Jejak Vol 18 (2) (2025): hlm 18-30. DOI: https://doi.org/10.15294/jejak.v18i2.34203

JEJAK

Journal of Economics and Policy

http://journal.unnes.ac.id/nju/index.php/jejak

Heterogeneity of Inclusive Green Growth and Institutions: Spatial Evidence from BRICS Plus

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Permalink/DOI: https://doi.org/10.15294/jejak.v18i2.34203

Received: March 2025 ; Accepted: July 2025 ; Published: September 2025

Abstract

This study analyzes the dynamics of Inclusive Green Growth (IGG) and institutions in BRICS countries through descriptive analysis and clustering. Using post-pandemic cross-sectional data, the Inclusive Green Growth Index (IGGI) and Balanced Inclusive Green Growth Index (BIGGI) are calculated based on three pillars: economy, social equity, and environment. The results show that although economic and social performance is quite good, environmental performance is relatively weaker in BRICS countries. BIGGI reveals that economic growth in some countries often exceeds environmental sustainability. In the cluster analysis using hierarchical clustering through Ward's method, three distinct groups of countries were identified. The first cluster (China, Russia, Brazil, Iran) represents large emerging economies that depend on natural resources with governance and environmental challenges. Group 2 (Ethiopia, Egypt, South Africa, India) consists of developing countries experiencing rapid growth but constrained by social, environmental, and institutional weaknesses. Group 3 (United Arab Emirates) has effective governance and strong social indicators but faces severe environmental pressures and limited democratic performance. This finding highlights the heterogeneity of BRICS Plus in terms of IGG and institutionalism. Environmental and development cooperation within BRICS Plus must adopt strategies tailored to the challenges of each group to ensure progress toward inclusive and sustainable development.

Key words : Inclusive Green Growth, Institutions, Clustering, BRICS

How to Cite: Zulfia, B., Soesilowati, E., & Dwiputri, I, N. (2025). Heterogeneity of Inclusive Green Growth and Institutions: Spatial Evidence from BRICS Plus. *JEJAK: Jurnal Ekonomi dan Kebijakan,* 18(1). doi: https://doi.org/10.15294/jejak.v18i2.34203

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p-ISSN 1979-715X
e-ISSN 2460-5123

INTRODUCTION

Post-pandemic global economic growth has driven an increase in energy demand and accelerated industrialization, which in turn has had serious implications for the environment. In the global context, the emergence and development of BRICS is one of the main facts that reflects the political and geopolitical transformation of the spatial and historical transition of the current global economic system (Merino & Tianjiao, 2025). Their emergence on the international stage in 2009, after the 2008 crisis, was a breakthrough for global capitalism as well as a new geopolitical moment at that time. The COVID-19 pandemic in 2020 has accelerated fundamental trends in economic transition with the macro trend of the emergence of China and other emerging powers (Merino, 2022). According to Zhao (2023), this secular macro trend has been ongoing since the 1980s under China's leadership and is expected to continue. In 2001, O'Neil coined the acronym BRIC (brick), which refers to large emerging markets with growth contributions that have the potential to exceed those of the G7 in terms of global economic expansion. O'Neil further explained that one of the reasons for this was the fact that China's nominal GDP in that year was already greater than Italy's GDP (O'Neil, 2001). Twenty years later, China's nominal GDP has increased tenfold when adjusted for purchasing power parity; while India's has quadrupled, Russia's has nearly doubled, and Brazil's has exceeded 30 percent of GDP (World Bank, 2024). This economic growth is one dimension of the increasingly significant socio-historical transformation process in the BRICS countries (Wang & Chen, 2024).

The expansion of the BRICS Plus space with the inclusion of other regions in the Global South encourages the formation of constructive forces in promoting global economic growth, global governance (Menegazzi, 2020), and the democratization of international relations (Merino & Tianjiao, 2025). In addition to being leading countries in terms of GDP size, technology, globalization index, and renewable energy (Voumik & Sultana, 2022), ironically, BRICS countries are also the largest contributors to emissions, responsible for a quarter of global CO_2 emissions (Sharma et al., 2021).

