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# Environmental Sustainability, Institutions and Inclusive Growth in MINT Countries: Pathways to Achieving SDG 13- Climate Action

# Zrównoważoność środowiskowa, instytucje i wzrost sprzyjający włączeniu społecznemu w krajach MINT: ścieżki do osiągnięcia SDG 13 – Działania na rzecz klimatu

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## Abstract

Devising pathways to achieving SDG-13 in MINT becomes crucial as the economies are positioned to become a powerful force in trade and growth due to their dominant geographic and demographic structures. While the economies are focused on driving inclusive growth, there remains a concern about how quality institutions could shape their achievement of environmental sustainability. Based on the sustainable development framework, data were obtained on key variables from 2000 through 2023. Environmental sustainability, inclusive growth, and institutions were proxied with the SDG-13 performance index, human capital index, and institutional quality index, respectively. The institutions were further decoupled into political, economic, and governance. Using the PSCE estimator to analyze the dataset, the findings show that (i) Inclusive growth frustrates environmental sustainability. (iii) All the institutional dimensions dampen the influence of inclusive growth on environmental sustainability. Amongst the recommendations is that the regulators pay particular attention to strengthening institutional dynamics in MINT countries by ensuring a system of transparency, accountability, and political stability to enhance public trust in the inclusive growth policies. Also, policy actors should ensure that inclusive growth policies are eco-friendly by initiating policies and programs that could raise citizens' awareness on the adoption of sustainable practices. The findings of this study are highly relevant to broader sustainable development goals. Strengthening political, economic, and governance institutions (SDG 16) promotes transparency and accountability in implementing climate-related projects (SDG 13). Similarly, integrating renewable energy investments (SDG 7) and fostering inclusive employment opportunities in green sectors (SDG 8) can reinforce both environmental and social dimensions of sustainability. Institutional efficiency also underpins innovation-driven industrialization (SDG 9), supporting a circular and low-carbon economy in MINT countries.

**Key words:** environmental sustainability, inclusive growth, institutions, climate action, SDG-13

## Streszczenie

Opracowanie ścieżek do osiągnięcia SDG-13 w MINT staje się kluczowe, ponieważ gospodarki są pozycjonowane jako silna siła w ekonomii ze względu na dominującą strukturę geograficzną i demograficzną. Podczas gdy gospodarki koncentrują się na napędzaniu wzrostu sprzyjającego włączeniu społecznemu, nadal istnieje obawa o to, w jaki sposób instytucje mogłyby wpłynąć na osiągnięcie przez nie zrównoważenia środowiskowego. W oparciu o ramy zrównoważonego rozwoju, dane dotyczące kluczowych zmiennych uzyskano z lat 2000–2023. Zrównoważenie środowiskowe, wzrost sprzyjający włączeniu społecznemu i instytucje zostały zrównane odpowiednio z indeksem wyników SDG-13, indeksem kapitału ludzkiego i indeksem jakości instytucjonalnej. Instytucje zostały dodatkowo oddzielone od czynników politycznych, gospodarczych i zarządzania. Analiza zbioru danych przy użyciu estymatora PSCE wykazała, że (i) wzrost sprzyjający włączeniu społecznemu niweczy zrównoważenie środowiskowe. (ii) Wszystkie wymiary instytucjonalne osłabiają wpływ wzrostu sprzyjającego włączeniu społecznemu na zrównoważenie środowiskowe. Wśród rekomendacji wskazujemy na to, żeby organy regulacyjne zwróciły szczególną uwagę na wzmocnienie dynamiki instytucjonalnej w krajach objętych programem MINT poprzez zapewnienie systemu przejrzystości, rozliczalności i stabilności politycznej w celu zwiększenia zaufania społecznego do polityki wzrostu sprzyjającego włączeniu społecznemu. Ponadto podmioty polityczne powinny zapewnić, aby polityka wzrostu sprzyjającego włączeniu społecznemu była przyjazna dla środowiska, inicjując strategie i programy, które mogłyby podnieść świadomość obywateli w zakresie wdrażania zrównoważonych praktyk. Wyniki niniejszego badania są niezwykle istotne dla szerszych Celów zrównoważonego rozwoju (SDGs). Wzmocnienie instytucji politycznych, gospodarczych i zarządczych (cel 16) promuje przejrzystość i rozliczalność we wdrażaniu projektów związanych z klimatem (cel 13). Podobnie, integracja inwestycji w energię odnawialną (cel 7) i wspieranie możliwości zatrudnienia sprzyjających włączeniu społecznemu w zielonych sektorach (cel 8) mogą wzmocnić zarówno środowiskowy, jak i społeczny wymiar zrównoważonego rozwoju. Efektywność instytucjonalna stanowi również podstawę industrializacji opartej na innowacjach (cel 9), wspierając gospodarkę o obiegu zamkniętym i niskoemisyjną w krajach MINT.


**Słowa kluczowe:** zrównoważoność środowiskowa, wzrost inkluzywny, instytucje, działania na rzecz klimatu, SDG-13

## 1. Introduction

MINT countries are dynamic and emerging groups of economies with unique characteristics and growth potentials. The acronym coined by Goldman Sachs comprises of four emerging countries, namely Mexico, Indonesia, Nigeria, and Turkey (MINT). The countries leveraged their distinct demographic, economic, and geographical strengths to exert significant influence on the world economies (Suleman et al. 2025). In terms of world economic ranking, MINT countries were rated 15th, 16th, 31st, and 18th, respectively (Odugbesan et al 2021). More so, these countries were geographically positioned for growth due to their proximity to developed countries. Illustratively, Mexico capitalized on its proximity to America; Indonesia to China, Turkey to the EU and Asia, while Nigeria is the economic hub of Africa.

Again, two of the countries, Nigeria and Mexico, are part of the top ten countries in international remittance across the globe. Another unique feature of the MINT countries is their surge in youthful population. The demographic potential offers them a unique growth structure that positions them as the largest economies in the world (Bekun et al, 2024). The total population of the MINT countries comprises about 633 million in 2014 and grew significantly to 741.15 million in 2025 and 748.19 million by 2025, accounting for about one-tenth of the world population, with a youth base of between 18 and 30 years. The burgeoning population dynamics serve as a crucial potential for becoming a powerful force in different continents with no formal cooperation like the BRICS (Osinubi et al. 2025).

The implication of their potential characteristics on inclusive growth and sustainability poses significant challenges. Climate change crisis may hypothetically threaten the actualization of their economic sustainability (Odugbesan and Rjoub, 2020; Adebayo et al. 2022). These countries experience ecological deficit due to the declining bio-capacity strains associated with unsustainable production and consumption alongside their escalating demands for energy and exploration of other resources (Adebayo et al, 2023). More so, as the country's population progresses, the possibilities of exerting pressure on traditional energy sources become essential to support mass production and consumption activities. Conventional energy sources have helped these countries keep up with global economic activities, but with great consequences on environmental quality. Accumulated methane, particulate matter, carbon dioxide ($CO_2$), and other Greenhouse gases (GHG) have been linked to the economic progress of the countries (Ameyaw et al. 2019; Gokmenoglu and Sadeghieh, 2019; Bekun et al. 2024). This growing concern calls for urgent action in advancing sustainable pathways for climate action.

Climate change remains a critical disturbance to global sustainability, as it forestalls sustainability and inclusivity in societies with long-term impacts on food security, healthy living, poverty, and escalated income inequality. Through its uneven impact, the climatic crisis and environmental degradation aggravate extreme poverty and simultaneously widen gaps in income inequality. Being recognized as a global phenomenon, countries agree on making efforts to keep global warming at a maximum of 1.5 degrees Celsius. Countries are transitioning from the use of traditional fossil fuels to green and clean energy sources. The eco-friendly sources such as wind, solar, geothermal, bioenergy, or hydropower may present themselves as efficient measures to minimize environmental harm (Liu et al. 2023). MINT countries are also not left behind in tackling the climate crisis to promote inclusive growth. In recent times, the MINT countries have also developed strategies to curb the global climatic crisis and achieve the Paris agreement and the global benchmark of 1.5 degrees Celsius. For instance, Mexico instituted policies to drive the adoption of alternative renewable energy sources from solar; Indonesia tapped the significant potential of hydropower and geothermal initiatives despite its heavy reliance on coal. Likewise, Turkey and Nigeria are exploring the possibilities of wind and solar energy installations.

Over the last few decades, considerable empirical studies have examined the relationship between economic growth and environmental sustainability, albeit with inconclusive outcomes. More importantly, the link between environmental issues and inclusive growth is lacking substantial attention. Aside, the growth-environment nexus, the transmission mechanism and role of quality institutions have not been paid much attention. Institutional quality is required in developing policies and programs that would improve the use of alternative energy sources, as well as striking a balance between human economic activities (Adebayo et al. 2022; Jaaffar et al., 2024).

