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Analysis of the BRICS countries' pathways towards a low-carbon environment

Agyemang Kwasi Sampene,*
School of Management, Jiangsu University (China)

Cai Li,
School of Management, Jiangsu University (China)

Fredrick Oteng Agyeman,

School of Management, Jiangsu University (China)

Robert Brenya,

Agricultural Economics and Management,
Nanjing Agricultural University (China)

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Abstract

Global climate change has emerged as humanity's greatest challenge, affecting both the natural security of the earth and the long-term growth of human society. Protecting the environment and fostering long-term growth while reducing carbon emissions has become a global concern. The BRICS countries (Brazil, Russia, India, China, and South Africa) are participating in the fight against climate change through the promotion of low-carbon environment (LCE). In this study, we use content analysis to discuss some of the policies, plans, and programs outlined by the various governments in the BRICS that can help them implement an LCE. The study indicates that currently Brazil, Russia, India, China, and South Africa are rated as "insufficient," "critically insufficient," "compatible," "incompatible," and "highly insufficient" respectively in their commitment to nationally determined contributions (NDC) to the Paris Agreement. The paper recommends that the BRICS countries achieve an LCE through expanding low-carbon investments and financing, focusing on taxation that goes beyond energy, investing in low-carbon cities, adapting to a circular economy and low-carbon technologies, expanding electricity markets, and promoting climate-friendly international trade among the BRICS countries.

* E-mail of the corresponding author: akwasiagyemang91@gmail.com

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Introduction

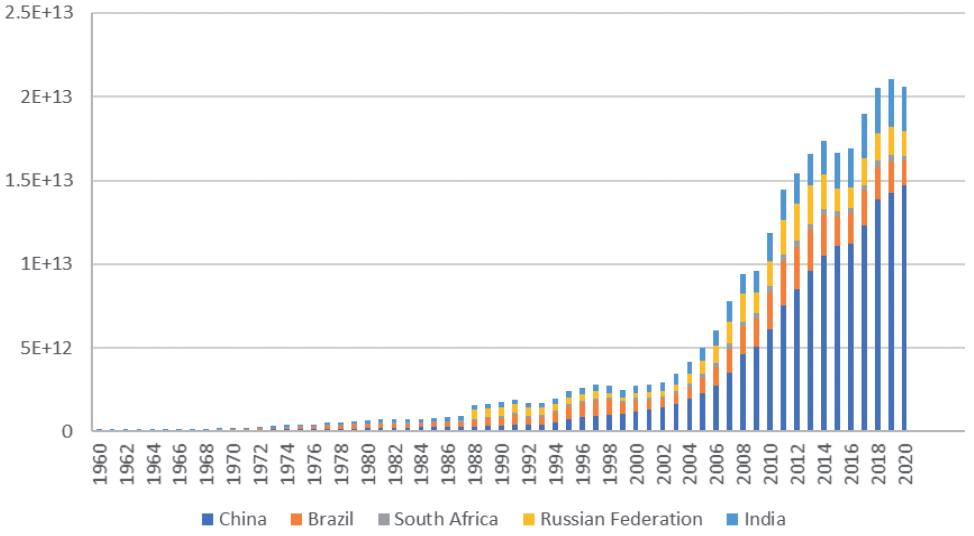
Low-carbon environment (LCE) implementation has become the subject of controversy among governments, scientists, policymakers, and the general public due to the obstacles associated with climate change (CC) and global warming. Economists have tried to assess the socio-economic performance of various countries through the lens of social and environmental welfare, taking into account the environmental and social costs of economic growth (Sheikh, 2021). The primary purpose of an LCE is to reduce global greenhouse gas (GHG) emissions and mitigate the effects of CC (Yang et al., 2019). According to a recent report by the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), global temperatures, GHG emissions, and other factors are increasing exponentially to stages that will have a devastating impact on society (Kirton, 2020). The United Nations report on climate indicates that rising sea levels, permanent changes in ocean currents, the hydrological cycle, vulnerable ecosystems, and more extreme weather events are among the many environmental issues posed by rising emissions (United Nations, 2020). A slew of environmental problems has escalated in the 21st century. Governments worldwide are looking for policies, rules, and ways to reduce the negative impact of socio-economic activities on the environment (Su & Pan, 2019).

Due to the need to protect the environment and foster long-term growth, reducing carbon emissions has become a global concern. During the 1997 Kyoto Protocol, the United Nations Framework Convention on Climate Change (UNFCCC) declared that signatory countries must reduce their GHG emissions by an average of 5% below their 1990 baseline between 2008 and 2012 (Lin et al., 2019). As a result of the UNFCCC Protocol, governments worldwide have implemented regulations to achieve this objective. Although the BRICS countries (Brazil, Russia, India, China, and South Africa) have signed the UNFCCC Kyoto Protocol to reduce emissions, there are still concerns about environmental issues in light of the recent economic boom in these countries (Zakarya et al., 2015). The current agreement on CC is the goal of the Paris Agreement for countries achieving warming below 2°C. The Paris Agreement and the 2030 Agenda for Sustainable Development represent a blueprint for an LCE, as well as climate change (CC) resilient and sustainable future for all countries that needs to be implemented as soon as possible (UNFCCC, 2018).

Over the past 60 years, the BRICS economies have consistently demonstrated high rates of economic development. It is estimated that by 2025, the BRICS economies will account for 50% of the global economy (Liu et al., 2020; Wilson & Purushothaman, 2003). CC has become a fundamental challenge that the BRICS nations and the rest

of the world are facing since 2020 (Kirton, 2020). The BRICS countries differ from each other in terms of cultural background, language, and economic structure. However, these countries have one thing in common: their economic development has exceeded that of the world's major industrialized nations. The BRICS countries continued to outperform the rest of the globe even after the global financial crisis began in 2007. While emerging economies on average decreased by 6% in 2009, Brazil remained stable, India expanded by 5.9%, and China grew by 8.1 %; the group's worst performer was Russia, which shrank by 7% (Zakarya et al., 2015).

The BRICS countries' contribution to global economic growth and development should not be underestimated. The financial assistance of these countries stems from the role that entrepreneurs and companies play in such industries as construction, manufacturing, mining, and others. The gross domestic product (GDP) per capita of the BRICS countries is shown in Figure 1. These figures indicate that the BRICS countries' GDP per capita has increased from $21,240 in 1960 to more than $ 20 trillion in 2020 (Liu et al., 2020). Specifically, in 2018, nominal growth of GDP in the BRICS countries accounted for 23% of global output (Liu et al., 2020).