Currently, combating climate change and reducing greenhouse gas emissions are important priorities on the agenda of BRICS countries (Tripathi & Bhattacharya, 2023; Voumik & Sultana, 2022). Collective commitment is demonstrated through various initiatives, such as climate change mitigation, which is one of their main areas of focus, as reflected in their commitment to outline international development priorities and global cooperation in addressing climate change until 2030 (Gladun & Ahsan, 2016). In 2015, BRICS initiated the formation of the BEST or BRICS Environmentally Sound Technology platform with the aim of facilitating EST exchange. In addition, the New Development Bank (NDB), a multilateral development bank, was launched and operated by BRICS in the same year. The NDB focuses on a number of areas such as sustainable urban development, economy, transportation infrastructure, and clean energy. Subsequently, BRICS countries expressed their willingness to continue working constructively with other parties to complete negotiations related to the UNFCCC in Katowice, and reaffirmed their commitment to implementing the Paris Agreement (Ministry of Foreign Affairs, 2022; Tripathi & Bhattacharya, 2023). However, challenges remain due to the heterogeneity of institutional quality among countries, which can affect the effectiveness of environmental policy implementation.

In the literature on economic growth and the environment, the inclusive approach emphasizes broader aspects than conventional growth. Inclusive green growth is a concept of sustainable development introduced at the United Nations Conference on Sustainable Development 2012 (Chen et al., 2020). This approach broadens the traditional perspective of growth to include improved welfare (Berkhout et al., 2018), focusing on integrated growth between the economy, society, and ecology (Li et al., 2021; Wu & Zhou, 2021), thereby achieving comprehensive and harmonious growth in economic, social, and environmental terms (Ren et al., 2022).

Based on empirical phenomena and gaps in the literature, this study attempts to examine inclusive green growth in BRICS Plus countries by simultaneously integrating economic, social, and environmental dimensions. The analysis focuses on spatial mapping and post-pandemic clustering, which enables the identification of internal heterogeneity in inclusive green growth achievements and institutional characteristics. Thus, this study not only provides an up-to-date empirical figure but also presents practical implications for future BRICS environmental cooperation.

The main objective of this study is to categorize BRICS countries based on inclusive green growth and institutional quality indicators. The results of the analysis are expected to explain the internal diversity among BRICS members and identify relevant opportunities and challenges in promoting the sustainable development agenda at the regional and global levels.

RESEARCH METHODS

This study is designed as a quantitative study because it involves the collection and analysis of numerical data with a focus on measuring the inclusive green growth index (IGGI). Referring to the inclusive green growth indicators developed by the Asian Development Bank (2018), this study uses post-pandemic data from 2022 with a cross-sectional approach. The units of analysis include nine countries: Brazil, Russia, India, China, South Africa, Iran, UAE, Ethiopia, and Egypt.

The Inclusive Green Growth Index divides the main variables of the study into three dimensions. First, the economic dimension, which is measured through indicators such as GDP growth rate, international trade, market concentration index, and dependency ratio. Second, the social dimension, which includes employment ratio, life expectancy, labor force participation, mortality rate, electricity access, and primary completion rate. Third, the environmental dimension, which is proxied by indicators of natural resource rent, availability of renewable freshwater resources, water productivity, and carbon dioxide (CO_2) emission levels. The following are the steps taken to compile the IGGI as referred to in the Asian Development Bank (2018) dan Mu'min et al. (2024).

Data normalization for each indicator using the maximum-minimum method.

- Normalization for indicators has a positive effect on the preparation of the IGGI.

$$Z = 5\ x\ \frac{country\ score - minimum\ value}{maximum\ value - minimum\ value} + 1 \quad \text{.....(1)}$$

- Normalization for indicators that have a negative effect on the preparation of the IGGI

$$Z = -5\ x\ \frac{country\ score - minimum\ value}{maximum\ value - minimum\ value} + 6 \quad \text{.....(2)}$$

1. After normalization, calculate the average of each indicator based on the

grouping of each pillar to form the economic, social, and environmental pillar values.