Economic risk, which is the potential risk in exchange rate, inflation, and loanable interest, may discourage investors from investing in green technologies for promoting green energy usage. Likewise, political risk due to instability, corrupt practices may circumvent the equitable and efficient process. The associated risk may further hinder the implementation of ecological regulations, thus encouraging ecological deterioration in a highly unstable political environment (Adebayo et al, 2023). Otherwise, a decline in violence, insecurity, and instability would improve democratic legitimacy, freedom of speech, and the right to demand a clean environment. Lastly, a legal and sound institutional framework may promote environmental quality as countries with strong institutions are more likely to emit lesser GHG's while inefficient institutions aggravate ecological pollutions, thus deteriorating the strength of environmental regulations due to corrupt practices and bureaucratic controls.

Given these linkages between environmental sustainability, institutions, and inclusive growth, this study seeks to unravel the extent at which the quality of institutions in MINT countries influences the link between environmental sustainability and inclusive growth. MINT countries offer a suitable study site because they face the risks of increasing ecological footprint and ounce of energy inefficiency due to their level of productivity and consumption activities. The bloc consumed 9036 TW-hours of fossil fuel in 2014, with an expectation of doubling in 2050 (Adebayo et al, 2023). Also, its burgeoning population exerts enormous pressures on deforestation, overexploitation of wildlife and natural resources, natural catastrophes, and increasing sanitation and waste disposal challenges due to rapid urbanization. Moreover, the tripartite linkage between environment, institution, and inclusive growth has not been critically examined in MINT countries.

The findings of this study are highly relevant to broader sustainable development goals. Strengthening political, economic, and governance institutions (SDG 16) promotes transparency and accountability in implementing climate-related projects (SDG 13). Similarly, integrating renewable energy investments (SDG 7) and fostering inclusive employment opportunities in green sectors (SDG 8) can reinforce both environmental and social dimensions of sustainability. Institutional efficiency also underpins innovation-driven industrialization (SDG 9), supporting a circular and low-carbon economy in MINT countries.

This study contributes to existing literature in the following ways: first, existing studies on MINT concentrated on economic growth and environmental degradation with little or no insight into how the relationship influences inclusive growth. Second, the study decomposed institutional quality into economic, political, and legal risk to unbundle the individual effect of the categories that enhance or hamper the relationship between environmental sustainability and inclusive growth. Third, the study utilizes an appropriate estimator that accommodates the nature of the dataset, thereby producing estimates that are robust and efficient.

## 2. Literature review

### *2.1. Theoretical review*

Extant theories have been used to describe the implications of environmental degradation on economic growth and nations' overall well-being (Adebayo et al. 2023; Bekun et al. 2024; Du et al. 2022; Tenaw, 2021). Of these theories, the EKC model primarily explains various stages of growth and its consequences of human use of existing natural resources. The model, developed by Kuznets between 1950 and 1960, originally expresses an inverted U-Shape to illustrate the role of income inequality on economic development. The model has since been adopted and applies to the impact of environmental issues on the economic growth of nations (Jahanger et al. 2022). This model explains three key developmental phases in the utilization of the country's natural resources. First, the countries with low-income levels strive to scale up their productive activities, thus they use more resources, which generate more pollution, leading to increasing environmental degradation. This indicated the positive relationship between environmental degradation and economic growth (Adeleye et al, 2022).

Second, as the countries mature in development, they often shift from heavy industrial pollutants sectors such as manufacturing to less pollutant industries like the service sectors, finance, and information technology. At the last stage, the peak of the Kuznets curve, Countries reached their full maturity, which leads to the demand for a cleaner environment, instituting environmental laws, and carbon pricing. In effect, countries and firms embraced the adoption of efficient eco-friendly production processes to improve environmental quality and sustainability (Liu et al, 2023).

However, the theoretical application of this model presented inconclusive outcomes (Adebayo et al., 2023; Bekun et al., 2024; Jahanger, 2022; Tenaw, 2021; Shah et al., 2025).

Amin et al. (2025) and Luan et al. (2025) emphasized clean-energy–growth linkages, while Imandojemu et al. (2025) and Osabohien et al. (2025) showed renewable-technology effects on carbon neutrality and footprints. Guo et al. (2025) and Wei et al. (2025) highlighted governance and climate risks across regions. Zheng et al. (2023) and Wang et al. (2024) connected business density and emissions reduction. Sahan et al. (2025) and Abd Majid et al. (2025) advanced the institutional and behavioral dimensions of sustainability. In another study, Tenaw (2021) affirmed that the EKC model is validated for countries in the SSA. In the same instance, Shah et al (2025) specified that the model is apparently justified for most developing countries across the world.

Adebayo et al (2023) conclude that MINT countries justified the authenticity of the EKC model, while Bekun et al (2024) noted otherwise for the same set of countries. Jahanger (2022) validated the theoretical illustration of the model on the relationship between environmental degradation and growth in Africa, Latin America, but not in the sampled Asian Countries. The inconclusive evidence on the efficacy of the model may be due to the countries' level of development and the other mediating channels that might inform the institutional behaviour of the countries. Using the model, this present study expands the EKC model to incorporate the role of sound institutions on the link between environmental degradation and growth from an inclusive point of view.

### *2.2. Empirics on environmental sustainability and inclusive growth*

The empirical investigation on the effect of environmental degradation on economic growth is well established, albeit with inconclusive outcomes in the literature. The outcomes demonstrate that the validity of the EKC hypothesis is apparent in some countries and at specific periods of time. Radulescu et al. (2025) opined that carbon pricing reduced emissions in the 26 EU members between 2011 and 2021. The study further expressed a multifaceted linkage between environmental taxes, green patents, and carbon pricing, thus emphasizing sustainable practices for environmental sustainability. In a similar study, Destek and Sinha (2020) pointed out that renewable energy reduces ecological footprints, while income growth deteriorated the ecosystem of the 24 OECD countries between 1980 and 2014.

For BRICS nations, Zhang et al. (2024) examined the factors influencing their ecological landscape. Using the MMQR model to analyze the dataset between 1995 and 2021. The study posits that an increase in nuclear energy aggravates the emission of carbon monoxide. It was equally evidenced that economic growth aggravates $CO_2$ emissions, thus emphasizing the need for efficient natural resource utilization for environmental sustainability. Another study by Radulescu et al. (2024) opined that energy transition has a significant and direct causal effect on environmental sustainability. The study found that green technological innovation and efficient natural resource utilization are important for sustainable development in BRICS countries. Wang et al (2024) focused on the importance of energy transition on ecological governance and environmental sustainability. The study suggests that ecological governance and the transition to clean energy reduce carbon emissions in the ten most emitting countries.

A similar disposition was observed for developing countries across the globe. Shah et al. (2025) identified the challenges and best options for improving carbon footprints in 70 developing countries. The Q-GMM analysis reveals that income growth, the level of urbanization, and natural resource utilization aggravated environmental degradation. Moreover, renewable energy and the circular economy dampen the effects of urbanization on carbon footprints. Tenaw (2021) enquired into the link between environmental sustainability on economic development in 20 SSA countries. Using the Pool mean Group to analyze the dataset from 1990 to 2015, the study found a link between income and environmental degradation to the extent of natural resource endowment. The study further revealed a long-term detrimental consequence of energy consumption and trade openness on environmental sustainability.

Apparently, literature on the link between environmental sustainability and growth in MINT countries is scarce, with the few studies marred by an inconclusive position on the linkages. Du et al. (2022) examined the efficacy of the EKC theory on environmental sustainability in MINT countries. The study, using the MMQR, affirmed that different phases of the EKC are apparent amongst the MINT countries. It pointed out that environmental pollution exerts a growth in income but threatens environmental sustainability. Adebayo et al (2023) used the cross-sectional ARDL to inquire into the role of renewable energy consumption on environmental quality in MINT countries between 1990 and 2018.

The study affirmed that income growth increases ecological footprints. The study further opined that trade openness and urbanization are some of the factors that deteriorate environmental quality. Whereas, the use of renewable energy, economic and financial risk positively impacts the environment. On the other hand, Bekun et al (2024) could not ascertain the efficacy of the EKC model on MINT countries as the study affirmed that the countries are at an initial developmental stage, hence the augmented footprint exerts enormous pressure on natural resources. This, in turn, aggravates the role of energy consumption on environmental sustainability as measured by its load capacity factor. The study opined that MINT countries require intensive investments in green technologies for a cleaner ecosystem.

