions, these findings imply that improvements in human rights may indirectly contribute to environmental sustainability and climate change mitigation through the expansion of renewable energy use.

However, this relationship becomes more complex when examined in the short run across regions. In Africa, Asia, and South America, positive shocks in human rights are associated with a temporary decline in renewable energy consumption. This counterintuitive result likely reflects transitional frictions, where expanding civil liberties introduces greater scrutiny, regulatory adjustments, and stakeholder engagement, which can delay or complicate project implementation in the short term [49, 50]. In contrast, the short-run effects in North America and Europe are weaker and statistically insignificant, suggesting that more mature institutional systems are better able to absorb such changes without disrupting energy development [51]. These differences highlight that the immediate impact of institutional improvements depends not only on governance capacity but also on regional energy structures, including the maturity of renewable energy markets, infrastructure readiness, and the degree of dependence on conventional energy sources.

The effects of negative shocks to human rights further reinforce the importance of regional context. In Europe, negative shocks to human rights lead to a reduction in renewable energy consumption even in the short run, consistent with the long-term pattern and reflecting the central role of institutional stability in advanced economies [52]. In contrast, South America shows a short-run increase in renewable energy following deteriorations in human rights. This may suggest that more centralized decision-making or reduced public opposition can accelerate implementation temporarily, although such gains may not be sustainable over time [53]. In Africa, Asia, and North America, the lack of significant effects indicates that short-run responses to institutional deterioration are less predictable and may depend on country-specific conditions [49, 54]. Overall,

these findings confirm that short-run dynamics are highly heterogeneous and shaped by transitional processes and institutional differences.

Turning to the control variables, economic capacity emerges as a key determinant of renewable energy consumption. Higher income levels are consistently associated with greater renewable energy use in the long run, reflecting the financial and technological resources required to support the energy transition [55, 56]. In contrast, population growth and urbanization do not exhibit robust long-term effects, suggesting that increases in scale or urban concentration alone do not guarantee a shift toward renewable energy [57, 58]. This reinforces the idea that structural and institutional factors are more critical than purely demographic ones. While urbanization shows a dynamic interaction with renewable energy in the broader system, its long-run direct effect appears limited in this specification.

Finally, the causality analysis provides additional insight into the dynamic relationship between human rights and renewable energy. The presence of bidirectional causality indicates a mutually reinforcing relationship. Improvements in human rights support renewable energy expansion, while the growth of renewable energy may also contribute to better institutional outcomes, consistent with previous studies, such as Khribich et al. [59] and Wang et al. [60], potentially through increased transparency, international cooperation, and societal engagement. In contrast, economic growth and population changes primarily act as drivers of renewable energy rather than being influenced by it, consistent with similar evidence reported by Omri et al. [61] and Vo & Vo [62]. Urbanization stands out with a bidirectional relationship, highlighting the interconnected nature of energy systems and spatial development [63]. Taken together, the results suggest that the transition to renewable energy is not solely driven by economic factors, but is deeply embedded in institutional quality and governance dynamics that evolve over time and across regions.

3.7. Policy Recommendations

At the global level, the findings suggest that human rights should be integrated directly into renewable energy policy design rather than treated as a separate objective. Policymakers need to strengthen transparency in project approval, ensure open access to information, and formalize stakeholder participation to build trust and reduce long-run policy uncertainty. This can be implemented through mandatory disclosure standards, independent regulatory oversight, and structured public consultation mechanisms for renewable projects. At the same time, to mitigate short-run delays associated with increased scrutiny, governments should streamline administrative procedures and set clear timelines for approvals. International institutions can reinforce this by linking climate finance to governance improvements and supporting institutional capacity building, while continued economic development remains essential to finance large-scale renewable investments.

At the regional level, policies should reflect differences in institutional capacity and adjustment dynamics. In Africa, Asia, and South America, where short-run disruptions follow improvements in human rights, governments should better coordinate governance reforms with energy planning, for example through integrated agencies and fast-track mechanisms for projects that meet social and environmental standards. In Europe, maintaining strong institutional quality is key to sustaining renewable energy growth, requiring consistent enforcement and regulatory stability. In South America, particular attention is needed to avoid short-term gains driven by weakened rights, by strengthening safeguards and ensuring inclusive decision-making. In North America, where effects are more stable, policymakers should focus on policy consistency and strengthening the link between urban development and renewable infrastructure. Overall, region-specific strategies should aim to reduce transitional frictions while preserving the long-run benefits of strong human rights frameworks.