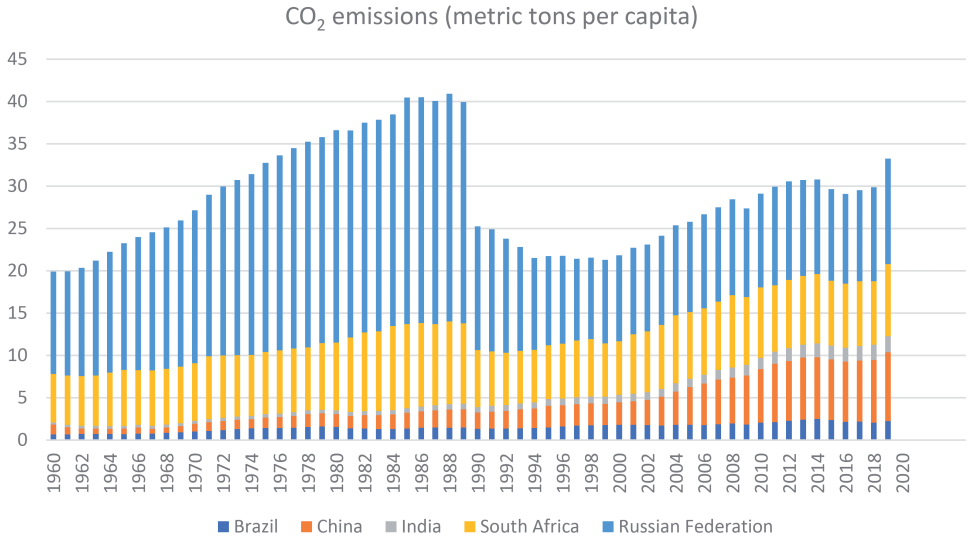


Source: (World Bank Data, 2021).

Figure 1. Dynamics of GDP of the BRICS countries per capita from 1960 to 2020

Concerns were expressed about the BRICS countries' social and environmental resilience. For these countries, bridging the economic and ecological gap and minimizing CC is critical for international sustainable development (Dong et al., 2017; Wang et al., 2016). Deterioration of the environment makes us aware of the consequent excessive CO_2 emissions, which contribute considerably to the GHG effect on global economic development (Dong et al., 2017). The BRICS nations had a significant impact on recent international economic growth, as well as on the environment and natural resources in recent decades (Tian et al., 2020). Figure 2 shows trends in CO_2 emissions per capita

in the BRICS countries from 1960 to 2019. The figures shows an increase in CO_2 emission due to the growth of economic development of the BRICS countries.



Source: (World Bank Data, 2021).

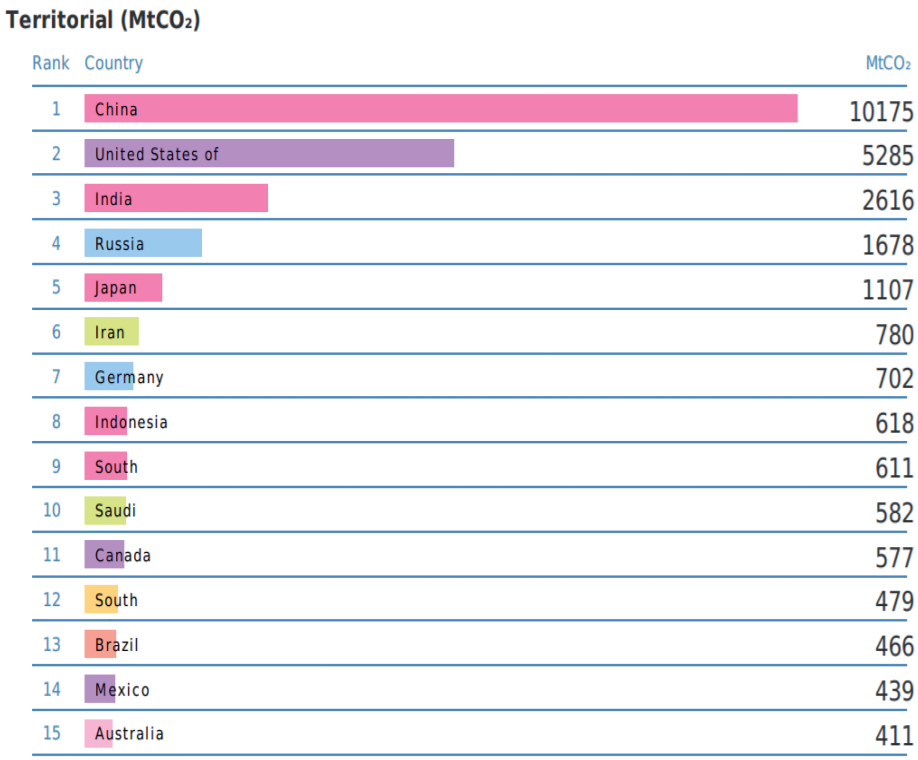
Figure 2. CO_2 emissions per capita in the BRICS countries from 1960 to 2019

Economists examined the socio-economic performance of various countries through the lens of social and environmental welfare, considering the social and ecological consequences of economic expansion (Sheikh, 2021). Recently, most countries have switched their attention to environmental protection and simultaneous development of their economies (L. Zhang et al., 2019). The interests of corporate entities, enterprises and lawmakers have evolved to encourage and develop new sustainable economic models that can be labeled "green" (Gibbs & O'Neill, 2015). Entrepreneurs are strongly encouraged to engage in green entrepreneurship, which benefits both the economy and the environment. Green entrepreneurship, which combines environmental, social and economic goals, is identified as a viable strategy for establishing a sustainable society (Soomro et al., 2020; Ye et al., 2020).

Global climate change has emerged as humanity's greatest challenge, affecting both the earth's natural security and the long-term growth of human society. As a result, lowering GHG emissions and slowing the trend towards climate change have become a significant concern worldwide. Therefore, it is critical to develop an LCE to address long-term economic and environmental issues (H. A. O. Li et al., 2020). The sustainability of the biological ecosystem is threatened by an increase in total CO_2 emissions, which also substantially impacts human society. CO_2 emissions associated with climate change have long been labeled a "super wicked problem," severely affecting human well-being (Liu et al., 2020). Firms in developing economies are reluctant to initiate significant green initiatives due to weak rules and regulations that fail to protect against unethical behavior

and the lack of well-developed communication channels for championing the enormous benefits of green initiatives (Shu et al., 2014; Zhou et al., 2020).

The concept of LCE and renewable energy is vital for all international communities due to the current dual difficulties in the world (the climate crisis and the need for economic development). The international community encompasses entrepreneurs and other key stakeholders who can help ensure a safe environment for human survival (Liu et al., 2020). Alister and Chloé (2020) note that, thanks to proposals to link stimulus packages to battle the coronavirus with a cleaner economy, all governments are under pressure to proclaim more ambitious climate actions within the Paris Climate Agreement's first five-year milestone. As can be seen from Figure 3, the BRICS countries are widely represented among the world's major carbon emitters, with all five countries ranking among the top fifteen. Almost two-fifths of the world's carbon emissions are attributed to BRICS. As a result, environmental sustainability concerns have been raised in the context of the BRICS countries (Wang et al., 2016).



Source: (Global Carbon Atlas, 2019).

