KASBIT BUSINESS JOURNAL

Journal homepage: www.kbj.kasbit.edu.pk

Socio-Economic Determinants of Green Growth: A Case of Selective South Asian Economies

Osman Rashdi [i], Dr. Muhammad Aqil [ii], Anum Muhammad Nasir [iii], Dr. Muhammad Asad Ali [iv]

i) *Programme Director, Denning Business School, Karachi osmanrashdi@gmail.com*
ii) *Associate Professor and Registrar, Shaheed Zulfikar Ali Bhutto Institute of Science and Technology (SZABIST) University, Karachi.*
iii) *Mphil, Scholar, University of Karachi.*
iv) *Assistant Professor, Shaheed Zulfikar Ali Bhutto Institute of Science and Technology (SZABIST) University, Karachi.*

ARTICLE INFO

Keywords:

Green growth,
Human development,
Carbon emission,
Governance,
Emerging Economies,
Pakistan,
Panel Data,
South Asian Economies.

ABSTRACT

This study investigates the impact of several key macroeconomics factors on green growth in India, Pakistan, Bangladesh, Nepal, and Bhutan from 2000 to 2023. Considering the region's vulnerability to environmental issues and development constraints, the analysis of this study incorporates GDP per capita, the human development index (HDI), and CO_2 emission as components of a composite Green Growth Index (GGI). GDP per capita growth, enrollment in secondary education, use of renewable energy, trade openness, and quality of government are the independent variables, and these data are collected form the World Bank and World Governance Indicators. The analysis with panel data and robust standard errors found that a better education system and strong governance significantly enhance green growth. Meanwhile, the growth of the economy is negatively associated to the use of renewable energy, and this may result from using traditional biomass. Trade openness does not show meaningful relationship with green growth. The overall results of this research suggest that both human capital and governance are essential for achieving sustainable development within countries. The study also concludes that policies designed to improve institutional quality will promote inclusive, long-term economic growth throughout South Asia by enhancing environmental regulation and governance capacity.

Corresponding Author: Dr. Muhammad Asad Ali, Email: dr.asad@szabist.edu.pk

Received: 10th March, 2026

Received in revised form: 8th April, 2026

Accepted: 9th April, 2026

1. Introduction

Global interest in green growth has increased as nations face the dual challenge of promoting economic development while mitigating environmental degradation. Accelerating climate change has prompted international commitments such as the Paris Agreement and the 2030 Agenda for Sustainable Development, both of which underscore the need for development pathways that reduce ecological harm. Green growth embodies this principle by linking economic expansion with the sustainable use of natural resources and environmental protection (Gavurová et al., 2021; Smulders et al., 2014; Liu et al., 2025).

South Asia has experienced rapid population and economic growth, placing significant pressure on regional ecosystems. Awan and Nawaz (2022) estimate that failing to address climate change could lead to a decrease in South Asia's economic output of as much as 8.8% by the year 2100. Even though there are many examples of empirical research focused on identifying the social and economic factors that contribute to green growth, within South Asia there is only a limited amount of regional empirical research available. This includes all aspects of green growth such as income, human capital, trade, energy mix, and governance (as determined by international studies), but there is little or fragmented information available on all socioeconomic aspects of green growth in South Asia.

Based on these factors, the objectives of this study include: (1) To analyze the relationship between per capita income and green growth, (2) To assess the impact of education on green growth, (3) To examine how trade openness influences on green growth, (4) To evaluate whether of use of renewable energy promotes green growth, and (5) To investigate how governance quality influences green growth in South Asia.

This study helps close this gap by developing a composite Green Growth Index and examining the determinants of green growth across five South Asian countries namely India, Pakistan, Bangladesh, Nepal, and Bhutan from 2000 to 2023. The results provide insight for policymakers to improve education systems, promote better governance, improve trading policies and support renewable energy development in achieving SDG 8 (Decent Work and Economic Growth) and SDG 13 (Climate Action).

2. Literature Review

The Green growth, as presented in the OECD's report Toward Green Growth (2011), integrates economic development with environmental sustainability. It prioritizes resource efficiency, technology innovation and integrating environmentally friendly production systems in all sectors (Naimoğlu, Şahin, and Özbek, 2025). Recent literature has created composite indices, such as entropy-based indices, to measure the multi-dimensionality of green growth, using indicators of energy transition; environmental quality; and technological progress (Dźwigoł et al., 2023; Lin & Zhou, 2021).

Empirical evidence shows that income, institutions, and technological change are key drivers of green growth. Tawiah et al. (2021) noted that while GDP per capita is positively related to green growth in advanced economies, it is less strongly, or not, positively related to green growth in developing economies, as suggested by the Environmental Kuznets Curve (EKC). The macroeconomic landscape of South Asia is often characterized by structural vulnerabilities. For instance, Ali and Aqil (2022) highlight how macroeconomic misalignments directly impact economic growth in Pakistan.

They report the need to stabilize economic indicators before a sustainable transition can be fully realized.

Over time, technological progress and new inventions have a major part in boosting green growth (Popp, 2012; Naimoğlu et al., 2025). Research studies by Mensah et al. (2019) and Nosheen et al. (2021) indicate that improving environmental patents and R&D spending always helps the growth of the environment in the OECD and EU regions

Green economic growth is greatly improved by education through its increase in human capital, promotion of new ideas, and increase in public awareness of the need to protect the environment. The study conducted by Liu et al. (2025) suggests that when countries offer more people secondary and tertiary education in STEM and environmental subjects, it increases green GDP in OECD members countries. Secondary education prepares workers for entry into the sector of renewable energy; tertiary education is a greater contributor toward new ideas or innovations and advances toward new levels of research/technology through low-carbon energy alternatives. The role of human capital in driving performance and sustainable outcomes is well-documented across developing Asian economies (Akbar et al., 2025). In the context of environmental sustainability, an educated populace is better equipped to adopt renewable technologies and support green policies.