3.8. Directions for Future Research

Despite providing valuable insights, this study has several limitations. First, the analysis is conducted using regional-level data to construct a global panel, which may mask heterogeneity across individual countries. Future studies could employ country-level data, where available, to provide more granular and policy-relevant evidence. Second, although the study period is sufficiently long to support dynamic estimation and capture long-run relationships, future research may benefit from extending the sample period as longer time-series data become available. Third, while this study adopts the advanced asymmetric (nonlinear) ARDL approach to account for potential nonlinear effects, future studies could further explore distributional heterogeneity by applying quantile nonlinear ARDL techniques. Such extensions would contribute to a more comprehensive understanding of the relationship under investigation and enhance the robustness of the empirical findings.

4. Conclusions

Human rights are a fundamental determinant of renewable energy development, as stronger civil liberties

create conditions that support transparency, accountability, and long-term policy stability. This study finds that the relationship is asymmetric, where improvements in human rights promote renewable energy consumption, while deteriorations hinder it in the long run. At the same time, short-run effects are more complex and vary across regions, reflecting transitional frictions, institutional adjustments, and differences in governance capacity. While economic growth consistently supports renewable energy expansion, demographic factors such as population growth and urbanization do not exhibit robust long-term influence. The evidence of bidirectional causality further indicates a mutually reinforcing relationship, where human rights and renewable energy evolve together over time, underscoring that the energy transition is deeply embedded in institutional quality and governance dynamics.

Beyond their implications for energy policy, these findings also have broader environmental significance. Given the role of renewable energy in reducing greenhouse gas emissions and dependence on fossil fuels, the positive long-run effect of human rights on renewable energy consumption suggests that stronger human rights protections may indirectly contribute to climate change mitigation and environmental sustainability. Consequently, strengthening civil liberties and institutional quality may support not only renewable energy expansion but also progress toward sustainable development goals related to clean energy, climate action, and sustainable governance.