Figure 3. Top fifteen metric tons of carbon dioxide equivalent ($MtCO_2$) in 2019

Global warming, climatic disasters, and climate transition risks can cause economic crises in developed and developing countries, resulting in increased financial instability, rising volatility of exchange rates, and a slowdown in growth rates (Bolton et al., 2020).

Climate disasters are becoming more common, endangering the lives and livelihoods of millions of people worldwide. Climate risks may force countries to take a path of lower growth marked by greater financial volatility, budgetary limitations, and poverty traps, in addition to a rapid economic and social catastrophe (Semmler et al., 2021). This is especially true for more vulnerable developing countries, many of which have been disproportionately affected by the economic consequences of COVID-19 (Semmler et al., 2021).

During the last BRICS summits in Xiamen 2017 and Johannesburg 2018, the BRICS leaders reaffirmed their decision to take resolute action in dealing with climate change through the Xiamen Declaration and the Johannesburg Declaration. Under the motto of Xiamen "BRICS: Stronger Partnership for a Brighter Future," the leaders pledged to strengthen BRICS cooperation in the field of climate change and expand green financing, as well as take actions to promote result-oriented cooperation in areas such as air and water pollution prevention, waste management, and biodiversity conservation (Petrone, 2019).

This requires research on further ways to enhance an LCE, especially in the BRICS countries where economic growth is observed. Given the scale of the fight against the terrible effects of climate change in the world, this study is essential. This study contributes to the discussion of multi-level policy, and plans adopted by the BRICS countries to achieve LCE. In addition, to achieve success in reducing the global CO_2 emissions and preventing the catastrophic impact of climate change in the BRICS countries, the governments in these countries, through the effort of various actors, are developing policies that can lead to the achievement of this target. It is necessary that the state decarbonization policy and equitable transition to green economy are coordinated at the international, national, and local levels. Furthermore, this study includes policy recommendations that will help generate fresh ideas for future low-carbon development and guide future practices in tackling CC in the BRICS countries.

This study discusses international, federal, and local climate policies set out by various governments in the BRICS countries to achieve an LCE through a multi-level perspective. Thus, the discussion will cover: fundamentals of the climate change reduction policy, trends and policies in the field of low carbon energy, as well as trends and policies in the field of energy efficiency. In addition, the research examines six important categories of the Climate Action Tracker (CAT) to assess each country's commitment to the Paris Agreement and the UNFCCC protocols.

The concept of an LCE was initially introduced in the United Kingdom's White Paper in 2003. LCE aims to increase economic production by reducing CO_2 and GHG emissions (Yin & Shi, 2019). The primary source of climate change is the increase in GHG emissions from human activity, particularly CO_2 emissions. As a result, establishing an LCE has become a universal consensus in fighting against global warming. According to a recent estimate by the Carbon Trust, global low-carbon exports will exceed $1 trillion by 2020 (Baranova, 2017). LCE can be defined as an economic model that aims at the minimum consumption of carbon energy (coal, oil, etc.) and output of GHG, specifically CO_2 (Zhao & Wu, 2010). The World Low Carbon and Eco-economy Conference

and Technical Exposition reports that LCE aims to use high technology, high energy efficiency, high economic benefit, low energy consumption, low pollution, and low emission by stakeholders (Zhao & Wu, 2010).

LCE is defined as "a way of thinking, behaving, and operating that minimizes carbon pollution while allowing for resource sustainability, economic development, and higher quality of life" (Baranova, 2017). Therefore, environmentally sustainable technologies are critical for tackling CC and easing the transition to an LCE (Demirel et al., 2019). The goal of an LCE is to improve the quality of life of people by increasing the efficiency of resource utilization and reducing emissions into the environment. Economic, commercial, and technical shifts will accelerate the need for global LCE. Governments, businesses, and consumers must work together to implement an LCE (Ding et al., 2018; Robertson, 2016; Yan et al., 2019).

2. Materials and methods

2.1. Description of the research area

This study focuses on the BRICS countries (Brazil, Russia, India, China, and South Africa). The abbreviation (BRIC) was created in 2001 to spotlight the growing economies such as Brazil, Russia, India, and China (BRIC), and South Africa was added in 2010, which changed the name of the bloc to BRICS (Morazán et al., 2012). The four participating countries began their annual informal diplomatic cooperation in 2006 when their Foreign Ministers met at the UN General Assembly's General Debate (UNGA). The BRICS was founded on the member-countries' long-term economic goals, including revamping the global financial and economic infrastructure, improving international law principles and norms, and promoting complementarity in many sectors of their economy (Kundu, 2016).

The total area of the BRICS countries is 39,746,220 km^2 (15,346,101.0 sq mi) with a population of approximately 3.21 billion people, accounting for about 26.656 % of the world's land surface and 41.53 % of its population. With the exception of South Africa, which ranks twenty-fourth in both population and area, four of the five nations are among the world's ten largest countries in terms of population and size (United Nations, 2019). The BRICS countries were selected for the present study because they expressed concerns about social and environmental resilience. Coordinating the interaction of the environment and the economy and minimizing the global warming impact is crucial for the international sustainable development of the BRICS countries (Dong et al., 2017; Wang et al., 2016).

2.2. Methodological approach

The methodology of this paper is based on data collected from the Climate Action Tracker (CAT) database. The CAT methodically approaches six critical areas in assessing

every country's commitment to nationally determined contributions (NDC) to the Paris Agreement and the UNFCCC protocols. Table 1 explains these six criteria of the CAT assessment. The Climate Action Tracker (CAT) project was launched in 2009 to provide policy makers, civil society and the media with an up-to-date assessment of countries' individual emission reduction targets and a global overview of their combined effects. All this is being done in order to make these pledges more transparent and to encourage the participation of those governments that have not yet done so. In addition, the CAT assesses whether countries are on track to meet their commitments in accordance with the current policies (Climate Action Tracker, 2021e).

Table 1. Criteria for nationally determined contributions to the Paris Agreement

Nationally determined contributions to the Paris Agreement	Meaning
Critically insufficient	NDCs with this rating fall outside of a country's "fair share" range and are not at all consistent with holding warming below 2°C, let alone with the Paris Agreement's stronger 1.5°C limit
Highly insufficient	NDCs with this rating fall outside of a country's "fair share" range and are not consistent with holding warming below 2°C, let alone with the Paris Agreement's stronger 1.5°C limit
Insufficient	NDCs with this rating are in the least stringent part of a country's "fair share" range and not consistent with holding warming below 2°C, let alone with the Paris Agreement's stronger 1.5°C limit
Compactible	NDCs with this rating are consistent with the 2009 Copenhagen 2°C goal and therefore fall within a country's "fair share" range but are not entirely consistent with the Paris Agreement
1.5°C Paris Agreement Compactible	This rating indicates that a government's efforts are in the most stringent part of a country's "fair share" range: it is consistent with the Paris Agreement's 1.5° C limit
Role Model	This rating indicates that a government's efforts are more ambitious than what is considered a "fair share" contribution: it is more than consistent with the Paris Agreement's 1.5°C limit

Source: (Climate Action Tracker, 2021d).

