Original Paper

doi 10.15826/recon.2025.11.4.025
UDC 338
JEL O43, Q56

Navigating sustainability: understanding the linkages between inclusive economic growth, institutional quality, and environmental degradation in BRICS Plus countries

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ABSTRACT

Relevance: Global economic growth has intensified concerns about environmental degradation, particularly in rapidly expanding economies such as the BRICS Plus countries. These countries contribute significantly to global GDP and trade, yet face rising challenges involving carbon emissions, resource scarcity, and socio-economic inequality. Understanding how inclusive growth affects the environment and how institutional quality shapes this relationship is essential for advancing sustainable development goals.

Research Objective: This study examines how inclusive economic growth affects environmental degradation, measured through CO_2 emissions, and assesses how institutional quality, specifically regulatory quality and government effectiveness, moderates this relationship in BRICS Plus countries.

Data and Method: This study uses macro panel data for BRICS countries from 2000 to 2023 and applies a quantitative design using several analytical techniques. Panel Ordinary Least Squares (OLS) provides the baseline estimates, while the Dynamic Generalized Method of Moments (GMM) is used to address endogeneity, with static OLS informing instrument selection. Inclusive growth is measured using the Social Mobility Curve (SMC) and a PCA-constructed index. The Environmental Inclusive-Growth Kuznets Curve (EIKC) framework is applied to examine the relationship between inclusive growth and environmental degradation, focusing on CO_2 emissions.

Results: The findings support the Environmental Inclusive-Growth Kuznets Curve (EIKC) hypothesis. At early development stages, inclusive growth increases CO_2 emissions due to industrial expansion and energy-intensive activity. After reaching a threshold, however, greater inclusiveness leads to environmental improvement. Institutional factors such as government effectiveness and regulatory quality strengthen the link between inclusive growth and environmental outcomes. This suggests that in BRICS Plus countries, institutional efficiency still tends to favor economic gains over environmental protection, which can amplify ecological pressures when incentives are oriented toward growth.

Conclusions: To ensure sustainable development in BRICS Plus countries, it is necessary to align institutional performance with environmental goals. Stronger environmental regulations, integrating sustainability metrics into governance evaluations, and improving policy coherence between social inclusion and environmental management are essential for ensuring that inclusive growth supports sustainability rather than contributing to additional environmental costs. Future work could examine subnational or sectoral patterns, broaden the set of environmental indicators, and analyze how formal and informal institutions differently influence sustainable inclusiveness.

KEYWORDS
inclusive economic growth, economic and environmental nexus, institutional quality, environmental inclusive-growth Kuznets curve, BRICS plus

ACKNOWLEDGMENTS
This study was supported by the Master's Thesis Research Grant from the Directorate of Research, Technology, and Community Service, Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia. The authors thank all individuals and institutions whose contributions made this research possible.

FOR CITATION
Zulfia, B., I. Dwiputri, N., Soesilowati, E., De Silva, S. (2025). Navigating sustainability: understanding the linkages between inclusive economic growth, institutional quality, and environmental degradation in BRICS Plus countries. *R-Economy*, 11(4), 463–487. doi: 10.15826/recon.2025.11.4.025

Управление устойчивым развитием: понимание взаимосвязи между инклюзивным экономическим ростом, качеством институтов и ухудшением состояния окружающей среды в странах БРИКС+

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АННОТАЦИЯ

Актуальность: Глобальный экономический рост усилил обеспокоенность по поводу ухудшения состояния окружающей среды, особенно в таких быстрорастущих экономиках, как страны БРИКС+. Эти страны вносят значительный вклад в мировой ВВП и торговлю, но при этом сталкиваются с растущими проблемами, связанными с выбросами углерода, дефицитом ресурсов и социально-экономическим неравенством. Понимание того, как инклюзивный рост влияет на окружающую среду и как качество институтов формирует эту взаимосвязь, имеет решающее значение для достижения целей устойчивого развития.

Цель исследования: В данном исследовании изучается влияние инклюзивного экономического роста на ухудшение состояния окружающей среды, измеряемое через выбросы CO_2, и оценивается, как качество институтов, в частности качество регулирования и эффективность государственного управления, смягчает эту взаимосвязь в странах БРИКС+.

Данные и методы: В данном исследовании используются панельные макроэкономические данные по странам БРИКС за период с 2000 по 2023 год, а также применяется количественный дизайн с использованием нескольких аналитических методов. Панельный метод наименьших квадратов (OLS) обеспечивает базовые оценки, в то время как динамический обобщенный метод моментов (GMM) используется для анализа эндогенности, а статический OLS используется для выбора инструментов. Инклюзивный рост измеряется с помощью кривой социальной мобильности (SMC) и индекса, построенного на основе PCA. Для изучения взаимосвязи между инклюзивным ростом и ухудшением состояния окружающей среды с акцентом на выбросы CO_2 применяется модель кривой Кузнеца «Экологический инклюзивный рост» (EIKC).

Результаты: Полученные данные подтверждают гипотезу кривой Кузнеца «Экологический инклюзивный рост» (EIKC). На ранних этапах развития инклюзивный рост увеличивает выбросы CO_2 в результате промышленного расширения и энергоёмкой деятельности. Однако после достижения определённого порогового значения более высокий уровень инклюзивности приводит к улучшению состояния окружающей среды. Институциональные факторы, такие как эффективность государственного управления и качество регулирования, усиливают связь между инклюзивным ростом и экологическими результатами. Это говорит о том, что в странах БРИКС+ институциональная эффективность по-прежнему, как правило, благоприятствует экономическим выгодам, а не охране окружающей среды, что может усиливать экологическую нагрузку, когда стимулы ориентированы на рост.

Выводы: Для обеспечения устойчивого развития в странах БРИКС+ необходимо согласовывать эффективность институтов с экологическими целями. Более строгое экологическое регулирование, интеграция показателей устойчивости в оценки государственного управления и повышение согласованности политики между социальной инклюзивностью и экологическим менеджментом имеют решающее значение для обеспечения того, чтобы инклюзивный рост способствовал устойчивому развитию, а не приводил к дополнительным экологическим издержкам. В дальней-

КЛЮЧЕВЫЕ СЛОВА

инклюзивный экономический рост, экономико-экологическая взаимосвязь, качество институтов, кривая Кузнеца для инклюзивного роста в сфере экологии, БРИКС+

БЛАГОДАРНОСТИ

This study was supported by the Master's Thesis Research Grant from the Directorate of Research, Technology, and Community Service, Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia. The authors thank all individuals and institutions whose contributions made this research possible.

ДЛЯ ЦИТИРОВАНИЯ

Zulfia, B., I. Dwiputri, N., Soesilowati, E., De Silva, S. (2025). Navigating sustainability: understanding the linkages between inclusive economic growth, institutional quality, and environmental degradation in BRICS Plus countries. *R-Economy*, 11(4), 463–487. doi: 10.15826/recon.2025.11.4.025

шем можно было бы изучить субнациональные или отраслевые модели, расширить набор экологических показателей и проанализировать, как формальные и неформальные институты по-разному влияют на устойчивую инклюзивность.

可持续发展管理：理解金砖国家+包容性经济增长、制度质量与环境退化之间的关系

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摘要
现实性：全球经济增长加剧了人们对环境恶化的担忧，尤其是在金砖国家+等快速增长的经济体中。这些国家对全球GDP和贸易贡献巨大，但同时面临着碳排放、资源短缺和社会经济不平等加剧等问题。了解包容性增长如何影响环境，以及制度质量如何塑造这种关系，对于实现可持续发展目标至关重要。
研究目标：本研究考察了包容性经济增长对环境恶化（以二氧化碳排放量为标准）的影响，并评估了制度质量（特别是监管质量和治理效率）如何调节金砖国家及其他国家之间的关系。
数据与方法：本研究采用2000年至2023年期间金砖国家面板宏观经济数据，并运用多种分析方法进行定量设计。面板最小二乘法（OLS）提供基础估计值，动态广义矩方法（GMM）用于分析内生性，静态OLS用于工具变量选择。包容性增长的衡量指标包括社会流动曲线（SMC）和基于主成分分析（PCA）构建的指数。环境包容性增长库兹涅茨曲线（EIKC）模型用于考察包容性增长与环境恶化之间的关系，重点则关注二氧化碳排放。
研究结果：研究结果支持生态包容性增长库兹涅茨曲线（EIKC）假说。在发展初期，包容性增长会因产业扩张和能源密集型活动而导致二氧化碳排放增加。然而，达到一定阈值后，更高的包容性水平会带来更好的环境效益。治理效能和监管质量等制度因素强化了包容性增长与环境效益之间的联系。这表明，在金砖国家及地区，制度效能仍然倾向于优先考虑经济收益而非环境保护，当政策激励以增长为导向时，这可能会加剧环境负担。
结论：为确保金砖国家+集团的可持续发展，必须使制度效能与环境保护目标相协调。加强环境监管、将可持续性指标纳入政府效能评估，以及提高社会包容性政策与环境管理政策的协同性，对于确保包容性增长能够促进可持续发展、而非带来额外的环境成本至关重要。未来的研究可以探讨国家内部或行业层面的模式，扩展环境指标体系，并分析正式与非正式制度如何对可持续包容性产生差异化影响。

关键词
包容性经济增长、经济生态关系、制度质量、环境领域包容性增长的库兹涅茨曲线、金砖国家+

致谢：
This study was supported by the Master's Thesis Research Grant from the Directorate of Research, Technology, and Community Service, Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia. The authors thank all individuals and institutions whose contributions made this research possible.

