Journal of Policy Research, 10(3), 447-458
https://jprpk.com
https://doi.org/10.61506/02.00363

Unpacking the Role of Renewable Energy Integration and Green Trade Policies on Environmental quality and Carbon-Neutral Economic Growth: A Dynamic Comparative Analysis of South Asian Economies

Ibrahim Omar Ibrahim Almajali[1], Sarab Salker Alaflaq[2*], Omar Ahmad Yousef Alkhatatneh[3], Ali Hassan[4]

Abstract

The purpose of this study is to measure the efficiency of green trade policies to encourage appropriate economic behavior. Some of the friendly trade eco policies such as Eco friendly trade agreement, –Carbon Tariffs, Technology transfers seek to spur some level of eco responsibility and reduce the economic infringements on the ecology. This research, therefore, seeks to examine the role of these policies in enhancing carbon neutral growth and their relevance as an instrument for development in South Asia. We conducted comparative research on South Asian countries regarding " the Role of Renewable Energy Integration and Green Trade Policies on Environmental quality and Carbon-Neutral Economic Growth: A Dynamic Comparative Analysis of South Asian Economies "using data from selected emerging nations. Data was gathered from the World Bank website, covering the period from 2001 to 2022, alongside data from Organizations such as the World Bank, IMF, Asian Development Bank, and Asian bank provide extensive datasets and publications related to Renewable Energy Integration and Green Trade Policies, Environmental quality and Carbon-Neutral Economic Growth. We conducted robustness checks, pairwise correlation tests, linear regression, symmetry analysis, and VIF tests. The present research contributes towards understanding the details of the interactions between RE integration, green trade policies and economic development of SA economies. The results reveal the importance of renewable energy sources in enhancing environmental quality as well as produce vivid revelation of the effect of CO_2 emissions on the environment. Increase in GDP has been predicted by the green trade policies thus indicating that sustainability of trade policies can enhance the growth of the economy hence supporting the economic hypothesis, about sustainability of trade polices but there impact on quality of outputs is unknown. Besides, technological advancement as an impediment of economic development as an element of innovation for a low-carbon economy. On the other hand, negative correlation between labor force participation and GDP reveals Lounge that calls for labor market changes with respect to productivity and efficiency.

Keywords: Renewable Energy Integration, Green Trade Policies, Environmental quality and Carbon-Neutral Economic Growth

1. Introduction

The struggle for sustainable development has identified two strategies, namely harnessing renewable energy and developing green trade policies on how to reversing the adverse impact done to the natural environment and how to enhance economic growth. As the climate situation in the world continues to worsen, countries of the world continue to ramp up their efforts to achieve economic development with sustainability (Lomborg, 2020). For this reason, South Asian economies are a particularly suitable target of research due to the fact of economic growth, continuously rising energy demand, and vulnerability to climate change. Renewable energy with particular emphasis on solar and wind power would be the solution in moving from an energy path defined by fossils and at the same time ensuring energy security and sustainability at affordable price (Bogdanov et al., 2021). On the same note, basket of eco-friendly trade policies such as the environmental trade measures and subsidies foster developments of cleaner forms of production and urge countries into partnership to combat global challenges. Altogether the given approaches might be helpful in raising the quality of the surrounding environment and stimulating carbon-neutral economy (Ahmad, Raihan, & Ridwan, 2024). It is for this reason that this paper proposes conducting a dynamic comparative analysis of these south Asian economies, with an aim of comparing the impact of renewable energy integration on green trade policies and their general impact on environmental quality and growth. Policy implications of this research also involves the use of cross-country analysis as well as cross-time analysis to present policy solutions (Mandel & Lazarus, 2021). The study's findings should extend understanding of sustainable development since it should offer policy recommendations for South Asian countries to align economic activities with the environment (Ma, 2022). This research not only introduces the shift of the chance of renewable energy and green trade but also explain why they play crucial roles in realizing the vision of the carbon-less future for one of the largest and diverse cultural continents in the world.

The South Asian area has been defined by major nation of South Asia being made up of India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan, and Maldives; it is among the most crowded as well as one of the most economically active areas on the planet. South Asia experiences rapid industrialization, urbanization and

[1] School of Economics and Trade, Hunan University, Changsha 410006, China.
[2*] School of Economics and Trade, Hunan University, Changsha 410006, China. sarabalaflaq976@gmail.com
[3] Department of Civil Engineering, Faculty of Engineering, China University of Geosciences, Wuhan, Hubei 430074, China
[4] School of Economics and Trade, Hunan University, Changsha, 410006, China.

economic growth, which it characterizes, at the same time, confronting serious environmental problems: as air and water pollution, deforestation and high carbon emission (Pandey & Asif, 2022). To this can be added the fact that the region is already experiencing and sensitive to the effects of climate change such as; the rising sea levels, extreme weather conditions, and the melting Himalayan Glaciers. Therefore, within transit, green trade policies' choice, and transition to renewable energy are an essential approach to sustainable development (Anwar et al., 2021). There lies an opportunity to at least limit emissions through integration of renewable energy resources while serving rising energy demand of the region. With as much renewable energy resources – solar, wind, hydropower and biomass – and, especially, promising economic outlook of green energy transition South Asia is undoubtedly a very promising region (Srivastava & Srivastava, 2020). However, establishing strength of these resources required some strategic planning which in turn deserves a massive policy support. Also, green trade policies–carbon tariffs, eco labelling etc., and International agreements and partners–can go a long way in come as a catalyst for pro-environment technologies and/or may push for pro-environment economy (Remy, Haynes, & Ellis-Bourne, 2021). The importance of this study is unique and timely in terms of offering dynamic comparative analysis on how the South Asian countries are integrating the renewable energy and also engaging the green trade policies for raising; the standard of environment and carbon neutrality of the economic development. Past research usually has been conducted on isolated aspects of energy policy or trade policy; the present study therefore examines the linkages between the two within the region. Unlike time series data, it offers a better picture of how trends and cross-country differences change by employing panel data and sophisticated methods of econometric analysis (Wang & Juo, 2021). This research is unique in understanding South Asia as an integrated, yet a diverse region, which makes it possible to identify the shared problems and the specific type of policy responses. The study also aligns with global aspirations for example the United Nations Sustainable Development Goals (UN-SDG) namely; SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), as well as caters for regional socio economic factors. This work provides therefore new empirical evidence for national decision makers and international organizations seeking to advance future goals. This suggests the need for regional frameworks that coordinate collective regional utilization of resources and knowledge for a sustainable, low carbon future in South Asia.