3. Results

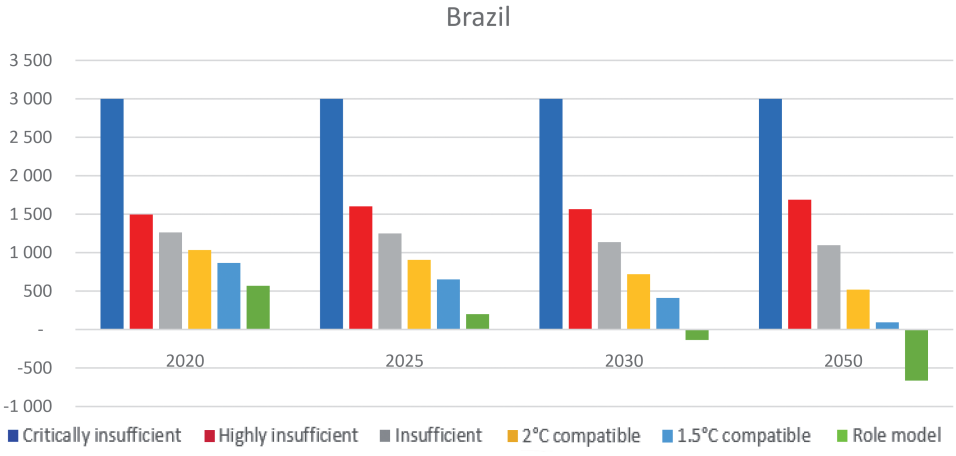
3.1. Brazil

Compared to its fair share contribution to climate action, the CAT rates Brazil's unconditional 2030 climate target, which begins in December 2020, as "critically insufficient." The "critically insufficient" rating indicates that Brazil's 2030 fair share target reflects little to no action and is incompatible with the Paris Agreement's 1.5°C temperature limit (Climate Action Tracker, 2021a). Brazil's target is inconsistent with any interpretation of a reasonable approach to meeting the Paris Agreement's 1.5°C limit. If all countries followed Brazil's lead, warming would exceed 4°C, as depicted in Table 2 and Figure 3.

Table 2. Brazil's nationally determined contributions to the Paris Agreement

Upper end of `	2020	2025	2030
Critically insufficient	3,000	3,000	3,000
Highly insufficient	1,495	1,601	1,565
Insufficient	1,262	1,249	1,137
2°C compatible	1,034	905	719
1.5°C compatible	866	651	411
Role model	568	200	–136

Source: (Climate Action Tracker, 2021a).



Source: (Climate Action Tracker, 2021a).

Figure 3. Brazil's nationally determined contributions to the Paris Agreement

3.2. Russia

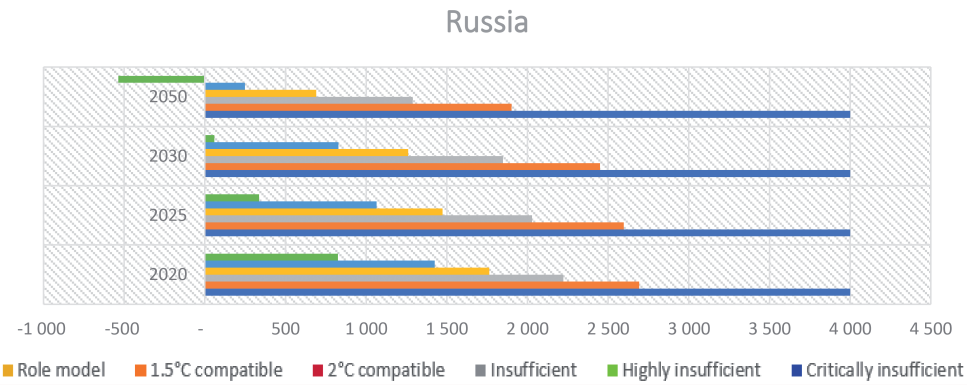
When Russia submitted its NDC update in November 2020, it failed to raise its ambitious goal. The CAT assesses the updated NDC target as "critically insufficient" compared to its fair share of emissions allocated to predicted domestic pathways, as shown in Table 3 and Figure 4. The flimsy target will be easily achieved within the framework of current policies and actions, which the CAT rates as "highly insufficient." The CAT rates Russia's climate targets, policies, and financing as "critically insufficient." (Climate Action Tracker, 2021d).

The "critically insufficient" rating indicates that Russia's climate policies and commitments represent little to no action and are incompatible with the Paris Agreement. Russia should set a more aggressive emissions reduction target, adopt and implement additional measures, and provide financial assistance to other countries to improve their CAT ratings (Climate Action Tracker, 2021d).

Table 3. Russia's nationally determined contributions to the Paris Agreement

Upper end of	2020	2025	2030	2050
Critically insufficient	4,000	4,000	4,000	4,000
Highly insufficient	2,692	2,597	2,449	1,902
Insufficient	2,222	2,028	1,848	1,289
2°C compatible	1,764	1,473	1,261	690
1.5°C compatible	1,425	1,064	828	248
Role model	824	337	59	-537

Source: (Climate Action Tracker, 2021d).



Source: Climate Action Tracker (Climate Action Tracker, 2021d).

Figure 4: Russia's nationally determined contributions to the Paris Agreement

3.3. India

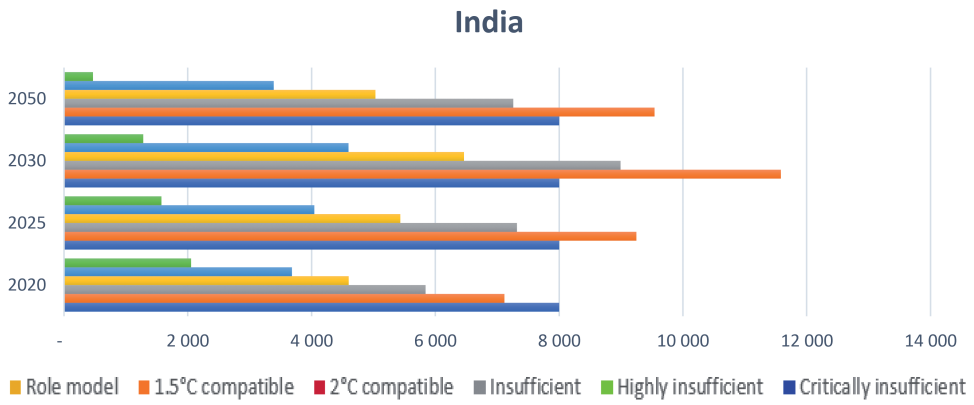
The CAT rates India's climate targets and policies as "highly insufficient," indicating that India's climate policies and commitments do not meet the Paris Agreement's 1.5°C temperature limit. Compared to a modeled domestic emissions pathway, India's current targets and policies indicate that emissions will continue to rise and are consistent with warming of 4°C or more. Compared to its fair share contribution to climate action, India's policies and actions will result in it exceeding its targets, but only by 2°C, as shown in Table 4 and Figure 5.