供引用
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Introduction

Sustainable growth and development have become a global strategic priority, built on three main dimensions: economic, social, and environmental. One of the key challenges is achieving economic growth while reducing resource intensity and safeguarding the quality of life for future generations. Yet the escalating threats of global warming and climate change remain a major concern, requiring policies that can anticipate how environmental quality will evolve alongside rising economic activity (Onafowora & Owoye, 2014).

A growing body of research shows that energy use, environmental resources, and economic growth are closely interconnected (Ali et al., 2019; Ibrahim & Abbas, 2022; Kamah et al., 2021; Khan et al., 2021; Kwilinski et al., 2023; Lau et al., 2018; Onafowora & Owoye, 2014; Zahid et al., 2023). However, unsustainable energy consumption can lead to climate change, natural resource depletion, and environmental degradation (Kamah et al., 2021).

According to the World Bank, global carbon emissions rose from 22.51 billion tons in 1990 to 38.52 billion tons in 2022, while global GDP increased from 36.05 trillion USD to 93.35 trillion USD by 2023. Economic growth fuels demand for energy, such as electricity and oil, across production processes, which in turn generates large volumes of carbon dioxide (Wang et al., 2023).

BRICS Plus countries play an influential role in global population trends, politics, environmental outcomes, the world economy, and domestic inequality. In 2017, BRICS nations contributed 18.82 trillion USD, or around 23.31 % of global GDP (Awosusi et al., 2022). They held more than 4 trillion USD in foreign exchange reserves, accounted for nearly 40 % of the global population, and were responsible for up to 17 % of world trade (Voumik & Sultana, 2022). The main driving forces behind the economic growth of BRICS countries are the increased use of production factors, large population scale, and abundant resources, which have led to economic performance that far exceeds that of other countries. (Awosusi et al., 2022; Voumik & Sultana, 2022; Zahid et al., 2023). In addition to their influence in the global economy, BRICS countries have proven themselves to be role models in choosing rapid economic transformation. At the same time, this rapid transformation intensifies energy demand and heightens environmental pressures (Zahid et al., 2023). Amidst increasing global pressures, managing sustainable economic growth in BRICS countries is crucial for achieving global development goals.

Literature on the relationship between economic growth and the environment has expanded in recent decades. Conventional growth, typically measured by GDP, is often viewed as a marker of development, but it has clear limitations, particularly in terms of how benefits are distributed. Ravallion (2014) argues that conventional economic growth has contributed to the eradication of absolute poverty. However, its impact is uneven, especially in countries with high income inequality, and tends to neglect environmental sustainability. Other studies highlight the need for growth that not only reduces poverty but also addresses the distribution of income, wealth, and opportunities to create a more inclusive and sustainable economic structure (De Haan, 2015). Unequal growth can influence GDP and carbon emissions through varying consumption patterns and environmental behaviors. Low-income groups may rely on less sustainable practices to meet basic needs, increasing environmental pressure (Liu et al., 2018; Wang et al., 2023). As a result, conventional growth models are often criticized for their excessive exploitation of natural resources and increased carbon emissions, which exacerbate climate change and ecosystem degradation.

In response to these criticisms, the concept of inclusive economic growth has emerged as an alternative paradigm that emphasizes the balance between economic efficiency and equitable social welfare. Inclusive growth refers to broad-based growth that creates equal opportunities for all (Bappenas, 2019). According to the Asian Development Bank (ADB), inclusiveness not only encompasses broad participation in the growth process, but also requires the active involvement of all levels of society in the creation and distribution of its benefits. This approach emphasizes social dimensions such as gender equality, ethnic and racial inclusion (Ngepah, 2017; Rauniyar & Kanbur, 2010; Zulfia et al., 2024), and adds environmental sustainability as a key element. Growth that neglects environmental considerations cannot be regarded as fully inclusive (Asian Development Bank, 2014a)[1].

Within this broader discussion, the Environmental Kuznets Curve (EKC) offers a relevant framework. Originally proposed by Kuznets (1955) to explain the nonlinear relationship between income inequality and per capita income, it was later adapted by Grossman & Krueger (1991) to environmental outcomes (Environmental Kuznets Curve (EKC)). The EKC suggests an inverted U-shaped relationship between environmental quality and economic growth. In the early stages of development, industrialization and urbanization intensify resource extraction and pollution. After income reaches a certain threshold, however, priorities shift toward sustainability, and cleaner technologies begin to improve environmental outcomes.

Empirical research also points to a strong link between institutional quality and environmental performance. Lau et al. (2018) find that institutional quality is central to CO_2 mitigation, espe-

[1] Asian Development Bank. (2014a). *Framework of Inclusive Growth Indicators 2014: Key Indicators for Asia and the Pacific Special Supplement* [4th Edition].

cially in developed countries, while the rule of law strengthens environmental governance in most contexts except low-income settings. Ibrahim & Law (2016) add that political instruments help balance economic development, environmental degradation, and social justice by enabling effective environmental policies. Strong institutions can accelerate the EKC turning point, allowing countries to reach peak environmental degradation earlier and transition sooner toward sustainability (Ali et al., 2019).

Building on the distinction between conventional and inclusive growth, this study develops the Environmental Inclusive-Growth Kuznets Curve (EIKC) to examine the relationship between inclusive growth and environmental degradation. Adapting the EKC turning point estimation method, the analysis incorporates the Social Mobility Curve (SMC) from Anand et al. (2013) to capture the pace and distribution of inclusive growth. This approach allows for a more precise assessment of inclusiveness in BRICS Plus countries and evaluates the interactive role of institutional quality in supporting environmental sustainability. BRICS Plus is selected due to its rapid growth dynamics and significant influence on global economic patterns, although unequal outcomes and weak institutional capacity remain key challenges.

The rest of the study is presented as follows: Section 2 reviews the theoretical framework. Section 3 outlines the methodology and model construction. Section 4 presents the empirical analysis and findings. Section 5 summarizes key results, discusses policy implications, and identifies limitations and avenues for future research.

Theoretical Framework

Inclusive Economic Growth and the Environment

After the 2000s, developing countries, including BRICS Plus, experienced rapid economic growth, often accompanied by rising income inequality and uneven development. The focus of economic growth has shifted from the goal of merely reducing poverty to promoting equity, a change increasingly emphasized in recent reports (OECD, 2015)[2].

The Commission on Growth and Development (2008) wrote that systematic inequality of opportunity can be "poisonous." Without equal opportunities and protection in market and labor transitions, achieving inclusiveness will be challenging and could potentially jeopardize political stability[3]. Kakwani & Pernia (2000) explain that pro-poor growth is a growth procedure whereby the poor benefit proportionally more. Meanwhile, Klasen (2010) emphasizes that pro-poor growth results in relative growth and inequality between people with low incomes and the non-poor, whereas inclusive growth reflects changes in inequality for all parties. This approach was later expanded by the Asian Development Bank (2014) by linking issues of gender, ethnicity, race, and the environment as integral components of inclusiveness[4].

Within an empirical framework, a number of studies define inclusive growth as a process based on expansion with social participation — through the provision of public facilities in the form of workplaces, public security, and social infrastructure (Angulo-Bustinza et al., 2022; Mitra & Das, 2018), and environmental sustainability (Rini & Hamonangan Tambunan, 2021). Efforts to measure inclusiveness have been made through multidimensional composite indices such as the index developed by Vellala et al. (2016) for India and the Regional Opportunity Analysis Tool employed by Kitagawa & Vidmar (2023) to reduce disparities between rural, semi-rural, and urban areas in the UK. Social approaches, including the Social Mobility Curve and the Poverty Equivalent Growth Rate, also highlight the importance of equal employment opportunities and the manufacturing sector's contribution to achieving inclusive economic growth (Zulfia et al., 2024).

