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Exploring Sustainability in Pakistan: A Data-Driven Analysis of Economic, Social, and Environmental Performance (2014-2024)

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Abstract

This paper analyzes sustainable development in Pakistan by examining economic, social, and environmental capital assets from 2014 to 2024. It explores past progress, status, and future challenges in sustainability. Since adopting the National Conservation Strategy Post-Agenda 21 (1992), Pakistan has implemented reforms aligned with global sustainability goals. Despite these efforts, economic growth challenges, weak policy implementation, low human capital investment, and unsustainable industrial practices hinder long-term progress. Utilizing the frameworks of the Brundtland Commission Report (1987) and Pearce and Warford (1993), this study constructs a Sustainability Development Index (SDI) through Factor Analysis and applies Newey–West regression for statistical robustness. GDP growth and literacy significantly enhance sustainability, while trade imbalances and deforestation negatively impact it. CO_2 emissions have a positive but complex association, reflecting current industrial growth within Pakistan's sustainability context, though this poses long-term environmental risk. The study highlights the crucial role of efficient governance, integrated policies, and adaptive regulations. This study concludes that Pakistan's path to sustainability hinges not merely on economic growth but requires a governance-led, integrated policy approach simultaneously strengthening human capital, correcting trade imbalances, and enforcing environmental conservation.

Keywords: Pakistan, Policy implementation, Sustainability, National Conservation Strategy

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Introduction

Sustainability has emerged as a cornerstone of economic and social policymaking worldwide, especially in developing economies such as Pakistan. Over the past decade, Pakistan has faced a myriad of sustainability challenges, including climate change, rapid urbanization, resource mismanagement, and socio-economic inequality (Shoaib, 2024). As a signatory to the United Nations' Sustainable Development Goals (SDGs), Pakistan has been working toward integrating sustainability principles into its economic, social, and environmental frameworks. However, progress remains uneven, and critical gaps persist in policy implementation and governance (Awais et al., 2019).

The country's economic sustainability has been shaped by fluctuating GDP growth, reliance on foreign aid, energy shortages, and the need for industrial expansion (Baz et al., 2021). While economic development initiatives such as the China-Pakistan Economic Corridor (CPEC) have contributed to infrastructural progress, concerns regarding equitable distribution of economic benefits and environmental degradation have raised pertinent questions about long-term sustainability (Khaskheli et al., 2023). Financial instability, inflation, and challenges in small and medium enterprises (SMEs) further complicate economic resilience. Some studies suggest that Pakistan has been following a path of weak sustainability due to governance challenges and unsustainable economic practices (Jabeen & Khan, 2022).

On the social front, Pakistan continues to struggle with disparities in education, healthcare access, and gender equality (Choudhry et al., 2019). Literacy rates remain below global averages, and health indicators—such as infant mortality rates and malnutrition—highlight the need for stronger public welfare policies. Meanwhile, urbanization-driven socio-economic shifts have placed additional pressure on housing, sanitation, and employment sectors, requiring innovative solutions to improve quality of life while maintaining social sustainability (Irfan et al., 2018).

Environmentally, Pakistan is among the most climate-vulnerable nations, frequently experiencing extreme weather events, water scarcity, deforestation, and air pollution. Rising carbon emissions, unregulated industrial waste, and inadequate environmental policies further exacerbate ecological degradation (Ambreen et al., 2025). While national efforts such as afforestation programs (e.g., the Billion Tree Tsunami) and renewable energy projects show promise, achieving environmental

sustainability requires a more robust governance framework, enforcement mechanisms, and international cooperation (Waheed et al., 2024). Pakistan's energy sector, for instance, remains heavily reliant on fossil fuels, contributing to environmental degradation despite growing investments in renewable energy (Naeem Nawaz & Alvi, 2018).

Despite extensive literature on these issues, few studies have empirically integrated economic, social, and environmental pillars into a unified assessment of Pakistan's sustainability performance over a consistent period. This study addresses that gap by constructing a composite Sustainability Development Index (SDI) using Factor Analysis (FA) and evaluating causal relationships through Newey–West regression for the decade 2014–2024. This integrated empirical model not only ensures rigorous statistical validity but also offers new insights into how macroeconomic, social, and environmental variables jointly impact sustainability outcomes in Pakistan. Pakistan's sustainability requires moving beyond single-pillar approaches toward integrated, governance-driven strategies that simultaneously address economic stability, human capital formation, and environmental stewardship through coordinated policy frameworks.

Review of the Literature

Sustainability integrates environmental, social, and economic dimensions to ensure long-term resource viability for future generations (Mensah, 2019). The concept gained prominence through the Brundtland Report (1987), which emphasized development that meets present needs without compromising future generations (Khan et al., 2013). These three pillars—economic growth, social inclusion, and environmental protection—serve as the foundation of sustainable development across global and local contexts (Van Niekerk, 2020).

In Pakistan, sustainability is increasingly viewed as central to national development (Khadim, 2024). Rapid urbanization, rising energy demands, and high climate vulnerability have made balancing industrial growth with environmental protection and social progress a pressing need (Dhindsa, 2017). National initiatives such as Pakistan Vision 2025 and alignment with the United Nations Sustainable Development Goals (SDGs) reflect this commitment, yet governance inefficiencies, inadequate infrastructure, and limited financial capacity continue to undermine progress (Dhindsa, 2017).

A consistent theme across the literature is that Pakistan's sustainability progress remains fragile despite numerous policy reforms (Zeewaqar, 2024). Economic instability persists due to fluctuating GDP growth, dependence on fossil fuels, and external borrowing from institutions such as the IMF (Abid et al., 2021; Aslam et al., 2022). On the social front, although there have been improvements in education and healthcare, inequities in access—especially across gender and rural lines—remain major obstacles (Fazil & Ahmad, 2023; Rehman et al., 2023). Social protection measures exist but are weakened by poor implementation and insufficient funding (Irfan et al., 2018).

Environmentally, Pakistan continues to face significant degradation, ranking among the world's most climate-vulnerable nations (Ahmad et al., 2021). Studies highlight recurring issues such as heatwaves, glacial melting, air pollution, and rapid deforestation that threaten ecological stability (Azhar et al., 2024; Hassan et al., 2021). The literature converges on the point that addressing these challenges requires effective governance, green innovation, and stronger public–private collaboration to promote renewable energy, sustainable urban planning, and environmental resilience (Hinduja et al., 2023).

In summary, the reviewed literature establishes that Pakistan's sustainability challenges are multi-dimensional, cutting across economic volatility, social inequality, and environmental vulnerability. These insights underpin this study's analytical framework, which integrates economic, social, and environmental indicators to construct the Sustainability Development Index (SDI) and assess the determinants of sustainable development in Pakistan.