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References

1. Brent, A. C. (2021). Renewable Energy for Sustainable Development, *Sustainability*, Vol. 13, No. 12, 6920. doi:10.3390/su13126920.
2. Saboor, A., Manzoor, Z., and Rehman, A. (2025). Renewable Energy Consumption and Its Role in Driving Green Economic Growth in BRICS Nations, *Pakistan Journal of Humanities and Social Sciences*, Vol. 13, No. 1, 366–377. doi:10.52131/pjhss.2025.v13i1.2718.
3. Almulhim, A. A., Inuwa, N., Chaouachi, M., and Samour, A. (2025). Testing the Impact of Renewable Energy and Institutional Quality on Consumption-Based CO2 Emissions: Fresh Insights from MMQR Approach, *Sustainability*, Vol. 17, No. 2, 704. doi:10.3390/su17020704.
4. Lin, T.-Y., Chiu, Y., Chen, C.-H., and Ji, L. (2025). Renewable Energy Consumption Efficiency, Greenhouse Gas Emission Efficiency, and Climate Change in Europe, *Geoenergy Science and Engineering*, Vol. 247, 213665. doi:10.1016/j.geoen.2025.213665.
5. Holechek, J. L., Geli, H. M. E., Sawalhah, M. N., and Valdez, R. (2022). A Global Assessment: Can Renewable Energy Replace Fossil Fuels by 2050?, *Sustainability (Switzerland)*, Vol. 14, No. 8, 1–22. doi:10.3390/su14084792.
6. Andreassen, B. A. (2021). Human Rights and Development: Civic Engagement, Approaches and Outcomes, *Research Handbook on Democracy and Development*, Edward Elgar Publishing. doi:10.4337/9781788112659.00026.
7. Hu, H., Chen, D., Chang, C., and Chu, Y. (2021). The Political Economy of Environmental Consequences: A Review of the Empirical Literature, *Journal of Economic Surveys*, Vol. 35, No. 1, 250–306. doi:10.1111/joes.12396.
8. Our World In Data. (2023). Energy.
9. Varieties of Democracy Institute. (2025). The V-Dem Dataset.
10. Jadhav, S., and Yannawar, V. B. (2022). Environmental Degradation and Violations of Human Rights, *International Journal for Research in Applied Science and Engineering Technology*, Vol. 10, No. 12, 2223–2227. doi:10.22214/ijraset.2022.48447.
11. Koçak, E., and Kızılkaya, O. (2020). Towards Sustainable Development in China: Do Political Rights and Civil Liberties Matter for Environmental Quality?, *Environmental Science and Pollution Research*, Vol. 27, No. 28, 35488–35500. doi:10.1007/s11356-020-09813-x.
12. von Stein, J. (2022). Democracy, Autocracy, and Everything in Between: How Domestic Institutions Affect Environmental Protection, *British Journal of Political Science*, Vol. 52, No. 1, 339–357. doi:10.1017/S000712342000054X.
13. Suniehin, S. (2025). Human Rights in the Context of Global Crises: Development Prospects, *Yearly Journal of Scientific Articles "Pravova Derzhava"*, No. 36, 38–48. doi:10.33663/0869-2491-2025-36-38-48.
14. Heiskanen, E., and Matschoss, K. (2017). Understanding the Uneven Diffusion of Building-Scale Renewable Energy Systems: A Review of Household, Local and Country Level Factors in Diverse European Countries, *Renewable and Sustainable Energy Reviews*, Vol. 75, 580–591. doi:10.1016/j.rser.2016.11.027.
15. Golubchikov, O., and O'Sullivan, K. (2020). Energy Periphery: Uneven Development and the Precarious Geographies of Low-Carbon Transition, *Energy and Buildings*, Vol. 211, 109818. doi:10.1016/j.enbuild.2020.109818.
16. Rehman, A., Batool, Z., Ain, Q. U., and Ma, H. (2025). The Renewable Energy Challenge in Developing Economies: An Investigation of Environmental Taxation, Financial Development, and Political Stability, *Natural Resources Forum*, Vol. 49, No. 1, 699–724. doi:10.1111/1477-8947.12418.
17. Qian, X., and Ghaziani, M. A. (2024). The Relationship between Transparency Obligations and Foreign Investment in Renewable

Energies: Realising the Potential Role of IIAs, *Energies*, Vol. 17, No. 11, 2721. doi:10.3390/en17112721.