Although less research has been conducted in developing economies, their results support the same overarching conclusion. Bu and Alola (2024) suggest that education helps to build green economic growth by increasing as a country moves further along the path toward development. Li et al. (2022) also report that there is a strong interaction between higher levels of education and ICT development, and that for every one percent of increase in ICT adoption, the green economic growth will be increased by approximately 1.3 percent.

Urban development has had both positive and negative environmental impacts. In terms of urban planning, well-planned urban center reduces the amount of energy consumed through greater overall efficiencies or reduced energy usage, and subsequently, reduce the amount of pollution produced. However, unstructured and rapid urbanization can lead to greater amounts of pollution and/or a greater strain on existing infrastructure in South Asian countries (Awan & Nawaz, 2022). As urban centers in both developed countries are becoming more developed and more urbanized, urbanization does not have a significant impact on green economic growth (Liu et al., 2025). For this reason, urbanization was excluded from the model, as it has a large positive correlation to GDP and quality of governance.

2.1 Openness, Trade, and Global Integration

The relationship between trade openness and green growth is complex. It has both positive and negative effects on green growth. On the positive side, trade openness allows countries to access cleaner technologies as well as methods of producing goods more environmentally efficiently. Conversely, where countries with weaker environmental regulatory regimes are shifting their pollution-intensive industries, they will ultimately cause an increase in emissions associated with that industry relocating. Tawiah et al. (2021) describe how trade openness, in various developing countries, has led to increased rates of environmental degradation as both resource extraction and pollution-producing industry are concentrated in these less developed regions.

Location and level of development affect the relationship among countries in South Asia. For example, Awan and Nawaz (2022) found that trade openness has a negative impact on green growth in Bangladesh, a positive impact on green growth in Pakistan, and no significant impact on green growth in India; these findings exemplify how the structural differences in exporting compositions and the extent of environmental governing regimes in the three countries affect the outcomes of trade openness on green growth in these three different countries.

Recently, the need to separate general trade openness from "green trade openness" has been emphasized. Tariq et al. (2023) created a Green Trade Openness Index to quantify imports and exports of goods that are environmentally friendly (i.e., impact the environment the least), demonstrating that green trade openness is associated with the ability to increase the rate of green growth and reduce emissions produced during the sale of goods traded internationally. Furthermore, as demonstrated by Naimoğlu et al. (2025), Minh and Van (2023), and Song et al. (2019), it appears that when trade openness is combined with robust domestic environmental regulations that support trade, green growth will receive an enhanced rate of improvement.

2.2 Energy Transition and Environmental Sustainability

The composition of the energy mix is one of the key components of an economy's green growth potential. Numerous empirical studies provide evidence that renewable energies can substantially reduce carbon emissions and play a supportive role for sustainable development (Tawiah et al., 2021; Taskin et al., 2020). Moreover, Murshed (2024) and Tariq et al. (2023) state that countries that have effective institutional frameworks for adopting renewable energy have the greatest likelihood of utilizing this source of energy effectively.

There is also evidence that the extent to which countries develop will influence how much renewable energy can positively impact their economies. According to a study by Wang et al. (2023), for example, in BRICS economies, the extent to which renewables can positively impact an economy will be dependent upon both environmental conditions as well as upon the technological readiness of the country to utilize renewable energy sources. In contrast, Dźwigoł et al. (2023) argue that while ultimately stringent environmental regulations can impede early economic growth, they will create an environment for innovation which will, over time, enhance long-term growth by transitioning to green technologies.

In South Asia, increasing solar, wind, and hydropower production are essential for limiting dependence upon coal and traditional biomass for energy. However, it is often the case that a significant percentage of what is referred to as "renewable energy consumption" is due to biomass-consuming, as opposed to modern renewables: thus, a high renewable energy share may not always reflect a true low-carbon transition but rather an outcome of energy poverty. Although energy efficiency also plays an important role, this variable has been excluded from this model due to the degree of correlation with GDP as well as with other economic indicators.

2.3 Institutional and Governance Factors

The principal driver of an economy's ability to achieve sustainable green growth is the institutional quality within it. Well-functioning institutions (governance) establish the framework required for successful environmental protection and innovation through regulatory consistency and transparency, enforcement of existing regulations, and the efficient delivery of public services. Conversely, poor institutions (governance) are a major contributor to an economy's inability to foster sustainable resources, corruption, and policy failures.

There is a temporal disconnect between existing evidence on the influence of institutions/governance on green growth, but findings differ. Tawiah et al (2021) found no strong relationship at the global level, while Kassi et al (2020) found that governance significantly moderates the relationships between renewable energy/finance and growth. Studies conducted in China (Dźwigoł et al, 2023; Pan et al, 2023) also show that anti-corruption reforms and improved institutions are directly related to better environmental outcomes.

The state of governance in South Asia is widely considered to be under-performing. Murshed (2024) and Tariq et al (2023) report results where strong institutions enhance the use and benefits of renewable energy and eco-innovation. Similarly, in Türkiye, results by Naimoğlu et al (2025) and Qamruzzaman & Karim (2024) support the conclusion that solid governance structures promote green investment and provide greater policy stability.

In the present study, governance is assessed based on the Government Effectiveness Index (GEI) (World Bank 2023), which provides an aggregate measure of the quality of public service delivery, quality of policy development and implementation, and quality of institutional delivery.

2.4 Research Gaps and Contribution

Research has produced a large volume of existing documents covering the topic of established green growth around the world. The basic theme of the research has focused on many areas including developing countries in South Asia; however, there are continuing gaps to be filled; for example most (if not all) research in developing economies was grouped together as one and/or primarily included only large emerging economies such as China at the expense of the South Asian region being studied as much as it has been. The article by Awan and Nawaz (2022) examined a limited sample of only three South Asian economies over a short time period, while the authors of this report expanded their examination to include five countries (India, Pakistan, Bangladesh, Nepal and Bhutan) over the last 24 years, creating a more comprehensive look at green growth in the region.