*2.3. Institutional quality and inclusive growth*

The institutional quality framework has been theoretically proposed to improve development and growth metrics across the globe. However, empirical findings suggest a non-uniform view. More importantly, the majority of the studies are centered on traditional growth indicators, with very scarce studies on institutions and inclusive growth. In an empirical examination by Onafoworan and Owoye (2024), it was affirmed that institutional quality indicators like rule of law, corruption control, government effectiveness, and regulatory quality promote economic prosperity and growth of countries in Latin America. Similarly, Solaymani and Motes (2024) found that increasing growth in New Zealand is stimulated by the quality of its governance and political institutions. In the sampled South Asian countries, Mehmood et al (2023) only corruption control, voice and accountability, and rule of law improved their growth metrics. In a different dimension, Ahmed et al (2022) found that institutional quality has an overall positive implication on green growth for the sampled South Asian countries.

Uddin and Rahman (2023) enquired into the implications of institutional quality on the economic growth of 79 developing countries. The study opined that corruption and political instability deter groups in the sampled countries, while government effectiveness and rule of law are growth enablers, thus increasing the growth of their national income. In contrast, Mahran (2023) affirmed that political governance improves economic growth in 116 countries compared to his study. Afolabi and Rabiu (2025) explored the impact of institutional quality on resilience in fragile and non-fragile countries in Sub-Saharan Africa. The study concluded that institutional quality improves economic resilience in fragile countries than the non-fragile countries.

In a two-decade analysis on the role of institutional quality on inclusive growth, Katuka et al (2024) confirmed that governance quality exhibits a significant and positive influence on Africa's inclusive growth. For regional blocs, Degbedi et al (2024) disclosed an uneven impact of institutional quality on green economic growth for countries in WAEMU. The study pointed out that institutional quality improves green economic growth in six of the eight countries, leaving a detrimental impact on the green growth metrics of Benin and Burkina Faso. Likewise, Tutuncu and Bayraktar (2024) opined that democracy is growth-enhancing for MINT countries, but corruption positively influences Indonesia and Mexico and negatively impacts economic growth in Nigeria and Turkey.

*2.4. Environmental sustainability, institutions and inclusive growth*

Extant empirical studies touched on the other factors that could influence growth and environmental degradation. Odugbesan et al. (2021) used the panel non-linear ARDL to examine the long-run relationship between financial development, remittances, and growth of MINT countries. The study affirmed that remittance inflow and financial development positively impact the economic growth of MINT countries in the long run. In a similar scenario, Tutunou (2024) opined that democracy is growth-enhancing for all the MINT countries. However, corruption positively influences economic growth in Mexico and Indonesia but dampens growth potentials for Nigeria and Turkey. There is therefore a need to strengthen institutions of affected countries through accountability, transparency, and government effectiveness. Similarly, Agbede et al (2023) found a long-run association between democracy, economic growth, and $CO_2$ emission. The quantile regression analysis suggests a significant but negative impact of democracy on income growth and carbon emission between 1971 and 2016.

With the sample size of 73 developing countries, Jahanger et al (2022) confirmed that natural resources consumption aggravates ecological footprint, while the embrace of technological innovations ameliorates the deteriorating impact. More so, globalization reduces ecological footprints in Africa and Latin America, but not with the Asians and the Caribbean. Lastly, financial development reduces ecological footprints only Asians while other continents experienced increasing footprints due to their increased engagement in financial development. Xu et al (2023) opined that institutional quality improves green finance and drives renewable energy adoption in South Asia. In Mahmood et al (2021)'s analysis, growth aggravates renewable and non-renewable energy consumption, but regulatory quality and political stability do not substantially influence the consumption of energy from different sources. On the contrary, Olaniyi et al (2025) affirmed that institutional quality improves renewable energy adoption in Africa.

Adebayo et al (2024) disclosed the time-varying implications of financial development on carbon emission for MINT countries between 1969 through 2019. The findings declared a unidirectional causality running from financial development to carbon emission. It further revealed that there is no clear pattern of increasing emissions or decreasing effect on financial development. Using the same population, Bekun et al (2024) found that poverty aggravates environmental pollution for Turkey within the sampled period 1990 to 2018. However, poverty levels were inconsequential to environmental degradation in Mexico, Nigeria, and Indonesia. Suleiman et al (2025) examined the drivers of trade markets and how they influence renewable energy consumption in MINT. The study affirmed that labour participation, trade reserves, and balance positively influence renewable energy consumption. On the contrary, exchange rate and population growth exhibit detrimental impacts on renewable energy consumption in the MINT countries.

A significant gap in the literature is the non-exhaustive implications of institutional quality on inclusive growth and how institutions moderate the relationship between inclusive growth and environmental sustainability. More so, a dearth of empirical outcomes is apparent in the use of the new climate action index as a proxy for environmental sustainability. To the best of our knowledge, such empirical investigation is lacking in MINT countries.

## 3. Methodology

*3.1. Pre-estimation diagnostics*

It is essential to conduct pre-diagnostic tests based on the envisaged contemporaneous, temporal and serial correlations amongst cross-sections in the dataset. The first pre-examination is the test for cross-sectional dependence (CSD) and its unobserved implications within the panel dataset. To address this, the study employs the CSD test by Chudik and Pesaran (2014). The equation is estimated as

$$CSD = \sqrt{\frac{2P}{U(U-1)}}\left[\sum_{i=0}^{U-1}\sum_{j=i+1}^{u}\eta_{ij}\right] \quad (1)$$

Where $P$ is the time, $U$ is the units within the cross-sections and $\eta_{ij}$ is the correlation coefficient of the units $i$ and $j$. The distribution is asymptomatic under the weak cross-sectional dependence of the null hypothesis.

Secondly, considering the slope heterogeneity is essential as it may inform biased and spurious long-run estimates. This is due to the assumption of homogeneous slope coefficients across units within the panel (Abbas et al. 2023; Uddin and Rahman 2023). In tackling this issue, the scaled slope heterogeneity test by Pesaran and Yamagata (2008) was employed. The test, an improvement on Swamy (1970) version, is valid when the period is assumed infinitesimal and cross-sections tend towards infinity (Adeleye et al. 2022; Shah et al. 2023). This test in Monte Carlo's experiment reveals the most efficient estimates based on its power and size properties. This study, therefore, adopts Pesaran and Yamagata (2008) to account for the apparent slope heterogeneity in the data. The model is specified as

$$\widetilde{Slh} = \sum_{i=1}^{N}\left(\left(\hat{\phi}_i - \widetilde{\phi\theta}_{WFE}\right)\frac{'X_i' I\eta_\tau X_i}{\tilde{\sigma}_i^2}\left(\hat{\phi}_i - \tilde{\phi}_{WFE}\right)\right) \quad (2)$$

Where $\widetilde{Slh}$ is the slope heterogeneity coefficient; $\phi$ connotes the vector of the pooled OLS coefficients; $\tilde{\phi}_{WFE}$ is the weighted coefficients of the fixed effect estimator; $I\eta_\tau$ is the identity matrix while $\tilde{\sigma}_i^2$ refers to the estimator for $\sigma_i^2$ . The standard delta derived by extending the Swamy's equation is built as:

$$\tilde{\Delta} = \sqrt{P}\left(\frac{N^{-1}\,\widetilde{Slh} - \kappa}{2k}\right) \quad (3)$$

The null hypothesis stipulates that slope homogeneity occurs when both conditions on P and U tend to be infinite.

$$\left((U,P) \to \infty \; as \; long \; as \; \sqrt{U/P}\right) \quad (4)$$

Thus, $\tilde{\Delta}$ exhibits standard normal asymptotic distribution$(\varepsilon \sim U(0,\sigma^2)$. Equally, through the bias-adjusted version, the expected delta can be used to improve small sample properties using the same normality condition of distributed errors as

$$\tilde{\Delta} = \sqrt{U}\left(\frac{U^{-1}\,\widetilde{Sl} - E(Z_{i,t})}{\sqrt{Var(\widetilde{Z_{i,t}})}}\right) \quad (5)$$

Where $\kappa$ is the mean of $E(Z_{i,t})$ and $Var(\widetilde{Z_{i,t}}) = \frac{2K(P-\kappa-1)}{P+1}$

Lastly, the stationarity level of the series is expected to be considered. The presence of a unit root in the panel suggests that the long-run estimates may suffer from inefficiency, bias, and become spurious. This study incorporates the cross-sectional augmented Dickey-Fuller (CADF) to examine the presence of stationarity within the series. The econometric specification for the test is

$$\Delta y_{i,t} = \rho_i + \vartheta_i \Delta y_{u,p-1} + \alpha_i\,\bar{y}_{p-i} + \gamma_i \Delta \bar{y}_p + \varepsilon_{u,p} \quad (6)$$

Where $\Delta y_{u,p}$ is the mean value of the first difference, $\rho_i$, $\vartheta_i$, $\alpha_i$, and $\gamma_i$ represents the slope coefficients obtained from the estimated ADF test for each of the countries. $\Delta y_{i,p-1}$ are the lagged mead differences while $\varepsilon_{i,t}$ is the error time-periods ($p$) across time and units (u). The estimates derived from the CADF test is employed to run the CIPS test. The equation is expressed as

$$CIPS = \frac{1}{U}\sum_{i=1}^{N} t_i(U, P) \quad (7)$$

Where $t_i(U, P)$ is the t-statistic of the least squares estimates of the equation $y_{u,p} = y_{u,p} + y_{up}^0$.