18. Pellow, D. N. (2025). *What Is Critical Environmental Justice?*, John Wiley & Sons.
19. Sovacool, B. K., Martiskainen, M., Hook, A., and Baker, L. (2019). Decarbonization and Its Discontents: A Critical Energy Justice Perspective on Four Low-Carbon Transitions, *Climatic Change*, Vol. 155, No. 4, 581–619. doi:10.1007/s10584-019-02521-7.
20. Geels, F. W., Sovacool, B. K., Schwanen, T., and Sorrell, S. (2017). The Socio-Technical Dynamics of Low-Carbon Transitions, *Joule*, Vol. 1, No. 3, 463–479. doi:10.1016/j.joule.2017.09.018.
21. Mehmood, U., Agyekum, E. B., Tariq, S., Haq, Z. U., Uhunamure, S. E., Edokpayi, J. N., and Azhar, A. (2022). Socio-Economic Drivers of Renewable Energy: Empirical Evidence from BRICS, *International Journal of Environmental Research and Public Health*, Vol. 19, No. 8, 1–10. doi:10.3390/ijerph19084614.
22. Bradley, P. (2021). An Institutional Economics Framework to Explore Sustainable Production and Consumption, *Sustainable Production and Consumption*, Vol. 27, 1317–1339. doi:10.1016/j.spc.2021.02.035.
23. Halldén, F., Hultberg, A., Ahmed, A., Uddin, G. S., Yahya, M., and Troster, V. (2025). The Role of Institutional Quality on Public Renewable Energy Investments, *Renewable and Sustainable Energy Reviews*, Vol. 215, 115585. doi:10.1016/j.rser.2025.115585.
24. Weber, H., and Weber, M. (2020). When Means of Implementation Meet Ecological Modernization Theory: A Critical Frame for Thinking about the Sustainable Development Goals Initiative, *World Development*, Vol. 136, 105129. doi:10.1016/j.worlddev.2020.105129.
25. Misra, S., and Agbaitoro, G. (2025). Mapping Human Rights Violations Connected to Renewable Energy Development in India: A Case Study of the ' Oran Land' at Thar Desert and Energy Transition, *Business and Human Rights Journal*, Vol. 10, No. 1, 249–259. doi:10.1017/bhj.2024.29.
26. Schwab De La O, L., and Jones, P. (2024). Contested Visions of Sustainable Development in Conflicts over Renewable Energy, Land, and Human Rights: A Case Study of Unión Hidalgo, Mexico, *Netherlands Quarterly of Human Rights*, Vol. 42, No. 1, 35–70. doi:10.1177/09240519231223655.
27. Levenda, A. M., Behrsin, I., and Disano, F. (2021). Renewable Energy for Whom? A Global Systematic Review of the Environmental Justice Implications of Renewable Energy Technologies, *Energy Research & Social Science*, Vol. 71, 101837. doi:10.1016/j.erss.2020.101837.
28. Basil, C. V., and Heffron, R. (2025). A Systematic Review of the Intersection between Energy Justice and Human Rights, *Renewable and Sustainable Energy Reviews*, Vol. 221, 115892. doi:10.1016/j.rser.2025.115892.
29. Maniruzzaman, A. F. M., and Al-Saleem, K. (2025). Renewable Energy and Energy Justice in the Middle East: International Human Rights, Environmental and Climate Change Law and Policy Perspectives, *The Journal of World Energy Law & Business*, Vol. 18, No. 1. doi:10.1093/jwelb/jwae021.
30. O'Neill, L., Thorburn, K., Riley, B., Maynard, G., Shirlow, E., and Hunt, J. (2021). Renewable Energy Development on the Indigenous Estate: Free, Prior and Informed Consent and Best Practice in Agreement-Making in Australia, *Energy Research & Social Science*, Vol. 81, 102252. doi:10.1016/j.erss.2021.102252.
31. Villavicencio Calzadilla, P., and Mauger, R. (2018). The UN's New Sustainable Development Agenda and Renewable Energy: The Challenge to Reach SDG7 While Achieving Energy Justice, *Journal of Energy & Natural Resources Law*, Vol. 36, No. 2, 233–254. doi:10.1080/02646811.2017.1377951.