Despite the existence of extensive research from abroad on the social and economic dimensions of green growth, there are very limited studies focused on measuring the impacts (for instance education or the quality of governance) of these social/economic dimensions of green growth within a developing economy. While empirical evidence has been documented in studies conducted within other regions of the world regarding the relevance of social/economic dimensions of green growth, there is not much empirical evidence on South Asia itself. Recent studies done by Bu and Alola (2024) and Liu et al. (2025) have noted the lack of empirical data with respect to how human capital systems affect green growth in developing economies. Unfortunately, the limited empirical evidence pertaining to this area does not allow for the quality of governance to be adequately measured either conceptually or empirically within the South Asian region.

A gap also exists in relation to trade openness. It is difficult to draw conclusions about the relationship between trade and green growth as different researchers have provided different perspectives. For instance, Tawiah et al. (2021) describe a negative correlation, where trade adversely impacts developing nations' green growth; however, Tariq et al. (2023) argue that green trade positively contributes to sustainable development. This research aims to eliminate the confusion by using standardized indicators and consistent empirical methodologies to provide more comparable results and to improve their interpretability.

In terms of methodology, this research offers an additional contribution. Most of the existing literature employs single-indicator proxies to measure green growth; however, we will use a composite Green Growth Index that is linked to OECD, UNDP, and World Bank frameworks and that captures the multi-faceted nature of sustainable development. We will also apply fixed-effects estimators with Driscoll–Kraay standard errors to protect against heteroskedasticity, serial correlation, and cross-sectional dependence. This methodology provides a highly rigorous but still accessible alternative to common GMM or ARDL models used in most studies.

Thus, by integrating the economic, institutional, and environmental elements of green growth into one analytical framework, the results of this study will help enhance understanding of the determinants of green growth on a regional basis.

3. Methodology

In this study we used balanced panel dataset of India, Pakistan, Bangladesh, Nepal and Bhutan from 2000-2023 resulting in 120 country-year observations. Since panel data includes both time series and cross-sectional data, it improves the estimation's accuracy and acknowledges differences that are not measured (Hsiao, 2014; Baltagi, 2008). For the primary method, fixed effects (FE) estimator is used, because it accounts only for time-invariant (i.e., geography, cultural and institutional structure) characteristics of the countries included in this study. Several previous studies on green growth have used FE estimates to account for within-country variation (Tawiah et al., 2021; Arellano, 2003). Additionally, year fixed effects will be included in order to control for global shocks (i.e., the financial crash of 2009, the COVID-19 pandemic, and global technology trends).

All variables are sourced from the World Development Indicators (WDI) and World Governance Indicators (WGI). The dataset includes measures of economic performance (GDP per capita and GDP growth), human capital (secondary school enrollment), renewable energy consumption, trade openness, and government effectiveness. All monetary values are reported in constant PPP-adjusted US dollars for comparability.

The sample encompasses diverse economic structures and development levels across South Asia. South Asia's different countries are included in the sample, and each country has a great diversity in income, governance, degree of openness, and types of energy within the region-create an opportunity to be able to examine the heterogeneity of the determinants for sustainable development. Data availability occurred over a long time period; therefore, it is possible to identify long-term relationships that are structurally consistent.

Following section briefly explains about the variables used in this article.

Green Growth Index (GGI): The Green Growth Index (GGI), the dependent variable in this study, is a composite that takes into account the per capita GDP, Human Development Index (HDI), and CO_2 emissions, and is scaled from 0 to 1. This composite fits the framework of the OECD and UNDP World Bank, that conceptualize green growth as a balance between economic performance, social well-being, and environmental sustainability.

GDP per capita growth (gdppc): The rate of growth of the economy (or GDP). The Environmental Kuznets Curve (Grossman and Krueger, 1995) indicates that the economy may grow at a rate that initially causes harm to the environmental but will ultimately lead to more sustainable practices as a nation becomes more affluent.

Secondary School Enrollment (se): Secondary school enrollment is a measure of the amount of human capital that is developed in an economy. As the population becomes better educated, they develop an awareness of their environment, become more productive, and are able to innovate.

Trade Openness (trade): Openness is measured by total trade to GDP. The degree of openness can either increase the efficiency with which technology is transferred and used, or there may be an increase in pollution due to the establishments of resource-intensive industries in the economy (Shahbaz, et al., 2015)

Renewable Energy Consumption (rec): The amount of renewable energy consumed as a percentage of the total final energy consumed. When this percentage is relatively high, the likelihood of creating conditions conducive to the growth of a green economy will increase.

Government Effectiveness (ge): Government effectiveness is a measure of quality of governance sourced from the 'World Governance Indicators' (WGI). Government effectiveness is indicative of how well an economy delivers public services, develops policy and administers the policy through bureaucracy.

Urbanization, energy intensity, and forest area were initially thought to be suitable independent variables; however, due to multicollinearity and overlap between these measures, they were dropped from the final analyses. The fixed effects may have also taken care of many of the omitted-variable issues related to these three variables.

3.1 Econometric Model Specification

The principal method used in this analysis is panel data regression analysis. Our baseline model general specification appears as described below:

$$GGI_{it} = \beta_0 + \beta_1 gdppc_{it} + \beta_2 se_{it} + \beta_3 rec_{it} + \beta_4 trade_{it} + \beta_5 ge_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where: gdppc shows GDP per Capita, se measures Secondary School Enrolment, rec is Renewable Energy Consumption, trade shows Trade Openness, ge stands for Governance effectiveness, and GGI represents Green Growth Index

Here β_0 are coefficients of the independent variables, μ_i for the country fixed effect and λ_t for the year-specific effect and $\varepsilon_{i,t}$ it represents the residual error. Among these options, a fixed-effects estimator (within transformation) is the best since it removes the μ_i parameter when making the estimation. Dummy and linear trend terms are part of the model every year to find out about similar world-wide situations like the financial crisis of 2009, the COVID-19 pandemic in 2020 and the increasing development of technology through years.