- **Economic Sustainability in Pakistan**

Economic growth is a vital indicator of Pakistan's sustainability, with GDP serving as a core measure of economic performance (Ali & Mohsin, 2023). Multiple factors—including macroeconomic policies, investment trends, population dynamics, and external trade—shape Pakistan's economic trajectory (Aniba Zia et al., 2024). Over the decades, GDP growth has fluctuated due to both internal and external shocks. Periods of high growth in the 1980s and 1990s, supported by foreign aid, industrialization, and policy reforms, were followed by instability caused by weak governance and global crises (Kirby, 2022a; Mahmud et al., 2008).

A consistent theme in the literature is that macroeconomic instability—marked by inflation, exchange rate volatility, and low investor confidence—remains a persistent challenge to sustainable growth. High inflation and rising interest rates erode purchasing power and discourage investment (George, 2023; Gokal & Hanif, 2004; Su & Soon, 2024). Similarly, fluctuating exchange rates affect trade competitiveness, weakening export performance (Afzal, 2009). While research underscores that investment in human capital, infrastructure, and stable macroeconomic management can enhance growth, political uncertainty and regulatory barriers continue to limit foreign direct investment, constraining long-term development potential (Awan, 2015).

- **Macroeconomic Determinants of GDP Growth**

The relationship between population growth and economic development in Pakistan has been extensively examined, revealing that rapid population expansion places pressure on limited economic resources, raising dependency ratios and slowing per capita income growth (Kirby, 2022b). Although a growing population provides potential labor strength, insufficient investment in education, healthcare, and infrastructure has prevented the country from fully utilizing this demographic opportunity (Bloom & Freeman, 1986).

The literature also emphasizes the importance of innovation and technological advancement as key drivers of sustainable growth. Research and development (R&D), entrepreneurship, and digital transformation are identified as crucial for enhancing productivity and long-term economic stability (Hysa et al., 2020; Mustafa & Sadaf, 2017; Usman et al., 2021). To achieve consistent economic progress, studies recommend strengthening macroeconomic stability through inflation control, balanced interest rates, and investor confidence (Ali, 2024). Similarly, improving human capital through education and vocational training, alongside fostering a secure and business-friendly environment, can attract foreign investment and increase productivity (SoniPawar & Devi; Umair et al., 2024). Managing population growth and promoting technological innovation are also seen as essential for optimizing economic resources (Kirby, 2022b; Zafar & Mustafa, 2017).

- **Industrialization, Trade, and Foreign Direct Investment (FDI) in Pakistan**

Industrialization, trade, and foreign direct investment (FDI) are key drivers of Pakistan's economic development (Munir & Ameer, 2020). The literature

consistently highlights that trade openness and FDI contribute to industrial expansion by attracting capital, enhancing productivity, and introducing modern technologies (Nasir, 2022; Ren et al., 2014). However, studies also reveal that macroeconomic instability, inflation, and weak investor policies often offset these gains, restricting the benefits of trade liberalization (Bacchetta & Jansen, 2003).

Empirical findings show that FDI and real GDP maintain a positive long-term relationship with industrial growth, whereas excessive trade openness and inflation exert negative effects (Nasir, 2022). The success of trade and investment-led industrialization thus depends heavily on sound monetary and fiscal policies and a stable exchange rate environment. Research on CPEC and the Gwadar Seaport further demonstrates that FDI enhances employment generation and industrial activity, creating opportunities for both skilled and unskilled labor markets (Dinh, 2023; Khan et al., 2023). Nonetheless, persistent infrastructure deficits and regulatory inefficiencies continue to limit Pakistan's ability to fully harness FDI's potential.

Broader analyses suggest that while FDI injects capital and technical expertise into developing economies, inadequate regulation may lead to market dominance by foreign firms and hinder domestic industry growth (Abor & Bekoe, 2025). Therefore, Pakistan's capacity to achieve sustainable industrial development is contingent on political stability, institutional strength, and an investor-friendly environment.

- **Energy Security and Sustainable Economic Policies in Pakistan**

Energy security is a crucial factor in ensuring Pakistan's sustainable economic development. The country faces persistent energy shortages, dependence on fossil fuel imports, and inefficiencies in energy utilization, which hinder economic growth. A sustainable energy policy must address these challenges by promoting renewable energy, enhancing energy efficiency, and ensuring an affordable and reliable energy supply.

Based on (Malik et al., 2020) Pakistan imports nearly a third of its energy resources, including oil, coal, and Liquefied Natural Gas (LNG). This heavy reliance on imported energy leads to vulnerabilities in global energy price shocks, increasing inflationary pressures that reduce the country's export competitiveness and economic stability. Malik et al. (2020) highlight that despite investments in energy infrastructure, Pakistan remains energy insecure due to inadequate domestic

production, a weak regulatory framework, and high external debt burdens associated with energy imports. The 4-A framework—availability, applicability, acceptability, and affordability—was used to assess Pakistan's energy security over a six-year period (2011–2017), showing an initial improvement but later deterioration in energy stability.

Based on (Aized et al., 2021) Renewable energy has been proposed as a long-term solution to Pakistan's energy security crisis. The Policy for Development of Renewable Energy (2006) aimed to promote sustainable energy sources, particularly solar and wind power, in off-grid rural areas. However, implementation gaps have resulted in continued energy shortages. (Aized et al., 2021) argue that although Pakistan has abundant renewable energy resources, their utilization remains minimal due to poor policy execution, lack of investment incentives, and infrastructure limitations. The study suggests that integrating a mix of nuclear, hydro, and solar energy with energy conservation measures would ensure long-term energy sustainability.

- **Social Sustainability in Pakistan**
- **Education and Literacy Rates in Pakistan**

Education is a cornerstone of socio-economic development, directly influencing a nation's sustainability and prosperity. In Pakistan, low literacy rates remain a significant challenge, hindering human capital development and economic growth. This section reviews key studies on education and literacy in Pakistan and connects them to the broader theme of sustainability in the country.

Based on (Akhtar et al., 2022) Pakistan's literacy rate has remained below 60% despite various government initiatives to improve education accessibility. (Fazil & Ahmad, 2023) argue that while the Constitution of Pakistan mandates free education for all children aged 5–16 (Article 25-A), implementation has been inadequate. The authors highlight inefficient policy execution, lack of educational infrastructure, and gender disparities as primary reasons for slow literacy growth.

Based on (Rehman et al., 2015) The province-wise literacy rate in Pakistan exhibits significant disparities, which, in turn, impact economic development. Punjab and Sindh have higher literacy rates, while Balochistan and Khyber Pakhtunkhwa (KPK) lag due to insufficient educational facilities and socio-cultural barriers. Rehman et al. (2015) found that urban centers like Lahore, Islamabad, and Karachi enjoy literacy

rates exceeding 75%, whereas tribal and remote areas report literacy rates as low as 9%. These disparities contribute to economic inequalities, as provinces with lower literacy rates also report higher unemployment and lower per capita income. The study (Rehman et al., 2015) also reveals that public expenditure on education remains disproportionately low, averaging 2% of GDP, which is among the lowest in South Asia. The misallocation of funds further exacerbates the literacy crisis, as higher education receives more funding at the expense of primary education, leaving basic literacy programs underdeveloped.