2. The values of each pillar are calculated in aggregate to form the IGGI using the following formula

$$IGGI = \frac{1}{3}(average\ economic\ pillar) + \frac{1}{3}(average\ social\ equity\ pillar) + \frac{1}{3}(average\ environtmental\ pillar) \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In addition to calculating the IGGI value, further calculations are needed, namely the IGGI Balance, to identify whether the three pillars have the same performance, with the following steps:

Calculate the total absolute gap

$$Total\ absolute\ gap = |economic\ pillar - social\ equity\ pillar| + |social\ equity\ pillar\ environmental\ pillar| + |environmental\ pillar - economic\ pillar| \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Normalization of absolute total values

$$= -5\ x\ \frac{total\ gap\ score - minimum\ value(gap)}{maximum\ value\ (gap) - minimum\ value\ (gap)} + 6 \quad \ldots\ldots (5)$$

Finally, calculate the BIGGI value using the equation

$$BIGGI = \frac{3}{4}(IGGI) + \frac{1}{4}(CPB) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Cluster analysis is a multivariate technique that functions to group objects based on their characteristics so that they are grouped according to the similarities of each group's characteristics (Muthahharah & Juhari, 2021). Hierarchical clustering methods can be agglomerative and can be formed through four approaches, namely single linkage, complete linkage, average linkage, and Ward's method (Aprilia et al., 2016). This study uses the hierarchical clustering method with the Ward's Method approach and the Squared Euclidean Distance measure the distance between objects which is visualized through a dendrogram to determine the most appropriate number of clusters. Ward's Method is used to minimize variance in clusters by calculating the Sum of Squared Errors (SSE) as in equation (7), so that each cluster formed is more homogeneous (Fathia & Rahmawati, 2016; Muthahharah & Juhari, 2021)

$$SSE = \sum_{j=1}^{p}\left(\sum_{i=1}^{n} x_{ij}^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_{ij}\right)^2\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where x_ij is the value for object i in cluster j, p is the number of variables measured, and n is the number of objects in the cluster formed.

After determining the optimal number of clusters, the analysis stage continues through the application of the non-hierarchical K-Means Clustering technique to obtain a more precise grouping configuration (Dwiputri et al., 2022). Next, the interpretation and validation of the cluster results are carried out by examining the output generated by the K-Means method, accompanied by an analysis of variance (ANOVA) test as an instrument to identify statistically significant differences between the groups formed (Ritonga, 2016).

RESULTS AND DISCUSSION

Descriptive statistical analysis of the pillars that make up the Inclusive Green Growth Index (IGGI) provides a comprehensive overview of the distribution and variation of development achievements in BRICS countries (see Table 1).

Table 1. Descriptive Statistics

Country	Economy	Social	Environment
China	2,48	4,82	1,77
Russian Federation	3,03	4,07	3,88

Brazil	2,58	4,26	2,69
Iran	3,02	4,00	2,75
Ethiopia	1,77	3,10	1,26
India	3,05	3,73	1,21
Egypt	2,19	3,18	1,29
South Africa	2,30	3,08	1,73
United Arab Emirates	2,56	4,89	4,19

The IGGI simultaneously reflects the complexity of inclusive and sustainability-oriented growth. In addition to the IGGI, a Balanced Inclusive Green Growth Index (BIGGI) was also calculated, which can serve as a barometer of development equity, as it accommodates social and environmental aspects (Mu'min et al., 2025).

Table 1. Descriptive Statistics (continued)

Country	IGGI	BIGGI
China	3,02	2,52
Russian Federation	3,66	4,24
Brazil	3,18	3,48
Iran	3,26	3,81
Ethiopia	2,04	2,54
India	2,66	2,57
Egypt	2,22	2,63
South Africa	2,37	3,09
United Arab Emirates	3,88	3,61

Source : Calculated by Author

Table 1 presents the IGGI and BIGGI calculations for the nine BRICS Plus member countries. In general, all countries scored above 2.0, which means that in terms of performance, these regions have achieved sufficient economic growth in social and environmental aspects in the post-pandemic period, although the environmental pillar score is still lower than the other pillars. However, there are significant variations between countries in economic, social, and environmental aspects.

Further identification can be analyzed through the performance equality of the three pillars that make up the IGGI by comparing them to the BIGGI score. The development of each pillar is said to be equivalent if the BIGGI value is higher than the IGGI (Aminata et al., 2022). India, China, and the United Arab Emirates have BIGGI values that are lower than IGGI, while other countries have recorded a balance in the development performance of the three pillars with BIGGI values that are greater than IGGI.