32. Buhmann, K., Bowles, P., Cambou, D., Skjervedal, A.-S. H., and Stoddart, M. (2021). Toward Socially Sustainable Renewable Energy Projects through Involvement of Local Communities: Normative Aspects and Practices on the Ground, *Renewable Economies in the Arctic*, Routledge, 165–183.
33. Fagan, P. (2023). The Social Justice and Human Rights Benefits of Domestic Renewable Energy, *Advances in Environmental and Engineering Research*, Vol. 04, No. 01, 1–29. doi:10.21926/aeer.2301021.
34. Finley-Brook, M., and Thomas, C. (2011). Renewable Energy and Human Rights Violations: Illustrative Cases from Indigenous Territories in Panama, *Annals of the Association of American Geographers*, Vol. 101, No. 4, 863–872. doi:10.1080/00045608.2011.568873.
35. Vermeylen, S. (2010). Resource Rights and the Evolution of Renewable Energy Technologies, *Renewable Energy*, Vol. 35, No. 11, 2399–2405. doi:10.1016/j.renene.2010.03.017.
36. World Bank. (2023). World Development Indicators.
37. Vo, D. H., Vo, A. T., and Ho, C. M. (2024). Urbanization and Renewable Energy Consumption in the Emerging ASEAN Markets: A Comparison between Short and Long-Run Effects, *Heliyon*, Vol. 10, No. 9, e30243. doi:10.1016/j.heliyon.2024.e30243.
38. Su, M., Wang, Q., Li, R., and Wang, L. (2022). Per Capita Renewable Energy Consumption in 116 Countries: The Effects of Urbanization, Industrialization, GDP, Aging, and Trade Openness, *Energy*, Vol. 254, 124289. doi:10.1016/j.energy.2022.124289.
39. Thi Mai, A. N., Xuan, V. N., Mai, H. Le, Xuan, H. P., and Thi Phuong, T. N. (2024). Population, Carbon Dioxide Emissions and Renewable Energy Consumption Nexus: New Insights from Vietnam, *Energy Exploration & Exploitation*, Vol. 42, No. 5, 1763–1798. doi:10.1177/01445987241252453.
40. Şanlı, D., Muratoğlu, Y., Songur, M., and Uğurlu, E. (2023). The Asymmetric Effect of Renewable and Non-Renewable Energy on Carbon Emissions in OECD: New Evidence from Non-Linear Panel ARDL Model, *Frontiers in Environmental Science*, Vol. 11. doi:10.3389/fenvs.2023.1228296.
41. Salisu, A. A., and Isah, K. O. (2017). Revisiting the Oil Price and Stock Market Nexus: A Nonlinear Panel ARDL Approach, *Economic Modelling*, Vol. 66, 258–271. doi:10.1016/j.econmod.2017.07.010.
42. Abdul-Mumuni, A., Amoh, J. K., and Mensah, B. D. (2022). Does Foreign Direct Investment Asymmetrically Influence Carbon Emissions in Sub-Saharan Africa? Evidence from Nonlinear Panel ARDL Approach, *Environmental Science and Pollution Research*, Vol. 30, No. 5, 11861–11872. doi:10.1007/s11356-022-22909-w.
43. Ahmed, N., Sheikh, A. A., Hamid, Z., Senkus, P., Borda, R. C., Wysokińska-Senkus, A., and Glabiszewski, W. (2022). Exploring the Causal Relationship among Green Taxes, Energy Intensity, and Energy Consumption in Nordic Countries: Dumitrescu and Hurlin Causality Approach, *Energies*, Vol. 15, No. 14, 5199. doi:10.3390/en15145199.
44. Idroes, G. M., Hafizah, I., Hartono, D., Dharma, D. B., Hardi, I., Noviandy, T. R., and Idroes, R. (2025). Investigating Hydropower Energy Consumption's Effect on Southeast Asia's Path to Achieving Environmental Sustainability and Carbon Neutrality, *Carbon Research*, Vol. 4, No. 1, 57. doi:10.1007/s44246-025-00218-4.
45. Chen, C., Pinar, M., and Stengos, T. (2021). Determinants of Renewable Energy Consumption: Importance of Democratic Institutions, *Renewable Energy*, Vol. 179, 75–83. doi:10.1016/j.renene.2021.07.030.
46. Dong, Z., Tan, C., Zhang, W., Zhang, L., and Zhang, L. (2024). Are Natural Resources a Blessing or a Curse for Renewable Energy? Uncovering the Role of Regulatory Quality and Government Effectiveness in Mitigating the Curse, *Resources Policy*, Vol. 98, 105346. doi:10.1016/j.resourpol.2024.105346.

