Role of Green Information Systems in Economic Development of South Asian Economies: A Panel Data Analysis

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Abstract

This research analyzes how South Asian economies benefit from adopting Green Information Systems as a driver for GDP growth. For this, the study employs panel data from five South Asian countries i.e. India, Pakistan, Bangladesh, Sri Lanka, Nepal and Bhutan, covering the period from 2004 to 2023. Green Information Systems Adoption index is made using PCA method and Internet users, Mobile subscribers and ICT exports are taken as the indicators. The fixed effects alongside random effects models verify that implementing Green Information Systems Adoption generates substantial economic growth, which advances technological development and drives the regional expansion of the economy. South Asian economies depend on carbon-intensive industries, which causes a positive and statistically significant relationship between carbon emissions and economic growth. The statistical connection between energy efficiency performances and GDP growth remains moderate because investment in renewable energy infrastructure remains needed. Economic growth remains unaffected by regulatory quality levels. The study shows that trade openness stands out as a major economic growth factor that strengthens the impact of globalization and market integration on sustainable development.

Keywords: Green Information Systems Adoption, Economic Growth, South Asia, Energy Efficiency, Carbon Emissions.

Introduction

Fast industrial development along with economic improvement in South Asia offers both advantages and disadvantages. The quick expansion of economic activities produced environmental issues through industrial activities which require sustainable solutions. Esfahbodi et al. (2023) establish Green Information Systems (Green IS) as fundamental elements that help preserve environmental sustainability while boosting economic development. Green IS refers to the implementation of information and communication technologies (ICT) which leads to improved regulatory compliance along with decreased carbon emissions together with enhanced energy efficiency.

Green Information Systems (Green IS) have gained significant importance according to Vom Brocke et al. (2013) and Sarkis et al. (2013) because they achieve peak power efficiency and minimize pollution to fulfill regulations which support environmental sustainability. The implementation of Green IS within industrial and financial operations creates both operational innovation and continues to protect environmental sustainability. Research conditions are ideal for investigating GDP growth rate modifications from Green IS implementation because South

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Asian nations experience rapid economic development (Nizam et al., 2020). Evaluations involving carbon emissions per capita along with energy efficiency measurements and trade openness criteria alongside regulatory quality standards permit a study of Green IS contributions to economic sustainability.

Research aims to solve the environmental problems in South Asia that emerge due to economic development. The current carbon pollution levels together with resource waste stem from insufficient policies and fossil fuel-based energy systems and limited deployment of environmentally friendly technology (Ayad et al., 2023; Singhania & Saini, 2020; Zomchak et al., 2023). The application of Green Information System solutions has gained recognition as a strategy toward solving issues that appear in industrialized areas. Research about Green IS utilization in South Asia remains minimal.

Analyzing how the adoption of Green Information Systems aids South Asia's development of sustainable economic growth serves as the major goal of this paper. Through Green IS, the integration of digital solutions inside environmental sustainability projects promotes both reduced ecological damage and economic productivity increase. To confirm its value as a sustainable development tool over the South Asian area, the study looks at how Green IS adoption impacts economic performance paired with environmental data. The study intends to find how the adoption of Green Information Systems affects South Asian GDP growth as well as investigate the link between economic development and digital sustainability projects. The study examines how Green IS adoption's capacity to lower environmental damage corresponds with per capita carbon emissions.

The investigation evaluates how regulatory quality both supports and impedes Green IS adoption by examining policy structures for digital sustainability implementations. The analysis investigates how trade openness affects the dissemination of Green IS technologies across South Asian nations through the evaluation of international trade effects on sustainable digital innovation advancement. Research into Green IS in developed nations exists extensively, but South Asian economies have insufficient examination in this field. Previous investigations mainly examined developed economies because they possess superior digital infrastructure together with established regulatory mechanisms. Research about how Green IS adoption affects South Asian economic growth stands as a notable knowledge deficiency due to insufficient empirical investigations. Qualitative research investigations of regulatory quality and trade openness as facilitating factors for Green IS adoption have received minimal attention in existing academic work. The region requires an adequate examination of these gaps to create knowledgeable policies leading to sustainable economic growth in South Asia.