Based on (Batul et al., 2019) Education directly correlates with economic growth by enhancing employability and productivity and conducted a time-series analysis from 1971 to 2016, confirming a long-run relationship between literacy rates and economic development. The study found that investment in education leads to higher wages, better living standards, and reduced poverty levels. However, Pakistan's education system struggles to provide equitable opportunities, particularly to marginalized groups, perpetuating cycles of poverty and underdevelopment. The study (Batul et al., 2019) further indicates that illiterate populations are more susceptible to economic vulnerability, as a lack of education limits their ability to secure stable employment. Consequently, efforts to reduce poverty must include literacy enhancement programs targeting rural and underprivileged communities.

Education and literacy rates are intrinsically linked to Pakistan's broader sustainability goals, which are the focus of this study. Sustainable development relies on a well-educated population capable of contributing to economic, social, and environmental progress (Shahzad et al., 2024). By integrating education as a key pillar of sustainability, Pakistan can enhance workforce productivity, improve social equity, and foster long-term economic resilience.

This study builds upon existing research by analyzing how literacy improvements from 2014 to 2024 have influenced Pakistan's progress toward sustainable economic, social, and environmental performance. Addressing the challenges identified in the literature, this research aims to provide a data-driven analysis of literacy as a determinant of sustainability, offering insights for policymakers and stakeholders to enhance educational strategies for a more sustainable future.

- **Healthcare and Human Capital Development in Pakistan**

Healthcare is a fundamental pillar of human capital development, directly contributing to productivity, economic growth, and social well-being (Bykova et al., 2024). In Pakistan, inadequate healthcare infrastructure, low government spending, and unequal access remain persistent challenges that constrain human capital formation and sustainable progress.

Studies reveal that government healthcare expenditure plays a crucial role in determining health outcomes and workforce efficiency. Study found that limited public spending on healthcare has resulted in poor health indicators, including high infant and child mortality rates. Areas with better healthcare facilities demonstrated higher life expectancy, whereas underfunded regions experienced worsening health outcomes. The research also emphasizes that increased healthcare investment strengthens human capital by reducing disease prevalence and improving productivity; however, Pakistan's spending remains well below the 5% of GDP benchmark necessary for sustainable development (Saleem, 2025).

Similarly, social welfare initiatives such as the Benazir Income Support Program (BISP) and Sehat Sahulat Program (SSP) have shown mixed effectiveness. Tariq et al. (2021) found that while BISP improved nutrition and living standards through cash assistance, its impact on healthcare access and quality remains limited (Tariq et al., 2021). Overall, the literature agrees that expanding healthcare funding, improving preventive services, and reducing urban–rural disparities are essential for strengthening Pakistan's human capital base (Llena-Nozal et al., 2019; Probst-Hensch et al., 2011; Reilly, 2021).

- **Gender Equality and Social Inclusion in Pakistan**

Gender equality is an essential pillar of sustainable development, promoting social inclusion, economic participation, and equitable access to opportunities (Sharma, 2023). In Pakistan, entrenched socio-cultural norms, weak institutional enforcement, and systemic discrimination continue to limit gender parity, thereby constraining overall sustainability.

Research indicates that while Pakistan has enacted progressive legislation—such as the Transgender Persons (Protection of Rights) Act, 2018—implementation remains weak, leaving marginalized groups vulnerable to exclusion (Aamir et al., 2024). Despite formal protections, transgender individuals continue to face social

stigmatization and economic marginalization, restricting their access to education, healthcare, and employment (Imran et al.). Similarly, women, particularly in rural areas, experience limited educational and professional mobility due to traditional gender roles and insufficient policy enforcement. These social and structural barriers impede Pakistan's advancement toward equitable and sustainable development.

Education emerges as a critical driver of gender equality. Ashraf and Waqar (2012) emphasize that gender-sensitive curricula and teacher training are essential to challenge stereotypes and promote inclusion (Ashraf & Waqar, 2012). However, the lack of such initiatives perpetuates gender bias within the education system, hindering girls' enrollment and retention in conservative regions. Inclusive education policies are therefore central to promoting gender awareness and fostering social cohesion.

Technological inclusion has also been identified as a transformative avenue for gender empowerment. Studies show that digital access provides women with new educational and entrepreneurial opportunities, especially in areas where social norms restrict mobility (Ge et al., 2022; Khurshid, 2024). Yet, challenges such as low digital literacy, limited internet availability, and cultural constraints continue to restrict women's participation (Debbarma & Chinnadurai, 2023). The literature consistently calls for gender-responsive technology policies aligned with Sustainable Development Goal 5 (SDG 5) to bridge these gaps and enhance equitable participation (Nanda et al., 2020).

- **Urbanization and Its Socio-Economic Implications in Pakistan**

Urbanization in Pakistan has accelerated rapidly over the past decades, driven by rural-to-urban migration, population growth, and economic restructuring (Qasim et al., 2023). Studies show that economic disparities between rural and urban areas, along with environmental stressors such as climate change and displacement caused by natural disasters, are major forces behind this trend (Riaz & Naz, 2024). Pakistan's urban population, growing at nearly 3% annually—the highest rate in South Asia—reflects shifts in demographic, social, and economic structures. Economic opportunities, better healthcare and education, and climate-induced migration are key factors motivating this movement.

Despite these benefits, the literature consistently highlights that unplanned urban expansion has created housing shortages, inadequate infrastructure, and rising political instability (Mishra, 2025). Environmental degradation, particularly water scarcity, pollution, and deforestation—has worsened due to unsustainable city growth. Urbanization is also reshaping Pakistan's social and political dynamics. Rathore and Ghani (2023) note that cities are witnessing a transition from traditional social hierarchies to merit-based structures, fostering a politically aware middle class (Rathore & Ghani, 2023). However, this shift has also led to ethnic and religious fragmentation, creating segregated neighborhoods and social tension. Urban migration has additionally transformed gender roles, with women gaining greater access to education and employment opportunities.

The lack of effective urban planning and governance remains a major concern. Waseem and Talpur (2021), in their study on Hyderabad, found that infrastructure development has failed to keep pace with rapid urban growth, leading to congestion, pollution, and weak public service delivery. Economic pull factors such as employment prospects and higher wages continue to drive migration, yet poor planning has resulted in expanding slums, sanitation challenges, and health risks (Waseem & Talpur, 2021). The reviewed literature suggests that urbanization in Pakistan represents a double-edged sword—creating opportunities while amplifying social and environmental pressures.