*3.2. Main estimator: Panel Corrected Standard Errors (PCSE)*

This study adopts a dynamic panel estimator to account for the incidences of heteroscedasticity and endogeneity bias in the models. The Panel Corrected Standard Errors (PCSE) estimator was adopted as the main estimator for this study. This estimator is preferred because it addresses one-term variance of observations and remains efficient as observations increase (Isola et al. 2020; Rahman et al. 2021). The model is also robust to correlations across cross-sections as it assumes diagonal elements of each unit of analysis are constant and all off-diagonal elements in the matrix are zero. More importantly, the estimator produces robust and efficient estimates for datasets exhibiting cotemporaneous correlations and heteroscedasticity (Olohunlana et al. 2022; Famanta et al. 2024). The theoretical considerations for the PCSE inform a baseline model written as

$$y_{it} = \varphi + \delta A_{it} + \epsilon_{it} \quad (8)$$

Where $y_{it}$ represents dependent variables for units ( $i$) in time ( $t$); $A_{it}$ is the vector of the regressor; $\delta$ is the vector of the coefficients of the variables and $\epsilon_{it}$ is the error term. The least squares estimator for $\delta$ is specified as

$$\hat{\delta}OLS = (A'A)^{-1}A'_y \quad (9)$$

The uniqueness of the PCSE lies in its variance-covariance matrix of the ordinary least squares coefficients – a sandwich-type estimator which is expressed as

$$Var(\hat{\delta}PCSE) = (A'A)^{-1}(A'\Omega A)(A'A)^{-1} \quad (10)$$

The Ω is the block diagonal matrix which accommodates contemporaneous correlations and heteroscedasticity across the cross-sectional units, while the error covariance matrix is accounted for by the OLS residuals. Basically, the estimator accounts for correlated errors across units in the same period, the variance of the errors in different cross-sections, and when there exist unit-specific AR (1) serial correlations.

*3.3. Model specification*

Based on the estimation strategy, this study illustrates the linkages between inclusive institutions and environmental sustainability in MINT countries from the year 2000 through 2023. The baseline objective of this study is twofold. The first illustrates the role of institutional quality dynamics on inclusive growth in MINT countries to ascertain the linear impact of quality institutions on inclusive growth. The model is expressed as

$$Incls_{it} = \gamma_o + \gamma_1 \sum_n Inst + \gamma_2 \sum_n Cont + \varepsilon_{it} \quad (11)$$

where Incl$s$ is inclusive growth; $inst$ represents the vector for institutional dimensions and $Cont$ is the vector of the other control factors influencing inclusive growth. Institutional quality is further decomposed into the six governance indicators- corruption control, government effectiveness, regulatory quality, rule of law, political stability, and voice and accountability. Following Asongu et al (2018), the study decomposed institutional quality into political, economic, and governance institutions to understand its structural dynamic impact on inclusive growth amongst the MINT countries. Expanding the model, the expressional relationship between is specified as:

$$Incls_{it} = \gamma_o + \gamma_1 pol_{it} + \gamma_2 eco_{it} + \gamma_3 gov_{it} + \gamma_4 \sum_n Cont + \varepsilon_i + \mu_t \quad (12)$$

Where pol is proxy with the average of political stability; pol is proxy with the average of political. Extant literature suggests inclusive growth influencing factors such as inflation, gross capital formation, trade openness, and renewable energy use, and per capita growth ((Annor et al. 2023; Radulescu et al. 2025). The second objective illustrates the mediating role of inclusive growth and institutional dynamics on environmental performance in MINT countries. The model is expressed as

$$Envs_{it} = \gamma_o + \gamma_2 Incls_{it} + \gamma_2 pol * Incls_{it} + \gamma_2 eco * Incls_{it} + \gamma_2 gov * Incls_{it} + \gamma_4 \sum_n Cont + \varepsilon_{it} \quad (13)$$

Where $Envs$ is environmental sustainability performance; $Incls$ is inclusive growth index; $pol * Incls$ , ; $pol * Incls$ ,; $pol * Incls$ represents the moderating indicators between inclusive growth, political, economic, and governance institutions, respectively. Other variables remain as previously defined.

*3.4. Data and descriptive statistics*

The detailed description of variables employed in this study, their measurements, and empirical validation are expressed in Table 1. Table 2 presents the summary statistics on the variables under study for the full sample and each country. In the table, the SDG-13 scores reveal a clear disparity in climate action performance. Nigeria records the highest score (97.68) with minimal variation, followed closely by Indonesia (93.23), both of which are above the full-sample mean of 91.46. In contrast, Mexico (87.97) and Turkey (86.98) fall below the sample average, indicating relatively weaker performance on climate action targets.

Interestingly, Nigeria's excellent SDG-13 score betrays its weak institutional indicators, suggesting that high climate performance metrics may be driven more by structural energy use patterns than by institutional capacity. The outstanding performance of Nigeria and Indonesia can be linked to lower industrialization, featured by carbon emission, compared to Turkey and Mexico, with relatively heavy industry, manufacturing, and high-energy transport systems.

Table 1. Variable definition and measurement, source*:* Authors' compilation, 2025

| Variable_Label | Measurement | Source |
|---|---|---|
| SDG_13 | SDG-13_Climat Action Performance Index Score | Sustainable Development Report, 2024 |
| Inclusive_Growth | Human capital index, based on years of schooling and returns to education | Penn World Table, 2025 |
| GDP_Per_Cap | GDP per capita growth (annual %) | WDI, 2025 |
| Gross_Capital | Gross capital formation (% of GDP) | WDI, 2025 |
| Inflation | Inflation, consumer prices (annual %) | WDI, 2025 |
| Trade_Open | Trade (% of GDP) | WDI, 2025 |
| Renewable | Renewable energy consumption (% of total final energy consumption) | WDI, 2025 |
| Green_House | Total greenhouse gas emissions excluding LULUCF per capita (t $CO_2e$/capita) | WDI, 2025 |
| Pol_Institution | Average (political stability and absence of violence and terrorism +voice and accountability) | Authors' Computation |
| Eco_Institution | Average (regulatory quality + government effectiveness) | Authors' Computation |
| Gov_Institution | Average (control of corruption + rule of law) | Authors' Computation |
| Incls_Pols | Human capital index*political-Inst | Authors' Computation |
| Incls_Eco | Human capital index*Economic-Inst | Authors' Computation |
| Incls_Gov | Human capital index*Governance-Inst | Authors' Computation |

In contrast to the above, Table 2 suggests that, in terms of human development, Turkey (0.768) and Mexico (0.756) rank the highest, surpassing the sample average of 0.676. Indonesia (0.673) stands close to the average, while Nigeria (0.508) falls significantly behind. Institutional quality indicators show that Mexico and Indonesia have relatively stronger political institutions (4.51 and 4.03, respectively), while Nigeria lags significantly (2.52). Economic institutions are strongest in Turkey (5.27) and Mexico (5.25), and weakest in Nigeria (3.05). Governance institutions follow a similar trend, with Turkey leading (4.69), Mexico (3.86), and Indonesia (3.79) in the middle, and Nigeria again at the bottom (2.73). Overall, stronger institutional capacity appears to align more closely with higher human development than with climate action scores, reinforcing the idea that Nigeria's climate performance may be structurally driven rather than institutionally supported.

This pattern suggests a positive relationship between human development and institutional quality, but not necessarily between human development and SDG-13 scores, as seen in Nigeria's case, where climate metrics are high, but HDI is low. The share of renewable energy in total energy consumption varies sharply. Nigeria stands out with an excellent high share (83.19%), far above the sample mean (35.02%), followed by Indonesia (32.71%), close to the average. Turkey (13.91%) and Mexico (10.28%) record low renewable energy shares. This indicates that Turkey and Indonesia rely more heavily on fossil fuels, while Nigeria's high renewable share could be due to high traditional biomass and limited fossil fuel infrastructure, not really a transition to modern renewable technologies.

The correlation matrix in Table 3 reveals many cases of strong correlations, above 0.50. Notably, the human development index shows very high positive correlations with greenhouse gas emissions (0.895), economic institutions (0.847), and governance institutions (0.744). Renewable energy has a strong negative correlation with HDI (-0.94), economic institutions (-0.935), and governance institutions (-0.804). Economic and governance institutions are highly correlated (0.883).