The first research objectives for this research study is: how has integration of renewable energy impacted the quality of environment and carbon emission in South Asian economies? Since the energy shortages are faced by the region and the inclination toward the fossil fuel utilization, solar, wind or hydropower could decentralize energy systems for triggering sustainable development (Kabeyi & Olanrewaju, 2022). Sound is a research which goal is to quantify contribution of renewable energy adoption towards addressing climate change and sustaining healthy environment in the region. A second main objective was to measure the efficiency of green trade policies to encourage appropriate economic behavior. Some of the friendly trade eco policies such as Eco friendly trade agreement, –Carbon Tariffs, Technology transfers seek to spur some level of eco responsibility and reduce the economic infringements on the ecology. This research, therefore, seeks to examine the role of these policies in enhancing carbon neutral growth and their relevance as an instrument for development in South Asia (Agrawal & Soni, 2021). Moreover, the study also aims at finding out how different extents of RE incorporation will interact with green trade policies to facilitate achievement of environmental and economic goals. The study examines how these strategies function or operate and tries to fill the gaps of what these strategic interactions may offer to the idea of carbon neutrality and sustainable development. This should however be done in a way that creates feasibility in attempt at driving synergy to achieve optimized integrated policy frameworks of the two strategies. This work is also mainly interested in a comparative, longitudinal study of the adoption and success of these strategies in South Asian economies (Peters et al., 2024). There is a vast social-economic inequality, energy consumption, and guidance of public policies. This study will also look at country-specific trends in order to examine the possibility, success and difficulties of every country. The last aims to develop the policies that align with the global climate plan starting from the United Nations Sustainable Development Goals (UN SDGs) and the Paris Agreement. This research shall show how to achieve sustainable development of the economic growth and environmental conservation by proposing solutions to fit the social-economic and ecological context of South Asia.

2. Literature Review

Transition to renewable energy and the use of green trade policies have come to be seen as two pivotal issues in responding to environmental degradation and ensuring carbon neutral economic growth worldwide. Such dynamics have a particularly important context in South Asian economies, which are characterized by their unique socio-economic and environmental challenges. In this literature review, important theoretical and empirical studies which can explain the role of renewable energy integration and green trade policies in enhancing environmental quality as well as sustainable development are reviewed.

2.1. Renewable Energy Integration and Environmental Quality

Renewable energy sources, solar, wind, hydropower and biomass, are known to integrate widely for reducing carbon emission as well as improving environmental quality. Renewable energy studies have proven that it limits

fossil fuel dependence and therefore reduces emittance of greenhouse gas (GHG). Renewable energy, they (Naheed, Nasreen, Tiwari, & Arsh, 2024) emphasized, is imperative to DE carbonization in developing economies such as South Asia where the demand for energy is growing rapidly. Like in (Hamid et al., 2022), we find that renewable energy adoption leads to substantial air quality improvements, especially in heavily polluted urban areas. Despite these challenges, integration of renewable energy systems is successful. These are especially critical in South Asia, where access to financial and technological capital widely varies, and calls for region specific policy frameworks (Mukherjee et al., 2023). However, potential in the region is abundant renewable energy potential, which is underutilized, and is therefore a promising area for policy intervention and investment.

Mitigation of environmental degradation and sustainability enhancement depends on renewable energy ... Unlike fossil fuels, renewable energy sources such as solar, wind, hydropower, and biomass emit much less greenhouse gas (GHG) emissions, and are therefore necessary in order to fight global warming and to improve air quality. Rapid industrialization in South Asian economies and surging energy requirements make them highly suitable to garner from renewable energy integration. Yet there are unique challenges and opportunities related to transitioning to renewable energy systems in the region. Renewable energy is repeatedly shown in empirical studies to provide environmental benefits. According to Ahmed et al. (2022) implementation of renewable energy technologies significantly minimizes carbon dioxide (CO_2) emissions especially in coal and oil using countries (Rahman, Murad, Mohsin, & Wang, 2024). In urban areas in South Asia, when the share of renewable energy in the energy mix is higher, air quality significantly improves while health related expenditure and environmental stress are significantly reduced, (Raihan, Muhtasim, Khan, Pavel, & Faruk, 2022). In South Asia, where air pollution is among the worst in the world, renewable energy integration could help save the public health and ecological stability.

Renewable energy development in South Asia is huge potential. For example, India and Pakistan have huge solar potential as well because of their topology. Abundant water resources in Nepal and Bhutan make these suitable countries for hydropower development, whereas Sri Lanka has introduced wind and biomass options (Raihan et al., 2022). Nevertheless, oncoming barriers to realize this potential range from inadequate infrastructure, high capital costs, and technological constraints. The key to accelerating renewable energy deployment more effectively in South Asian countries, according to (Ahmed, Ahmad, Caglar, & Pinzon, 2024), is strategic investments and regional collaboration. South Asia has an enormous potential for integration of renewable energy though the region faces policy and implementation challenges in doing so its environmental promise. The key impediments to momentum for getting to a cleaner energy system are a lack of cohesive policies, fragmented markets and dependence on heavily subsidized fossil fuels (Watts). Furthermore, renewable energy projects suffer from socio economic issues such as land acquisition disputes and forced community displacements. To address these challenges robust governance frameworks, and public–private partnerships that give priority to environmental quality in balance with social equity are needed.

2.2. Green Trade Policies and Carbon-Neutral Economic Growth

Important tools for triggering carbon neutral economic growth include green trade policies like environmental tariffs, carbon pricing mechanisms and subsidies of sustainable technologies. Green trade policies are of interest to the (Ahmed et al., 2022), because they serve to spur forward looking and international efforts aimed at addressing global environmental challenges through adoption of cleaner technologies. For South Asia such policies can enable technology transfer and fuel environmentally sound production practices. As (Shafique, Azam, Rafiq, & Luo, 2021) research shows, robust green trade policies reduce environmental degradation without declining economic growth in implementing countries. While trade-offs may exist in particular for less developed regions such as South Asia where traditional industries dominate export products (Shahnazi, Jamshidi, & Shafiei, 2024). To achieve equitable growth and minimize socio economic disparities, policymakers have to ensure strike a balance between environmental goals and economic priorities.

As the regions of South Asia are increasingly viewed as having to choose between economic expansion and environmental degradation, green trade policies are increasingly seen as pivotal mechanisms to repositioning economic growth toward carbon neutral growth. Policy initiatives included carbon pricing, climate friendly trade agreements that promote the use of low carbon technologies, eco labeling standards and subsidies for sustainable production (Tariq, Xu, Ullah, & Dong, 2024). Green trade policies seek to link economic development with environmental sustainability by rewarding cleaner production processes, and lower carbon intensity of trade. Research in this vein strongly supports the use of green trade policies to spur carbon neutral growth. (Al-Zubairi, AL-Akheli, & ELfarra, 2024) highlight that countries adopting green trade policies experience a dual benefit, environmental degradation that is reduced and economic growth is sustained. It is achieved by encouraging environment friendly technology adoption, facilitating international cooperation and draw market opportunities for green products. Such policies could be used to gain momentum in industrial modernization in the South Asian context without causing additional environmental harm associated with traditional, resource intensive industries (Asif, Khan, & Pandey, 2024). Energy intensive sectors, manufacturing, agriculture, transport imply that robust green trade policies are required in south Asia. For instance, carbon tariffs and environmental trade standards associated with trade can encourage exporters to use cleaner technologies which lower the carbon footprint of