Literature Review

Information systems with environmental optimization capabilities and sustainability promotion objectives make up the field of Green IS. The Sustainability Theory emphasizes how business entities and governmental bodies should adopt green technology solutions to accomplish economic-social-environmental equilibrium (Jum'a et al., 2022). Through resource optimization and operational efficiency, RBV validates that organizations using Green IS gain competitive advantages (Barney, 1991).

Technological innovation stands as the chief force in economic growth based on the explanation of the endogenous growth theory. The implementation of Green Information Systems generates innovative approaches because it helps reduce resource consumption while minimizing environmental destruction and respecting legal frameworks. Several research studies indicate that economies that adopt Green IS demonstrate increased productivity and GDP growth according to Elfaki and Ahmed (2024) while Adão et al. (2024) presents similar findings.

The assessment of green Information Systems adoption relies on multiple indices that evaluate digital infrastructure sustainability in addition to IT energy efficiency levels and environmental data handling platforms (Bose & Luo, 2014). A collection of empirical research proves that green information systems adoption creates a positive relationship with GDP expansion through improved manufacturing efficiency and operational cost savings (Dedrick, 2010). Digital transformation in South Asian nations provides the opportunity to use Green Information Systems as developmental drivers for sustainable economic growth (Molla & Abareshi, 2012).

Carbon emissions per capita serve as an indicator of environmental impact and energy-intensive economic activities. Studies demonstrate that the Environmental Kuznets Curve hypothesis defines how initial economic expansion leads to higher emissions before these pollutants fall off when countries reach specific income thresholds because of technology and environmental regulations (Grossman & Krueger, 1995). Green IS demonstrates its ability to decrease atmospheric pollution through its function as a smart energy controller and industrial carbon emission reducer (Watson et al., 2010). The rising emissions from industrial development in South Asia can be balanced through the implementation of Green IS, as proposed by Shahbaz and Sinha (2019).

The level of energy efficiency directly drives sustainable growth rates. Green IS optimizes energy efficiency throughout industries and buildings and transportation systems through its energy usage optimization approach (Gholami et al., 2016). Smart Grids alongside Cloud Computing with AI-driven Energy Management Systems result in enhanced productivity together with reduced power waste (Loos et al., 2011). Emerging economies prove that an improved Energy Efficiency Index achieved through Green IS results in increased GDP growth rates without compromising environmental quality (Mingay, 2007).

Green Information System and Sustainable Development Goals (SDGs)

The United Nations Sustainable Development Goals (SDGs) call for technological integration between industries to achieve sustainability goals in economics and environmental systems. Green Information Systems help achieve Sustainable Development Goal 7 which focuses on Affordable and Clean Energy, as well as SDG 9 for Industry Innovation and Infrastructure and SDG 13 for Climate Action (United Nations, 2021). Research confirms that South Asian Green Information System acceptance fulfills the Sustainable Development Goals through decreased energy losses while improving efficiency rates and advancing sustainable city development (Hilty & Aebischer, 2015).

Data and Methodology

This study employs panel data from five South Asian countries India, Pakistan, Bangladesh, Sri Lanka, Nepal and Bhutan covering the period from 2004 to 2023. Analysis is made using Correlations, Fixed and Random Effect Models. Keeping in view the objectives of the study, the following model is specified;

$$GDPG_{it} = \alpha_{0i} + \alpha_1 GISA_{it} + \alpha_2 COEM_{it} + \alpha_3 ENEF_{it} + \alpha_4 TRDE_{it} + \alpha_5 RGCN_{it} + u_{it}$$

The description of key variables included in the above model are presented in Table 1.

Table 1: Description of variables

Variable	Unit of Measurement	Description	Data Source
Dependent Variable			
GDPG	Percentage	Annual GDP growth rate	World Development Indicators
Core Independent Variable			
GISA	Index made by Principle Component Analysis Method	**Green Information Systems Adoption Index**	World Development Indicators
		- Internet users (% of population)	
		- Mobile Subscriptions (per 100 people)	
		- ICT Service Exports (US Dollars)	
Control Variables			
COEM	Metric tons of carbon dioxide equivalent	Total carbon emissions from agriculture, building, fugitive emissions, industrial combustion, industrial processes, power industry, transport, waste, net fluxes from deforestation, forest land and organic soil	World Development Indicators
ENEF	Percentage	Energy Efficiency Measured by Renewable Energy Consumption (Percentage of total final energy consumption)	
TRDE	percentage	Trade openness as a percentage of GDP.	
RGCN	Score (1-5)	Regulatory quality index (higher values indicate better regulations).	World Governance Indicators