These correlation coefficients signal potential multicollinearity if used together in regression models. To this end, the study engages in stepwise regression analysis.

Figure 1 illustrate trends in SDG-13 (Climate Action) scores and Human Development Index (HDI) across MINT countries (Mexico, Indonesia, Nigeria, Turkey) from 2000 to 2025. The charts reveal contrasting patterns between climate action (SDG-13) and human development in MINT countries from 2000 to 2024. In the SDG-13 trends, Nigeria consistently outperforms others, maintaining scores around 97–98 with minimal fluctuation, while Indonesia follows with scores above 92 but showing a gradual decline over time. Mexico and Turkey remain lower, mostly between 85 and 90, with Turkey exhibiting the most volatile and a slightly downward-sloping pattern.

The Human Development Index (HDI) trends, on the other hand, reveal a different ranking. Turkey leads with steady improvement from around 0.70 in 2000 to above 0.85 by 2024, followed by Mexico and Indonesia, both showing consistent upward trajectories. Nigeria, despite its top SDG-13 performance, records the lowest HDI, though it has risen gradually from about 0.43 to 0.55 over the period. These trends suggest that high climate action scores, as in Nigeria's case, do not necessarily translate into higher human development, which highlights structural and economic differences in the drivers of environmental and development outcomes.

Table 2. Summary statistics, source: Authors' computation

| Variables | Mean | Std. Dev. | Min | Max. | Mean | Std. Dev. | Min | Max. |
|---|---|---|---|---|---|---|---|---|
| | Full Sample | | | | Indonesia | | | |
| SDG-13 | 91.463 | 4.45 | 85.179 | 97.959 | 93.226 | 0.887 | 91.859 | 94.612 |
| Human Dev. Index | 0.676 | 0.113 | 0.435 | 0.853 | .67325 | 0.040 | 0.60 | 0.728 |
| GDP Per-cap | 2.608 | 3.494 | -9.103 | 12.210 | 3.676 | 1.550 | -2.894 | 4.950 |
| Gross Capital | 25.536 | 5.258 | 14.904 | 35.072 | 29.727 | 4.599 | 21.404 | 35.072 |
| Inflation | 11.008 | 11.837 | 1.560 | 72.309 | 5.973 | 3.224 | 1.560 | 13.109 |
| Trade Openness | 50.859 | 14.381 | 20.723 | 88.387 | 49.825 | 10.288 | 32.972 | 71.437 |
| Renewable Energy | 35.020 | 29.616 | 9 | 88.1 | 32.707 | 9.025 | 19.8 | 45.6 |
| Green-house Emission | 4.296 | 1.688 | 1.690 | 7.423 | 3.334 | 0.506 | 2.605 | 4.268 |
| Political Inst. | 3.654 | 0.909 | 2.012 | 5.288 | 4.030 | 0.748 | 2.605 | 4.788 |
| Economic Inst. | 4.547 | 1.004 | 2.772 | 5.883 | 4.628 | 0.637 | 3.537 | 5.882 |
| Governance Inst. | 3.769 | 0.801 | 2.002 | 5.138 | 3.790 | 0.439 | 2.952 | 4.386 |
| | Mexico | | | | Nigeria | | | |
| SDG-13 | 87.974 | 0.873 | 86.505 | 90.018 | 97.678 | 0.218 | 97.052 | 97.959 |
| Human Dev. Index | 0.756 | 0.023 | 0.712 | 0.789 | 0.508 | 0.037 | 0.435 | 0.560 |
| GDP Per-cap | 0.471 | 3.253 | -9.103 | 5.343 | 2.382 | 3.366 | -4.019 | 12.210 |
| Gross Capital | 22.678 | 1.342 | 20.237 | 24.582 | 22.243 | 5.850 | 14.904 | 34.110 |
| Inflation | 4.761 | 1.562 | 2.721 | 9.492 | 13.127 | 4.462 | 5.388 | 24.660 |
| Trade Openness | 63.689 | 12.797 | 44.740 | 88.387 | 35.951 | 9.189 | 20.723 | 53.278 |
| Renewable Energy | 10.28 | 1.110 | 9 | 13 | 83.188 | 2.425 | 79.900 | 88.1 |
| Green-house Emission | 5.714 | 0.250 | 5.078 | 6.052 | 2.220 | 0.445 | 1.690 | 3.207 |
| Political Inst. | 4.506 | 0.383 | 4.105 | 5.288 | 2.517 | 0.268 | 2.012 | 3.063 |
| Economic Inst. | 5.245 | 0.396 | 4.405 | 5.721 | 3.047 | 0.167 | 2.772 | 3.320 |
| Governance Inst. | 3.860 | 0.434 | 3.118 | 4.500 | 2.733 | 0.311 | 2.002 | 3.071 |
| | Turkey | | | | | | | |
| SDG-13 | 86.976 | 1.672 | 85.179 | 90.543 | | | | |
| Human Dev. Index | 0.768 | .0656869 | 0.669 | 0.853 | | | | |
| GDP Per-cap | 3.902 | 4.285 | -6.915 | 10.429 | | | | |
| Gross Capital | 27.494 | 3.852 | 18.025 | 35.040 | | | | |
| Inflation | 20.172 | 19.659 | 6.251 | 72.308 | | | | |
| Trade Openness | 53.972 | 9.235 | 42.354 | 81.170 | | | | |
| Renewable Energy | 13.906 | 1.968 | 11.400 | 18.100 | | | | |
| Green-house Emission | 5.914 | 0.982 | 4.414 | 7.423 | | | | |
| Political Inst. | 3.561 | 0.608 | 2.386 | 4.399 | | | | |
| Economic Inst. | 5.270 | 0.402 | 4.523 | 5.883 | | | | |
| Governance Inst. | 4.693 | 0.388 | 3.986 | 5.138 | | | | |

Table 3. Correlation Matrix, source: Authors' computation

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Human Dev. Index | | | | | | | | | |
| 2 | GDP Per-cap | -0.043 | | | | | | | | |
| 3 | Gross Capital | 0.306 | 0.380 | | | | | | | |
| 4 | Inflation | -0.021 | 0.047 | -0.035 | | | | | | |
| 5 | Trade Openness | 0.612 | 0.021 | 0.076 | 0.001 | | | | | |
| 6 | Renewable Energy | -0.94 | 0.042 | -0.281 | 0.077 | -0.601 | | | | |
| 7 | Green-house Emission | 0.895 | -0.014 | 0.229 | 0.049 | 0.608 | -0.872 | | | |
| 8 | Political Inst. | 0.574 | -0.102 | 0.273 | -0.282 | 0.265 | -0.751 | 0.484 | | |
| 9 | Economic Inst. | 0.847 | -0.031 | 0.278 | -0.152 | 0.409 | -0.935 | 0.806 | 0.773 | |
| 10 | Governance Inst. | 0.744 | 0.036 | 0.311 | 0.020 | 0.156 | -0.804 | 0.688 | 0.601 | 0.883 |

Figure 2 show the performance of political, economic, and governance institutions across MINT countries (Mexico, Indonesia, Nigeria, and Turkey) from 2000 to 2025. In terms of political Institutions, Mexico and Turkey show the highest and most stable scores, reflecting stronger democratic systems, while Nigeria lags significantly due to instability and weak rule of law. Indonesia displays moderate but inconsistent progress. For economic institutions, Turkey and Mexico also lead with steady improvements. However, Nigeria scores lowest, while Indonesia remains middling with slow reforms. Finally, Turkey outperforms others in terms of governance institutions, likely due to centralized administration, followed by Mexico. Nigeria struggles with governance inefficiencies, and Indonesia shows incremental gains.