The coefficients β_1 to β_5 show the effect of direct impact on the Green Growth Index despite other conditions. Since the log transformation of GDP gives semielasticity, β_1 measures the average GGI change that results from a 1% increase in GDP per capita. Positive β_1 tells us that an income increase is connected with better green growth for countries at a certain development level (Tawiah, Zakari, & Adedoyin, 2021). Also, a positive β_2 suggests that extra spending on education – especially secondary school – improves GGI.

If the coefficient β_3 is negative, it would support the notion that South Asia is a polluter due to foreign trade, while positive results suggest the region gets environmental benefits from access to new green products on the world market (Tawiah, Zakari, & Adedoyin, 2021). Higher renewable energy share (represented by a positive β_4) shows that using more renewables in the energy mix helps to keep the composite green growth growing. The coefficient β_5 should also be positive, therefore, proving that good governance enables the countries of South Asia.

3.2 Estimation Techniques

To increase the reliability of the panel model, many diagnostic and fixative actions were applied (not shown for the purpose of brevity). Next, the stationarity of every variable was checked with appropriate panel unit root tests i.e., IPS and LLC. After showing non-stationary values, GDP per capita was changed into growth rates to prevent spurious regression.

After running the basic regression, the approach found typical concerns in country-level panel data, mainly issues of heteroskedasticity, autocorrelation, and cross-sectional dependence. For this reason, the research used Driscoll–Kraay robust standard errors in conjunction with a fixed-effects (FE) model. Such method addresses the issues noted earlier and becomes stronger when year dummies are added to manage any shocks that happen at a specific time period. Modifying the data enables the estimates to be more reliable and helps you make appropriate conclusions from hypothesis testing.

Before starting regression analysis, all the variables' summary statistics were established. This part was important to address any problems in the data and examine how the distribution of the data. The IPS and LLC unit root tests were carried out for all the variables at level and with lagged values. After the test of stationarity, the regression model was estimated and regression diagnostics were performed including cross sectional dependence using Pesaran CD test and Modified Wald test for Heteroskedasticity in residuals of the estimated model. For serial correlation, we used Wooldridge test or serial correlation. Since the study found these concerns present in the model, we opted for Driscoll-Kraay standard errors corrected model. The reliable findings are made possible because this approach tackles common issues with panel data and guarantees that the regression coefficients have statistical value.

4. Results and Discussion

The descriptive statistics indicate that the included countries have experienced notable improvements in both social and economic indicators over the past two decades. GDP per capita has generally increased, accompanied by enhanced human development outcomes. As an example, secondary education enrollment in the country of Bangladesh increased from 20 to 65 percent, signifying that Human Capital had improved and thus increased the Human Development Index (HDI). However, human capital and environmental pressures also show positive relation, i.e., both increasing, (particularly in Pakistan, India and Bangladesh), due in part to fossil fuel usage resulting in increased CO_2 emissions. In contrast, Nepal and Bhutan use primarily renewable energy leading to low levels of emissions.

Cross-country differences in trade openness, governance quality and the Green Growth Index (GGI) also indicates a wide variation among countries (range from 0.0 to 0.74). Generally speaking, countries with superior educational systems, effective governance and sustainable energy usage perform better relative to the GGI, which is consistent with the perspective that human capital and institutional quality are important determinants of green growth.

Table 4-1 provides summary statistics of the key variables for the five countries over a 24-year period (2000 – 2023). Each variable is represented by 120 observations. GDP per capita is expressed in constant U.S. dollars (adjusted for PPP); secondary education enrollment expresses the percentage of students who attend secondary school, renewable energy expresses the percentage of total final energy used; trade openness is defined as total trade divided by GDP; governance quality is based on World Governance Indicators (WGI); and GGI is a score ranging between 0 (Lowest) and 1 (Highest).

Table 4-1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per Capita (US$)	120	1339.268	853.895	223.830	3711.328
Secondary Enrollment (%)	120	56.589	18.036	19.912	90.804
Renewable Energy (% of TFEC)	120	59.257	22.304	25.000	92.000
Trade Openness (% of GDP)	120	47.956	22.148	21.460	108.158
Governance Quality (WGI)	120	-0.366	0.533	-1.135	0.702
Green Growth Index (GGI)	120	0.330	0.188	0.000	0.741

The descriptive statistics highlight substantial heterogeneity among countries. The GDP per capita varies from as low as $224 to as high as $3,711, with an average of $1,339 (SD = 854), indicating that there is a significant difference in the economic situation of the different countries. While there is an average of 56% of the population being enrolled in secondary school, several countries have comparatively low levels of secondary school enrollment. While there is a significant amount of variation in the amount of renewable energy that different countries utilize, there are also numerous differences in the amount of energy infrastructure and the availability of resources for renewable energy to produce. Trade openness ranges from 21% to 108% of GDP; the quality of governance has an even greater range of distribution across nations, with an average value of less than zero, implying that there are many nations with very limited capacity for institutional effectiveness. The GGI has a range from 0.0 to 0.741, with an average value of 0.330 (SD = 0.188), suggesting significant differences in relative green growth performance across countries. Overall, the panel data represent a very diverse array of country conditions; thus, the use of fixed-effects estimation should be utilized to provide more accurate inferences.

To test for stationarity, two widely used panel unit root tests were employed: the Im-Pesaran-Shin (IPS) test and the Levin-Lin-Chu (LLC) test. The IPS permits for autoregressive coefficient heterogeneity among countries – thus the IPS is appropriate for countries with differing economic circumstances. On the other hand, the LLC presumes that all cross-sections possess a similar autoregressive coefficient – therefore a more restrictive, but complementary, test. The dual testing concludes we may determine an accurate & reliable characterization of the data's time-series behaviour. Table 4-2 reflects the results of the stationarity test results at both a lag 0 & lag 1 for all variables. The results indicate that most variables were stationary at level or became stationary after minor transformation, such as converting GDP per capita into its growth rate. GDP growth, secondary school enrollment, governance quality, renewable energy consumption, trade openness, and the Green Growth Index all satisfied the stationarity condition. This confirms that the data are stable over time and suitable for panel regression, ensuring that the subsequent econometric analysis is reliable and free from spurious relationships.