There is evidence confirming the relationship between inclusive growth and the environment (Ali et al., 2019; Annor et al., 2023; Ibrahim & Abbas, 2022; Kamah et al., 2021; Khan et al., 2021; Kwilinski et al., 2023; Lau et al., 2018; M. Lee et al., 2014; Onafowora & Owoye, 2014; Phung et al., 2023; Vidyarthi, 2015; Zahid et al., 2023). Ka-

[2] OECD. (2015). *Inclusive Growth: The OECD Measurement Framework* (OECD Statistics Working Papers No. 2015/06; OECD Statistics Working Papers, Vol. 2015/06). https://doi.org/10.1787/5jrqppxjqhg4-en

[3] Commission on Growth and Development. (2008). *The Growth Report: Strategies for Sustained Growth and Inclusive Development*. https://elibrary.worldbank.org/doi/abs/10.1596/978–0-8213–7491–7

[4] Asian Development Bank. (2014a). *Framework of Inclusive Growth Indicators 2014: Key Indicators for Asia and the Pacific Special Supplement* [4th Edition].

Online ISSN 2412-0731

mah et al. (2021) introduced the concept of the environmental inclusive-growth Kuznets curve (EIKC), which explains that in the early stages of inclusive growth, there is an increase in environmental degradation. However, in the later stages, environmental degradation actually decreases. Annor et al. (2023) explore this further by reconceptualizing the Environmental Kuznets Curve into the Financial Development Environmental Kuznets Curve (FDEKC), which explains the financial-environmental relationship in various strata of economic development in Sub-Saharan Africa. Meanwhile, Vidyarthi (2015) and Phung et al. (2023) confirm that restructuring the renewable balance sheet can promote economic inclusiveness.

Thus, inclusive growth can be understood as a multidimensional concept that combines economic equality, social protection, and ecological sustainability. Various studies confirm that achieving this kind of growth is highly dependent on the quality of institutions, income distribution, and human resource capacity in supporting the transition to fair and sustainable development.

Institutions and the Environment

Institutions are conceptualized as a composition of rights, rules, and decision-making processes through levels of social organization, with an emphasis on the environment and resources (Ali et al., 2019). Romer (1990) asserts that an economy without regulatory institutions is not an optimal system; institutions are necessary to reduce transaction costs, encourage innovation, and ensure the diffusion of knowledge (North, 1991). Strong institutions can play a role in promoting economic growth (Mahran, 2023), ensuring inclusiveness (Kwilinski et al., 2023), influencing household and corporate behavior (Dwiputri et al., 2019), and explaining inequality through government effectiveness (Dwiputri et al., 2018). In addition, strong institutions can reduce the influence of ethnicity in the political process (Kalu & Aniche, 2024) and curb environmental degradation (Khan et al., 2021; Lau et al., 2018) by ensuring that potentially polluting industries comply with environmental regulations (Ali et al., 2019).

The Transaction Cost Economics and Endogenous Growth Theory frameworks provide tools for understanding how institutional efficiency can reduce information asymmetry, enhance innovation incentives, and strengthen adaptive capacity for green growth policies (North, 1991; Romer, 1990). Such efficiency supports inclusive and sustainable growth. In the case of China, Wu & Ling (2023) write that the institutional system of environmental accountability, which emphasizes government oversight and effectively influences stakeholder strategies, encourages the government to implement stricter environmental regulations through political incentives and reputation mechanisms. This motivates polluting companies to comply with emission standards through sanction mechanisms and encourages local communities to channel their protests institutionally through responsive mechanisms.

Cross-country empirical literature shows a complex relationship between institutional quality and the environment (Abid, 2016, 2017; Ali et al., 2019; Carlsson & Lundström, 2003; Halkos & Tzeremes, 2013; Hassan et al., 2020; Ibrahim & Law, 2016; Kamah et al., 2021; Kerekes, 2011; Lau et al., 2014, 2018; Zakaria & Bibi, 2019). Carlsson & Lundström (2003) found that countries with higher levels of political freedom allow their citizens to voice their views on environmental issues, and therefore tend to have better environmental quality. Furthermore, sustainable agribusiness and environmentally friendly agribusiness require institutional support and governance oriented towards job creation, poverty alleviation, economic growth, and a pro-environment core-plasma system (Damelia & Soesilowati, 2016; Soesilowati & DWP, 2015).

Political stability, law enforcement, and corruption control reduce CO_2 emissions (Abid, 2016, 2017; M. H. Ibrahim & Law, 2016; Khan et al., 2021; Lau et al., 2014, 2018; Zakaria & Bibi, 2019). Meanwhile, according to Hassan et al. (2020), high levels of corruption limit government officials in designing and implementing efficient environmental policies. Weak institutions create opportunities for domestic and multinational firms to engage in polluting industries and facilitate the transfer of outdated, environmentally harmful technologies. As a result, low institutional quality is linked to slower development and greater environmental degradation (Shahzad, 2020; Shahzad et al., 2020).

However, some studies suggest a more complex picture. Halkos & Tzeremes (2013) state that improvements in institutional factors, including legal rules and corruption control, do not always have a positive impact on the environ-

Online ISSN 2412-0731

ment. Improved institutions actually worsen pollution due to the effects of "growth bias" and production orientation (Kerekes, 2011; Le & Ozturk, 2020). This difference shows that the role of institutions is not linear, but depends on incentive structures and the domestic political-economic context.

Linking Inclusive Growth, Institutions, and Environment: The EIKC Framework

Conceptually, inclusive growth changes the environmental pressure turning point through three main mechanisms: income redistribution, clean technology diffusion, and equitable human capital investment. In endogenous growth theory, human capital investment triggers learning by doing, which encourages the creation of environmentally friendly technologies. This dynamic shifts people's preferences toward the environment, thereby promoting equitable social demand for environmental protection, which effectively moves the EKC curve downward earlier. Furthermore, institutional integration in the Environmental Inclusive-Growth Kuznets Curve (EIKC) model positions institutions as a transmission mechanism between inclusive growth and environmental outcomes. Adaptive institutions have the potential to accelerate the turning point through policies that balance economic expansion and ecological efficiency, while weak institutions may slow down or even delay the transition to sustainability (see Figure 1).

This study broadens the EKC literature by integrating the dimensions of inclusive and institutional growth into the EIKC framework and empirically testing it in the BRICS Plus countries. This method provides a clearer understanding of how inclusive growth interacts with environmental degradation within the BRICS Plus, which is a new economic bloc with varied governance and environmental policies. Two inclusive growth indices are employed: the PCA composite main index and the Social Mobility Curve (SMC)-based index, to illustrate social mobility across income deciles. This research offers both theoretical and empirical insights into the mechanisms driving sustainable transition in large developing nations.

Research Method

This study uses panel data from nine BRICS Plus member countries — Brazil, Russia, India, China, South Africa, Iran, Egypt, Ethiopia, and the United Arab Emirates — during the period 2000–2023. This time frame reflects the emergence of rapid economic growth in emerging countries. The BRICS Plus countries were selected as the focus of this study for several key reasons.

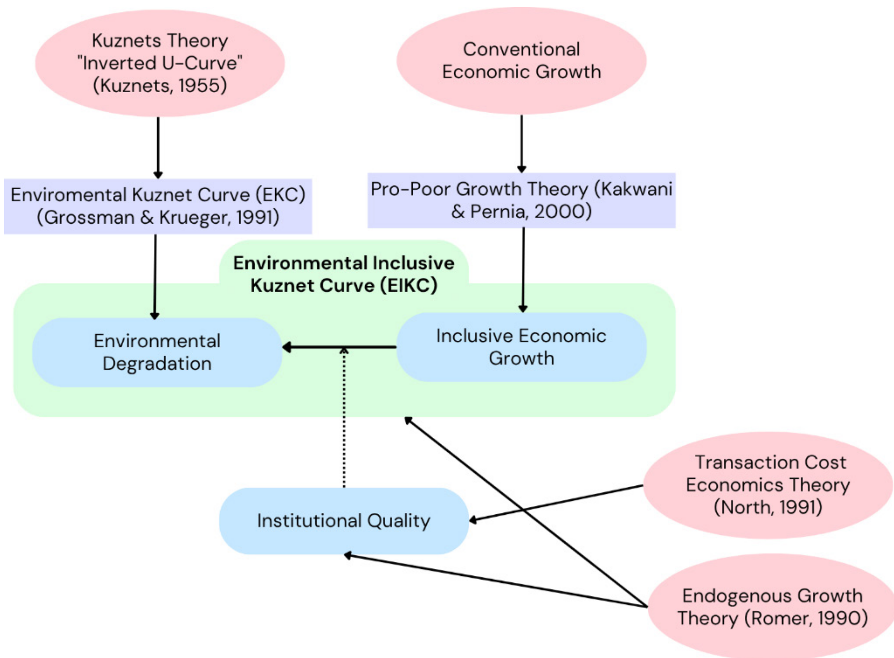

Figure 1. *Conceptual Framework*

Source: Developed by the authors (2025)

First, they account for a substantial share of global GDP, trade, and population, while facing significant challenges such as inequality, carbon emissions, and natural resource scarcity. Their rapid economic transformation has also resulted in considerable environmental costs. Second, the expansion of BRICS Plus enhances their collective economic and geopolitical influence and highlights the diversity of their institutional frameworks.