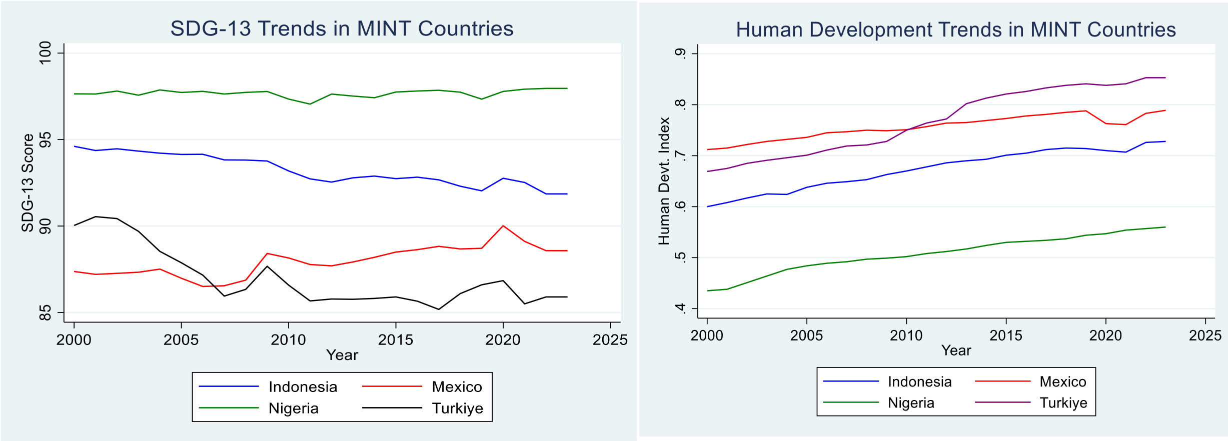


Figure 1. Trend analyses of SDG-13 and Human Development Index

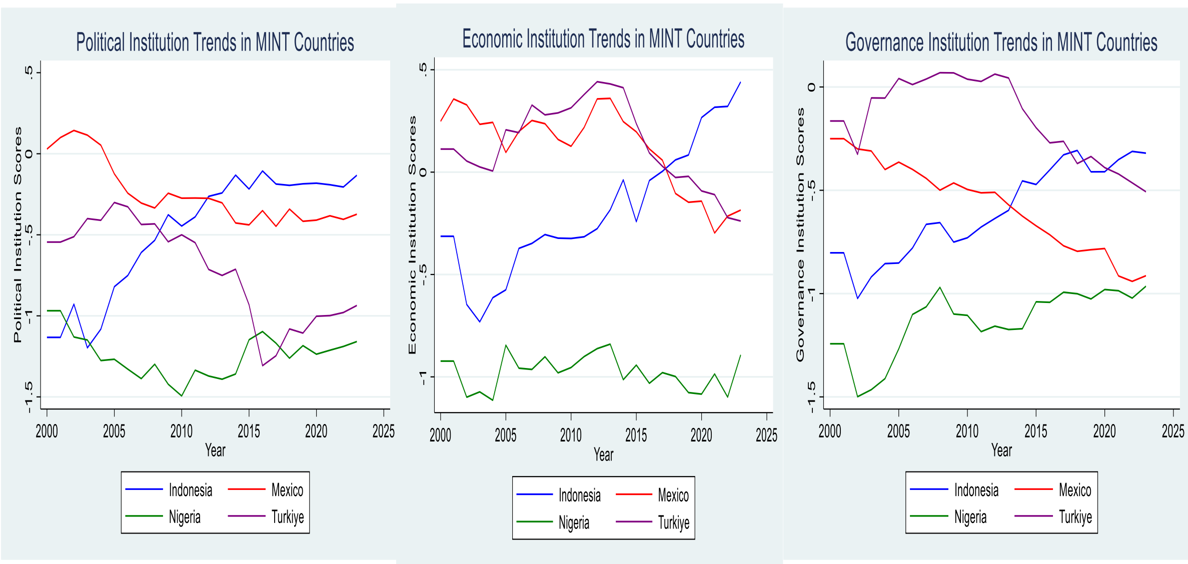


Figure 2: Trend analyses of economic, governance and political institutions

To observe if the outbreak of COVID-19 has altered the nexus, Figure 4 in the appendix present two side-by-side scatterplots that analyze the relationship between SDG-13 (Climate Action) scores and two sustainability metrics, before and after COVID-19.1. The left plot shows a strong positive relationship between SDG-13 scores and the percentage of renewable energy. Higher SDG-13 scores are associated with greater renewable energy use. Both pre-COVID and post-COVID periods show similar positive trends, as the SDG-13 score increases, renewable energy usage increases. The fitted lines and their confidence intervals largely overlap, suggesting that the relationship did not change drastically after COVID. Both clusters follow a similar trajectory, although there is a slight spread indicating minor changes during and post-COVID.

Conversely, the right plot in Figure 3 indicates a strong negative correlation between SDG-13 scores and per-capita greenhouse gas emissions. Higher SDG-13 scores align with lower greenhouse gas emissions per person. Linear downward trends are observed for both periods, with nearly parallel fitted lines indicating consistency before and after COVID. The distribution and clustering of dots imply the pattern held up during the pandemic, with only slight variations. In Figure 4, plots illustrate the relationship between the Human Development Index (HDI) and three different types of institutions (political, economic, and governance), both before and after COVID-19. Overall, there is a positive relationship between HDI and politics; during and after COVID-19, the strength of the relationship seems to weaken.

Before the pandemic, there was a clear positive correlation: stronger political institutions leading to higher HDI. However, in the post-COVID period, this correlation flattens, and the data points become more dispersed. This means that political institutions may have become more unstable or inconsistent relative to HDI, possibly due to the political pressures and disruptions brought on by the pandemic. The middle plot in Figure 4 shows that HDI and economic institutions were strongly and positively correlated before COVID-19. In the post-COVID data, although the positive trend persists, it is less pronounced and shows more variability. The wider confidence interval suggests that the pandemic may have disrupted economic institutions, particularly in higher-HDI countries, where economic resilience may have been tested.

The right plot suggests that governance institutions were strongly and positively correlated with HDI before COVID-19. In the post-COVID era, this relationship becomes weaker, especially at higher HDI levels, where governance scores appear to have declined or become more scattered. This may indicate that governance structures, even in more developed nations, were overwhelmed during the pandemic. The loss of strength in this relationship suggests challenges in maintaining governance standards and effectiveness during crises, pointing to possible institutional erosion or declining public trust.