Scholars propose several strategies to align urbanization with sustainability goals: implementing sustainable city planning and smart infrastructure (Angelidou et al., 2018), expanding affordable housing through government and private collaboration (AlQahtany, 2022), strengthening governance and urban management systems (Relhan et al., 2012), and conserving natural resources through improved waste and pollution management (Awewomom et al., 2024).

- ❖ **Environmental Sustainability in Pakistan:**
- **Climate Change and Its Impact on Pakistan**

Climate change poses one of the greatest challenges to Pakistan's sustainability, disrupting economic growth, agricultural productivity, public health, and disaster resilience (Hussain et al., 2020a). Given its diverse geography—from northern glaciers to southern deserts—Pakistan faces heightened vulnerability to floods, droughts, and heatwaves that threaten both environmental and socio-economic stability (Adnan et al., 2024).

Across the literature, a consistent pattern emerges: climate change in Pakistan manifests through intensified weather extremes and declining natural resource stability. Rasul et al. (2012) and Hussain et al. (2020a) both emphasize that rising temperatures and erratic rainfall have triggered recurrent droughts and floods, particularly in Sindh and the Indus basin, while glacial melt has accelerated flood risks. The compounding effects of deforestation, urbanization, and poor resource management exacerbate these hazards. Hussain et al. (2020a) further note that inadequate early warning systems and weak disaster governance amplify the country's exposure to climate-induced losses, as seen during the 2010 floods that displaced over 20 million people (Hussain et al., 2020b; Rasul et al., 2012).

The agricultural sector emerges as the most climate-sensitive domain. Fahad and Wang (2020) and Ali, (2017) both report that temperature fluctuations, declining soil fertility, and changing precipitation patterns have reduced wheat and rice yields across Punjab and Sindh. Although farmers have adopted limited adaptive responses—such as crop diversification and irrigation upgrades—financial and institutional constraints hinder large-scale resilience. These findings collectively illustrate a cycle of vulnerability, where environmental stress undermines food security and economic stability simultaneously (Ali, 2017; Fahad & Wang, 2020).

In response, scholars converge on a set of adaptive strategies that integrate environmental and economic priorities. (Adnan et al., 2024) advocate the development of drought-resistant crops, while (Ashraf et al., 2023) emphasize improving disaster management and early warning systems. Sustainable water management through rainwater harvesting and groundwater recharge (Akbar et al., 2024), coupled with green infrastructure initiatives like reforestation and wetland restoration (Mitra et al., 2024), is viewed as essential to mitigating floods and preserving biodiversity. Strengthening climate governance and enforcing adaptation policies at all administrative levels remain recurring recommendations across studies (Gogoi et al., 2017).

- **Water Scarcity and Environmental Degradation in Pakistan**

Water scarcity and environmental degradation pose severe threats to Pakistan's sustainability (Zhang et al., 2020). The country's worsening water shortages stem from climate change, inefficient management, and rapid urbanization (Ahmed et al., 2020). Pakistan ranks among the most water-stressed nations globally, with per capita water availability falling below 1,000 cubic meters—an indicator of critical

scarcity (Nabi et al., 2019). Approximately 80% of the population depends on polluted water sources, resulting in widespread health crises. Contaminated water, often containing sewage, industrial waste, and pesticides, accounts for nearly 80% of diseases and 30% of deaths nationwide (Krishan et al., 2023).

Deforestation further intensifies the water crisis by diminishing rainfall retention, increasing soil erosion, and depleting groundwater reserves (Shah et al., 2022). Between 1990 and 2005, Pakistan lost over 625,000 hectares of forest, accelerating desertification and reducing water availability for agriculture and human use. Deforestation also undermines biodiversity, as the loss of forest cover disrupts ecosystems, destroys wildlife habitats, and amplifies climate change impacts. Effective solutions require reforestation programs, sustainable land management, and stricter regulatory frameworks (Faye et al., 2021).

Agriculture, consuming over 90% of Pakistan's freshwater, is acutely impacted by water scarcity (Baig & Faisal, 2009). Inefficient irrigation methods, excessive groundwater extraction, and outdated farming practices have significantly reduced crop productivity. Addressing these issues necessitates efficient irrigation systems, adoption of water-saving agricultural technologies, and robust regulation of groundwater use.

Integrating these findings, scholars emphasize that Pakistan's path toward sustainability depends on coordinated efforts in water management, pollution control, agricultural modernization, and ecosystem restoration (Pal et al., 2018; Ray & Majumder, 2024; Shah, 2022). Strengthening water purification infrastructure, enforcing safe drinking water policies, and promoting reforestation collectively form the foundation of an analytical framework linking environmental protection with sustainable economic development in Pakistan.

- **Air Pollution and Environmental Health in Pakistan**

Air pollution remains a major environmental and public health challenge in Pakistan, posing severe threats to human well-being, economic productivity, and ecological sustainability (Anjum, Ali, Subhani, et al., 2021). Rapid industrialization, vehicular congestion, and ineffective environmental governance have accelerated the emission of harmful pollutants across major cities. Industrial activities are a dominant source of this pollution. Zubair et al. (2017) identified carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM) as

key pollutants emitted from textile industries in Faisalabad. Their findings revealed that emissions from oil-based power generators exceeded Pakistan's National Environmental Quality Standards (NEQS) by 40%, mainly due to inefficient combustion processes. This not only exacerbates environmental degradation but also elevates the incidence of respiratory illnesses among urban populations (Zubair et al., 2017).

Air pollution's health impacts are profound and far-reaching. (Anjum, Ali, Imad-ud-din, et al., 2021) reported that Pakistan's exposure to high levels of PM2.5, NOx, and volatile organic compounds (VOCs) contributes to respiratory and cardiovascular diseases, causing approximately 22,000 premature deaths annually and over 163,432 disability-adjusted life years (DALYs) lost. Major cities such as Lahore, Karachi, and Islamabad consistently record air quality levels exceeding WHO safety limits, underscoring the severity of the public health crisis linked to poor air management. Despite growing evidence of environmental and health deterioration, Pakistan's policy response remains weak. The observed that regulatory enforcement is undermined by insufficient monitoring, inadequate institutional capacity, and limited political will. These deficiencies have rendered existing environmental policies largely ineffective in controlling emissions from industrial and transport sectors (Nasir et al., 2024).

To advance environmental health and sustainable development, researchers emphasize the necessity of strengthening industrial emission standards and ensuring strict compliance with NEQS (Khanam et al., 2023). Transitioning industries toward cleaner technologies, particularly in fossil fuel-based sectors, is essential for reducing pollutant output and mitigating health risks (Munsif et al., 2021). Furthermore, improving air quality monitoring, promoting cleaner fuels, and raising public awareness are critical to reducing exposure and long-term health burdens (Ogwu et al., 2024).