products traded internationally. As argued in Zhang et al. (2021), regional trade agreements can incorporate green clauses such that they help foster technology transfer and the adoption of low carbon technologies in South Asian countries. However, the implementation of green trade policies in South Asia has its threat. Resistance from traditional industries, limited institutional capacity to enforce environmental regulations and related concerns about possible negative impact on trade competitiveness are among them. When policy makers in developing economies like Bangladesh and Pakistan have to choose between environmental goals and economic priorities, they have a tradeoff between these goals. Yet, studies show that well designed green trade policies can balance these objectives. For example, subsidies for green technologies and support for small and medium-sized enterprise (SME) can bear short term economic costs and create room for sustainable transition (Tu & Wu, 2021). Green trade policies, when combined with renewable energy integration, offer an additional role in fostering carbon neutral economic development. They concluded that trade policies which encourage importation and deployment of renewable energy technologies are effective at lowering the cost and increasing the availability of clean energy (Tu & Wu, 2021). That last part links the clean energy to a feedback loop where cleaner energy supports sustainable production, and in turn green trade continues to incentivize renewable adoption.

2.3. The relationship between Renewable Energy and Green Trade Policies

Recently, in the literature, the synergy between renewable energy integration and green trade policies has been increasingly recognized. Combining these approaches can amplify their own individual benefits through a positive feedback loop for sustainable development, as suggested in the studies. For example, (Van Zanten & van Tulder, 2021) showed that green trade policies can expedite the adoption of renewable energy reducing costs and facilitating entry to the clean energy market. However, the interplay between these two strategies in the South Asian context is not well explored. While individual countries have moved forward on renewable deployment or environmental trade related reforms, research has been scant about how their efforts coordinate with or impact each other (Tahir, Luni, Majeed, & Zafar, 2021). This underscore the need of a perspective at regional level to find common opportunities and challenges in alignment of these strategies.

Synergistic approach to ecological sustainability and economic development is represented by the interplay of renewable energy integration and green trade policies. Renewable energy tries to cut usage of fossil fuels, while green trade policies are pushing the adoption of green technologies and practices. Together these strategies form a reinforcing feedback loop to achieve carbon neutral economic growth and high environmental quality (Naheed et al., 2024). Usually such investments in clean technologies and infrastructure are necessary. Green trade policies enable the transition primarily by removing barriers to technology transfer, and encouraging international cooperation. These policies not only reduce costs, but also promote innovation in renewable energy technologies by expanding the size of market for such technologies (Bogdanov et al., 2021). South Asia's potential for alignment of renewable energy integration with green trade policies, however, is immense. Trades policy that encourages import of clean energy technologies has supported countries such as India and Bangladesh who have already made strides in renewable energy deployment. But in terms of using trade as a lever for accelerating regional renewable energy uptake, there is a long way to go. (Raihan et al., 2022) recommends regional cooperation among South Asian nations to encourage harmonized green trade policies through cross boarder investments in renewable energy infrastructure.

Both strategies are enhanced by the interplay between them. Renewable energy decreases the carbon intensity of production and trade, allowing countries to meet the requirements of green trade, and enter environmental conscious markets. Green trade policies, however, motivate investment in renewable energy by providing economic incentives, e.g., subsidies or tax breaks for exporters utilizing clean energy. (Watts) note that this mutual reinforcement is a virtuous cycle, whereby trade encourages the uptake of renewable energy, and use of renewable energy propels sustainable trade practices. All these synergies notwithstanding, the alignment of renewable energy and green trade policies remains challenging in South Asia (Ahmed et al., 2022). The tense political and economic differences between countries in the region often make it difficult to formulate the same policies. Secondly, these strategies fail to take advantage of existing disparities in technological and financial capacities, thereby giving different opportunities for benefits of these strategies. (Kabeyi & Olanrewaju, 2022) highlight that to tackle these challenges we need work to ensure that renewable energy technologies are accessible to all and to consider diverse economic structures by designing trade policies.

2.4. Dynamic Comparative Analysis in South Asia

Existing studies tend to be based on either particular countries or on static analysis and do not capture the comparative and dynamic dimensions of policy effectiveness in South Asia. This gap has been attempted to be addressed in a few recent works. For illustration, (Al-Zubairi et al., 2024) make use of panel data to study the contrasting effects of renewable energy policies on economic growth and emissions reduction in numerous South Asian nations. Nonetheless, the focus of the study was not on the role of green trade policies, and space remains for additional exploration on this topic. In this study we offer a dynamic comparative analysis that adds to the existing literature by integrating renewable energy and green trade policies and analyzing the effects in the regions of South Asia on environmental quality and carbon neutral growth (Naheed et al., 2024). It aims to look at

temporal trends and cross country variations and provide actionable insights for policymakers and stakeholders in the region.

This dynamic comparative analysis provides a nuanced understanding of the variability and temporal trends of the impact of renewable energy integration and green trade policies on economic growth, and environmental quality in South Asian countries. This analytical method captures the changing policies and outcomes over time, while explaining how countries differ (Bogdanov et al., 2021). The socio-economic diversity and shared environmental problems of South Asia require a dynamic comparative framework so as to identify both common strategies and country specific insights. We also note that South Asia's economies, left to themselves, will vary significantly in terms of their levels of development, energy infrastructure and policy frameworks (Raihan et al., 2022). For example, India leads the region in renewable energy capacity, from solar and wind, while Bhutan and Nepal depend heavily on hydropower, while Pakistan and Bangladesh are developing their renewable sectors with great potential. As is norms in regard to green trade policies, there are varied adoptions and enforcement of such policies by nations, a few emphasize on eco-friendly export policies while others face regulatory limitation. These differences get missed by a static approach while a dynamic approach captures how policies evolve and how they shape outcomes over time. The dynamic comparative analysis also captures the interaction between economic growth and environmental policies. As (Watts) note, economic trajectories in South Asia are particularly closely linked with external shocks: global oil prices, climate impacts, and international trade agreements. Dynamic analysis can be performed by incorporating time series data and panel econometric methods to identify whether or not renewable energy and green trade policies respond to these changing conditions. Several of these studies point to the utility of dynamic comparative analysis for South Asia. For instance, (Ahmed et al., 2022) employed a panel data approach to analyze renewable energy adoption at the country level within several countries and determined decreases in carbon resulting from long term investments in clean energy. For instance, (Kabeyi & Olanrewaju, 2022) showed that the economic competitiveness is affected by green trade policies, but the policy efficiency relies on the consistency between the trade regulation and the goals of domestic environment. How renewable energy and trade policies impact the evolution and long run effects on environmental quality and economic growth. Compared progress of countries in integrating renewable energy and in carrying out green trade initiative, and identified best practices and policy gaps. Opportunities for regional collaboration, in the form of shared renewable energy infrastructure, and harmonized trade policies (Al-Zubairi et al., 2024). Learning about how national policies resulting from these global trends such as increases in green product demand or international agreements on climate change. Dynamic comparative advantage provides comparative advantage with value, but it also necessitates strong data and careful methods. However, environmental indicators and policy implementation metrics are often not available, or available but of poor quality in South Asia (Naheed et al., 2024). Moreover, cross country comparisons can be complicated by disparities in institutional capacities across country. However, to resolve these problem areas, researchers have to use standardized methodologies and be transparent in data gathering, and analysis (Bogdanov et al., 2021). It also provides dynamic comparative analysis to assist policymakers in delivering evidence based strategies relevant to each country's needs and capacities. Successful policies and their determinants can be identified, which South Asian nations can replicate and scale best practices. Additionally, dynamic analysis can be used by regional initiatives, such as South Asian Association for Regional Cooperation (SAARC), in formulating coordinated strategies of sustainable development in the region.