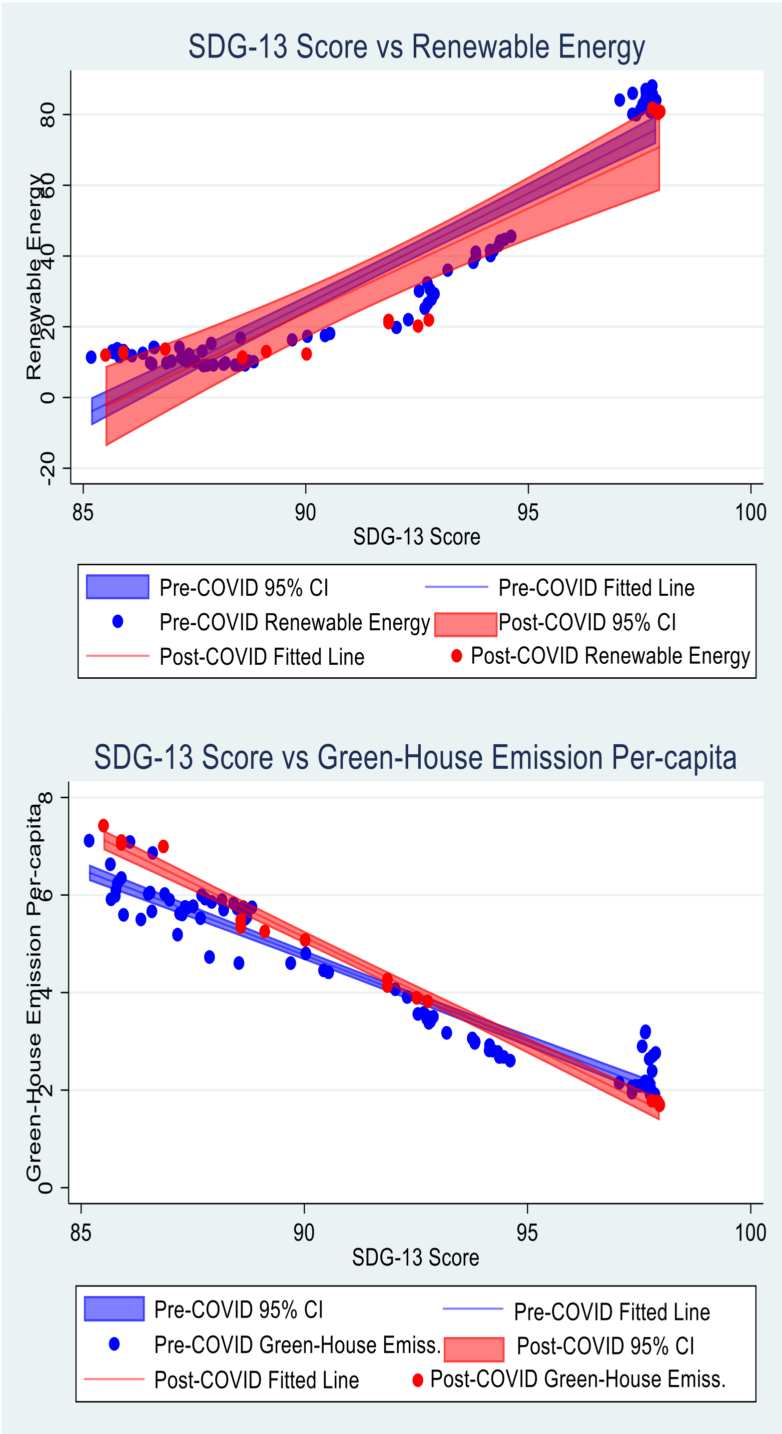


Figure 3. SDG13-Sustainability Nexuses: pre vs. during and post-COVID

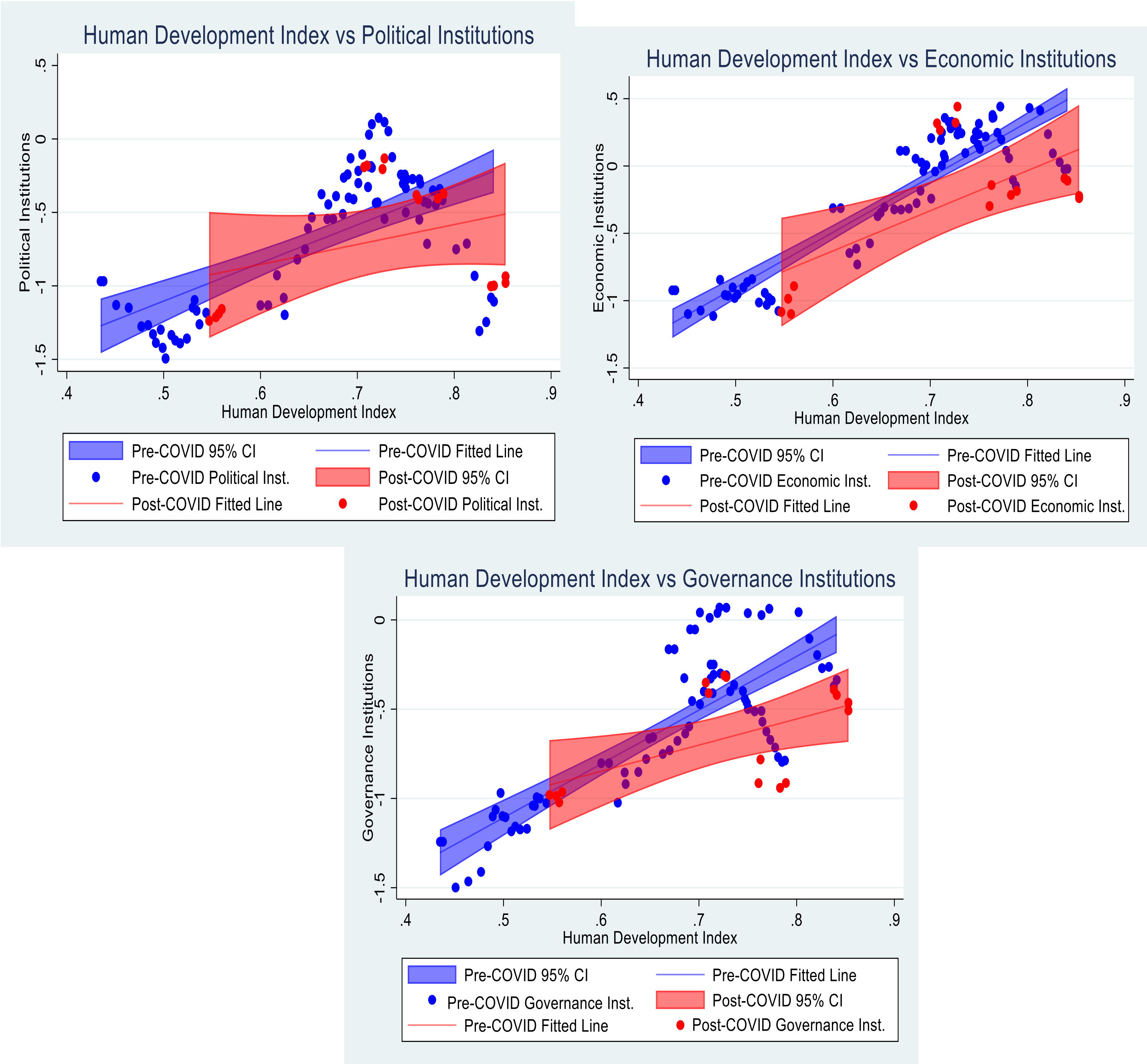


Figure 4. Human dev.-institution nexuses: pre vs. during and post-COVID

## 4. Results and discussion

### *4.1. Inclusive growth models*

Table 4 presents estimation results of panel corrected standard errors (PSCE) and bias-corrected least square dummy variable (LSDV) dynamic panel estimators. Across both estimation techniques, the results suggest a consistent and significant role of institutional quality, especially economic and political institutions, in enhancing human development. Across both estimation techniques, the results suggest a consistent and significant role of institutional quality, especially economic and political institutions, in enhancing human development. This aligns with the submissions of Onafowora and Owoye (2024); Solaymani and Montes (2024); Afolabi and Raifu (2025) who opined that quality institutions improve inclusivity and growth in Latin America, New Zealand, and fragile countries in Sub-Saharan Africa. Unlike the other studies, Tutuncu and Bayraktar (2024) contradicts the assertion with a complex position of corruption, indicating a deleterious impact on economic growth in MINT countries.

Table 4. Institutional quality dynamics and inclusive growth among MINT countries

| | Panel Corrected Standard Errors | | | | | Bias-corrected LSDV Dynamic Panel Estimator with Bootstrapped SE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Hum. Dev.** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** | **(9)** | **(10)** |
| Hum. Dev.$_{it-1}$ | | | | | | 0.100 | -0.213*** | -0.449*** | 0.218 | 1.978 |
| | | | | | | (0.092) | (0.069) | (0.122) | (0.167) | (2.370) |
| GDP Per-cap | 0.002** | -0.002 | 0.002 | 0.001 | -0.003* | 0.002 | -0.001 | -3.10e-06 | 0.004* | 0.011 |
| | (0.001) | (0.002) | (0.003) | (0.001) | (0.001) | (0.001) | (0.001) | (0.003) | (0.002) | (0.015) |
| Gross Capital | -0.0003 | 0.003*** | 0.002 | 0.0004 | 0.001 | 0.002** | -0.005*** | 0.003 | 0.0007 | 0.004 |
| | (0.0005) | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) | (0.001) | (0.005) |
| inflation | 0.001*** | -0.001 | 0.0014** | 0.002*** | -6.96e-06 | 0.001** | -0.0003 | 0.001 | 0.002** | 0.004 |
| | (0.0002) | (0.0005) | (0.001) | (0.0003) | (0.0003) | (0.0004) | (0.0003) | (0.001) | (0.001) | (0.005) |
| Trade Open | 0.001*** | 0.002*** | 0.004*** | 0.003*** | 0.004*** | -0.001 | 8.19e-05 | 0.002*** | 0.001* | 0.006* |
| | (0.0002) | (0.0004) | (0.001) | (0.0003) | (0.0002) | (0.0004) | (0.0004) | (0.0005) | (0.0004) | (0.003) |
| Renewable | -0.003*** | | | | | -0.004*** | | | | |
| | (8.53e-05) | | | | | (0.0003) | | | | |
| Green-House | | 0.047*** | | | | | 0.062*** | | | |
| | | (0.004) | | | | | (0.005) | | | |
| Pol. Inst. | | | 0.039*** | | | | | 0.064*** | | |
| | | | (0.010) | | | | | (0.009) | | |
| Eco. Inst. | | | | 0.084*** | | | | | 0.122*** | |
| | | | | (0.004) | | | | | (0.0151) | |
| Gov. Inst. | | | | | 0.092*** | | | | | 0.277 |
| | | | | | (0.005) | | | | | (0.206) |
| Constant | 0.692*** | 0.252*** | 0.171*** | 0.051* | 0.023 | | | | | |
| | (0.0225) | (0.039) | (0.047) | (0.026) | (0.026) | | | | | |
| Observations | 96 | 96 | 96 | 96 | 96 | 72 | 72 | 72 | 72 | 72 |
| R-squared | 0.973 | 0.936 | 0.920 | 0.936 | 0.940 | | | | | |
| Number of year | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5. Inclusive growth, institutions and SDG-13 performance in MINT countries