- **Renewable Energy and Sustainable Development in Pakistan**

Pakistan is undergoing an energy transition, increasingly prioritizing renewable energy (RE) sources to meet its growing energy demand, mitigate environmental degradation, and reduce dependence on imported fossil fuels (Khatri et al., 2022). The country possesses substantial RE potential, particularly in solar, wind, and hydropower resources. Zafar et al. (2018) estimate that solar energy alone could produce over 1,600 GW, while wind energy potential is around 122.7 GW. Despite

this vast capacity, renewables account for only 0.3% of Pakistan's total energy mix, highlighting the gap between potential and implementation (Zafar et al., 2018).

Policy frameworks have been introduced to promote RE development. (Nishtar & Afzal, 2023) note that initiatives such as the Alternative Energy Development Board (AEDB) Act and the Renewable Energy Policy (2006) were designed to attract private investment and streamline project approval processes. However, persistent regulatory inefficiencies, inadequate financial mechanisms, and limited technological infrastructure have prevented these policies from achieving their intended outcomes.

Institutional and policy-related barriers remain critical constraints to the RE transition. (Mirza et al., 2024; Zafar et al., 2018) identify policy inconsistency, insufficient financial incentives, and outdated grid infrastructure as central impediments. The government's ongoing reliance on fossil fuel-based solutions and subsidies undermines the progress of renewable alternatives. Furthermore, weak enforcement mechanisms and slow policy implementation have hindered the scaling of RE initiatives despite growing private-sector participation.

Technological and financial limitations further exacerbate these challenges. Kamran et al. (2020) and Ali et al. (2021) highlight that high capital costs, insufficient research and development, and inadequate energy storage systems are major obstacles to RE deployment. Kamran et al. (2019) emphasize that the absence of robust financial frameworks deters investors, while Ali et al. (2020) stress the importance of integrating green technologies and strategic financial planning to enhance project feasibility (Kamran et al., 2020). The studies collectively suggest that government-backed subsidies, public-private partnerships, and international collaborations are essential to unlocking Pakistan's RE potential.

To align renewable energy development with sustainable growth objectives, scholars advocate leveraging Pakistan's vast solar, wind, and hydropower capacity (Bhandari et al., 2024). Strengthening existing policy frameworks like the AEDB Act, resolving financial and technological bottlenecks, and modernizing grid infrastructure are critical steps forward (Yar et al., 2022). Additionally, encouraging private-sector investment, promoting green technologies, and instituting fiscal incentives will accelerate the transition toward a sustainable and resilient energy future (Adenekan, 2024).

❖ Sustainability Policies and Government Initiatives

Sustainability in Pakistan has become a central focus in both policy and academic discussions, particularly regarding the nation's economic, social, and environmental performance. The adoption of the Sustainable Development Goals (SDGs) and Pakistan Vision 2025 provides a comprehensive roadmap for achieving long-term sustainable progress (Cho et al., 2016). However, despite strong alignment between Vision 2025 and the global SDGs framework, Pakistan continues to face difficulties in operationalizing these objectives due to institutional, financial, and governance limitations. Cho et al. (2016) emphasize that the SDGs in Pakistan are interdependent, where progress in one sector—such as economic growth—directly influences others, including poverty alleviation and environmental protection. Consequently, addressing systemic weaknesses, such as poor institutional coordination, inadequate investment in social infrastructure, and climate-induced disruptions in agriculture and industry, remains critical for advancing sustainable outcomes.

Ul Hassan (2021) provides a comparative perspective, analyzing Pakistan's transition from the Millennium Development Goals (MDGs) to the SDGs. The study reveals that Pakistan achieved only 26% of its MDG targets, signaling the need for stronger policy implementation and accountability mechanisms to avoid repeating past shortcomings. Persistent economic disparities and insufficient investment in education and healthcare continue to hinder progress toward the SDGs. ul Hassan (2021) further stresses that localizing SDGs—through integration at provincial and municipal levels—is essential for effective execution and measurable progress (ul Hassan, 2021).

Quantitative evidence from Gable et al. (2015) complements these findings by assessing Pakistan's socioeconomic and environmental indicators. While the country has shown improvement in areas such as road infrastructure, electricity access, and reductions in maternal mortality, substantial gaps remain in primary school enrollment, child mortality, CO_2 emissions, and digital connectivity. Environmental vulnerabilities, including rising urban pollution and climate risks, further threaten sustainability gains. The study concludes that without robust policy intervention and the adoption of green, inclusive growth strategies, Pakistan's progress toward SDG targets will remain limited (Gable et al., 2015).

- **Environmental Protection Laws and Enforcement in Pakistan**

Pakistan's environmental protection framework is defined by regulatory laws, enforcement challenges, and international obligations. Key instruments such as the Pakistan Environmental Protection Act (PEPA) 1997 (Haider et al., 2024) and the Environmental Impact Assessment (EIA) framework (Razif & Persada, 2016) were established to control pollution and promote sustainability. However, implementation has remained inconsistent due to weak governance, limited institutional capacity, and economic constraints (Mukhtar, 2023).

PEPA 1997 serves as the foundation for environmental governance, setting quality standards for air, water, and soil, and mandating EIAs for development projects (Mukhtar, 2023; Umar et al., 2023). Despite this, the Environmental Protection Agency (EPA) struggles to enforce compliance with National Environmental Quality Standards (NEQS) due to procedural inefficiencies and low public awareness (AMJAD et al.; Imran et al., 2023). Many infrastructure projects proceed without proper EIA compliance, and public participation remains minimal (Imran et al., 2023).

The China-Pakistan Economic Corridor (CPEC) has further exposed gaps in Pakistan's environmental policy. Large-scale projects raise concerns about transboundary pollution and ecological degradation, as existing trade and environmental agreements lack sufficient safeguards (Khan & Xu, 2021).

Although institutions like the CLEAN Central Laboratory for Environmental Analysis and Networking were established under PEPA to monitor pollution, they face funding shortages and limited technical capacity. Transparency and accountability in EPA decision-making remain weak, while public hearings are often overlooked. Scholars argue that decentralizing enforcement and strengthening public-private partnerships are essential to improving compliance and trust in environmental governance (Mukhtar, 2023).

- **Challenges and Barriers to Sustainability in Pakistan**

Pakistan's sustainability challenges stem from governance inefficiencies, economic instability, institutional weaknesses, and growing climate vulnerabilities. Munir Ahmed (2023) highlights that despite the National Climate Change Policy (NCCP) 2012 and its revisions setting ambitious goals, policy execution remains fragmented due to insufficient political will, poor coordination, and financial limitations (Munir

Ahmed, 2023). Similarly, Syed et al. (2024) emphasize that overlapping institutional mandates and bureaucratic inefficiencies hinder the coherent implementation of sustainability initiatives (Syed et al., 2024).