Table 4-2: Panel Unit Root Test Results

variable	Lag	IPS		LLC	
		Statistics	P-value	Statistics	P-value
gdppc	0	3.366	1.000	1.533	0.937
	1	2.431	0.992	0.572	0.716
se	0	0.145	0.558	-1.570	0.058
	1	0.364	0.642	-1.457	0.073
rec	0	-0.624	0.266	-1.814	0.035
	1	-0.528	0.299	-1.767	0.039
trade	0	-1.636	0.051	-1.518	0.064
	1	-2.628	0.004	-2.339	0.010
ge	0	-4.916	0.000	-5.210	0.000
	1	-1.786	0.037	-1.393	0.082
gg	0	-5.316	0.000	-5.857	0.000
	1	-2.276	0,011	-1.090	0.138
Gdppc growth	0	-4.8570	0.0000	-4.7258	0.0000
	1	-4.2196	0.0000	-3.4301	0.0003

The study focuses on the factors that determine green growth using the Green Growth Index (GGI) as the dependent variable with GDP growth rate, secondary school enrolment, renewable energy usage, governance quality and degree of trade openness as independent variables. To account for both the within and between country variations, pooled OLS, fixed effects (FE) and random effects (RE) panel regression techniques were used with the outcome of the Hausman test providing evidence to select the fixed-effect model emphasising the value of factors unique to each country in determining green growth.

To determine the most appropriate estimation technique between Fixed Effects (FE) and Random Effects (RE), a Hausman test was conducted. The test yielded a chi-square statistic of -266.6 with a p-value more than 0.99, leading to the rejection of the null hypothesis. Consequently, the Fixed Effects model was selected. While the cross-sectional dimension of the panel is small (N=5), the FE estimator remains conceptually and econometrically robust for this analysis. As established in foundational econometric literature (e.g., Baltagi, 2021; Wooldridge, 2010), when a sample constitutes a specific, non-random geographic and economic bloc, rather than a random draw from a larger global population, FE is the preferred approach to control for unobserved, time-invariant heterogeneity unique to these specific nations

The baseline regression results for pooled OLS, fixed effects and random effects are presented in Table 4-3 along with the estimated coefficients, standard errors and the level of statistical significance of each independent/explanatory variable. The findings from the baseline regression are presented in Table 4-3. Model results consistently demonstrate that secondary school enrollment has a positive and statistically significant effect on growth as measured by GGI, which illustrates that developing human capital plays an important role in promoting green growth. GDP growth has a negative impact on GGI, which is consistent with predictions of the Environmental Kuznets Curve where rapid economic growth leads to increased environmental degradation before environmental protection becomes a priority. The negative coefficient estimate for renewable energy consumption in the fixed effects model was unexpected, but could be attributed to countries with large amounts of traditional use of biomass energy and small-scale hydr; energy plants, which do not contribute significantly towards achieving sustainable development. The quality of governance was statistically significant in both the pooled OLS and random effects models. Yet findings from the fixed effect model indicate that institutional differences across countries are more relevant than year-by-year changes within a country for determining GGI. Finally, trade openness has consistently produced a statistically insignificant coefficient across all regression specifications.

Table 4-3: Baseline Regression Results

VARIABLES	(1) Pooled OLS	(2) Fixed Effects	(3) Random Effects	(4) Driscoll-Kraay standard errors
gdpgr	-0.350***	-0.175**	-0.350***	-0.350***
	(0.101)	(0.0700)	(0.101)	(0.107)
Governance Quality	0.165***	0.0544	0.165***	0.165***
	(0.0299)	(0.0494)	(0.0299)	(0.0556)
Trade Opennes	-0.00145	0.000256	-0.00145	-0.00145
	(0.000930)	(0.000840)	(0.000930)	(0.00179)
Renewable Energy Consumption	-0.00316***	-0.00540***	-0.00316***	-0.00316**
	(0.000635)	(0.00146)	(0.000635)	(0.00115)
Secondary School Enrolment	0.00571***	0.00894***	0.00571***	0.00571***
	(0.000584)	(0.000730)	(0.000584)	(0.000550)
Constant	0.351***	0.163	0.351***	0.351***
	(0.0478)	(0.133)	(0.0478)	(0.0699)
Observations	115	115	115	115
R-squared		0.815		0.716
Number of countries	5	5	5	
chibar2(01)	0		-266.6	
Prob > chibar2	1		1	
Number of groups				5

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

Fixed-effects estimates, examining intra-country variability over time, reaffirm the importance of education as secondary education enrollment has a coefficient of 0.00894 ($p < 0.01$). GDP growth continues to have a significant negative effect on green growth (coefficient = –0.175, $p < 0.05$), suggesting that growing the economy without taking care of the environment as we do so could be harmful to the environment. Traditional renewable forms of energy also have a negative impact on green growth and suggest that these forms will not be sufficient on their own to facilitate an increase in green growth. Governance and trade do not show any significant effects at the intra-country level, which indicates the predominance of structural or historical influences.

Random-effects estimates that both intra- and inter-country variability indicate that governance quality has a significant positive effect on green growth (coefficient = 0.165, $p < 0.01$), suggesting that positive institutional capacity leads to a greater amount of green growth across all countries. Other variable estimates, generally consistent with the fixed-effects estimates, suggest that education has a positive effect on the GGI, while GDP growth has a statistically significant negative impact; trade has no statistical significance.