| | Panel Corrected Standard Errors | | | | | | Bias-corrected LSDV Dynamic Panel Estimator with Bootstrapped SE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SDG-13** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** | **(9)** | **(10)** | **(11)** | **(12)** |
| SDG-13$_{t-1}$ | | | | | | | -0.252*** | -0.527*** | -0.203*** | -0.702*** | -0.187** | 0.473*** |
| | | | | | | | (0.086) | (0.052) | (0.060) | (0.062) | (0.083) | (0.148) |
| GDP Per-cap | -0.123* | -0.026 | -0.075 | -0.205** | -0.082 | 0.037 | -0.036 | 0.031 | 0.002 | 0.001 | -0.062 | -0.028 |
| | (0.068) | (0.053) | (0.055) | (0.105) | (0.054) | (0.051) | (0.049) | (0.032) | (0.028) | (0.054) | (0.042) | (0.054) |
| Gross Capital | 0.079** | -0.004 | 0.081*** | 0.070 | 0.075*** | 0.063** | -0.114*** | 0.068*** | -0.059*** | -0.102*** | -0.026 | -0.008 |
| | (0.039) | (0.023) | (0.029) | (0.059) | (0.027) | (0.025) | (0.031) | (0.022) | (0.017) | (0.035) | (0.024) | (0.032) |
| inflation | -0.038*** | 0.024** | -0.008 | -0.096*** | -0.051*** | -0.0004 | 0.026** | 0.053*** | 0.037*** | 0.036** | 0.014 | 0.007 |
| | (0.014) | (0.010) | (0.011) | (0.013) | (0.014) | (0.011) | (0.012) | (0.008) | (0.007) | (0.015) | (0.012) | (0.014) |
| Trade Open | -0.003 | -0.018* | 0.034*** | -0.085*** | -0.032** | -0.076*** | 0.006 | -0.012 | 0.001 | -0.050*** | -0.017* | -0.091*** |
| | (0.014) | (0.011) | (0.011) | (0.021) | (0.013) | (0.010) | (0.012) | (0.010) | (0.008) | (0.011) | (0.009) | (0.009) |
| Renewable | 0.146*** | | | | | | 0.114*** | | | | | |
| | (0.007) | | | | | | (0.011) | | | | | |
| Green-House | | -2.434*** | | | | | | -1.677*** | | | | |
| | | (0.108) | | | | | | (0.156) | | | | |
| Human Dev. | | | -42.98*** | | | | | | -33.47*** | | | |
| | | | (1.948) | | | | | | (2.304) | | | |
| Human*Pol | | | | -3.465*** | | | | | | -1.908*** | | |
| | | | | (0.305) | | | | | | (0.251) | | |
| Human*Econ | | | | | -3.836*** | | | | | | -3.397*** | |
| | | | | | (0.161) | | | | | | (0.305) | |
| Human*Gov | | | | | | -4.349*** | | | | | | -6.204*** |
| | | | | | | (0.187) | | | | | | (0.582) |
| Year Effect | Yes | Yes | Yes | Yes | Yes | Yes | | | | | | |
| Constant | 85.90*** | 103.3*** | 114.8*** | 105.6*** | 104.2*** | 104.8*** | | | | | | |
| | (1.821) | (0.794) | (0.994) | (1.795) | (1.066) | (0.862) | | | | | | |
| Observations | 96 | 96 | 96 | 96 | 96 | 96 | 72 | 72 | 72 | 72 | 72 | 72 |
| R-squared | 0.919 | 0.999 | 0.987 | 0.914 | 0.983 | 0.997 | | | | | | |
| No. of Years | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |

Standard errors in parentheses*** $p<0.01$, ** $p<0.05$, * $p<0.1$

In the bias-corrected LSDV dynamic models, the sign of institutional factors remains positive but with larger coefficients than in PCSE, with economic institutions having the largest and most robust influence. Overall, the evidence implies that strong institutions, especially economic and political ones, remain critical drivers of human development in MINT countries, even in the face of environmental sustainability challenges. However, the negative association of renewable energy with human development and the positive link between emissions and welfare point to a development–environment tension, where short-term growth drivers may undermine long-term sustainability unless accompanied by institutional reforms that align environmental policies with development objectives. In the PCSE results, the renewable energy share is unexpectedly negative and highly significant, which means that in the MINT context, renewable energy expansion lowers human development. In contrast, higher greenhouse gas emissions (GHG) are positive and significant in affecting human development. This indicates that economic activities driving emissions are still contributing to welfare in the short run. The renewable energy variable remains negative and significant with a slightly larger coefficient. Similarly, GHG emissions maintain its positive and significant effect with also larger coefficient. This points to the growth–environment trade-off pattern. GDP per capita and trade openness have small but occasionally significant effects, while gross capital formation shows inconsistent signs across models.

*4.2. SDG-13: climate action models*

In Table 5, the Panel Corrected Standard Errors (PCSE) model shows that renewable energy adoption has a significant and positive effect on climate action (SDG-13), asserting that transitioning to cleaner energy sources helps mitigate climate change. However, the Bias-corrected LSDV model also supports this but with a slightly weaker coefficient and level of significance (see Columns 1 & 7). Both estimation techniques show that higher greenhouse gas emissions significantly worsen SDG-13 performance (see columns 2 & 8). The slightly smaller coefficient in the dynamic model may reflect that emissions' negative effects accumulate gradually rather than immediately. Human development alone has a negative and significant effect on climate action across both specifications. Even when human development is interacted with economic, governance and political institutions, the effects remain negative and significant across both PCSE and LSDV specifications

Across both estimation techniques, the results reveal a clear tension, where renewable energy expansion supports climate action, while greenhouse gas emissions and current development strategies undermine it. Institutions, while generally positive for economic and social outcomes, appear to undermine with environmental sustainability, as reflected by the negative effects of human development–institution interactions. The consistency of these results across static and dynamic models points to the robustness of the results.

## 1. Conclusion, implications and future research directions

*5.1. Conclusion*

This study explores the mediating impact of quality institutions and inclusive growth on environmental sustainability in MINT countries before and after the occurrence of the COVID-19 pandemic. Data on the variables of interest were obtained from three databases, namely, the Sustainable Development Report, the World Bank database of the development indicators, and the World Penn Table for the years between 2000 and 2024. Using the panel corrected standard error, the study finds that all the dimensions of institutional quality exhibit positive significance on inclusive growth. The controlling influence of gross capital formation is positive across models for inclusive growth and environmental sustainability.

Trade and the emission of greenhouse gas promoted inclusive growth while reducing environmental quality. The robustness check conducted using an alternative estimator like the Bias-corrected LSDV dynamic panel estimator with bootstrapped SE lends credence to the consistency of the results. While this study directly addresses SDG 13, the insights also reinforce pathways toward SDG 7, SDG 8, SDG 9, and SDG 16, which collectively define the institutional and economic pillars of sustainability. Future policy frameworks should therefore adopt an integrated SDG approach to ensure that progress in climate action complements economic inclusiveness, institutional strength, and technological innovation.

*5.2. Policy implications*

Arising from the findings, some policy implications are instructive. First, the political, economic, and governance institutions must be strengthened in MINT countries. Policy actors should ensure a system of transparency, accountability, electoral credibility, and political stability to enhance public trust in the inclusive growth policies. Also, policy actors should advocate for transparent and systematically independent frameworks for corruption checks and a functional judiciary to ensure adherence to legal principles. Public awareness and effective legal protection would further improve the efficient delivery of inclusive policies in the countries.

Regulators and policy actors should ensure that inclusive growth policies are eco-friendly by initiating policies and programs that could raise citizens' awareness on the adoption of sustainable practices. More so, developmental

projects in education, learning, and health should be executed using green models using hybrid teaching technologies to reduce waste from traditional learning models. Telemedicine, green water, sanitation, and housing models should also be embraced in promoting inclusive growth in MINT countries. To embrace sustainable capital inflow for inclusive growth and environmental sustainability, the government should prioritize investments that are nature-friendly and promote renewable channels in sustainable production patterns. Lastly, trade liberalization should be addressed with caution as it reverses the progress on environmental sustainability. Consumption trade should be less prioritized.
The policy implications extend beyond climate action (SDG 13). Strengthening political and governance institutions supports peace and justice (SDG 16), while investing in green infrastructure and innovation contributes to SDG 9. Inclusive, eco-friendly growth strategies enhance decent work and economic growth (SDG 8) and help reduce inequalities (SDG 10). Integrating clean-energy financing and partnerships aligns with SDG 7 and SDG 17, fostering a synergistic pathway toward sustainable development."

*5.3. Future research directions*
This study lays emphasis on the moderating role of institutions and inclusive growth in powerfully emerging economies with weak institutional quality. So, caution should be exercised in generalization to other countries with strong institutional quality. Hence, it becomes essential to undertake the same empirical investigation in developed regional blocs that have had considerable progress in quality institutions. This will set a comparative path for developed and developing countries in the bid to achieve global environmental sustainability. Alternatively, emerging research may focus on decoupling the environmental performance to its various pillars and examine how each pillar performed with respect to quality institutions and inclusive growth. Furthermore, engaging alternative governance indices like democratic quality on inclusive growth and environmental quality may report interesting findings.

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