Due to missing data points, unbalanced panel data are used in the study. Observations with more than two consecutive years of missing data are removed to ensure consistent estimates. Data sources include the World Development Indicators (WDI) for economic and social indicators and the Worldwide Governance Index (WGI) for institutional quality, government effectiveness, and regulatory quality. Carbon emissions represent environmental degradation variables. However, ecological footprint, air quality, and biodiversity cannot be included in the analysis due to limitations in consistent data across BRICS Plus countries.

The analysis was carried out in the following stages: (1) constructing an inclusive growth index using Principal Component Analysis (PCA) and the Social Mobility Curve (SMC); (2) formulating a theoretical model based on the Environmental Inclusive-Growth Kuznets Curve (EIKC) and incorporating institutional variables; (3) estimating the baseline model using OLS; (4) addressing potential endogeneity with a dynamic GMM model; and (5) validating and interpreting key results for policy implications (see Figure 2).

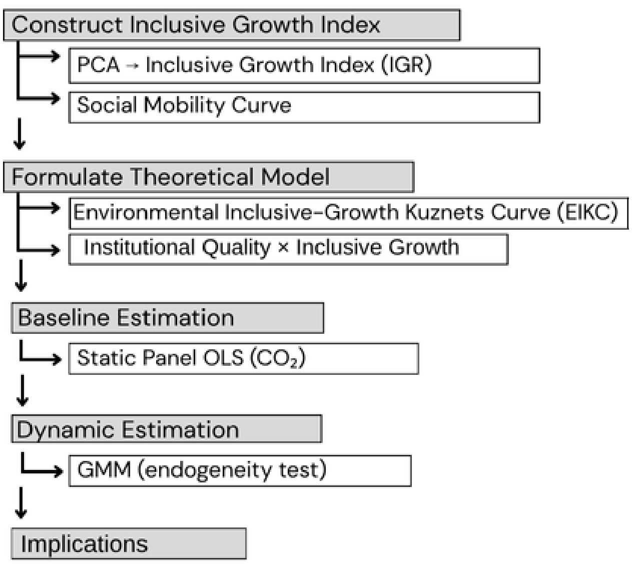

Figure 2. *Methodological Flowchart*
Source: Developed by the authors (2025)

Initial estimation was performed using Panel Ordinary Least Squares (OLS) to analyze the fundamental relationship between the dependent variable, environmental degradation, and independent variables such as inclusive economic growth, institutional quality, and control variables. Classical assumptions of normality, heteroscedasticity, and multicollinearity were tested to ensure the model's validity. Robustness tests were also conducted to identify the most appropriate model through the Hausman test, Chow test, and Lagrange Multiplier test. Additionally, inter-individual dependence was examined using standard fixed effects (FE) and random effects (RE) models, as proposed by Driscoll & Kraay (1998) that these estimates can be valid under the assumption that inter-spread dependence is caused by unobserved common factors (with effects felt through disturbances) but are not correlated with the explanatory variables. The model can be expressed as follows:

$$ENV_{it} = \gamma_1 IGR_{it} + \gamma_2 IQ_{it} + \gamma_3 IGR^2_{it} + \\ + \gamma_4 (IGR_{it} \cdot IQ_{it}) + \gamma_6 Z_{it} + \eta_t + \lambda_i + \varepsilon_{it}. \quad (1)$$

To address potential endogeneity issues arising from the reciprocal relationship between variables, the Dynamic Panel Generalized Method of Moments (GMM) method was used (Ali et al., 2019; Gyamfi et al., 2022; Ibrahim & Law, 2016; Kamah et al., 2021; Lau et al., 2014; Ofori et al., 2023). This method uses lags of the dependent variable as instruments, with the validity of the instruments tested through the Sargan Test, while the model specification is tested through AR (1) and AR (2) (Kripfganz & Schwarz, 2019).

The following is the empirical model for the dynamic panel that will be used in this study:

$$ENV_{it} = \gamma_1 ENV_{it-1} + \gamma_2 IGR_{it} + \gamma_3 IQ_{it} + \\ + \gamma_4 IGR^2_{it} + \gamma_5 (IGR_{it} \cdot IQ_{it}) + \gamma_6 Z_{it} + \\ + \eta_t + \lambda_i + \varepsilon_{it}. \quad (2)$$

The ENV variable represents environmental degradation, measured through carbon emissions. The variable ENV_{it-1} is a lag of the dependent variable that captures the dynamics of environmental change over time. Meanwhile, the IGR variable measures inclusive economic growth, and IGR2 is used to evaluate the non-linear relationship between environmental degradation and inclusive economic growth in accordance with the Environmental Kuznets Curve hypothesis. Institutional quality IQ_{it} is represented by two main indicators, namely government effectiveness and regulatory quality, which reflect the effectiveness of governance in controlling environmental degradation.

The control variables include education, trade, foreign direct investment (FDI), population growth, and urbanization, as supported by previous studies. Specifically, education is referenced by Anand et al. (2013); Dwiputri et al. (2018); Gyamfi et al. (2022); Kamah et al. (2021); trade by Ali et al. (2019); Annor et al. (2023); Kamah et al. (2021); FDI by Annor et al. (2023); Lau et al. (2014); Ofori et al. (2023); population by Gyamfi et al. (2022); Khan et al. (2021), and urbanization by Ali et al. (2019); Kamah et al. (2021).

Measuring Inclusive Economic Growth

Social Mobility Function Framework

This study assumes the concept of inclusive growth by following the Asian Development Bank (ADB) Framework and the study by Anand et al. (2013), which states that inclusive growth depends on income growth and income distribution. This concept defines the measure of inclusiveness in a general concentration curve called the Social Mobility Curve. SMC can be explained as follows

$$S^c \approx \left(x_i \frac{x_1 + x_2}{2} \ldots \frac{x_1 + x_2 \ldots + x_n}{n} \right). \quad (3)$$

In Equation (3), the number of people in the population with income $x_1, x_2, \ldots, x_n$ is represented by n. x_1 represents the poorest person in the population, while x_n represents the wealthiest person in the population. According to Anand et al. (2013), the general concentration curve is essentially the cumulative distribution of the social mobility vector $S \approx (x_1, x_2, \ldots, x_n)$ with the underlined function $m = m\ (x_1, x_2, \ldots, x_n)$. This concept must satisfy two properties of the social welfare function. First, it requires a dimension of growth, and second, a dimension of distribution through income transfer. Redistribution of income among individuals in a more equitable manner will flatten the curve of the function. A higher concentration curve indicates higher income in the population. In this case, the two curves can be ranked based on which curve provides higher social benefits, considering the area under the curve.

To measure the magnitude of changes in income distribution, a simple form of the following equation can be used to calculate the area under the social mobility curve

$$\bar{x}^* = \int_0^{100} \bar{x}_i d_i. \quad (4)$$

The income in the population is greater the higher the value of $\bar{x}^*$. Equity is achieved -values of $\bar{x}^*$ and $\bar{x}_i$ when the incomes of all individuals are equal. However, if the value of $\bar{x}^*$ is smaller than the value of $\bar{x}_i$, income distribution is unequal or inequality occurs. Based on this, Ali & Son (2007) came up with the Income Equity Index (IEI), which is as follows:

$$m = \frac{\bar{x}^*}{\bar{x}_i}. \quad (5)$$

Perfect social equality occurs when $m = 1$. The closer the value of m is to 1, the more equal the income of the society and vice versa. Thus, Equation (5) can be rearranged as follows:

$$\bar{x}^* = m\bar{x}_i. \quad (6)$$

Since there are two dimensions to fulfill in the SMC approach, $\bar{x}^*$ needs to be increased to achieve inclusive growth. An increase in $\bar{x}^*$ can be realized by an increase in average income $\bar{x}_i$ through economic growth. Then, the income equity index m must be increased through increased equity. Thus, to determine the change in the magnitude of inclusive growth, Equation (6) is differentiated as follows:

$$\partial \bar{x}^* = m \cdot \partial \bar{x}_i + \bar{x}_i \cdot \partial m. \quad (7)$$

Economic growth is considered inclusive if the social mobility index, $\partial \bar{x}^*$, has a positive change. Therefore, the right-hand side of Equation (7) represents the direction and intensity of inclusive growth. The results of the Social Mobility Curve (SMC) measurement will be one of the inclusive economic growth indexes in this study and combined with the inclusive growth index referring to the ADB's Inclusive Growth Framework formed through Principal Component Analysis (PCA) as an independent variable (see Table 1). Both indices are used to test the robustness of the effect of the independent variable IGR in the model.

Online ISSN 2412-0731

doi 10.15826/recon.2025.11.4.025

Principal Component Analysis (PCA)

PCA is an approach that allows the projection of observations from a dimension of p variables to a space of k smaller dimensions, where $k < p$, so that maximum information is preserved. This approach transforms many interrelated indicators into unrelated variables called PCs (Senna et al., 2019). The first component captures the largest variance among the other indicators, while the second component captures the second largest variance from the set of indicators and so on (Mahran, 2023). More simply, Principal Component Analysis (PCA) serves to reduce the dimensions of independent variables that have high correlation and produce principal components that retain the main information of the original data (Gyamfi et al., 2022).