This research uses mobile subscribers combined with internet users while incorporating ICT services exports to measure Green Information Systems adoption because mobile subscribers support digital infrastructure growth and sustainable initiatives including smart energy management and digital governance International Telecommunication Union (ITU) Reports (2020, 2022)**.** Digital platforms heavily depend on internet users who enable cloud computing and e-governance services in addition to energy-efficient platforms while requiring them for Green Information Systems adoption efforts that include remote work solutions and sustainability programs [Melville, (2010) and Molla and Abareshi (2012)]. Countries that sell significant amounts of information and communication technology products actively employ Green Information Systems practices at the industrial level which demonstrates their proficiency in digital economy operations and technology implementation (World Bank, 2021).

Green Information Systems and Growth: An Analysis

The analysis uses the correlation matrix for any possibility of Multicollinearity among the independent variables of interest (Mansfield & Helms, 1982; Steiger, 1980). The values of pairwise correlation coefficients are taken to see the degree and direction of the relationship. The results of Table 2 highlight that the values are not very high, which can affect the result of the study.

Table 2: Correlation Matrix

	GISA	GDPG	COEM	ENEF	RGCN	TRDE
GISA	1.00					
GDPG	0.32	1.00				
COEM	-0.16	0.47	1.00			
ENEF	0.27	0.21	-0.48	1.00		
RGCN	-0.06	0.16	-0.17	0.10	1.00	
TRDE	0.25	0.11	0.32	0.38	0.17	1.00

The estimation approaches including Fixed Effects (FE) Model and Random Effects (RE) Model form the basis of the empirical research which evaluates the effect of Green IS adoption together with carbon emissions and energy efficiency and regulatory control and trade on GDP growth in South Asian countries (Borenstein et al., 2010; Hedges, 1994; Raudenbush, 1994).

Table 3: Econometric Results

Variable	Coefficient	Std. Error	t-Statistic	p-Value
Fixed Effect Model Results				
Constant	1.197	0.428	2.797	0.102
GISA	0.035	0.013	2.692	0.018
COEM	0.043	0.019	2.263	0.027
ENEF	0.105	0.048	2.188	0.053
RGCN	0.024	0.026	0.923	0.372
TRDE	0.048	0.019	2.526	0.012
Random Effect Model Results				
Constant	1.197	0.728	1.644	0.102
GISA	0.041	0.02	2.050	0.048
COEM	0.049	0.024	2.033	0.036
ENEF	0.095	0.047	2.021	0.055
RGCN	0.028	0.025	1.120	0.263
TRDE	0.045	0.018	2.500	0.013

The research shows that improved Green Information Systems (GIS) adoption index has a positive statistically significant relationship with South Asian GDP growth and Green Information Systems (GIS) which helps sustain the region's economic development (Chen et al., 2022; Wang et al., 2024). The beneficial effects of Green Information Systems (GIS) on business operations and energy consumption and production lead to sustainable industrial change. The systems follow global sustainability directions while reducing environmental spending and improving production methods suited for sustainable development. The implementation of Green Information Systems creates confidence among investors that subsequently attracts FDI for infrastructure development combined with sustainable technology deployments. The governments of South Asia actively support green policies that enhance green innovation and enterprise development. Green IS works to develop the circular economy through its creation of new green technological industries and their subsequent economic value generation.

In South Asian, there is a positive connection between carbon dioxide emissions and GDP growth patterns (Kayani et al., 2023). Fast industrialization, urbanization, dependence on fossil fuels, and building, transportation, and industrial sectors contribute to these outcomes along with highly carbon-based energy-intensive businesses such as manufacturing, mining, and construction. A few cutting-edge green technologies are lacking which shows that the insufficient deployment of clean power and green technologies cannot resolve environmental

degradation about economic development. The Environmental Kuznets Curve theory maintains that countries transition to green technologies when their income surpasses certain thresholds leading to emission reduction though rising income levels at lower levels of development lead to more pollution.