47. Uzar, U. (2024). Free Speech, Green Power: The Impact of Freedom of Expression on Renewable Energy, *Sustainability*, Vol. 16, No. 19, 8723. doi:10.3390/su16198723.

48. Agrawal, H., El-Katiri, L., Muiruri, K., and Szoke-Burke, S. (2023). Enabling a Just Transition: Protecting Human Rights in Renewable Energy Projects: A Briefing For Policymakers, *SSRN Electronic Journal*. doi:10.2139/ssrn.4438576.

49. Olawuyi, D. S. (2018). Energy (and Human Rights) for All: Addressing Human Rights Risks in Energy Access Projects, *Energy Justice*, Edward Elgar Publishing. doi:10.4337/9781786431769.00011.

50. Wewerinke-Singh, M. (2022). A Human Rights Approach to Energy: Realizing the Rights of Billions within Ecological Limits, *Review of European, Comparative & International Environmental Law*, Vol. 31, No. 1, 16–26. doi:10.1111/reel.12412.

51. Hesselman, M. (2023). Governing Energy Poverty in the European Union: A Regional and International Human Rights Law Perspective, *European Journal of Comparative Law and Governance*, Vol. 10, Nos. 3–4, 438–517.

52. Krupnik, S., Wagner, A., Vincent, O., Rudek, T. J., Wade, R., Mišík, M., Akerboom, S., Foulds, C., Smith Stegen, K., Adem, Ç., Batel, S., Rabitz, F., Certomà, C., Chodkowska-Miszczuk, J., Denac, M., Dokupilová, D., Leiren, M. D., Ignatieva, M. F., Gabaldón-Estevan, D., et al. (2022). Beyond Technology: A Research Agenda for Social Sciences and Humanities Research on Renewable Energy in Europe, *Energy Research & Social Science*, Vol. 89, 102536. doi:10.1016/j.erss.2022.102536.

53. Tsakalogianni, I. (2025). Balancing Green Energy Development And Indigenous Rights In Latin America: An Examination Of Constitutional And Jurisprudential Tensions, *A Right to Energy: A Multilevel Constitutional Perspective*, 18.

54. Strand, H. (2018). Breaking Barriers to Renewable Energy Production in the North American Arctic, *Alaska L. Rev.*, Vol. 35, 67.

55. Hardi, I., Afjal, M., Aburizaiza, S. O., Saeed, M. A., Idroes, G. M., and Noviandy, T. R. (2026). Redefining Economic Trajectories: Examining the U-Shaped Dynamics between Renewable Energy and Economic Leading Indicators, *Humanities and Social Sciences Communications*, Vol. 13, No. 1, 137. doi:10.1057/s41599-025-06442-y.

56. Ahmed, E. M., and Elfaki, K. E. (2024). Enhancing Environmental Quality and Economic Growth through Potential Effects of Energy Efficiency and Renewable Energy in Asian Economies, *Scientific Reports*, Vol. 14, No. 1, 22914. doi:10.1038/s41598-024-73679-z.

57. Salim, R. A., and Shafiei, S. (2014). Urbanization and Renewable and Non-Renewable Energy Consumption in OECD Countries: An Empirical Analysis, *Economic Modelling*, Vol. 38, 581–591. doi:10.1016/j.econmod.2014.02.008.

58. Oyedele, O. (2025). Short- And Long-Run Effects of Renewable Energy Transition on Population Growth and Environmental Sustainability: Evidence from Dynamic Panel GMM Models, *Prizren Social Science Journal*, Vol. 9, No. 3. doi:10.32936/pssj.v9i3.754.

59. Khribich, A., Kacem, R. H., and Dakhlaoui, A. (2021). Causality Nexus of Renewable Energy Consumption and Social Development: Evidence from High-Income Countries, *Renewable Energy*, Vol. 169, 14–22. doi:10.1016/j.renene.2021.01.005.

60. Wang, H., Zhang, T., Zhang, Z., and Feng, Y. (2025). What Is the Global Causality between Geopolitical Risks, Government Governance, and Energy Transition? Empirical Evidence from Cross-Country Data, *Carbon Balance and Management*, Vol. 20, No. 1, 31. doi:10.1186/s13021-025-00322-3.

61. Omri, A., Ben Mabrouk, N., and Sassi-Tmar, A. (2015). Modeling the Causal Linkages between Nuclear Energy, Renewable Energy and Economic Growth in Developed and Developing Countries, *Renewable and Sustainable Energy Reviews*, Vol. 42, 1012–1022. doi:10.1016/j.rser.2014.10.046.

62. Vo, D. H., and Vo, A. T. (2021). Renewable Energy and Population Growth for Sustainable Development in the Southeast Asian Countries, *Energy, Sustainability and Society*, Vol. 11, No. 1, 30. doi:10.1186/s13705-021-00304-6.

63. Nguea, S. M. (2024). Combining the Role of Urbanization and Renewable Energy in Sustainable Development: Testing the EKC Hypothesis for Africa, *Environmental Science and Pollution Research*, Vol. 31, No. 20, 29595–29609. doi:10.1007/s11356-024-33175-3.