To improve its rating, India must increase its unconditional NDC target to significantly slow the emissions growth rate. With international assistance, India should also set an ambitious conditional target to reduce the expected increase in emissions due to its dependence on fossil fuels and begin the transition to a net-zero economy (Climate Action Tracker, 2021c).

Table 4. India's nationally determined contributions to the Paris Agreement

Upper end of	2020	2025	2030	2050
Critically insufficient	8,000	8,000	8,000	8,000
Highly insufficient	7,116	9,248	11,582	9,541
Insufficient	5,842	7,318	8,992	7,259
2°C compatible	4,600	5,434	6,463	5,032
1.5°C compatible	3,683	4,045	4,597	3,389
Role model	2,054	1,575	1,281	469

Source: (Climate Action Tracker, 2021c).



Source: (Climate Action Tracker, 2021c).

Figure 5: India's nationally determined contributions to the Paris Agreement

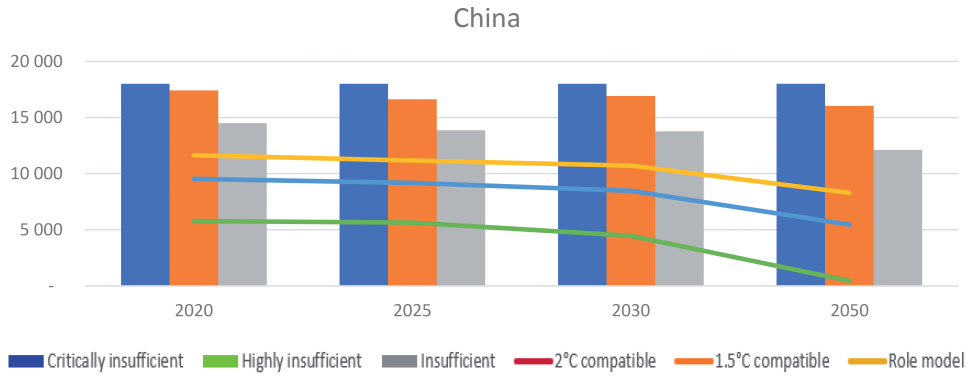
3.4. China

The CAT rated China as "highly insufficient in its commitment to PA." China's climate commitments for 2030 are also rated as "highly insufficient" since emission levels projected under the highest affinity surging and non-fossil share NDC targets are compatible with warming levels from 3°C to 4°C by the end of the 21st century if all countries follow this ambition. The CAT treats China's NDC pledge as unwavering for this rating system, because it has not indicated a level of ambition that could be achieved with international assistance, as indicated in Table 5 and Figure 6 (Climate Action Tracker, 2021b).

Table 5. China's nationally determined contributions to the Paris Agreement

Upper end of	2020	2025	2030	2050
Critically insufficient	18,000	18,000	18,000	18,000
Highly insufficient	17,411	16,627	16,910	16,033
Insufficient	14,486	13,863	13,776	12,113
2°C compatible	11,629	11,166	10,715	8,285
1.5°C compatible	9,522	9,176	8,458	5,462
Role model	5,777	5,639	4,446	444

Source: (Climate Action Tracker, 2021b).



Source: (Climate Action Tracker, 2021b).

Figure 6: China's nationally determined contributions to the Paris Agreement

3.5. South Africa

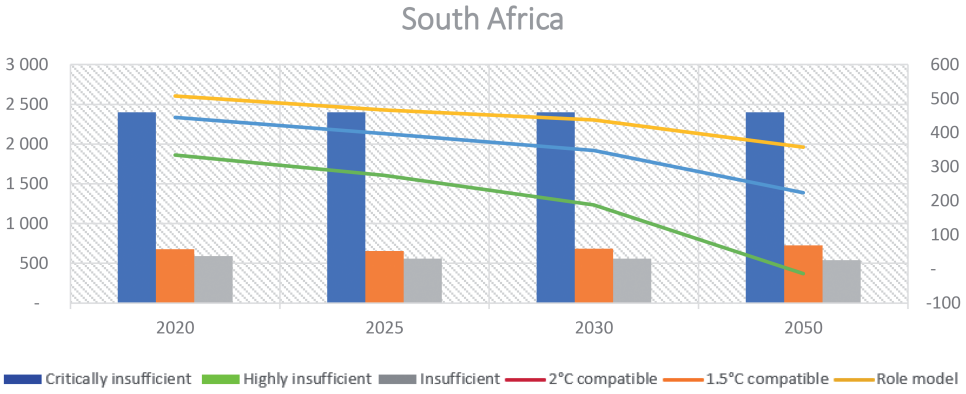
Table 6 and Figure 7 depict South Africa's efforts to contribute to the Paris Agreement to reduce emissions. South Africa was classified by the CAT as "highly insufficient" in terms of the countries fair share of contribution to the NDC target set by the Paris Agreement.

The implication is that South Africa falls out of its fair share and its NDC contributions are inconsistent with the PA agreement. The "highly insufficient" range means that if most countries fall within this category, global warming will reach from 3°C to 4°C. South Africa's 2030 emissions reduction target is rated as "insufficient" compared to predicted domestic pathways and "highly insufficient" compared to its fair share contribution to climate action. South Africa's targets and policies are insufficient to keep warming to 1.5°C.

Table 6. South Africa's nationally determined contributions to the Paris Agreement

Upper end of	2020	2025	2030	2050
Critically insufficient (end of graph)	2,400	2,400	2,400	2,400
Highly insufficient	679	656	684	724
Insufficient	592	560	559	539
2°C compatible	508	467	437	357
1.5°C compatible	445	398	348	224
Role model	334	275	188	–13.6

Source: (Climate Action Tracker, 2021e).



Source: (Climate Action Tracker, 2021e).

Figure 7: South Africa's nationally determined contributions to the Paris Agreement

4. Discussion

4.1. Multilevel policy to reduce carbon emissions in the BRICS countries

This paper provides an overview of the strategy adopted by the BRICS countries to reduce carbon emissions. The BRICS summits and meetings of environment ministers supported

the UN in the field of CC, in particular, the intensification of the activities of the G20 and UN summits in the field of sustainable development, CC, and biodiversity. The UN has received similar support from the majority of BRICS summit commitments. Improving collaboration and continuing the exchange of knowledge to reduce the adverse effect of CC on food security and agriculture is one of the aims of the BRICS countries (Kirton, 2020). The study delves into three recent policies adopted by each government in the BRICS countries to address CC issues, GHG, carbon emission, and general environmental problems. This section provides insight into the aims and objectives of some of these projects and policies, as well as how they can lead to an LCE in the BRICS countries.