Table 1

Variable used in constructing IGR index

	Variables
1	Voice and accountability
2	GDP per capita growth (annual %)
3	Employment to population ratio, ages 15–24, total (%) (modeled ILO estimate)
4	Access to electricity (% of population)
5	Ratio of female to male labour force participation rate (%) (modeled ILO estimate)
6	Government expenditure on Health, total (% of government expenditure)
7	Percentage of seats held by women in national parliament
8	Government expenditure on education as a percentage of total government expenditure
9	Immunization (% of children ages 12–23 months)
10	Mobile cellular subscriptions (per 100 people)

Source: Authors' computation using WGI and WDI data

The algorithm for deriving PCs depends on analyzing the data matrix X_{ij}. The covariance matrix Σ can be decomposed into an eigenstructure as follows (Mahran, 2023);

$$\Sigma = V \Lambda V^t. \tag{8}$$

With Λ being the diagonal matrix of eigenvalues; V being the corresponding load matrix and t for the transpose. The eigenvalues in Λ give the variance of PC_r which is written as follows:

$$PC_r = XV_r. \tag{9}$$

Where V_r represents the contribution of each variable X in the r-th PC. The extracted components are ordered by the amount of total variance explained by the indicators that make up the variable. This study calculates the inclusive growth index by retaining the first three principal components, which cumulatively explain approximately 71.79 % of the variation in all indicators used (see Table 2). The index values have been standardized (z-score) to enable comparison between countries and over time, following the approach of Gyamfi et al. (2022); Kamah et al. (2021); and Ofori et al. (2023).

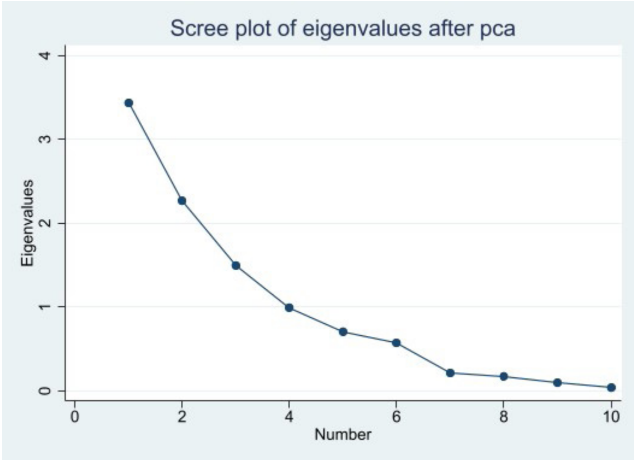

***Figure 3.** Scree plot of Eigenvalues After PCA*

Source: Calculated by the authors using WGI and WDI data

Environmental Inclusive-Growth Kuznets Curve (EIKC)

This study refers to the turning point calculation method in the Environmental Kuznets Curve (EKC) (Kamah et al., 2021; Khan et al., 2021; and Lau et al., 2018). In the EKC hypothesis, the relationship between inclusive economic growth and environmental degradation depends on the coefficient values of γ_{IGR} and inclusive growth squared γ_{IGR^2}. In general, under the EKC hypothesis, a monotonically increasing linear relationship (no turning point) is obtained if the inclusive growth coefficient $\gamma_{IGR} > 0$ and $\gamma_{IGR^2} = 0$. This implies that an increase in inclusive growth is associated with an increase in the rate of environmental degradation. Conversely, if $\gamma_{IGR} < 0$ and $\gamma_{IGR^2} > 0$, then the relationship formed is U-shape, where in the early stages inclusive growth decreases environmental degradation, but after reaching a certain point it increases environmental degradation. As for the relationship that validates EKC, there is an inverted U-shaped nonlinear relationship if

Table 2

PCA results

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	3.433	1.167	0.3433	0.3433
Comp2	2.266	.7691	0.2266	0.5700
Comp3	1.497	.5022	0.1497	0.7197
Comp4	.9949	.2864	0.0995	0.8192
Comp5	.7085	.1359	0.0709	0.8900
Comp6	.5726	.3582	0.0573	0.9473
Comp7	.2144	.0383	0.0214	0.9688
Comp8	. 1760	.0781	0.0176	0.9864
Comp9	.0979	.0595	0.0098	0.9962
Comp10	.0384		0.0038	1.0000

Source: Calculated by the authors

the inclusive growth coefficient is $\gamma_{IGR} > 0$ and the squared inclusive growth coefficient $\gamma_{IGR^2} < 0$. This pattern shows that in the early stages, inclusive economic growth harms the environment, but after reaching a certain point, there is an improvement in environmental quality.

To calculate the turning point of inclusive economic growth, the following equation is used:

$$\frac{\partial^2 ENV}{\partial IGR^2} = \gamma_2 + 2\gamma_4 IGR. \quad (10)$$

This expression represents the second derivative of Equation (10)

$$\frac{\partial^2 ENV}{\partial IGR^2} = 2\gamma_4, \quad (11)$$

when $\gamma_4 < 0$, it implies the existence of local maxima which means the existence of an inverted U-curve. $\gamma_4 > 0$ implies local minima or the existence of a U-shaped relationship. The turning point of the EKC is obtained by setting the first derivative — as in Equation (11) — equal to 0 — Equation (12) — and solving using *IGR*.

$$\gamma_2 + 2\gamma_4 IGR = 0. \quad (12)$$

Using Equation (12), the expression is rearranged into Equation (13) to compute the corresponding *IGR* value

$$IGR^* = \frac{-\gamma_2}{2\gamma_4}. \quad (13)$$

Here *IGR** indicates the threshold (turning) point of inclusive economic growth.

Variable and Measurement

There is insufficient convergence in how environmental sustainability indicators are defined, even though the existing literature describes the concept in explicit terms. Nonetheless, environmental degradation, most commonly proxied by CO_2 emissions, has often been used as an inverse measure of sustainability. This study adopts a set of environmental degradation indicators, including CO_2 emissions, to represent environmental sustainability in the opposite direction. The variables used in this study are summarized in Table 3 below.

Result and Discussion

The discussion of the analysis results begins by presenting the descriptive statistics of the variables used in the model estimation, as shown in Table 4. The table summarizes the core indicators: environmental degradation (measured by CO_2 emissions per capita); inclusive economic growth (calculated in two ways — IGR following the ADB framework and IGR_SMC using the Social Mobility Curve); and institutional quality (government effectiveness and regulatory quality). The control variables include tertiary school enrollment, trade openness, foreign direct investment (FDI), population growth, and the urban population.

Presenting data distribution is essential to essential for understanding the nature and characteristics of the dataset that underpins this study's conclusions. The average per capita CO_2 emissions for the BRICS Plus countries stand at 7.135 metric tons, with the highest level reaching

Table 3

Variable and Measurement

Variable	Measurement	Scale	Data Source
IGR	Inclusive growth generated using the PCA	standardized PCA score	Authors
IGR_SMC	Inclusive growth is measured by Social Mobility Curve	Index 0 to 1	Authors
CO_2	Carbon dioxide emission per capita	Ratio	WDI
Gov	Government effectiveness evaluates the efficiency of public and administrative services, as well as the authority's ability to develop and implement policies efficiently.	(estimated value, —2.5 weak; 2.5 strong)	WGI
Reg	Regulatory quality measures the authority's capability to encourage and develop the private sector by formulating and implementing effective policies and sound regulations.	(estimated value, —2.5 weak; 2.5 strong)	WGI
Education	School enrollment, tertiary	total	WDI
Trade	Merchandise trade	% of GDP	WDI
FDI	Foreign direct investment, net inflows	% of GDP	WDI
Population	Population growth	annual %	WDI
Urban	Urban population	% of total population	WDI

Source: Authors' computation using WGI and WDI data

Table 4

Descriptive Statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
Environment					
CO2	207	7.135	7.175	.0574	27.17
Inclusive Growth					
IGR	144	–8.67e	.9238	–1.889	1.834
IGR_SMC	100	.3021	.0610	.1806	.4882
Institution					
GOV	207	–.084	.5793	–1.21	1.6
REG	207	–.324	.6697	–1.71	1.1
Control					
EDUC	153	37.28	22.78	1.166	84.51
TRADE	216	46.92	35.68	13.13	186.2
FDI	211	2.162	1.772	–1.756	9.660
POP	216	1.614	2.250	–.4600	18.12
URBAN	216	57.86	22.51	14.74	87.78

Source: Calculated by the authors

27.17 metric tons in the United Arab Emirates — a figure that significantly exceeds the BRICS average. The Inclusive Growth Rate (IGR) variable was constructed using the PCA method applied to a set of socio-economic indicators derived from the Asian Development Bank (ADB) framework. While the original indicators all carry positive values, the PCA-generated IGR score may appear as either positive or negative. This results from the standardization process applied prior to PCA, where each indicator is normalized using a z-score transformation to produce a mean of zero and a standard deviation of one. PCA then forms a composite score by generating a linear combination of these normalized variables. As a result, countries with relatively lower values in some indicators — or imbalances across components — may obtain negative PCA scores. A negative IGR score signals that a country exhibits comparatively lower inclusive growth. Within this dataset, IGR values range from — 1.385 to 2.179.