3. Methodology

We conducted comparative research on South Asian countries regarding " the Role of Renewable Energy Integration and Green Trade Policies on Environmental quality and Carbon-Neutral Economic Growth: A Dynamic Comparative Analysis of South Asian Economies "using data from selected emerging nations. To ensure effective data collection, we relied on a reliable and consistent source of information. Identifying appropriate variables is crucial to assess the impact of these integrations. Data was gathered from the World Bank website, covering the period from 2001 to 2022, alongside data from Organizations such as the World Bank, IMF, Asian Development Bank, and Asian bank provide extensive datasets and publications related to Renewable Energy Integration and Green Trade Policies, Environmental quality and Carbon-Neutral Economic Growth.

3.1. Data Analysis

We conducted robustness checks, pairwise correlation tests, linear regression, symmetry analysis, and VIF tests.

3.2. Model Specification

The main objective of this study is to investigate the relationship encapsulated by " the Role of Renewable Energy Integration and Green Trade Policies on Environmental quality and Carbon-Neutral Economic Growth: A Dynamic Comparative Analysis of South Asian Economies "Our focus is on exploring the causal relationships between specific variables within this context. To achieve this, we developed panel data regression models to examine Role of Renewable Energy Integration and Green Trade Policies on Environmental quality and Carbon-Neutral Economic Growth. These models allow us to represent all the relationships between independent and dependent variables within the regression equations:

3.3. Environmental Quality Model

$$EnvQit = \beta 0 + \beta 1REit + \beta 2GTPit + \beta 3GDPit + \beta 4Indit + \beta 5CO2it + \varepsilon it$$

Where:

EnvQit: Environmental quality in country *i* at time *t.*
REit: Share of renewable energy in total energy consumption.
GTPit : Index or proxy for green trade policies
GDPit: GDP per capita.
Indit: Industrial output or share of industry in GDP.
CO2it: (% of CO2 Emission).
εit: Error term.

Economic Growth Model

$$GDPGit = \alpha 0 + \alpha 1REit + \alpha 2GTPit + \alpha 3Kit + \alpha 4Lit + \alpha 5Techit + \mu it$$

Where:

GDPGit: GDP growth rate in country *i* at time *t.*
Kit: Capital stock or investment.
Lit: Labor force or employment rate.
Techit: Technological advancement index or R&D expenditure.
μit: Error term.

4. Results

Table 1. Descriptive Analysis

Variable	Mean	Std. Dev.	Min	Max	skewness	kurtosis
EnvironmentalQuality	44.72	22.791	13.156	80.888	.1330944	1.71195
RenewableEnergy	19.055	17.414	0.4	50	.536555	1.63746
CO2emissionskt	2065098	2836853.3	284463.3	10944686	2.052136	5.928372
GreentradePolicies	3.654e+09	8.425e+09	-4.472e+09	2.973e+10	2.036122	6.36737
GDPpercapita	7.916e+08	1.110e+09	1400000	5.614e+09	2.46252	9.319855
Laborforce	64.824	23.51	19.94	93.785	-.5053941	2.39979
TechAdvancement	4.472e+09	6.403e+09	3000000	3.447e+10	2.519955	9.91363
Industrialoutput	41.025	29.5	1.464	81.289	-.1605805	1.555544

In the table 1 descriptive statistics which contain measures of central tendency and variability offer an overall presentation of the variables used in the analysis with the sample. On average, the sampled countries had an average environmental quality index of 44.72 + - 22.79 and ranged from a minimum of 13.16 to a maximum of 80.89. Zero-order skewness of 0.13 indicates that most countries' distances from mean are slightly above it and the kurtosis of 1.71 points to a relatively flattened distribution. Renewable energy usage is less stable compared to a mean and exhibits variability with mean & of 19.06 percent and SD of 17.41. The Descriptive statistics for the REN share reveals mean of 0.4 to 50, min value 0.10 and max value 50 show the variation in terms of adoption; the skewness 0.54 also explains more number of countries with lower REN shares and also the kurtosis 1.64 also shows that the distribution shape of the REN share is flat. CO_2 emissions at an average of 2,065,098 kilotons, with a large standard deviation of 2,836,853, are highly skewed, varying between minimum of 284,463 to a maximum of 10,944,686 kilotons. The value 2.05 depicts a strong positive skewness that indicates that emissions are highly concentrated in a number of high emitting nations and similarly, kurtosis 5.93 depict that tails of the distribution are also heavy. In the same manner, green trade policies with a mean value of 3.65 billion and high standard deviations of 8.43 billion demonstrate variation across country partners. The range spans negative values (- 4.47 billion) and can reach positive values up to 29.73 billion; in other words, policy effects are uneven. The positive skewness (2.04) and high kurtosis (6.37) further indicate that green trade activity is dominated by a few nation. There remains a significant variance in components, such as GDP per capita, indicating representatives' mean (792 million), high standard deviation (1.11 billion), and values ranging from 1.4 million to 5.61 billion. However, the overall labor force participation rate of the U.S = 64.82 % seems to oscillate less, and is not as skewed as the employment rate; the standard deviation = 23.51, and the range is between 19.94% and 93.79%. Although, this has a near normal distribution as evidenced by slightly negative skewness, -0.51 and a kurtosis of 2.40. Technological advancement has a median of 4.47 billion with large variance (sd of 6.4 billion) and range of 3m to 34.47billion. Kurtosis (9.91) and skewness (-2.52) suggest the problem of concentration in the industry across a few technologically developed nations only. Third, the average percentage of industrial output is 41.03% with the standard deviation of 29.50; the coefficients vary between 1.46% and 81.29%. The skewness coefficient is, therefore, almost zero (-0.16), and the kurtosis coefficient is low also (1.56), indicating that the distribution is almost normal – more balanced.