Financial constraints are another major obstacle. Pakistan's fiscal deficits, external debt, and low foreign direct investment (FDI) restrict funding for sustainability projects. Ali et al. (2024) note that the country's dependence on low-tech exports and weak industrial infrastructure limits domestic investment in climate adaptation and mitigation, which require $7–14 billion annually. Consequently, reliance on international aid has slowed progress toward sustainable development goals (Ali et al., 2024).

Climate vulnerabilities further aggravate these barriers. Pakistan ranks among the most climate-affected nations, facing recurrent floods, heatwaves, and glacial melt. Masud and Khan (2024) attribute these issues to deforestation, unplanned urbanization, and environmental degradation, which amplify disaster risks. The agriculture sector—employing 38% of the population—remains highly sensitive to climate shocks, threatening food security and livelihoods (Masud & Khan, 2024).

Political instability and weak enforcement mechanisms also undermine sustainability. Muhammad et al. (2025) observe that frequent political transitions and policy discontinuity disrupt long-term sustainability planning, while corruption and limited institutional capacity allow unsustainable industrial practices to persist (Muhammad et al., 2025). Syed et al. (2024) further indicate that agencies like the Environmental Protection Agency (EPA) lack both autonomy and resources to ensure effective regulation.

Educational deficiencies compound these challenges. Ajaz Shaheen (2024) finds that higher education institutions (HEIs) in Pakistan struggle to integrate sustainability into curricula and research due to limited faculty training, inadequate funding, and low student engagement. This limits the development of sustainability-oriented leadership and innovation essential for long-term progress (Ajaz Shaheen, 2024).

The reviewed literature reveals that Pakistan's sustainability is shaped primarily by economic, social, and environmental dynamics. Studies consistently highlight that fluctuations in GDP growth, rising inflation, and unstable trade performance underscore the fragility of Pakistan's economic sustainability, justifying the

inclusion of GDP growth as a measure of macroeconomic performance and Trade Balance as a reflection of industrial and external trade efficiency. On the social dimension, persistent inequalities in education continue to limit human capital formation, making Adult Literacy Rate a key determinant of social sustainability and long-term productivity. Environmental studies emphasize that increasing carbon emissions and deforestation threaten ecological balance and climate resilience, supporting the inclusion of CO_2 Emissions per Metric Ton and Forest Area Coverage as core indicators of environmental sustainability. Together, these variables represent the multidimensional framework through which Pakistan's economic growth, social progress, and environmental protection interact to determine its overall sustainability trajectory.

❖ **Comparative Analysis**

- **Sustainability Progress in Similar Economies**

Sustainability progress across developing economies varies significantly due to differences in governance, policy implementation, and economic structures (Angel & Rock, 2009). Pakistan has made moderate progress in areas like renewable energy expansion, climate resilience policies, and public-private partnerships, with initiatives such as the Billion Tree Tsunami Project and Pakistan Vision 2025 aiming to align with global sustainability goals. However, weak governance, economic instability, and inconsistent policy enforcement continue to hinder effective implementation (Syed et al., 2024). In contrast, India has emerged as a leader in renewable energy and circular economy initiatives, implementing large-scale solar projects, market-based energy efficiency mechanisms, and sustainable financing models, making it the third-largest producer of renewable energy globally (Garg, 2021). Bangladesh, despite facing similar climate vulnerabilities as Pakistan, has successfully developed community-based sustainability initiatives, including solar home systems, microfinance-driven green projects, and climate-adaptive urban planning under the Bangladesh Delta Plan 2100 (Anmol, 2020; Group, 2023; Iqbal & Kutubuddin, 2021). Vietnam has integrated sustainability into its industrial policies, focusing on green industry zones, eco-tourism, and sustainable trade agreements, positioning itself as a hub for green manufacturing (Tran, 2023). Meanwhile, Brazil has made significant strides in deforestation control and sustainable agribusiness through international climate finance mechanisms like the Amazon Fund, although governance inconsistencies have led to challenges in maintaining environmental protections (Aleixo & Junior, 2022). Compared to these nations, Pakistan still struggles with sustainability implementation due to weak institutional frameworks,

financial constraints, and a lack of comprehensive climate adaptation strategies, necessitating a more structured approach to achieving long-term sustainability goals.

- **Lessons Learned and Best Practices for Pakistan**

Pakistan can learn valuable lessons from the sustainability progress of similar economies by enhancing policy implementation, expanding renewable energy initiatives, and integrating climate adaptation measures. One key area requiring improvement is policy enforcement, as countries like India and Vietnam have effectively used digital governance and financial incentives to ensure sustainability targets are met. Investing in renewable energy expansion through public-private partnerships, foreign investments, and green financing mechanisms is essential, given Pakistan's slower transition to clean energy compared to India and Bangladesh. Additionally, climate adaptation strategies, particularly at the community level, can be strengthened by adopting Bangladesh's localized approaches, such as flood management systems, microfinance-based sustainable businesses, and urban resilience planning. Pakistan's industrial sector can benefit from Vietnam's green industrialization model, which focuses on low-carbon industrial zones and sustainable supply chains to attract environmentally conscious foreign investors. Leveraging international climate finance, as seen in Brazil's Amazon Fund and India's green bonds, can provide much-needed financial support for Pakistan's sustainability initiatives. Establishing a National Sustainability Fund, developing green bond markets, and engaging in bilateral sustainability agreements will help address financial barriers and drive long-term progress. By integrating global best practices, strengthening governance, and ensuring financial and technological partnerships, Pakistan can enhance its sustainability efforts and achieve more effective economic and environmental outcomes.

Methodology

This study adopts a quantitative econometric approach to evaluate the impact of economic, social, and environmental factors on sustainable development in Pakistan (Cerchione et al., 2025). Factor Analysis (FA) was used to derive statistically weighted indicators, while Newey-West regression corrected for heteroskedasticity and autocorrelation, ensuring robust estimates (Kumar, 2023; Tripathi & Singal, 2019). The analysis covers 2014–2024 using national-level time-series data from reliable secondary sources (SBP, PBS, WB, UNDP, and the Ministry of Finance). The

sample size (n=11) represents the most consistent and reliable data available for decade-long national analysis, providing a credible foundation for sustainability assessment in Pakistan (Kumar, 2023). All statistical analyses, including FA, SDI computation, and regression modeling, were conducted using STATA.

- **Selection of Variables**

This study categorizes sustainability into three core dimensions: Economic Factors: GDP Growth (%) and Trade Balance (Yusuf & Nasrulddin, 2024). Social Factors: Adult Literacy Rate (%) (Grotlüschen et al., 2025). Environmental Factors: CO_2 Emissions (Metric Tons per Capita) and Forest Area Coverage (%) (Huang et al., 2024; Tsegaye et al., 2023).