Meanwhile, IGR_SMC, measured using the Social Mobility Curve (SMC) approach, has an average value of 0.3021, with a minimum of

Online ISSN 2412-0731

 doi 10.15826/recon.2025.11.4.025

Table 5

Correlation Matrix

	CO2	IGR	IGR_SMC	GOV	REG	EDUC	TRADE	FDI	POP	URB
CO2	1.00									
IGR	–0.091	1.00								
IGR_SMC	0.216	–0.115	1.00							
GOV	–0.131	0.290	0.062	1.00						
REG	–0.153	0.424	–0.358	0.467	1.00					
EDUC	0.737	–0.132	0.137	–0.242	–0.169	1.00				
TRADE	0.531	0.104	0.168	–0.049	0.102	–0.017	1.00			
FDI	–0.211	0.552	–0.353	0.145	0.669	–0.115	0.089	1.00		
POP	–0.642	–0.263	–0.028	–0.109	–0.377	–0.576	–0.343	–0.276	1.00	
URBAN	0.456	–0.052	–0.359	–0.415	–0.138	0.698	–0.171	–0.002	–0.404	1.00

Source: Calculated by the authors

0.1806 and a maximum of 0.4882. The standard deviation of 0.0610 reflects relatively low variation but provides enough insight to distinguish the level of social mobility between countries. The average institutional quality suggests relatively low institutional standards across the region. Meanwhile, the average trade value indicates a fairly high level of openness. The FDI values, however, show a relatively low level of FDI.

Table 5 displays the correlation matrix illustrating the relationships among all the variables used. The correlation results indicate a relatively weak relationship — below 0.8 — so there is no issue with multicollinearity in the model. The negative correlations of IGR, GOV, and REG variables with CO_2 align with the initial hypothesis that inclusive growth and improved institutional quality can help reduce environmental degradation.

The above indifference curves serve as a tool to analyze the evolution of inclusive growth in BRICS Plus countries over time (appendix 2). In all cases, during both the initial and final years of observation, the indifference curves tend to shift upward, generally reflecting the overall increase in society's income. However, the magnitude of the relative shift and the curvature of the indifference curve are crucial in evaluating the nature of the growth. A steeper curve indicates greater income inequality between deciles, especially between the highest and lowest income groups. Most BRICS countries have a particularly steep indifference curve in the tenth decile, that is, the top 10 percent of the income group earns significantly more than the group below. China's inclusive growth, for instance, has benefited the wealthiest, obscuring inequality while still producing high growth. The same pattern applies to India, Brazil, and Ethiopia, where growth has decreased levels of equality. Another example is South Africa, which did not experience a significant shift in its income growth curve. However, sharp increases in the 9th and 10th deciles have reinforced inequality.

The empirical analysis results are presented in Table 6, with carbon dioxide (CO2) as the dependent variable. It can be seen that all Hausman tests reject the initial hypothesis regarding the development of a random effects regression model. Therefore, in this section, a fixed effects regression model is used to explore the nonlinear relationship between inclusive growth and environmental sustainability.

Dynamic panel GMM estimation was performed to assess the potential persistence of CO_2 emissions and control for endogeneity. Since fixed effects OLS (OLS-FE) may be biased when an AR(1) autoregressive process exists, lagged values of the dependent variable are necessary to address this. If an AR (1) process is present, it can lead to endogeneity issues that fixed effects models cannot resolve (Kripfganz & Schwarz, 2019).

The results showed no evidence of AR (1), and the AR (2) p-value indicated no consistent second-order serial correlation, suggesting no first- or second-order serial correlation in the first-differenced residuals. The lagged dependent variable ($CO_2(-1)$) was consistently insignificant across all specifications, indicating a lack of strong dynamic effects. Moreover, the Sargan–Hansen test supported the overall validity of the instruments.

Online ISSN 2412-0731

Table 6

Result of Fixed Effect Regression Estimation (Dependent variable: CO_2)

Variable	1	2	3	4
IGR	.869*** (.151)	.461** (.193)	.352* (.182)	.438 (.291)
IGR^2	–.320*** (.079)	–.543*** (.083)	–.450*** (.084)	–.424*** (.137)
IGR_SMC				–4.56 (18.4)
IGR_SMC^2				.119 (29.3)
Gov	.863*** (.244)	.089 (.260)		–.553 (1.54)
Gov*IGR	.901*** (.256)	.956*** (.317)		.281 (.418)
Gov*IGR_SMC				2.71 (4.48)
Reg	.190 (.328)		.345 (.260)	.916 (1.07)
Reg *IGR	–.031 (.243)		.416** (.193)	.187 (.327)
Reg*IGR_SMC				–4.56 (3.28)
Educ		–.006 (.007)	–.008 (.007)	–.017* (.008)
Trade		–.014* (.007)	–.013* (.007)	–.012 (.010)
FDI		–.004 (.024)	–.015 (.025)	.057 (.049)
Population		.542*** (.159)	.556*** (.165)	.535** (.251)
Urban		.125*** (.030)	.167*** (.028)	.179*** (.041)
Constant	6.01*** (.114)	–.576 (1.77)	–2.86* (1.64)	–2.47 (3.68)
Turning point (IGR*) %	0.139	0.125	0.08	0.09
No. of Obs.	144	114	114	72
F-test	17.78	33.71	30.98	15.05
Cross-section	Yes	Yes	Yes	Yes
HausmanTest	20.64***	99.19***	98.60***	53.26***

Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
All models have met the OLS assumption of passing the test of normality, non-heteroskedasticity, and non-multicollinearity.

Source: Calculated by the authors

Additionally, the Portmanteau test confirmed no serial correlation ($p \approx 0.43$), suggesting that the instrument set did not overfit the data. Therefore, although the GMM estimation was statistically valid, the model appeared better suited for static estimation methods like OLS.

The analysis shows that inclusive growth has a positive and significant relationship with CO_2 emissions, while the quadratic term of inclusive growth is associated with a significant negative impact on environmental degradation. This indicates an inverted U-shaped nonlinear relationship, where the linear coefficient is positive ($\gamma_{IGR} > 0$) and the quadratic coefficient ($\gamma_{IGR^2} < 0$) is negative (see Table 6). Furthermore, this study confirms that the pattern holds even when the economic growth used is based on inclusive measures instead of conventional growth. The estimated turning point (IGR) for the four EIKC model specifications ranges from 0.08 to 0.14, based on the standardized inclusive growth index generated from PCA. Since this index is normalized, these values should be interpreted in relative rather than absolute terms. The results suggest that when the level of inclusive growth rate improves by approximately 0.1 standard deviations above its mean, the trend of environmental degradation begins to decline. In other words, moderate improvements in inclusive growth — characterized by equitable access to economic opportunities, social inclusion, and environmental participation — are enough to trigger a phase of EIKC decline in the BRICS Plus economies. These findings reinforce the argument that inclusivity accelerates environmental turning points by promoting wider technology diffusion, better regulatory compliance, and collective environmental awareness, in line with the endogenous growth and institutional quality frameworks (see Figure 1). In the early stages of inclusive growth, the focus is on balancing differences in societal in-

Table 7

GMM Estimation (Dependent Variable: CO_2)

	GMM			
Variable	**5**	**6**	**7**	**8**
$LagCO_{2\,(-1)}$	0.447 (0.736)	0.154 (0.906)	0.066 (0.928)	–2.21 (2.20)
IGR	–1.39 (2.00)	4.49*** (1.68)	1.05 (.765)	–1.47 (1.65)
IGR^2	–0.244 (0.971)	0.445 (0.997)	–2.00 (1.53)	2.12* (1.13)
Gov	–10.1* (5.96)			
Gov*IGR		–4.85* (2.88)		
Reg			3.32 (1.91)	
Reg *IGR				–4.97* (2.95)
Educ	–0.11 (0.082)	2.88** (0.047)	0.011 (0.020)	0.050*** (0.019)
Trade	–0.003 (0.006)	0.028** (0.013)	0.004 (0.003)	0.016** (0.006)
FDI	–0.260 (0.197)	–0.030 (0.088)	0.151 (0.096)	–0.099 (0.073)
Population	–0.312 (0.907)	–5.24* (2.90)	–1.51 (1.03)	–0.351 (0.644)
Urban	0.123 (0.124)	0.116 (0.124)	0.167 (0.144)	0.276 (0.211)
Constant	–	–	–	–
Turning point (IGR*) %	–0,16958	–0,99903	1,05	1,5582
No. of Obs.	111	111	111	111
No. of Countries	9	9	9	9
No of Instruments	24	24	24	24
AR (2): P-value	0.657	0.009	0.469	0.711
Sargan-Hansen test	0.877	0.877	0.877	0.877
Portmanteau test	0.438	0.437	0.427	0.437

Standard errors in parentheses; *** and ** indicate significance at 0.01 and 0.05 levels, respectively.
Note: The variable *IGR_SMC* is not included in the GMM models due to a limited number of observations, which resulted in its omission during estimation. As such, the effects of *SMC* are analysed solely within the OLS framework.