Table 2 Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) EnvironmentalQuality	1.000							
(2) RenewableEnergy	0.105	1.000						
	(0.231)							
(3) CO2emissionskt	0.160	-0.109	1.000					
	(0.074)	(0.223)						
(4) GreentradePolicies	0.015	-0.038	0.578*	1.000				
	(0.876)	(0.698)	(0.000)					
(5) GDPpercapita	-0.050	-0.034	0.274*	0.226	1.000			
	(0.695)	(0.793)	(0.034)	(0.070)				
(6) Laborforce	0.425*	0.216*	-0.063	0.016	-0.116	1.000		
	(0.000)	(0.015)	(0.481)	(0.872)	(0.378)			
(7) TechAdvancement	-0.103	0.442*	-0.216*	-0.021	0.062	0.140	1.000	
	(0.301)	(0.000)	(0.033)	(0.839)	(0.624)	(0.170)		
(8) Industrialoutput	0.498*	-0.253*	0.008	0.004	-0.105	0.853*	-0.121	1.000
	(0.000)	(0.004)	(0.927)	(0.965)	(0.425)	(0.000)	(0.240)	

**** p<0.01, ** p<0.05, * p<0.1*

In the table 2, correlation analysis provides major information into the direction and degree of the associations between variables of interest. Environmental quality has a moderate positive correlation with the labor force participation and industrial output ($\rho = 0.425$, $p < 0.01$) and ($\rho = 0.498$, $p < 0.01$) respectively; these findings imply that, countries with high of labor force engagement and industrial production have improved environmental quality conceivably because of efficiency in resource use or enhanced environmental policies. Nonetheless, there is only a very weak positive relationship between the two with renewable energy adoption (Pearson's $r = 0.105$, $p = 0.231$).

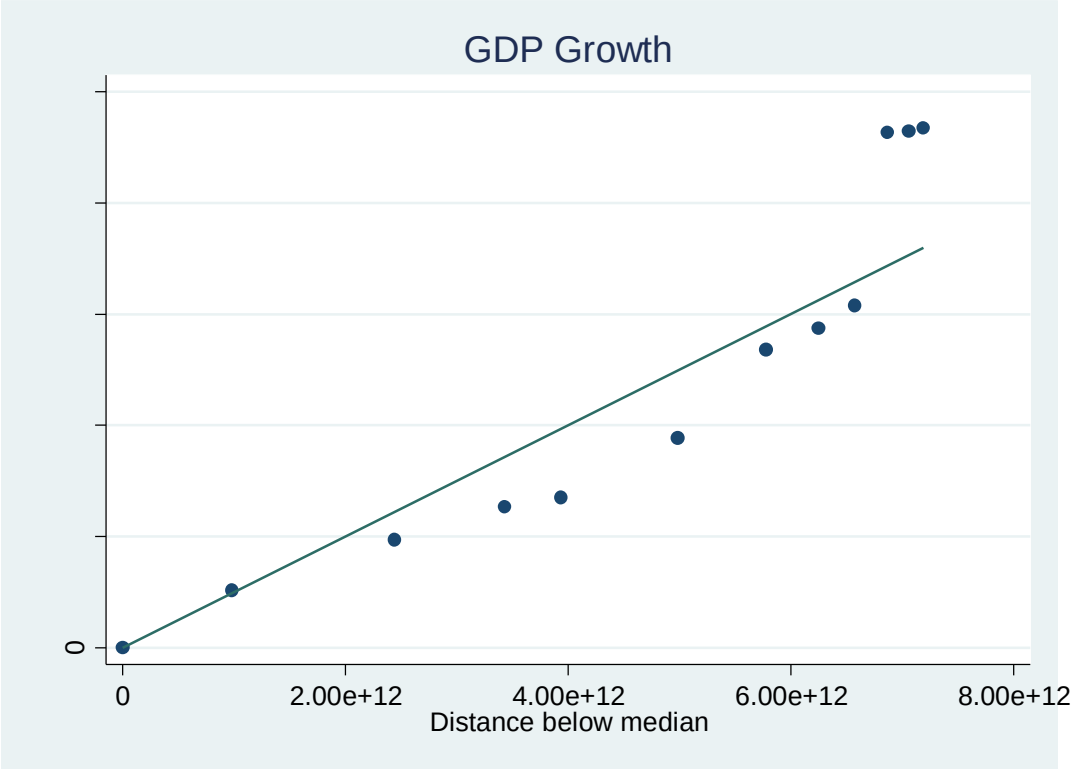
Technological development is a strong positive predictor of renewable energy consumption with the correlation coefficient standing at 0.442, C = 0.01." Nevertheless, its negative correlation with the industrial output indicates that economy with heavy dependence on industrial activities ($r = -0.253$, $p = 0.004$) may still depend on fossil energy to a large extend making integration of renewable energy testing in the economies. CO_2 emissions are positively and significantly related with green trade policies ($r = 0.578$; $p < 0.01$), which suggest that high emission countries are likely to adopt green trade policies probably due to their effort to mitigate their emissions. Also, emissions are significantly and positively with GDP per capita ($r = 0.274$, $p = 0.034$). Thus emerging is positively correlated with emissions and only moderately and positively correlated with the share of its GDP ($r=0.465$, $p<0.000$) while emissions are weakly and negatively correlated with technological advancement ($r=-0.216$, $p=0.033$). A positive relationship between labor force participation and industrial output is observed ($r = 0.853$, $p < 0.01$) showing the embeddedness of human capital in the industrial process. Industrial output is also significantly but positively related with Environmental quality (Pearson correlation coefficient = 0.498, Sig. level= 0.01, Pearson correlation = 0.498, significance level = 0.01) but negatively correlated with renewable energy adoption (Pearson correlation coefficient = - 0.253, Sig. level = 0.004) Therefore, it can be inferred that so called manufacturing(Category 3) is Finally, green trade policies are weakly connected to most of the variables of this study (except emissions), meaning that the adoption of such policies responds to carbonization activities more than it proactively seeks to instigate structural change.

Table 3 Variance inflation factor

	VIF	1/VIF
EnvironmentalQuality	3.282	.305
RenewableEnergy	3.126	.32
CO2emissionskt	1.422	.703
GreentradePolicies	1.087	.92
GDPpercapita	1.083	.923
Mean VIF	2	.

In the table 3, test on multicollinearity is done through the tool called Variance Inflation Factor (VIF). All of the VIF values are substantially less than the cutoff point of 10, thus suggesting that multicolinearity is not a problem with the sets of variables in the current data set. Environmental quality item has the largest VIF of 3.282 followed by renewable energy with 3.126. They are not highly correlated as is evident with the other predictors since both values lie within the acceptable range of multicollinearity. Other variables including CO⁄ emissions (VIF = 1.422), green trade policy (VIF = 1.087), and GDP per capita (VIF = 1.083) are relatively small, which shows minimal

multicollinearity with other variables. The mean VIF of 2 also assures that on average the predictors do not pose significant multicollinearity threat that would otherwise compromise estimation of regression coefficients. The results of the VIF in this study indicates that the model is well-specified and the independent predictors. Interestingly, the two indices of environmental quality and renewable energy show moderate multicollinearity but there is little danger of threatening the stability of the model.