Overall, the highest IGGI scores were recorded by the UAE (3.88) and Russia (3.66), which illustrate relatively solid and balanced IGG achievements. Meanwhile, the lowest index scores were recorded by Ethiopia (2.04) and Egypt (2.22), highlighting fundamental limitations in economic, social, and environmental aspects. Higher BIGGI scores in Russia (4.24) and South Africa (3.90) indicate a relatively more balanced distribution. In addition, lower BIGGI scores in India (2.57), China (2.52), and the UAE (3.61) reflect imbalances in development, particularly in the environmental pillar.

Figure 1. Spatial Map of the Inclusive Green Growth Index (IGGI) in BRICS Plus Countries

In the economic dimension, India (3.05) and Russia (3.03) recorded the highest scores, reflecting economic growth with

significant momentum for national development. In contrast, Ethiopia (1.77) was the country with the lowest economic performance. This illustrates the limited structural capacity to support growth, while also pointing to sharp economic disparities within the BRICS group (see Figure 2).

Figure 2. Spatial Map of Economic Pillars in BRICS Plus Countries

The performance of the social equity pillar shows relatively higher achievements compared to the other two pillars that make up the IGGI. The United Arab Emirates (4.89) and China (4.82) have the highest scores, indicating substantial progress in social welfare indicators such as labor, health, infrastructure, and education. On the other hand, Ethiopia (3.10) and South Africa (3.80) have the lowest social equity pillar scores. The low social equity pillar scores in these countries indicate that there are still challenges in terms of equitable access to and quality of social services (see Figure 3).

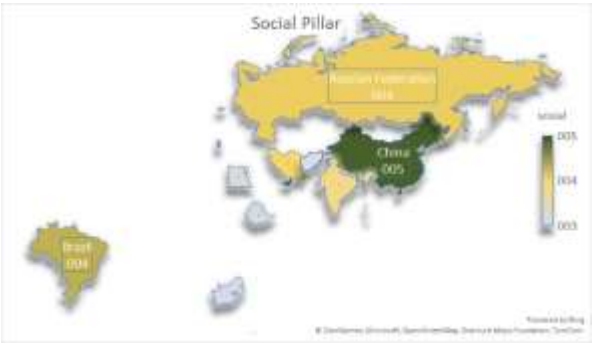

Figure 3. Spatial Map of Social Pillar Values in BRICS Plus Countries

The next pillar is the environment, which remains a weak point in achieving inclusive green growth in BRICS countries. Almost all countries scored lower than the economic and social pillars. India (1.21) and Ethiopia (1.26), for example, have low environmental performance, indicating high ecological pressure due to industrialization and weak mitigation capacity in maintaining the sustainability of natural resource production in line with climate change. Conversely, Russia (3.88) and the UAE (4.19) show relatively higher environmental performance, although still lower than the social pillars of each country. The findings of this analysis reinforce that environmental issues remain a structural challenge that has not been optimally integrated into the growth agenda in BRICS (see Figure 4).

Figure 4. Spatial Map of Environmental Pillar Values in BRICS Plus Countries

There are several important notes regarding the index results. First, the high social pillar scores in a number of BRICS countries are in line with the study by Zulfia et al. (2024), which emphasizes that increased employment opportunities can drive inclusive economic growth, as demonstrated in the case of East Java. This confirms that the social dimension serves as an important foundation, particularly through improved access to education, health, and the labor market. Second, the analysis of the environmental

pillar reveals significant diversity among countries. For example, Russia, which has a relatively stable economy, has a higher environmental score than India or Ethiopia. This is consistent with the arguments of Klasen (2010) and Wafiq & Suryanto (2021), who state that environmental quality can be maintained with relatively inclusive economic growth, because economic success provides fiscal and technological space to reduce environmental damage.

However, differences in achievements between pillars in several countries—such as the high gap between economic, social, and environmental pillars—show that green inclusive growth is still not balanced. To understand these variations more deeply, an institutional perspective needs to be added. Governance quality can serve as an important dimension that distinguishes the characteristics of BRICS Plus countries. By incorporating institutional factors into the IGG cluster analysis, this study not only highlights the performance of green inclusive growth, but also maps how the combination of governance and sustainable development shapes the pattern of internal heterogeneity within BRICS Plus. This approach allows for the identification of groups of countries with similar development and institutional profiles, while providing a stronger foundation for policy recommendations on environmental and economic cooperation in the region.