Source: Calculated by the authors

equality, thus paying less attention to the environmental impact (especially CO2 tends to be overlooked) (Kamah et al., 2021).

This finding supports the three main foundations proposed by Grossman & Krueger (1991) regarding the existence of EKC, where the shape of the inverted U-curve between income and environmental quality can be explained through by three effects namely: scale effect, composition effect, and technique effect. The scale effect appears in the early phase of industrialization, where increased economic activity drives environmental degradation. The composition effect, on the other hand, occurs when the structure of the economy changes towards industry and resource extraction, often without adequate environmental regulation, in which case natural resource consumption is based on comparative advantage and environmental policies/laws are less stringent. The quality of institutions implementing environmental policies has a positive impact on inclusive growth and consequently on environmental sustainability. Finally, the engineering effect reflects increased awareness and adoption of environmentally friendly technologies as incomes and public pressure rise.

This finding is also in line with previous studies (Ahmed et al., 2019; Annor et al., 2023; M. D. Ibrahim & Abbas, 2022; Kamah et al., 2021; Mu'min et al., 2024; Sarkodie & Strezov, 2018; Wang et al., 2023; Yan et al., 2022). The significant positive effect on CO_2 emissions can be attributed to economic progress and development — in BRICS Plus countries — which goes hand in hand with large resource extraction, industrial activity, and trade that can potentially increase CO2 emissions. In this case, inclusive growth that includes economic improvement, addressing inequality, education, health, and other social protections may have a negative impact through CO_2 emissions.

For example, Ibrahim & Abbas (2022) found that in the short run, an increase in per capita income exacerbates environmental damage. They identified the EKC pattern in the Indonesian province of Java and detected an N-shape EKC with two turning points. Using threshold effect regression approach, Wang et al. (2023) examined the relationship between income inequality and carbon emissions. Along with rapid economic growth, the constraining effect of income inequality on carbon emission efficiency increases so that there is an inverted U-shaped relationship between income inequality and carbon emission efficiency. The ASEAN study by Mu'min et al. (2024) emphasizes the need for an inclusive approach in combating the negative impacts of energy transition on social dimensions. Similarly, Ahmed et al. (2019) concluded that the shift from labour-intensive to capital-intensive technologies also worsens environmental quality if not accompanied by institutional reforms.

Institutional quality in this study is measured through two main indicators: government effectiveness and regulatory quality. Regulatory quality reflects the government's capacity to design and implement effective policies, especially in encouraging private sector growth without compromising good governance. The positive and significant coefficient of government effectiveness and its interaction with inclusive growth (IGR × GE), including the quality of regulation interacting with inclusive growth, indicates that, in the BRICS Plus economy, institutional effectiveness can actually exacerbate environmental degradation. This suggests that although institutions operate efficiently in promoting economic activity, their governance structures tend to prioritize facilitating growth over ecological preservation. In practical terms, a one-unit increase in government effectiveness — when combined with inclusive growth — corresponds to a proportional increase in CO_2 emissions, implying that institutional efficiency has been directed toward speeding up industrialization and investment rather than supporting environmental protection (Kerekes, 2011; Le & Ozturk, 2020).

This paradox highlights a widespread 'growth-biased policy' in BRICS Plus countries, where the development agenda focuses on infrastructure growth, energy security, and maximizing output to sustain rapid economic change. In this context, effective institutions can streamline bureaucratic processes, reduce investment barriers, and mobilize resources, yet they can also weaken environmental oversight due to political and fiscal trade-offs. These outcomes align with the concept of regulatory capture, where powerful industrial and extractive sectors sway policy enforcement, and with governance trade-offs, where environmental protection is overlooked during economic expansion (Hassan et al., 2020; Le & Ozturk, 2020).

A crucial component of regulatory quality lies in the protection and enforcement of property rights, as emphasised by Kerekes (2011). Stronger property rights institutions can encourage private investment and capital formation, but without strong environmental regulations, such institutional improvements can indirectly worsen pollution through more intensive production. While clear property rights can reduce deforestation and improve access to clean water, they are also correlated with higher air pollution due to industrial expansion. Similarly, geopolitical instability and governance vulnerabilities — challenges that are common in some BRICS Plus member countries — can exacerbate emissions by disrupting regulatory consistency and encouraging reliance on environmentally damaging sectors (Halkos & Tzeremes, 2013).

Furthermore, among BRICS Plus members, institutional heterogeneity, ranging from democratic to state-led governance, creates uneven environmental accountability. For example, state capitalist systems (China, Russia) often demonstrate high administrative efficiency but limited transparency, while democratic systems (Brazil, South Africa) face political fragmentation that hinders consistent law enforcement. As a result, increased institutional effectiveness does not necessarily lead to ecological sustainability unless environmental mandates are embedded in institutional performance metrics.

In this study, the control variables include education, trade, foreign direct investment (FDI), population growth, and urbanization because of their potential impact on inclusive growth and the environment as described by previous studies (Ali et al., 2019; Anand et al., 2013; Annor et al., 2023; Dwiputri et al., 2018; Gyamfi et al., 2022; Kamah et al., 2021, 2021; Khan et al., 2021; Lau et al., 2014; Ofori et al., 2023). Based on the estimation results in Table 6, some important findings are obtained.

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Population growth and urbanization have a significant positive impact on environmental degradation, consistent with empirical evidence reported by Alam et al. (2016); Ali et al. (2019); Khan et al. (2021). This influence emphasizes the role of demographic dynamics as a catalyst for ecological pressure in BRICS Plus countries. Rapid population growth boosts demand for resources, especially energy, housing, transportation, and industrial goods, thereby worsening fossil fuel use and waste production. Likewise, faster urbanization, often paired with poor infrastructure planning and weak regulatory enforcement, leads to increased air pollution, land conversion, and ecological footprint growth.

Conclusion and Policy Implications

This study uses macroeconomic data from the nine BRICS countries (2000–2023) to examine how inclusive economic growth affects environmental degradation, particularly CO_2 emissions. While earlier research generally shows that economic growth produces harmful environmental externalities, this study expands the debate by incorporating inclusive growth into the Environmental Inclusive-Growth Kuznets Curve (EIKC) framework. This shift reflects a broader understanding of growth — one that evaluates not only its scale but also how widely its benefits are distributed.

From this perspective, the EIKC suggests an inverted U-shaped relationship between environmental quality and inclusive growth. As with the traditional EKC, early-stage inclusive growth raises emissions because of industrial and energy-intensive development. Once a certain level of inclusiveness is achieved, however, income redistribution, technological advancement, and human capital investments strengthen environmental preferences and help reduce emissions. These mechanisms effectively lower the EIKC curve.

Empirical evidence from a static panel Fixed Effects Model supports the EIKC hypothesis for BRICS Plus economies. This finding signals the importance of prioritizing inclusive growth in emerging economies; sacrificing inclusiveness for short-term expansion may undermine long-term sustainability.

Institutional quality also plays a crucial moderating role. Yet the study identifies a paradox: government effectiveness and regulatory quality, while essential for economic coordination, can intensify environmental degradation when growth-oriented institutions lack ecological safeguards. Rapid population growth and urbanization further strain the environment by increasing demand for resources and fossil fuel consumption, especially where regulatory capacity is weak.

The central policy challenge for BRICS Plus governments, therefore, is to align inclusive growth strategies with environmental objectives so that economic inclusion becomes a driver of ecological sustainability rather than a trade-off. Strengthening environmental laws, improving transparency in environmental spending, and integrating ecological accountability into bureaucratic performance evaluations can enhance institutional credibility and ensure that governance efficiency supports sustainability. Informal mechanisms, such as policy cohesion, decentralization, cultural norms, and public participation, can also reinforce long-term resilience, especially in countries with complex social structures like India and Ethiopia.

The study has several limitations. Aggregate indicators such as CO_2 do not capture the full extent of environmental pressures, including biodiversity loss or localized air quality issues. Future research could expand the analysis by using subnational datasets, alternative environmental indicators, or distinctions between formal and informal institutional arrangements to better understand non-linear interactions. Examining policy experiments, such as green industry incentives, environmental taxation, or just-transition programs, would also provide deeper insights into how inclusive growth can be aligned with environmental sustainability.