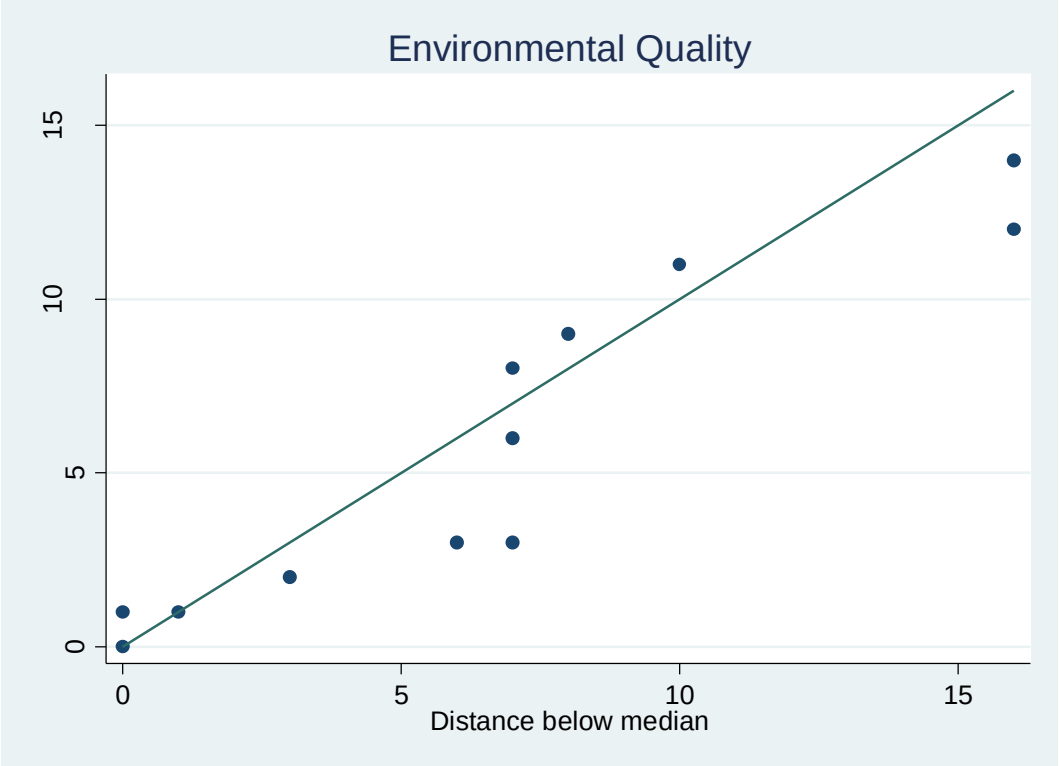


Table 4 Regression results (FE with robust) EnvironmentalQuality

EnvironmentalQuality	Coef.	St.Err.	t-value	p-value	Sig
RenewableEnergy	9.35e-11	2.49e-11	3.75	0.020	**
CO2emissionskt	-4.53e-10	1.69e-10	-2.68	0.055	*
GreentradePolicies	.2510448	.3444586	0.73	0.506	
GDPpercapita	9.25e-11	4.00e-11	2.31	0.082	*
Laborforce	-3.647905	.5729218	-6.37	0.003	***
Constant	115.9106	32.8434	3.53	0.024	**

R-squared	0.717	Number of obs	59
F-test	24.880	Prob > F	0.000
Hausman Test (p-value)	0.0000	Wooldridge Test (Prob > F)	0.0295

**** p<.01, ** p<.05, * p<.1*

From the results shown in the table 4, regression results offer considerable information on the determinants for environmental quality. The model has an acceptable level of fitness by any standard; the analysis yields an R-Square of 0.717; this result denotes that 71.7% of the data variability is attributable to the independent variables. The overall model is statistically significant and this is verified by the F-test that is equal to 0.000. Consequently, diagnostic tests support the credibility of the outcomes obtained, the Hausman Test indicating the appropriateness of fixed effects (p=0.0000) and the Wooldridge Test negating the possibility of serial correlation (p=0.0295). Among all the predictors, there is a more significant positive and statistically significant association of renewable energy with environmental quality with p= 0.020 This shows the necessity of the adoption of renewable energy in enhancing environmental quality. On the other hand, CO_2 emissions have a negative impact on environmental quality as the negative environmental consequences of carbonization, p=0.055. GDP per capita; though poorly significant (Sig = 0.082) also has positive correlation, so it may be explained by more resources available for preservation of environment. Nevertheless, the compulsory forcing factor; labor force participation delivers the environmental quality function significantly negatively affected (p=0.003), meaning enhanced labor force involvement including those damaging the environment, reduces environmental quality. Uniquely, green trade policies have a non-significant result (p=0.506), which implies that their effects on the quality of the environment may not directly affect or might only affect it when some conditions are met. The coefficient of the constant is a positive sign (p= 0.024) which can be used as the baseline of environmental quality for all the predictors at zero. Thus, the results focus on the positive impact of the RE and future environmental quality while introducing the problem of CO_2 emissions and some particular types of economic activities.

Table 5. Regression results (FE with robust) GDP

GDP	Coef.	St.Err.	t-value	p-value	Sig
CO2emissionskt	.000044	.000015	2.93	0.043	**
GreentradePolicies	.0002787	.0000578	4.82	0.009	***
GDPpercapita	-55926.42	106019.5	-0.53	0.626	
Laborforce	-.0000444	.0000168	-2.64	0.057	*
TechAdvancement	960165.4	190859.6	5.03	0.007	***
Constant	-2.05e+07	5978097	-3.43	0.027	**

R-squared	0.740	Number of obs	59
F-test	27.8450	Prob > F	0.0000
Hausman Test (p-value)	0.0000	Wooldridge Test (Prob > F)	0.0002

**** p<.01, ** p<.05, * p<.1*

Table 5, regression analysis reveals more informative data about the GDP factors. The model has a high level of explained variance with regards to GDP since the R-squared value shows that the model explains 74.0% of the change in GDP. The F-test result validate the overall significance of the model where the p-findings show a value of 0.0000. Checks for models' suitability through Hausman Test (Chi-square = 0.0000) and Wooldridge Test (Chi-square = 0.0002) confirm credibility of fixed effects and absence of serial correlation. It was demonstrated that CO_2 emissions have a significant and positive impact on GDP (beta=0.000044; p=0.043), which explains that the studied type of economic growth is connected with the growth of emissions and the increase of carbon-intensive activities. Sustainable Trade policies equally show a positive and a very high level of significance to the GDP (β= 0.0002787, P .009), suggesting the need for more sustainable trade policies that can be adopted to bolster the economy. On the other hand, what we find for labor force participation is a much smaller yet statistically significant negative impact on GDP (β = -0.0000444, p<0.1) which basically suggest that structural problems in the way labor is used may explain lack of productivity in the economy. This implies that technological advancement has a large and significant a positive impact on GDP (β= 960,165.4, p= 0.007); this is concretized by the fact that technological advancement, as has been earlier emphasized, is a key driver of growth. Surprisingly,

there is no correlation between GDPPC and GDP (r =-0.626) indicating that changes in per capita income are not directly related to the changes in the aggregate GDP in this regard. The intercept again is negative and equally significant (β= −20,500,000; p=0.027), showing conditions at baseline, when all the predictor variables are set to zero. This analysis shows that the trends in CO_2 emissions and green trade policies positively affect GDP together with emphasizing the technology's ability to turn the economy.