4.2. Brazil's pathway to a low carbon economy

Brazil is among the five significant emerging BRICS countries, and it ranks sixth in the world in terms of GHG emissions (Scarano & Ceotto, 2015). In the run-up to the Paris climate change summit, Brazil boosted the ambition of its climate initiatives through various programs and activities (Scarano & Ceotto, 2015). Green finance tools, such as green bonds and green loans, can channel vast private capital towards climate and environment-friendly investments. Investors commit to climate-related projects by expanding the use of renewable energy, improving energy efficiency, and adapting to CC. The Ministry of Mines and Energy (MME) and the Brazilian Energy Research Company have launched the 2050 National Energy Plan (PNE 2050). The MME coordinates the program, supporting construction, appliances, and manufacturing efforts. Other more recent measures emphasizing energy efficiency include the MME's (PNE 2030), which estimates that by 2030, Brazil will cut its energy use by 10%. The MME is currently working on the PNE 2050 National Energy Plan, which is likely to be completed shortly (Nachmany et al., 2015). Analysis and estimates of economic development, energy demand and output potential will be used to pursue energy policy for the next 30 years (Nachmany et al., 2015).

The Executive Committee for the Control of Illegal Deforestation and the Recovery of Native Vegetation was established by a Government Decree comprising 12 articles. It outlines the above committee's composition, tasks, and responsibilities, proposing planning, formulation and integrating strategies to prevent and control illegal deforestation and native vegetation recovery (da Silva et al., 2020). Forest legislation was defined as a system of laws regulating the exploitation and utilization of forest resources. The plan aimed at protecting regions or resources in Brazil dates back to the colonial period, with the primary goal of ensuring control over the management of certain objects, such as flora, water, and soil (Castelo, 2015)

4.3. Russia's pathway to a low-carbon economy

Russia saw its emissions nosedive after the Soviet Union's smokestack industries fell in 1991(Safonov, 2021). The country's production is still less than it was in 1990, reducing CO_2 emissions compared to the UN's benchmark. Russia started to fight CC back in the

1980s. By the late 1980s, climatologists reached a consensus on human contributions to current global warming, resulting in the 1992 ratification of the UNFCCC. The Soviet Union has always been a leading voice on the climate agenda (Safonov, 2021). Russia has been actively involved in international climate negotiations for more than two decades within the framework of the United Nations, the G8 and G20, and the BRICS bloc, including the UNFCCC and the Paris Agreement's commitment to avoid "dangerous interference with the climatic system" and achieve net-zero carbon emissions by 2050 (Climate Action Tracker, 2018).

In June 2020, the Russian government approved a new Energy Strategy until 2035. The strategy states that one of Russia's primary objectives is to become a global leader in hydrogen production and use. It also sets concrete goals for the export of hydrogen, which should amount to 0.2 million tons by 2024 and 2 million tons by 2030 (Mitrova & Yermakov, 2019). To meet these goals, the government plans to undertake the following measures (Frolov, 2021):

- investments in production, transportation and consumption of hydrogen and hydrogen-based energy mixes
- increase of natural gas-based hydrogen generation, including using renewable and nuclear energy
- development of Russian low-carbon technologies for producing hydrogen by methane pyrolysis, electrolysis, and other methods, including by localization of foreign technologies
- internal market demand for hydrogen fuel cells in transportation, as well as use of hydrogen and hydrogen-based energy mixes as energy storage and a conversion tool to increase efficiency of centralized power supply systems.

On January 4, 2020, Russia issued a comprehensive strategy for adapting its economy and society to climate change. The Russian government published a National Action Plan for the First Phase of Climate Change Adaptation for up to 2022. The statement lays out steps that federal and regional governments will take to lower the economy's effect on natural environment's susceptibility to climate change impacts. Furthermore, it identifies several potential opportunities that may arise due to climate change (Devyatkin, 2020). This national plan lays out economic and social measures that will be implemented by federal and regional executive bodies to reduce the vulnerability of the Russian population, economy, and natural resources to CC's effects, as well as seize the opportunities that such changes present. This authorized national plan is the first step in adapting the economy and the population to CC. It includes structural, organizational, and methodological strategies to help develop CC adaptation solutions (Ingram, 2020).

4.4. India's pathway to a low-carbon economy

India's energy future is important for both global and national development goals. India's existing and projected emissions are significant enough to impact international mitigation efforts (Dubash et al., 2018). India's multi-level energy and climate governance framework includes the national level, federal states, and cities, each with its own set of

obligations, challenges, and opportunities. It can be argued that since India's economic liberalization in 1991, its states have grown in importance and have become critical stakeholders in the country's multi-level energy and climate governance frameworks (Jörgensen & Wagner, 2017).

India's Ministry of Environment, Forests and Climate Change (MoEFCC) has formed a high-level inter-ministerial Apex Committee for Implementation of the Paris Agreement (AIPA), confirming the country's commitment to go to CC "step by step" (Sangomla, 2020). AIPA intends to provide a coordinated response to CC concerns so that India keeps up with its Paris Agreement obligations, especially its nationally determined contributions (NDC). AIPA will also act as a national authority to regulate carbon markets in India under Article 6 of the Paris Agreement. AIPA will also issue guidelines on carbon pricing, market mechanisms, and other similar instruments that affect CC and NDCs. It will assess the business sector's and multilateral agencies' contributions to CC and provide recommendations on better aligning their climate actions with national priorities. (Sangomla, 2020).

The Ministry of New and Renewable Energy has created this program to assist farmers with financial incentives to switch from fossil fuel-powered pumps to new solar-powered machinery. The primary goal of this program is to make farmers economically self-sufficient. Farmers will be allowed to install solar plants on their farm's idle land either by themselves or in partnership with an investor under the initiative, which will allow them to earn a regular income (Bhopal, 2021).

The National Action Plan on Climate Change (NAPCC) addresses urgent and critical concerns of the country by changing the direction of development, including enhancing the current and planned activities outlined in the technical document (NAPCC, 2021). The NAPCC also presents several steps to simultaneously advance India's development and CC-related objectives of adaptation and mitigation. The NAPCC lists eight national climate change missions: (1) National Solar Mission; (2) National Energy Efficiency Mission; (3) National Mission on Sustainable Habitat; (4) National Water Mission; (5) National Mission for Sustaining the Himalayan Ecosystem; (6) National Mission for a Green India; (7) National Mission for Sustainable Agriculture; (8) National Mission on Strategic Knowledge for Climate Change (Firstpost, 2021; NAPCC, 2021).

4.5. China's pathway to a low-carbon economy

China surpassed the United States as the world's leading GHG producer in 2007, accounting for approximately 28–30% of total worldwide emissions (Heggelund, 2021). China's significant emissions can be attributed to its huge size of about 1.4 billion people, as well as its second-largest economy, largest export of products, most significant energy consumption and largest energy import. China has made remarkable economic progress over the past three decades, with a fast growth rate and an increase in annual GDP (Y. Li et al., 2020; Wei et al., 2018). China's export is predominantly focused on value-added intermediate goods and processing trade. Y. Li et al. (2020) argue that rapid economic expansion leads to very high energy consumption and carbon emissions per GDP. Wei et al.