The results of hierarchical cluster analysis visualized through a dendrogram (Figure 5) show that the nine BRICS Plus member countries can be grouped into three main clusters based on similarities in economic, social, environmental, and institutional characteristics.

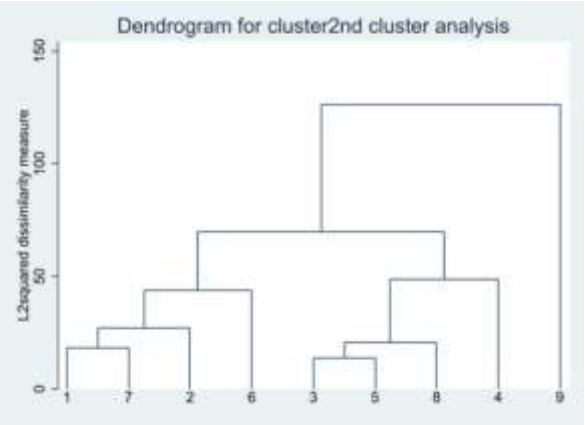

Figure 5. Hierarchical Cluster Analysis Dendrogram

In the next stage, the average value of each variable in z-score was clustered using a non-hierarchical method or K-means, so that the initial value of each cluster could be determined (Table 2). The final results of the K-Means analysis summarized in Table 3 show the averages (final cluster centers) of various economic, social, environmental, and governance indicators for each cluster. These results reveal significant differences in development structures between groups.

Table 2. Initial Cluster Centers

	Cluster		
	1	*2*	*3*
Zscore(GDP)	-0.35	0.58	-0.94
Zscore(TRD)	-0.33	-0.32	2.59
Zscore(MCI)	0.41	-0.37	-0.16
Zscore(ADP)	0.84	-0.50	-1.36
Zscore(EMP)	0.30	-0.68	1.52

Zscore(LEX)	0.50	-0.87	1.47
Zscore(LFP)	0.14	-0.12	-0.07
Zscore(MOR)	-0.66	0.90	-0.99
Zscore(ELC)	0.44	-0.55	0.44
Zscore(PCR)	0.46	-0.58	0.47
Zscore(NR)	0.40	-0.58	0.72
Zscore(RWS)	0.66	-0.52	-0.57
Zscore(WP)	-0.22	-0.44	2.62
Zscore(CO)	0.12	-0.65	2.12
Zscore(DI)	-0.15	0.44	-1.18
Zscore(VO)	-0.29	0.39	-0.41
Zscore(PS)	-0.10	-0.37	1.92
Zscore(GE)	-0.37	-0.13	1.98
Zscore(RO)	-0.49	-0.01	1.99
Zscore(RL)	-0.58	0.13	1.79
Zscore(COC)	-0.45	-0.12	2.27
Zscore(CPI)	-0.43	-0.13	2.23

Source : World Development Indicators (World Bank); Worldwide Governance Indicators; Democracy Index, 2025 (processed by authors).

When setting foot in Vietnam, the first The first cluster is characterized by moderate economic growth (GDP of 3.06%) and a relatively balanced trade level reaching 36.26% of GDP. Although the economic and social pillars are relatively strong, this cluster shows dependence on natural resources with an average natural resource rent of 14.65% of GDP. Social indicators are relatively good, with life expectancy (LEX) reaching 75.61 years and nearly full and equitable electrification of the population. However, the biggest challenge lies in the environmental dimension. Although the availability of fresh water is quite high, as seen from the renewable fresh water resources (RWS) of 15,062 m^3 per capita, carbon emissions are also quite high at 8.03 metric tons per capita. In terms of governance, relatively negative scores for voice and accountability (-1.02) and rule of law (-0.63) indicate institutional limitations, although the level of corruption, as seen from the CPI value of 3.40, is relatively better than other clusters. Thus, this cluster can be categorized as a large economy with governance and environmental challenges.