5. Research Discussion

In light of the regression analysis, there are various significant correlations between some aspects of economic and ecological realms for South Asian economies. This work found that renewable energy has an overall positive and statistically significant impact on environmental quality and supports the assumption that higher levels of renewable energy would enhance environmental quality. On the other hand, CO_2 harms environmental quality in a way that informs of environment cost of carbon dominated growth (Ekins & Zenghelis, 2021). But, green trade policies are ineffective in the improvement of environmental quality which can raise the possibility that they have indirect or contingent effect. Two of the most popular indicators for economic growth for both CO_2 emissions and green trade policies are directly linked with GDP; this implicates that while carbonaceous activities boost development, a sustainable trade system promotes growth. Technological improvement highly contributes to the increase in GDP and strengthens the concept of the critical importance of innovations in economic progress. While the labor force participation has a negative effect on the GDP it is likely to indicate inefficiencies in labor market conditions. When tested with GDP it failed to exhibit a good correlation; GDP per capita Thus incomes inequalities may limit its direct contribution towards economic growth (Al-Zubairi et al., 2024). These findings only corroborate the fact that pursuing economic development compatible with environmental preservation in South Asia is a multifaceted challenge requiring technology advancement and policy measures. Consequently, the results of the present study offer valuable implications and directions for better understanding how South Asian economies relate economic development to environmental conditions and policies directed towards sustainable goals. The results also show a positive and significant correlation between CO_2 emissions and GDP proving that these economies continue to depend on carbon activities to fuel their economies. This shows a cost of the environment as economies grow and points towards the need for economy-transformation, toward a model of development that is not tied to greenhouse gas emissions. This is in line with previous studies that indicate the industrial and energy sectors of South Asia depend adamant fossil energy consequently hindering the environmental sustainability. Of course, the huge and positive effect of green trade policies on the GDP uncovered that sustainable trade practices could stimulate the economy (Hamid et al., 2022). This discovery means that the polices meant enhance green trade leads to increase in economic actions while embracing sustainable development. It supports the existing literature that with green trade policies, it may unlock new markets for clean technologies and longevity products which can act as a blueprint for countries' carbon-neural growth.

Technological advancement has a positive and significant impact on GDP [see table 1] and hence is an important determinant of economic performance. This helps support the argument that funding in technology does more than increase efficiency and encourage movement to cleaner economic models. The high value of this variable further amplifies the call to cultivate innovation to realize sustainable and enduring economic and environmental effectiveness. What may also be remarkable, negative association between labor force participation and GDP suggests inefficiencies in labor market conditions which can include underemployment, skills mismatch or reliance on labor intensive but low productivity sectors (Pandey & Asif, 2022). This underscores the need for investment in skills that is the development of the workforce as well as structural changes to fully realize utility of labor. This absence of significance for GDP per capita in this model means that, income differentials or economic inequality might reduce the direct association between per capita incomes on the one hand and total economic growth on the other. This could be interpreted as meaning the benefits are not spread widely, or accrued in a way that fails to generate broad economic benefits, especially to other sectors or areas, thus requiring research on inclusive growth methods. In from of that the above studies and results indicate that South Asian economies need to spur up on growth process while they need to lower down the adverse environmental impact. As such, green trade opportunities and technology evolution is identified as critical co-facilitators of growth pathways towards a carbon neutral future. Nevertheless, linking CO_2 emissions to economic performance once more served as a reminder that policy actions focused on the promotion of renewable energy and reduction of emissions are integral to enhancing energy efficiency and low-carbon economic development. I have included these research findings into a body of knowledge advancing the knowledge of sustainable economic development especially in the developing world, South Asia in particular. They stress the role of special deviations ensuring the economically rational, sociably reasonable, and environmentally sound development of the region.

5.1. Research Implications

This study has clear implications for policymakers, researchers and practitioners interested in sustainable development and economic and environmental policies in South Asian countries. First of all, the role of renewable energy towards the quality of the environment is positively disposed and thus there is a need for the region to move to utilizing clean energy. Another policy decision avenue that needs more attention of the policymakers is

investment in renewable energy supply structures since such investments can achieve twin goals of minimizing negative environmental impacts and obtaining sustainable economic benefits. Since CO_2 emissions are inversely related to the environment quality, these findings leading to call for more stringent polices regulating carbon emission and directing industries as well as energies towards sustainable practices. The paper also discovers that green trade policies can create both environmental and economic benefits. Although they do not appear to have had a positive impact on environmental quality in this study, the significant positive correlation with GDP indicates that they might play an important role in fostering the potential for green technologies and green products markets. It is about time that trade policies were consistent with sustainable development objectives to fulfill the enabling environment for green technologies and enterprise. In addition, the appreciation of the impact of technology on the economy calls for increased investment on technology and research. This stresses the need for creating an enabling environment for development of technology particularly in clean and green technologies in order to unlock the element for carbon-neutral growth. The adverse relation with LFP and GDP implies that there is need to adopt institutional change that can improve the labor market and minimize the level of unemployment, especially in areas that may be costly to productivity and growth. Equally the findings reveal that increasing GDP per capita does not correlate with the overall GDP growth rate, which can be a sign of rising income disparity and other constraints to inclusive growth. Government should develop competency in ensuring that an array of people and regions benefits from economical activities rather than a selected few. All in all, the study indicated that for South Asian economies would have to work to maintain the most important policy objectives of economic growth as well as environmental sustainability in renewable energy policies, green trade, technological progress, and labor market flexibility.

5.2. Conclusion

The present research contributes towards understanding the details of the interactions between RE integration, green trade policies and economic development of SA economies. The results reveal the importance of renewable energy sources in enhancing environmental quality as well as produce vivid revelation of the effect of CO_2 emissions on the environment. Increase in GDP has been predicted by the green trade policies thus indicating that sustainability of trade policies can enhance the growth of the economy hence supporting the economic hypothesis, about sustainability of trade polices but there impact on quality of outputs is unknown. Besides, technological advancement as an impediment of economic development as an element of innovation for a low-carbon economy. On the other hand, negative correlation between labor force participation and GDP reveals Lounge that calls for labor market changes with respect to productivity and efficiency. The research further reveals that, the GDP per capita doesn't have positive direct relationship with the value and GDP growth rate, which implies that whilst it may have the potential of enhancing overall economic growth, income inequality issues or structures in the economy may drag this back. Therefore, it is necessary to adopt the correlated policies stimulating usage of renewable power, green trade, advanced technologies, and the qualification of labor market for making sustainable growth of South Asian economy as well as environmental conservations. Thus, it may be concluded that various South Asian economies are presently in a crucial position of the need for sustainable economic development. Thus, the outcomes of the study underscore the importance of integrated policy strategies that reconcile economic imperatives with environmental imperatives, to help the region start the process of moving towards a low-carbon and more sustainable and inclusive growth path. Subsequent research can extend this work by examining the specific patterns in the different sectors and assessing the occurrence of those policies' long-run impacts on environmental standards of living and the economy.