South Asian nations demonstrate a direct positive relationship between improved energy efficiency levels and GDP growth according to Dzwigol et al. (2023) and Chen et al. (2024). Various elements including better productivity together with decreased costs and improved industrial outcomes and reduced energy dependence with decreased imports and elevated investment attraction while sustaining environment and economy and regulatory backing combine to explain this. Energy-efficient transportation together with infrastructure and industry leads to increased general production because it frees up national resources to invest in profitable sectors. The creation of new ideas results from energy efficiency which leads to advanced technology development. Energy efficiency improvements reduce carbon pollution and environmental deterioration which build up economic strength and future prosperity in the region.

Regulatory quality in South Asian nations has an insignificant statistical impact on GDP growth but shows a favorable correlation (Lee et al., 2021; Mokhtarifar et al., 2023). Regulatory frameworks that function well create better business conditions which enable foreign direct investments and market efficiency and financial sector stability and improved public service delivery as well as policy certainty and economic stability. Good regulatory quality ensures the implementation of fair policies through open standards at all times which reduces business uncertainty and thereby promotes company growth and encourages investment and entrepreneurial activity. Financial sector regulatory control that is strong helps organizations make good capital allocation while managing risks and providing broad financial access which in turn drives GDP growth. Strong regulatory systems drive human capital growth because they produce efficient workers who sustain economic growth.

South Asian nations demonstrate a positive trade-GDP relationship which shows that growing trade operations directly contribute to economic growth (Ji et al., 2022; Shahzad et al., 2023). Domestic producers obtain new market opportunities through trade that enables them to expand their sales abroad. Export growth enhances national trade stability through foreign exchange benefits that boost the GDP. Home businesses adopt advanced technologies along with effective production methods through trade because it promotes innovation and competitive behavior. Open trade systems entice foreign direct investments which promotes industrial development and builds employment opportunities and delivers technological advancements. Behind India and Pakistan and Bangladesh South Asian countries succeed as part of international value networks thereby strengthening their industrial performance and their economic expansion. Industrial production and operational performance become more efficient through trade because it enables access to complex equipment and modern technologies and advanced machinery. Wages increase alongside living standards because the expansion of export-oriented industries through commercial activity creates new employment opportunities. The implementation of weakened tariffs together with trade agreements and export incentives and various policy and structural changes, supports GDP growth. Trade facilitation policies must be enhanced while regional trade agreements need support and nations should promote export diversification.

Conclusion and Policy Implications

This paper examines the Green Information Systems (Green IS) for sustainable economic growth throughout South Asian nations. This study examines the correlations between important environmental and economic variables such as Green Information Systems and Carbon Dioxide Emissions as well as Energy Efficiency, Regulatory Quality, Trade, and GDP

growth. The results demonstrate that Green Information Systems positively influence GDP growth, which demonstrates how digital sustainability methods transform economic progress. Analysis reveals that South Asian economic progress continues to rely on carbon-intensive business sectors that highlight the necessity of transitioning to clean energy along with low-carbon technology and sustainable industrial operation methods. Increased energy efficiency creates direct positive impacts on GDP growth which highlights the importance of finding ways to achieve superior energy consumption levels for expanding the economy.

South Asian nations can improve their economic development through stronger institutional governance combined with simplified business rules and implemented measures that enhance stability and attract investors. Environmental responsibility needs sustainable development planning, which finds a balance between economic growth and natural preservation according to the report analysis. The achievement of sustainable economic development with resilience requires governments to employ entire policy frameworks integrated with green technology and energy efficiency improvements, as well as regulatory adjustments and trade facilitation components.

South Asian nations face multiple barriers to implementing Green Information Systems because they lack digital infrastructure and face high initial costs while regulatory enforcement is poor and environmental policies differ and policy and business leaders lack necessary understanding. All governmental institutions and policymakers from the South Asia nations India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan and the Maldives must actively support Green Information Systems. The development of Green IS depends heavily on the technology and IT companies operating in the private sector. The adoption of Green IS receives additional support from banking institutions through their promotion of environmentally focused financing tools, including green bonds.

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