Table 3. Final Cluster Centers

Variable	*Cluster*		
	1	*2*	*3*
	4	*4*	*1*
GDP	3.06	4.43	2.18
TRD	36.26	36.84	186.21
MCI	0.10	0.06	0.07
ADP	18.17	8.33	2.07
EMP	60.34	48.60	75.02
LEX	75.61	68.77	80.49
LFP	63.89	56.74	58.10
MOR	8.08	25.95	4.20
ELC	100.00	85.18	100.00
PCR	99.01	86.16	99.17
NR	14.65	5.38	17.63
RWS	15062.32	689.70	15.67
WP	21.05	9.06	173.93
CO	8.03	2.73	21.72

VO	-1.02	-0.43	-1.13
PS	-0.87	-1.09	0.74
GE	-0.42	-0.25	1.30
RO	-0.84	-0.48	1.03
RL	-0.63	-0.19	0.84
COC	-0.67	-0.44	1.16
CPI	3.40	3.78	6.70
DI	-0.50	3.75	-8.00

Source: World Development Indicators (World Bank); Worldwide Governance Indicators; Democracy Index, 2025 (processed by authors).

The second cluster has higher economic growth characteristics with an average GDP of 4.43%, but relatively weak social and environmental indicators. The employment ratio is lower than the other two clusters, with a high mortality rate of 25.95 per 1,000 live births. Access to electricity is lower at 85.18%, and primary school completion rates (PCR: 86.16%) also lag behind the other two clusters. From an environmental perspective, the natural resource rent value is only 5.38% and water availability is very low (RWS: 690 m^3 per capita), although carbon emissions are relatively low with carbon dioxide at around 2.73 metric tons per capita. In terms of institutions, the scores are relatively negative in almost all indicators. With a higher democracy index (DI of 3.75), this cluster appears to face a dilemma between democratization and governance effectiveness. Overall, this cluster can be labeled as a developing economy with social-environmental and institutional burdens.

Figure 6. Cluster Analysis of BRICS Plus Countries Based on Economic, Social, Environmental, and Institutional Indicators

The UAE occupies a separate cluster with a very distinctive profile. From a social perspective, the UAE scores highest with an employment ratio of 75.02%, life expectancy of 80.49 years, and almost universal access to electricity and basic education for the entire population. The economy is very open, as indicated by a very high trade ratio (TRD) of 186.21% of GDP, reflecting a heavy dependence on exports and imports. However, this is offset by serious environmental pressures: carbon emissions reach 21.72 tons per capita and water availability is very low (RWS: 15.67 m^3 per capita). The UAE's governance actually shows positive scores, including government effectiveness (1.30), rule of law (0.84), control of corruption (1.16), and a CPI score of 6.70 much higher than the other two clusters. However, democracy is recorded as negative (DI: -8.00), indicating authoritarianism with highly effective governance. Thus, the UAE can be positioned as a best practice in governance and social development, but with serious challenges in energy transition and democratization.

CONCLUSION

A descriptive analysis of the Inclusive Green Growth Index (IGGI) shows that most BRICS Plus countries have achieved relatively good performance in the economic and social dimensions, but the environmental pillar still lags behind. The Balanced IGGI (BIGGI) score provides an additional figure of the equality of development between pillars, with some countries such as India, China, and the United Arab Emirates showing imbalances due to the dominance of the economic or social dimensions over the environment. In contrast, other countries such as Russia and Brazil are relatively more balanced. This fact indicates that the achievements of inclusive green growth after the pandemic have not been entirely evenly distributed, with the biggest challenge lying in the aspect of environmental sustainability.

The next step, through non-hierarchical cluster analysis, produced three groups of countries with different characteristics. The first cluster (China, Russia, Brazil, Iran) is characterized by large economies with dependence on natural resources and environmental governance challenges. The second cluster (Ethiopia, Egypt, South Africa, India) features developing countries with relatively high economic growth, but overshadowed by social, environmental, and institutional constraints. The third cluster (United Arab Emirates) forms a separate group with effective governance and high social achievements, but faces environmental pressures and a democratic deficit.

These results confirm the internal heterogeneity of BRICS Plus, both in terms of green inclusive development and governance. Therefore, environmental and development cooperation strategies within the BRICS Plus framework cannot be implemented uniformly, but must be tailored to the characteristics of each cluster. A differential policy approach is important to ensure that the green inclusive growth agenda can be achieved without neglecting the specific challenges faced by each country.

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