References

Agrawal, S., & Soni, R. (2021). Renewable energy: Sources, importance and prospects for sustainable future. *Energy: Crises, Challenges and Solutions*, 131-150.

Ahmad, S., Raihan, A., & Ridwan, M. (2024). Role of economy, technology, and renewable energy toward carbon neutrality in China. *Journal of Economy and Technology*.

Ahmed, Z., Ahmad, M., Caglar, A. E., & Pinzon, S. (2024). Achieving carbon neutrality and SDGs: assessing roles of solar energy, government stability, and population aging in greenhouse gas emissions. *International Journal of Sustainable Development & World Ecology*, 1-15.

Ahmed, Z., Ahmad, M., Murshed, M., Shah, M. I., Mahmood, H., & Abbas, S. (2022). How do green energy technology investments, technological innovation, and trade globalization enhance green energy supply and stimulate environmental sustainability in the G7 countries? *Gondwana Research, 112*, 105-115.

Al-Zubairi, A., AL-Akheli, A., & ELfarra, B. (2024). The impact of financial development, renewable energy and political stability on carbon emissions: sustainable development prospective for arab economies. *Environment, Development and Sustainability*, 1-23.

Anwar, M. N., Shabbir, M., Tahir, E., Iftikhar, M., Saif, H., Tahir, A., . . . Aghbashlo, M. (2021). Emerging challenges of air pollution and particulate matter in China, India, and Pakistan and mitigating solutions. *Journal of Hazardous Materials, 416*, 125851.

Asif, M., Khan, M. I., & Pandey, A. (2024). Navigating the inclusive and sustainable energy transitions in South Asia: Progress, priorities and stakeholder perspectives. *Energy Conversion and Management, 313*, 118589.

Bogdanov, D., Ram, M., Aghahosseini, A., Gulagi, A., Oyewo, A. S., Child, M., . . . Barbosa, L. D. S. N. S. (2021). Low-cost renewable electricity as the key driver of the global energy transition towards sustainability. *Energy, 227*, 120467.

Ekins, P., & Zenghelis, D. (2021). The costs and benefits of environmental sustainability. *Sustainability Science, 16*, 949-965.

Hamid, I., Alam, M. S., Kanwal, A., Jena, P. K., Murshed, M., & Alam, R. (2022). Decarbonization pathways: the roles of foreign direct investments, governance, democracy, economic growth, and renewable energy transition. *Environmental Science and Pollution Research, 29*(33), 49816-49831.

Kabeyi, M. J. B., & Olanrewaju, O. A. (2022). Sustainable energy transition for renewable and low carbon grid electricity generation and supply. *Frontiers in Energy research, 9*, 743114.

Lomborg, B. (2020). Welfare in the 21st century: Increasing development, reducing inequality, the impact of climate change, and the cost of climate policies. *Technological Forecasting and Social Change, 156*, 119981.

Ma, S. (2022). Growth effects of economic integration: New evidence from the Belt and Road Initiative. *Economic Analysis and Policy, 73*, 753-767.

Mandel, H., & Lazarus, A. (2021). Contextual effects on the gendered division of housework: A cross-country and cross-time analysis. *Sex Roles, 85*(3), 205-220.

Mukherjee, M., Abhinay, K., Rahman, M. M., Yangdhen, S., Sen, S., Adhikari, B. R., . . . Shaw, R. (2023). Extent and evaluation of critical infrastructure, the status of resilience and its future dimensions in South Asia. *Progress in Disaster Science, 17*, 100275.

Naheed, Z., Nasreen, S., Tiwari, A. K., & Arsh, S. (2024). Analyzing the effectiveness of energy aid for driving the transition towards energy decarbonization; Evidence from Asian developing countries. *Journal of Environmental Management, 360*, 121125.

Pandey, A., & Asif, M. (2022). Assessment of energy and environmental sustainability in South Asia in the perspective of the Sustainable Development Goals. *Renewable and Sustainable Energy Reviews, 165*, 112492.

Peters, R., Berlekamp, J., Kabiri, C., Kaplin, B. A., Tockner, K., & Zarfl, C. (2024). Sustainable pathways towards universal renewable electricity access in Africa. *Nature Reviews Earth & Environment, 5*(2), 137-151.

Rahman, A., Murad, S. W., Mohsin, A., & Wang, X. (2024). Does renewable energy proactively contribute to mitigating carbon emissions in major fossil fuels consuming countries? *Journal of Cleaner Production, 452*, 142113.

Raihan, A., Muhtasim, D. A., Khan, M. N. A., Pavel, M. I., & Faruk, O. (2022). Nexus between carbon emissions, economic growth, renewable energy use, and technological innovation towards achieving environmental sustainability in Bangladesh. *Cleaner Energy Systems, 3*, 100032.

Remy, J. Y., Haynes, R., & Ellis-Bourne, K. (2021). THE TRADE AND CLIMATE CHANGE INTERFACE Initial Considerations for CARICOM.

Shafique, M., Azam, A., Rafiq, M., & Luo, X. (2021). Investigating the nexus among transport, economic growth and environmental degradation: Evidence from panel ARDL approach. *Transport Policy, 109*, 61-71.

Shahnazi, R., Jamshidi, N., & Shafiei, M. (2024). Informal economy and CO2 emissions: threshold effects of information and communication technology. *Clean technologies and environmental policy*, 1-19.

Srivastava, R. K., & Srivastava, R. K. (2020). Risk profiles of South Asia-urbanization context. *Managing Urbanization, Climate Change and Disasters in South Asia*, 1-21.

Tahir, T., Luni, T., Majeed, M. T., & Zafar, A. (2021). The impact of financial development and globalization on environmental quality: evidence from South Asian economies. *Environmental Science and Pollution Research, 28*, 8088-8101.

Tariq, M., Xu, Y., Ullah, K., & Dong, B. (2024). Toward low-carbon emissions and green growth for sustainable development in emerging economies: Do green trade openness, eco-innovation, and carbon price matter? *Sustainable Development, 32*(1), 959-978.

Tu, Y., & Wu, W. (2021). How does green innovation improve enterprises' competitive advantage? The role of organizational learning. *Sustainable Production and Consumption, 26*, 504-516.

Van Zanten, J. A., & van Tulder, R. (2021). Improving companies' impacts on sustainable development: A nexus approach to the SDGS. *Business Strategy and the Environment, 30*(8), 3703-3720.

Wang, C. H., & Juo, W. J. (2021). An environmental policy of green intellectual capital: Green innovation strategy for performance sustainability. *Business Strategy and the Environment, 30*(7), 3241-3254.

Watts, J. Partisanship in EU energy security policy: The fragile equilibrium and a fragmented constellation.