To ensure statistical validity, variables with high collinearity were omitted, retaining only the most independent and significant indicators. The selection aligns with established sustainability frameworks, such as the Brundtland Report (1987) and Pearce & Warford's (1993) model, emphasizing the integration of economic, social, and environmental factors. Standardized values of the variables were used in the analysis to ensure consistency and comparability. The choice of these specific variables is driven by their direct and measurable impact on sustainability. GDP Growth and Trade Balance capture economic stability and external trade efficiency, both crucial for long-term sustainable development. Adult Literacy Rate reflect human capital investment, which strengthens social resilience and economic productivity. CO_2 Emissions and Forest Area Coverage represent the environmental footprint, balancing industrial growth with conservation efforts. The chosen variables directly and measurably reflect Pakistan's sustainability dynamics: GDP Growth and Trade Balance capture macroeconomic performance and external trade stability; Adult Literacy Rate represent human-capital investment and social resilience; and CO_2 Emissions and Forest Area Coverage indicate environmental pressure and resource conservation.

- **Construction of Sustainability Development Index (SDI) and Econometric Model Specification**

This study constructs the Sustainability Development Index (SDI) to measure Pakistan's overall sustainability performance by integrating economic, social, and environmental dimensions. The SDI was developed using Factor Analysis (FA) on standardized data for GDP Growth, Trade Balance, Adult Literacy Rate, CO_2 Emissions, and Forest Area Coverage. The purpose of FA was to assign statistical

weights to indicators based on their contribution to the underlying sustainability structure, ensuring an objective, data-driven approach free from subjective bias.

Before applying FA, a Principal Component Analysis (PCA) was conducted to identify the optimal number of factors to retain. The Kaiser criterion (eigenvalues > 1) and scree plot (Figure 1) confirmed that two principal components should be extracted. The scree plot indicated a clear break after the second component, while the eigenvalue table 1 showed eigenvalues of 2.13786 and 1.21757 for the first two components, which together explained 67.11% of the total variance.

Component	*Eigenvalue*	*Difference*	*Proportion*	*Cumulative*
Comp1	2.13786	0.92029	0.4276	0.4276
Comp2	1.21757	0.31124	0.2435	0.6711
Comp3	0.90633	0.29497	0.1813	0.8523
Comp4	0.61135	0.48444	0.1223	0.9746
Comp5	0.12690	–	0.0254	1.0000

Table 1; Principal Component Analysis Results

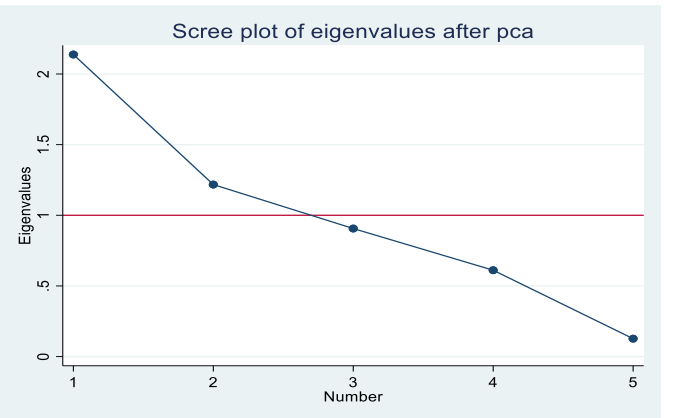


Figure 1.

Next, Factor Analysis using Principal Component Factoring (PCF) was performed, and two factors were retained following the PCA results. To enhance interpretability, Varimax orthogonal rotation was applied. The rotated factor matrix (Table 3.2b) revealed distinct loading patterns corresponding to two sustainability dimensions.

Variable	*Factor 1*	*Factor 2*	*Uniqueness*
GDP Growth	-0.4508	0.6143	0.4195
Trade Balance	0.1746	-0.7403	0.4215
Literacy Rate	0.5816	0.5910	0.3124
CO_2 Emissions	0.7972	-0.2288	0.3121
Forest Area	-0.9038	0.0639	0.1790

Table 2

Factor 1 represents environmental and social sustainability (dominated by CO_2 emissions, forest area, and literacy rate), while Factor 2 captures economic and human capital sustainability (represented by GDP growth, trade balance, and literacy). The two factors collectively explained 67.11% of the total variance, with Factor 1 contributing 40.49% and Factor 2 contributing 26.62%, indicating a strong underlying multidimensional structure.

Variable	*Factor 1*	*Factor 2*
GDP Growth	-0.15909	0.42533
Trade Balance	0.00325	-0.55543
Literacy Rate	0.36611	0.52723
CO_2 Emissions	0.38105	-0.08528
Forest Area	-0.45475	-0.05538

Table 3

Factor scores were generated using the regression method, producing F_1 and F_2 for each year (2014–2024). The composite Sustainability Development Index (SDI) was calculated as a weighted linear combination of these two factors based on their explained variance:

$$SDI = 0.404(F1) + 0.2662(F2)$$

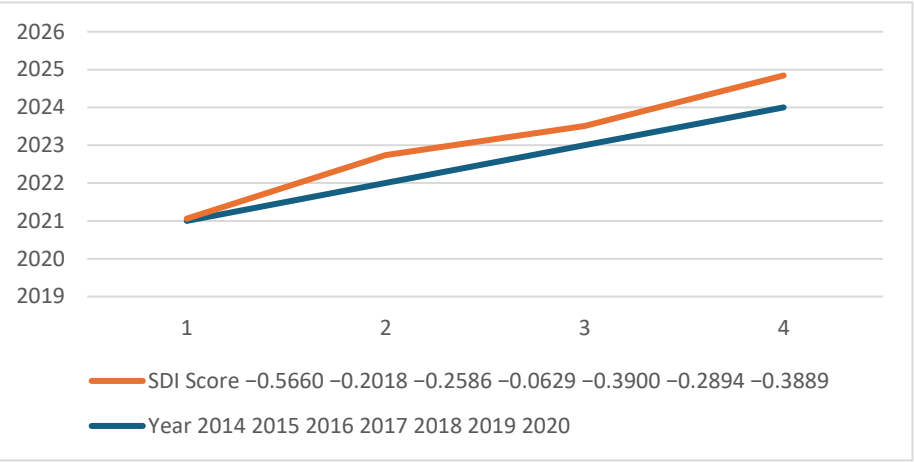
This formula ensures that factors explaining greater variance have a proportionally higher influence on the index. The computed SDI reflects Pakistan's overall sustainability performance across the period 2014–2024. Positive SDI values indicate above-average sustainability, while negative values signify periods of weak or declining sustainability performance.

Year	*SDI Score*
2014	–0.5660
2015	–0.2018
2016	–0.2586

2017	−0.0629
2018	−0.3900
2019	−0.2894
2020	−0.3889
2021	0.0597
2022	0.7422
2023	0.5120
2024	0.8440

Table 4: Author's calculations based on Factor Analysis (Varimax rotation) results

Figure 2



The SDI trajectory shows that Pakistan's sustainability weakened between 2014 and 2020, largely due to macroeconomic instability and environmental stress. A steady improvement from 2021 to 2024 suggests recovery driven by policy reforms and social investments, highlighting the importance of sustained economic diversification and environmental management.