(2015) observe that, according to forecasts, China will face sustainable demands to reduce CO_2 emissions in the medium and long term due to the country's current economic situation. China must find long-term solutions to achieve an LCE while maintaining an appropriate economic growth rate. In 2005, the Chinese government announced that by 2020, emissions of CO_2 per unit of GDP would be reduced by 40% to 45% (Y. Li et al., 2020).

The National Development and Reform Commission has developed a draft environmental legislation. It intends to improve the internal investment management, reinforce and standardize the central budget for pollution control, energy conservation and CO_2, and mobilize "social capital" to participate in pollution control, energy conservation, and CO_2 reduction. This document is intended to replace Interim Measures for the Special Management of Investment in Ecological Civilization Construction within the Central Budget (Climate Change Laws of the World, 2021).

This working report describes a path to carbon neutrality by 2060 with emissions peaking by 2030 as China ramps up efforts to decarbonize its economy. The government has set a goal to reduce energy intensity by about 3% by 2021. Over the next five years, the authorities intend to reduce energy intensity by 13.5 % and carbon intensity by 18%. According to this report, an "action plan" for achieving peak carbon emissions will be developed by the end of the decade (Ashwin Kaja, 2021). The 14th Five-Year Plan lays out China's development goal and roadmap for 2021–2025, as well as concrete environmental and efficiency targets. The strategy reaffirms the previously stated goal of carbon neutrality by 2060 and sets a target for reaching peak emissions in 2030 (Cooper, 2021; Xinhua News Agency, 2021).

The New Energy Vehicle Industry Development Plant aims to help the country produce electric and fuel cell automobiles. The 2020 New Energy Vehicle (NEV) Promotion Subsidy Plan provides for governmental support for the electrification of vehicles in the areas of public transportation, urban public transport, road passenger transportation, rental (including online car-hailing), environmental sanitation, urban logistics and distribution, postal express, civil aviation, airport and party transportation for the period from 2020 to 2022 (Chu, 2021). China's Plan for 2021–2035 aims to put the country in a position to meet the future demand for autonomous, connected, electrified and shared mobility. Its three main objectives are:

- establishing a globally competitive auto industry with advanced NEV technologies and a positive brand reputation
- transition to an energy-efficient and low-carbon society with a convenient charging service network and battery-powered electric vehicles as the main sales direction
- improving national energy security and air quality, mitigating climate change and stimulating economic growth (Chu, 2021).

4.5. South Africa's pathway to a low-carbon economy

In light of the growing need for CO_2 emissions and realizing potential benefits of a green-based society, the South African government has established plans to reduce carbon

emissions by 34% and 42% by 2020 and 2025, respectively (Ganda & Milondzo, 2018). Climate change is having a significant influence on South Africa, considerably increasing the temperature and water variability. The rate of global warming recorded in the west and northeast is 2°C per century or more, which is more than twice the worldwide temperature increase (Gazette, 2020). By 2030, the National Development Plan (NDP) of South Africa intends to eradicate poverty, protect the environment, and promote economic development (Vinet & Zhedanov, 2011). South Africa is a signatory to the Paris Climate Change Agreement and has ratified it. South Africa's emissions are predicted to peak, plateau and decline beginning in 2025. The energy industry is responsible for about 80% of the country's total GHG emissions, with half of this volume coming from power generation and liquid fuel production (Ziervogel et al., 2014). Three of the most recent policies outlined by South Africa to achieve LCE are discussed below.

South Africa's economic reconstruction and recovery plan aimed at fostering equitable and inclusive growth was launched in October 2020. Many of proposed measures could help South Africa adapt to CC and reduce CO_2 emissions, bringing long-term social and economic benefits (Modise, 2021). On March 24, 2021, the government enacted a revised draft of the nationally determined contributions (NDC), the basis of South Africa's CC response. Under the UNFCCC and the Paris Agreement, South Africa has agreed to contribute to the global CC effort (Modise, 2021). Green recovery initiatives and more aggressive action on climate change can complement each other to reduce GHG emissions, build resilience and boost economic growth. Countries can think about how these recovery actions will help them improve their NDCs and meet the long-term goals of the Paris Agreement, which is essential with the approach of the COP26 in Glasgow (World Resources Institute, 2021).

South Africa's National Climate Change Adaptation Strategy (NCCAS) puts forth a coherent vision of adaptation and resilience to CC and critical sectors for achieving that vision (Department of Environmental Affairs, 2016). As stipulated in the Paris Agreement, the NCCAS serves as South Africa's National Adaptation Plan and demonstrates its commitment to its international obligations under the UNFCCC. The NCCAS will serve as the foundation for fulfilling South Africa's adaptation responsibilities under the nationally determined contributions (Department of Environmental Affairs, 2016). The South African Department of Energy has released an Integrated Resource Plan that predicts the country's estimated energy demand for the next 20 years, from 2010 to 2030. The IRP is a capacity plan for energy that attempts to estimate the country's electricity demand, how it will be supplied and how much it will cost. The Department of Energy envisions the IRP as a "life plan" that will be regularly revised (Hofmeyr, 2021).

5. Policy recommendations for the BRICS countries' transition to an LCE

This section discusses several strategies and recommendations for the BRICS countries' pathway to an LCE (Figure 9). These strategies can also be applied at various scales to reduce CO_2 emissions in the BRICS countries.