To address the possible issues surrounding heteroskedasticity, serial correlation, and cross-sectional dependence in our models, we estimated our models again after using Driscoll-Kraay (DK) robust standard errors. The DK correction confirmed all of the previous main results and allowed for a more reliable inference. Using DK-corrected estimates, rapid GDP per capita growth continued to show a significant negative relation with the Green Growth Index, which provided further support that unregulated economic growth is related to increased environmental degradation. The relationship between secondary school enrollment and green growth continued to show a significant positive relationship, which highlights the important role of human capital in generating green economic growth. The negative relationship between renewable energy use and green growth still existed due to the reality of energy scarcity in the region along with continued dependence on traditional biomass and hydro resources.

On the other hand, DK-corrected estimates indicated a statistically significant relationship for governance quality, demonstrating that countries with well-designed institutions are better positioned to achieve sustainable development. The results support that there are context specific/time dependent relations between governance and the ability of countries to promote green growth. Conversely, trade openness remained mostly insignificant indicating that liberalized trade by itself will not provide the necessary conditions for continued improvement of environmental quality without supportive domestic policies to help drive improvements.

Overall, the application of DK robust standard errors strengthened the validity of the study's conclusions. The evidence consistently identifies education and governance as the primary enablers of short-term green growth, while rapid economic expansion and traditional energy consumption can hinder sustainability. Trade activity plays a limited role. These insights underscore the importance of policy interventions that prioritize human capital development, institutional capacity building, and the modernization of energy infrastructure to support sustained green growth in South Asian economies.

For the five developing economies of East Asia, the empirical results show that green growth is the result of a combination of social, economic and institutional factors, as indicated by the two different sets of models' (fixed-effects and Driscoll–Kraay adjusted) results and how they interrelate.

As with many other variables tested, secondary education enrolment rates consistently have a positive and statistically significant relationship with the Green Growth Index (FE coefficient = 0.00894, $p < 0.01$; DK-adjusted = 0.00571, $p < 0.01$). This indicates that countries with high levels of education (i.e., high secondary enrolment rates) are more likely to have the capabilities to adopt practices that are environmentally sustainable. An educated population is likely to have a greater understanding of environmental issues, is more likely to be advocates for green policies, and is more likely to implement technologies that are considered environmentally friendly than countries with lower education levels. For instance, the average secondary enrolment rate across the five countries included in this analysis is only 56.6 per cent, while countries with secondary enrolment rates above the average have higher GGI scores. Thus, the development of human capital is shown to be an essential contributing factor to the success of green growth.

GDP per capita growth is shown to have a negative relationship with the Green Growth Index (FE coefficient = -0.175, $p < 0.05$; DK-adjusted coefficient = -0.350, $p < 0.01$). This finding supports the Environmental Kuznets Curve theory that indicates that rapid (short term) GDP per capita growth typically results in an increase in environmental degradation. Countries experiencing faster GDP growth often rely on energy-intensive industries, leading to higher CO_2 emissions and resource depletion. The negative impact is particularly evident in Pakistan, India, and Bangladesh, where industrialization and fossil fuel use are increasing. The results imply that while economic expansion is necessary, it must be accompanied by environmental regulations to avoid harming green growth.

In contrast to the initial hypothesis, there is a statistically significant negative relationship between GGI and renewable energy use (FE Coefficient = -0.00540, $p < 0.01$; DK-Adjusted = -0.00316, $p < 0.05$). This counterintuitive finding highlights a critical socio-economic reality within the region. In several of these developing nations, the aggregated 'renewable energy' metric is disproportionately dominated by traditional, low-efficiency biomass (such as wood, dung, and agricultural waste) rather than modern renewable technologies (like solar or wind). Consequently, a high reliance on these traditional forms of biomass is indicative of 'energy poverty' rather than a successful green transition. This demonstrates that simply having a high volume of renewable energy consumption is insufficient; the quality, technological maturity, and infrastructure of that energy are what truly facilitate sustainable development.

The evidence for the effect of governance quality on GGI is mixed. In the fixed-effects (FE) analysis, it appears to be positive but is statistically insignificant (coefficient = 0.0544, $p > 5\%$), while in DK-Adjusted and random effects (RE) analyses the impact of governance becomes statistically significant (coefficient = 0.165, $p < 0.01$). Stronger institutions (measured by government effectiveness, rule of law, and regulatory quality) are therefore positively associated with achieving green economic growth, though there may be delays or variability in realizing those benefits across different countries. The correlation between higher governance scores (Bhutan and Nepal) and higher GGI scores indicates that the existence of institutional capacity is closely associated with the ability to achieve sustainable development in the sample countries. There is no significant correlation between trade openness and green growth as indicated by the following results: Fixed Effects (FE) Coefficient = 0.00026, $p>0.7$; DK-adjusted Coefficient = -0.00145, $p>0.1$. This means that simply being integrated into global markets will not ensure that the outcome will be environmentally sustainable; therefore, trade must be accompanied by domestic environmental regulations and policies in order to positively affect green growth. Overall, these results demonstrate that human capital and governance are the strongest indicators of green growth in the sample countries; however, rapid economic growth and the current state of renewable energy will provide difficulties with regards to green growth. Trade openness appears to have little or no direct impact. Thus, policy frameworks that align economic activities with achieving environmental sustainability are essential to facilitate green growth.

This research tested five different hypotheses to determine the factors contributing to green growth. The first hypothesis was that there is a positive relationship between economic growth and the Green Growth Index (GGI). However, this hypothesis was not supported; this means that rapid growth of GDP per capita has a negative effect on green growth, which suggests that "growth" or "raising GDP per capita" without adequate regulation, can actually cause more environmental degradation. On the other hand, the second hypothesis (education) was supported; specifically, a higher level of secondary school enrollment has a significant and postivie effect on the GGI. It also demonstrates the importance of human capital in supporting sustainability. The third hypothesis (renewable energy) was not substantiated; in other words, increases in renewable energy usage were found to be positively correlated with lower GGI, which reflects utilization of wasted or traditional renewable resources in certain countries. Similarly, the fourth hypothesis was not supported; in other words, there was no significant or positive relationship between green growth and trade. The final hypothesis received only limited support; in other words, while countries with higher governance standards tend to have better GGI, there were also factors that only occur over time related to each country's context that can influence results. Overall, the empirical evidence highlights education and governance as key enablers of green growth, while rapid economic expansion and current renewable energy practices can pose challenges to sustainability. Trade openness alone is inadequate, underscoring the need for targeted policy interventions such as investing in human capital, strengthening institutions, and adopting efficient renewable energy infrastructure to achieve sustainable development objectives.