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ARTICLE INFO: received July 18, 2025; accepted November 18, 2025

ИНФОРМАЦИЯ О СТАТЬЕ: дата поступления 18 июля 2025 г.; дата принятия к печати 18 ноября 2025

doi 10.15826/recon.2025.11.4.025

Appendix 1

Estimation Results

Variable	CEM-OLS				REM				GMM			
	1	2	3	4	5	6	7	8	9	10	11	12
$LagCO_{2\,(-1)}$									0.447 (0.736)	0.154 (0.906)	0.066 (0.928)	−2.21 (2.20)
IGR	4.23*** (0.371)	1.35*** (0.461)	1.51*** (0.536)	3.15*** (1.06)	.959*** (.158)	1.35*** (.480)	1.51*** (.517)	3.15*** (.956)	−1.39 (2.00)	4.49*** (1.68)	1.05 (.765)	−1.47 (1.65)
IGR^2	−1.26*** (0.382)	−0.141 (0.241)	0.075 (0.250)	−0.285 (0.452)	−.319*** (.084)	−.141 (.246)	.075 (.246)	−.285 (.366)	−0.244 (0.971)	0.445 (0.997)	−2.00 (1.53)	2.12* (1.13)
IGR_SMC				64.6 (61.1)				64.6 (66.9)				
IGR_SMC^2				−110.2 (94.3)				−110.2 (108.2)				
Gov	2.16* (1.22)	−1.67** (0.700)		8.80 (6.94)	.902*** (.259)	−1.67** (.720)		8.80 (6.07)	−10.1* (5.96)			
Gov*IGR	4.75*** (1.39)	2.48*** (0.884)		0.856 (1.21)	.969*** (.271)	2.48*** (.945)		.856 (1.25)		−4.85* (2.88)		
Gov*IGR_SMC				−26.2 (20.3)				−26.2 (17.7)				
Reg	−2.65*** (0.683)		−1.74*** (0.533)	−1.74 (3.51)	.352 (.341)		−1.74*** (.496)	−1.74 (3.73)			3.32 (1.91)	
Reg *IGR	−.438 (0.986)		0.608 (0.639)	3.14** (1.34)	.025 (.257)		.608 (.681)	3.14** (1.25)				−4.97* (2.95)
Reg*IGR_SMC				0.321 (10.2)				.321 (11.6)				
Educ		0.081*** (0.009)	0.076*** (0.009)	0.107*** (0.018)		.081*** (.010)	.076*** (.012)	.107*** (.016)	−0.11 (0.082)	2.88** (0.047)	0.011 (0.020)	0.050*** (0.019)
Trade		0.110*** (0.012)	0.132*** (0.011)	0.187*** (0.023)		.110*** (.013)	.132*** (.011)	.187*** (.021)	−0.003 (0.006)	0.028** (0.013)	0.004 (0.003)	0.016** (0.006)
FDI		−0.48*** (0.098)	−0.40*** (0.095)	−0.33*** (0.188)		−.487*** (.084)	−.401*** (.088)	−.332** (.164)	−0.260 (0.197)	−0.030 (0.088)	0.151 (0.096)	−0.099 (0.073)
Population		−1.60*** (0.264)	−1.54 (0.205)	−1.43*** (0.380)		−1.60*** (.316)	−1.54*** (.295)	−1.43*** (.424)	−0.312 (0.907)	−5.24* (2.90)	−1.51 (1.03)	−0.351 (0.644)
Urban		−0.009 (0.019)	−0.015 (0.020)	−0.041 (0.031)		−.009 (.017)	−.015 (.018)	−.041 (.030)	0.123 (0.124)	0.116 (0.124)	0.167 (0.144)	0.276 (0.211)
Constant	5.31*** (.455)	1.23 (1.47)	.086 (1.26)	−11.2 (10.3)	6.90*** (1.07)	1.23 (1.34)	.086 (1.17)	−11.2 (10.6)	–	–	–	–

Online ISSN 2412-0731

doi 10.15826/recon.2025.11.4.025

Variable	CEM–OLS				REM				GMM			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Turning point (IGR*) %	2,6649	0,095175	–0,05663	0,448875					–0,16958	–0,99903	1,05	1,5582
No. of Obs.	144	114	114	72	114	114	114	72	111	111	111	111
No. of Countries					9	9	9		9	9	9	9
No of Instruments									24	24	24	24
Adjusted R^2	0.52***	0.88***	0.89***	0.93***								
F-test	43.82	134.47	145.37	105.3	107.60***	825.94***	874.61****	745.39***				
AR (2): P-value									0.657	0.009	0.469	0.711
Sargan-Hansen test									0.877	0.877	0.877	0.877
portmanteau test									0.438	0.437	0.427	0.437

Standard errors in parentheses; *** and ** indicate significance at 0.01 and 0.05 levels, respectively.
Note: The variable *IGR_SMC* is not included in the GMM models due to a limited number of observations, which resulted in its omission during estimation. As such, the effects of *SMC* are analyzed solely within the OLS framework.

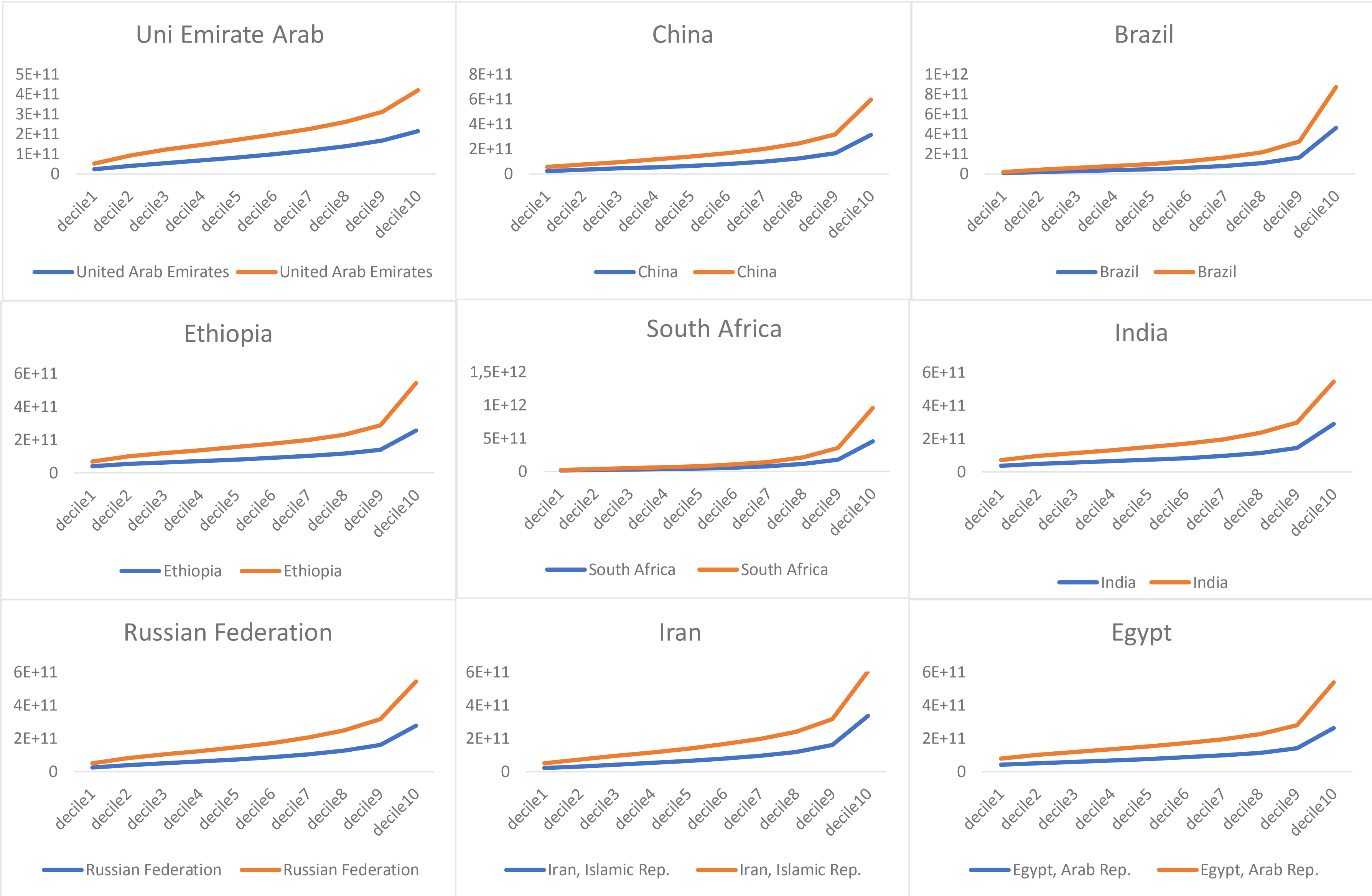
Source: Calculated by the authors

Online ISSN 2412-0731

doi 10.15826/recon.2025.11.4.025

Appendix 2

Distribution of BRICS on the inclusiveness matrix



Online ISSN 2412-0731