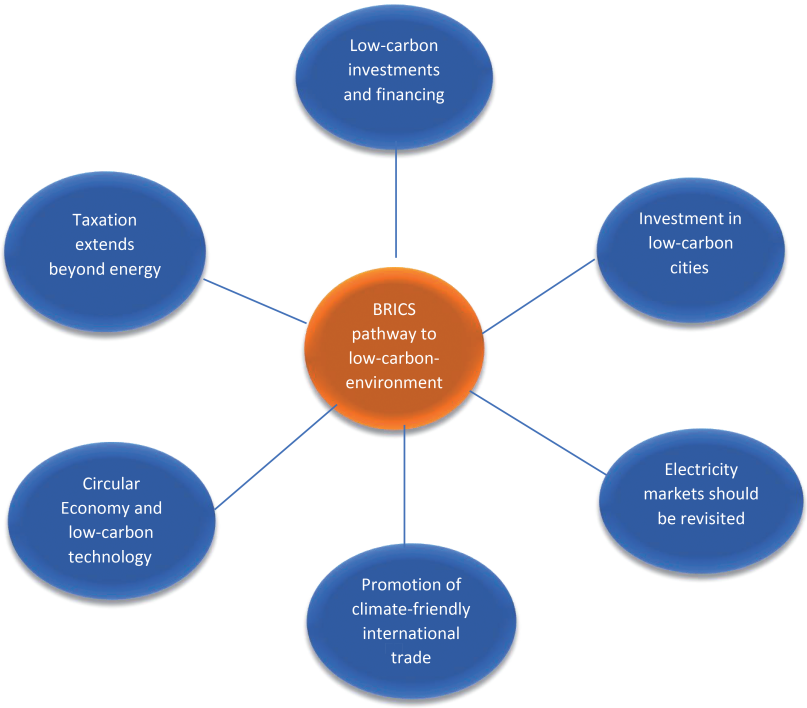


Figure 8. The BRICS pathway to a low-carbon environment

5.1. Expanding low-carbon investments and financing in the BRICS countries

There is a unique opportunity to ensure that new infrastructure investments serve the climate agenda while also encouraging economic development, and this is urgent and unprecedented. For the BRICS regions, additional short-term costs of switching to a low-carbon energy system will account for only a small fraction of the overall infrastructure financing required (OECD/IEA/NEA/ITF, 2015). If the BRICS governments reevaluate their support for investments in greenhouse-gas-intensive activities and mainstream climate objectives into public procurement and official development assistance, public finance and investment can also catalyze the low-carbon transition. Public finance is just one of several tools that can facilitate the transition, such as infrastructure development, cleaning up sites, training and retraining. An essential part of creating a transition strategy is identifying potential investors and entrepreneurs in the region who may be willing to make the most effective use of public financing (Kustova et al., 2021).

Focus on taxation extends beyond energy. The most frequently researched environmental tax mechanisms are taxes on particular activities or consumption that generate highly damaging emissions, effluents or residues, such as energy taxes and carbon taxes (Vence & López Pérez, 2021). While subsidies and tax expenditures favoring the development and use of fossil fuels impede low-carbon innovation, the current low oil prices also

present a chance for reforms. In addition, governments in the BRICS regions can provide tax incentives and subsidies to organizations or entrepreneurs who are engaged in green business. Howard et al. (2021) note that an economy-wide carbon tax and government commitments to global action to reduce CO_2 emissions are other ways to reduce cross-sectoral leaks in the economy.

Investment in low-carbon cities. As a concept of urban development, low-carbon consumption and production in cities can help create more cost-effective and environmentally-friendly urban energy and ecological systems. Reduced greenhouse gas emissions and minimal energy use are required in low-carbon cities (M. Zhang, 2021). Cities play a significant role in global greenhouse gas emissions, especially urban regions, which account for 67–76% of worldwide CO_2 emissions and energy consumption (Han et al., 2020). Cities have evolved into fundamental units for implementing measures to reduce emissions. Reduced greenhouse gas emissions and low energy usage are required in low-carbon cities in addition to a focus on economic development. To create a win-win situation between urbanization and environmental protection, it is necessary to change traditional energy technologies and introduce innovations to limit the consumption of high-carbon energy and the production of urban greenhouse gases (M. Zhang, 2021). Therefore, the study recommends that the various governments in the BRICS should invest more in low-carbon cities, leading them to an LCE. Yang et al. (2019) add that after 2009, many cities released their plans for low-carbon economic development and low-carbon city construction. Low-carbon pilots, sponge cities, low-carbon community pilots, and national low-carbon city (town) pilots are primarily responsible for achieving low-carbon cities.

Adapting to circular economy and low-carbon technology. A circular economy is a business model that highlights the ecosystem's regenerative capacity by reducing the consumption of non-renewable resources, extending the usable life of commodities, and reusing all materials that enter the economic cycle to reduce waste and pollution (Vence & López Pérez, 2021). Low-carbon technology will become more widely used as solutions become more mature in the market. The transition to clean and secure electricity will lay the groundwork for end-use electrification, which is one of the main priorities (IAEA, 2021). Low-carbon technology is one of the specialized methods of reducing carbon dioxide emissions in buildings. Low-carbon technology emits the least amount of GHGs into the environment, in particular CO_2 (Ali et al., 2020). Evaporative cooling, passive ventilation and cooling, solar photovoltaic, dehumidification, and energy recovery systems are examples of renewable and sustainable energy technologies (Ali et al., 2020).

The BRICS countries should expand electricity markets. To achieve effective decarbonization of energy systems, electricity must be used. On the other hand, deregulated electricity markets do not provide a long-term price signal for investments in high-capital-cost low-carbon technologies. New market arrangements, such as long-term supply agreements, as well as a robust and steady CO_2 price signal, will be needed to ensure competitive and timely investment in low-carbon solutions. To stimulate investment in low-carbon technologies, jurisdictions with regulated systems should consider providing greater competition (OECD/IEA/NEA/ITF, 2015).

Promoting climate-friendly international trade among the BRICS countries. Although the international trade regime does not restrict states from implementing aggressive climate measures, some international trade barriers may undercut climate goals. Import restrictions, for example, continue to penalize trade in some technologies required for the low-carbon transition. Many countries that promote greener growth by favoring domestic manufacturers of low-carbon technologies must exercise caution. Where these regulations impede international trade, they may have a negative impact on total investment and the adoption of sustainable technologies (OECD/IEA/NEA/ITF, 2015). The BRICS countries' pathway to LCE can be successful through the promotion of climate-friendly trade among themselves.

Conclusion

The discussion above shows that various governments in the BRICS countries have taken measures to control CC and its consequences on people. All these policies are aimed at achieving an LCE, which is highly recommended. However, the critical issue that needs to be addressed is the implementation of such policies. This will require strict measures to monitor the practical evaluation of the plans and procedures in the BRICS countries to achieve the target of an LCE. The study discusses Brazil's policies, which include the National Energy Plans for 2030 and 2050 and the Plan to Control Illegal Deforestation and Recovery of Native Vegetation that provides for the establishment of the Amazon Fund. Russia also adopted Energy Strategy 2035 for Russia, which approved the hydrogen roadmap 2021–2024 for Russia, and the National Action Plan for the First Phase of Adaptation to Climate Change. India's actions and plans also include Apex Committee for Implementation of the Paris Agreement of India, the Prime Minister's Farmer Energy Security and Upliftment Campaign, and the National Action Plan on Climate Change. China has also implemented these strategies: Pollution Control, Energy Conservation and Carbon Reduction, The 14th Five-Year Plan, and The New Energy Vehicle Industry Development Plan. South Africa's initiatives include the Economic Reconstruction and Recovery Plan, the National Climate Change Adaptation Strategy, and the Integrated Resource Plan. The study advocates that the BRICS counties can achieve an LCE through expansion in low-carbon investments and financing, focus on taxation that extends beyond energy, investment in low-carbon cities, adaptation to a circular economy and low-carbon technologies, expanding electricity markets, and promotion of climate-friendly international trade among the BRICS countries.

Abbreviations

LCE — low-carbon environment; CC — climate change; GHG — global greenhouse gas; IPCC — Intergovernmental Panel on Climate Change; IPBES — Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; UNFCCC — United Nations Framework on Climate Change; MAPA — Brazil's Ministry of Agriculture,

Livestock, and Supply; NDC — nationally determined contributions; MME — Ministry of Mines and Energy; PNE — National Energy Plan; CAT — Climate Action Tracker.

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