5. Conclusion

This study examined the socio-economic factors that contribute to green growth in some South Asian countries through the use of a combined measure called the Green Growth Index (GGI), which incorporates economic, social, and environmental aspects of sustainable development. The analysis shows that while economic growth is an important factor for development, it alone will not lead to a sustainable environment. The evidence indicates that a rapidly expanding economy results in negative effects to green growth, supporting the concept known as the Environmental Kuznets Curve. It indicates that if a country has rapid growth without any regulations or controls, there will be significant levels of environmental degradation until there is appropriate infrastructure and technology put into place to address those issues.

A key contributor to the promotion of green growth in South Asia is education. Increased enrollments in secondary schools directly correlate to increases in GGI scores, which confirms the importance of human capital in creating sustainable practices, raising awareness about environmental issues and allowing societies to implement innovative green technologies. Additionally, governance has a very significant impact on GGI scores. Countries that have better quality institutions and carry out their policies effectively experience higher levels of success in achieving positive environmental outcomes. However, the effect of governance appears to be dependent upon cultural characteristics, which will take time to become evident, stressing not only the necessity for long-term policy stability but also institutional strengthening as well.

The analysis showed an unexpected finding of a negative correlation between the use of renewable energy as a whole and green growth in this area. The explanation for these findings is the impact of energy poverty, the widespread use of traditional biomass for energy and the lack of technological advancement in low-income countries. Simply providing increased amounts of renewable energy does not lead to green growth; renewable energy must also be usable, easily obtained and able to fit into the current energy system in order to foster green growth. The degree of trade freedom within an economy was not related to the overall level of green growth attained. Therefore, if an economy is to experience sustainable growth as a result of their participation in global markets, their domestic environmental policies must be strong.

Overall, these findings provide substantial evidence that education and quality of institutions are fundamental pillars for achieving green growth. However, if rapidly growing economies utilize traditional forms of renewable energy, these will impede green growth unless structural changes occur. The findings included in this study have significant policy implications for the economies of South Asia. For example, all governments within these countries should develop comprehensive strategies to enhance human capital, improve systems of governance, upgrade energy infrastructure, and create trade policies that support environmental objectives. Addressing issues related to the availability of statistics, consistency in measurement and causation could further enhance the understanding of the dynamics associated with green growth as well as foster more positive government policies. Achieving sustainable development in the region requires a holistic and context-sensitive approach, emphasizing the interconnectedness of economic, social, and environmental policies. By prioritizing education, institutional quality, and efficient energy systems, South Asian countries can advance inclusive, low-carbon growth while mitigating environmental risks and ensuring long-term sustainability.

While this study provides valuable insights into the determinants of green growth in South Asia, several limitations must be acknowledged to guide future research. First, the small cross-sectional sample size (N=5) inherently restricts the generalizability of these findings beyond this specific geographic bloc. Second, due to data constraints, this study employs a static panel data approach and does not fully correct for potential endogeneity or dynamic reverse causality between variables (such as education, governance, and green growth); therefore, these findings represent robust associations rather than strict causal relationships. Third, the reliance on a linear GDP per capita growth term captures the current industrializing trajectory of these nations but does not test the full quadratic U-shape of the Environmental Kuznets Curve (EKC). Finally, the aggregated nature of regional macroeconomic data prevented the empirical disaggregation of traditional biomass from modern renewable energy sources. Future research employing dynamic panel estimators, such as System GMM, alongside disaggregated modern energy data, would further enrich the understanding of these complex sustainability dynamics

References

Akbar, W., Ali, M. A., Nasir, A. M., Sattar, R. A., Akmal, S., & Kumar, M. (2026). Human Capital Development and Firm Profitability in Malaysia: A 35-Year Systematic Review. *International Journal of Academic Research in Business and Social Sciences*, 16(1), 134–153. http://dx.doi.org/10.6007/IJARBSS/v16-i1/26975

Ali, M. A., & Aqil, M. (2022). Nexus between real exchange rate misalignment and economic growth: a case of Pakistan. *Journal of Entrepreneurship, Management, and Innovation*, 4(1), 188-209.

Ali, S. S. ., Mubeen, M., Lal, I. ., & Hussain, A. . (2018). Prediction of Stock Performance by Using Logistic Regression Model: Evidence from Pakistan Stock Exchange (PSX). *Asian Journal of Empirical Research*, *8*(7), 247–258. https://doi.org/10.18488/journal.1007/2018.8.7/1007.7.247.258

Aquino Jr, P. G., Jalagat Jr, R. C., Mubeen, M., Mehmood, W., & Zehra, B. (2022). Enterprise risk management: An important process for feasible profit and growth. *Contaduría y administración*, *67*(2), 118-141, https://doi.org/10.22201/fca.24488410e.2022.3068

Arellano, M. (2003). *Panel data econometrics*. Oxford University Press.

Awan, A., & Nawaz, S. (2022). Towards Green Growth: Monitoring Progress and Investigating Its Determinants in South Asia. *Journal of Economic Impact*, 4(3), 252–264. https://doi.org/10.52223/jei4032212

Baltagi, B. H. (2008). *Econometric analysis of panel data* (4th ed.). Wiley.

Bu, S., & Alola, A. (2024). Role of education and natural resources in achieving green economic growth in China: A wavelet quantile correlation approach. *Natural Resources Forum*. https://doi.org/10.1111/1477-8947.12399

Dźwigoł, H., Kwiliński, A., Lyulyov, O., & Pimonenko, T. (2023). The Role of Environmental Regulations, Renewable Energy, and Energy Efficiency in Finding the Path to Green Economic Growth. *Energies, 16*(7), 3090. https://doi.org/10.3390/en16073090

Gavurová, B., Megyesiova, S., & Hudák, M. (2021). Green Growth in the OECD Countries: A Multivariate Analytical Approach. Energies. https://doi.org/10.3390/en14206719

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. The Quarterly Journal of Economics, 110(2), 353–377. https://doi.org/10.2307/2118443

Hsiao, C. (2014). *Analysis of panel data* (3rd ed.). Cambridge University Press.

Hussain, Z., Mehmood, B., Khan, M., & Tsimisaraka, R. (2022). Green Growth, Green Technology, and Environmental Health: Evidence From High-GDP Countries. *Frontiers in Public Health, 9*, 816697. https://doi.org/10.3389/fpubh.2021.816697

Kassi, D., Sun, G., & Ding, N. (2020). Does governance quality moderate the finance-renewable energy-growth nexus? Evidence from five major regions in the world. *Environmental Science and Pollution Research*, 27(10), 12152–12180. https://doi.org/10.1007/s11356-020-07716-5

Kwiliński, A., Lyulyov, O., & Pimonenko, T. (2023). Greenfield Investment as a Catalyst of Green Economic Growth. *Energies, 16*(5), 2372. https://doi.org/10.3390/en16052372

Li, X., Shaikh, P. A., & Ullah, S. (2022). Exploring the potential role of higher education and ICT in China on green growth. *Environmental Science and Pollution Research*, 29, 64560–64567. https://doi.org/10.1007/s11356-022-20292-0

Lin, B., & Zhou, Y. (2021). Measuring the green economic growth in China: Influencing factors and policy perspectives. *Energy, 241*, 122518. https://doi.org/10.1016/j.energy.2021.122518

Liu, C., Padhan, H., Rekha, V., & Gözgör, G. (2025). The path to green growth in OECD economies: The role of energy transition and education. *Energy Economics, 145*, 108419. https://doi.org/10.1016/j.eneco.2025.108419

Mubeen, M. and Hanif, M. (2017), Sustainable Growth of Nonfinancial Firms: Microeconometric Evidence from Pakistan, *Pakistan Business Review, 19(*3), 630-648

Naimoğlu, M. (2022). Yenilenebilir enerji kullanımının yeşil büyüme üzerindeki etkisi: Yükselen ekonomiler örneği. *Akdeniz İİBF Dergisi, 22*(2), 1–13. https://doi.org/10.25294/auiibfd.1077576

Naimoğlu, M., Şahin, S., & Özbek, S. (2025). Governance, Corruption, Trade Openness, and Innovation: Key Drivers of Green Growth and Sustainable Development in Türkiye. *Sustainable Development*. https://doi.org/10.1002/sd.3346

Nosheen, M., Iqbal, J., & Abbasi, M. A. (2021). Do Technological Innovations Promote Green Growth in the European Union? *Environmental Science and Pollution Research, 28*, 21717–21729. https://doi.org/10.1007/s11356-020-11926-2

OECD. (2011). *Towards green growth*. OECD Publishing. https://doi.org/10.1787/9789264111318-en

Paramati, S. R., Mo, D., & Gupta, R. (2017). The effects of stock market growth and renewable energy use on CO_2 emissions: Evidence from G20 countries. Energy Economics, 66, 360–371. https://doi.org/10.1016/j.eneco.2017.06.009

Shahbaz, M., Mallick, H., Mahalik, M. K., & Loganathan, N. (2015). Does globalization impede environmental quality in India? *Ecological Indicators*, 52, 379-393. https://doi.org/10.1016/j.ecolind.2014.12.025

Smulders, S., Toman, M., & Withagen, C. (2014). Growth Theory and "Green Growth". Oxford Review of Economic Policy, 30, 423-446. https://doi.org/10.1093/OXREP/GRU027.

Solarin, S.A., Al-Mulali, U. Influence of foreign direct investment on indicators of environmental degradation. *Environ Sci Pollut Res* 25, 24845–24859 (2018). https://doi.org/10.1007/s11356-018-2562-5

Song, X., Zhou, Y., & Jia, W. (2019). How do Economic Openness and R&D Investment Affect Green Economic Growth? Evidence from China. *Resources, Conservation and Recycling, 146*, 405–414. https://doi.org/10.1016/j.resconrec.2019.03.050

Tariq, M., Xu, Y., Ullah, K., & Dong, B. (2023). 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*(2), 959–978. https://doi.org/10.1002/sd.2711

Taskın, D., Vardar, G., & Okan, B. (2020). Does renewable energy promote green economic growth in OECD countries? *Sustainability Accounting, Management and Policy Journal, 11*(7), 1237–1256. https://doi.org/10.1108/SAMPJ-04-2019-0192

Tawiah, V., Zakari, A., & Adedoyin, F. F. (2021). Determinants of green growth in developed and developing countries. *Environmental Science and Pollution Research, 28*, 39227–39242. https://doi.org/10.1007/s11356-021-13429-0

United Nations Development Programme (UNDP). (2023). *Human Development Index (HDI)*. https://hdr.undp.org/en/content/human-development-index-hdi

Wang, H., Peng, G., & Razzaq, A. (2023). Asymmetric influence of renewable energy, ecological governance, and human development on green growth of BRICS countries. *Renewable Energy, 205*, 305–315. https://doi.org/10.1016/j.renene.2022.12.125

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). MIT Press.

World Bank. (2021). *The changing wealth of nations 2021: Managing assets for the future*. World Bank Publications.

Zubair, M., Burney, A., Sarwat, S. S., & Mubeen, M. (2014). Macroeconomics relations between exchange rate instability, exchange rate volatility, trade and economic growth variables: The case of Pakistan. *Journal of Economics and Sustainable Development*, *5*(13), 44-53