Econometric Model

The econometric model used in this study is specified as follows:

$$\boldsymbol{SDI_t = \beta_0 + \beta_1 ECON_t + \beta_2 SOC_t + \beta_3 ENV_t + \mu_t}$$

Where:

- SDI = Sustainability Development Index (Dependent Variable)
- ECON = Economic Factors (GDP Growth, Trade Balance)

- SOC = Social Factors (Adult Literacy Rate)
- ENV = Environmental Factors (CO_2 Emissions, Forest Area Coverage)
- μt = Error term capturing unexplained variations

This model evaluates the relative impact of economic, social, and environmental factors on sustainability and is estimated to use Newey-West regression to correct for heteroskedasticity and autocorrelation.

❖ Regression Models and Results

To examine the relationship between sustainability and its determinants, the study initially applied Ordinary Least Squares (OLS) regression as a baseline model. OLS is widely used in econometric research for its unbiased estimation properties (Greene, 2012; Gujarati & Porter, 2009) and has been applied in sustainability studies to quantify the impact of economic, social, and environmental variables (Koop & Tole, 2004). However, diagnostic tests revealed the presence of autocorrelation and heteroskedasticity, which could lead to inefficient standard errors and unreliable inference. To address these econometric issues, Newey-West regression was employed as the final estimation method. This method, developed by Newey & West (1987), corrects for heteroskedasticity and serial correlation, ensuring that the estimated coefficients remain efficient and unbiased. As Stock & Watson (2003) and Baldwin & Dixon (2008) suggest, Newey-West estimators are particularly effective for sustainability models that involve economic and environmental time-series data. Given these advantages, Newey-West regression was deemed the most suitable approach for ensuring robust statistical inference in this study.

SDI	*Coefficient*	*std. err.*	*t*	*P>|t|*	*95% conf. interval*
zgdp	0.0488083	2.80e-09	1.7e+07	0	0.0488083 – 0.0488083
ztrade	-0.1465366	2.71e-09	-5.4e+07	0	-0.1465366 – -0.1465366
zlit	0.2885863	1.35e-09	2.1e+08	0	0.2885863 – 0.2885863
zco2	0.1315856	2.63e-09	5.0e+07	0	0.1315856 – 0.1315856
zforest	-0.19887	3.21e-09	-6.2e+07	0	-0.19887 – -0.19887
_cons	-9.5E-10	1.68e-09	-0.57	0.596	-5.27e-09 – 3.37e-09

Table 5

The Newey–West regression results (Table 5) reveal that GDP Growth exerts a positive and statistically significant impact on sustainability ($\beta = 0.0488$, $p < 0.01$), indicating that higher economic growth enhances Pakistan's overall sustainability performance. Conversely, Trade Balance shows a negative and significant effect ($\beta = -0.1465$, $p < 0.01$), suggesting that trade instability and persistent deficits hinder sustainable progress.

The Adult Literacy Rate has a positive and significant association with sustainability ($\beta = 0.2886$, $p < 0.01$), confirming that improvements in education and human capital directly strengthen long-term sustainability outcomes. Similarly, CO_2 Emissions demonstrate a positive and significant relationship ($\beta = 0.1316$, $p < 0.01$), which may reflect that industrial activity contributing to emissions also drives economic and infrastructure development in the short run.

In contrast, Forest Area Coverage exhibits a negative and statistically significant effect ($\beta = -0.1989$, $p < 0.01$), implying that deforestation and declining green cover negatively influence sustainability performance. The intercept term is statistically insignificant ($p = 0.596$), indicating that sustainability levels are largely explained by the selected economic, social, and environmental indicators.

Overall, these findings suggest that while economic and human capital development positively contribute to sustainability, environmental degradation through deforestation offsets some of these gains. The statistically significant coefficients and robust standard errors confirm that the model effectively captures Pakistan's sustainability dynamics during 2014–2024.

This evidence reinforces the multidimensional nature of sustainability, demonstrating that balanced progress across economic growth, trade stability, education, and environmental management is essential for achieving long-term sustainable development.

Discussion

The findings of this study reaffirm that Pakistan's sustainability is not solely dependent on economic growth but also on the combined influence of human capital, trade efficiency, and environmental conservation. The Sustainability Development Index (SDI), constructed using Factor Analysis (FA) with Principal

Component Factoring (PCF) and Varimax rotation, provided a comprehensive measure of national sustainability performance. The FA identified two primary factors explaining 67.11% of the total variance, capturing economic, social, and environmental dimensions in a balanced structure. This data-driven approach allowed the SDI to objectively represent Pakistan's sustainability dynamics between 2014 and 2024.

Subsequently, the Newey–West regression model was employed to analyze the determinants of sustainability while addressing heteroskedasticity and autocorrelation. The regression results revealed that economic and social factors exerted a substantial positive influence on sustainability, whereas environmental variables demonstrated mixed effects. Specifically, GDP Growth showed a positive and statistically significant impact ($\beta = 0.0488$, $p < 0.01$), indicating that sustained economic expansion enhances sustainability performance. In contrast, Trade Balance displayed a negative and significant coefficient ($\beta = -0.1465$, $p < 0.01$), suggesting that trade instability and deficits undermine long-term sustainability.

Among social indicators, the Adult Literacy Rate had a strong positive effect ($\beta = 0.2886$, $p < 0.01$), confirming that human capital development through education plays a central role in sustainable progress. On the environmental side, CO_2 Emissions showed a positive but context-dependent association ($\beta = 0.1316$, $p < 0.01$), reflecting that industrial growth contributing to emissions also drives short-term development gains. However, Forest Area Coverage exhibited a negative and significant relationship ($\beta = -0.1989$, $p < 0.01$), underscoring that deforestation and loss of green cover threaten Pakistan's long-term ecological balance and sustainability trajectory.

These findings align with the broader sustainability literature emphasizing that growth-oriented strategies must be accompanied by effective resource management and institutional oversight. The positive relationship between GDP growth and sustainability supports the notion that economic prosperity, when inclusive and well-managed, contributes to sustainable development. However, the negative trade balance and forest loss indicate that unchecked economic activity can have adverse implications if not supported by environmental safeguards and trade reforms.

The results also reinforce the importance of education as a foundation for sustainability. A literate and skilled population enhances labor productivity,

promotes innovation, and supports the implementation of green and socially inclusive policies. Meanwhile, the complex relationship between CO_2 emissions and sustainability highlights Pakistan's dual challenge—balancing industrialization with environmental responsibility.

Overall, this study establishes that sustainability is a multi-dimensional and governance-driven process. Economic, social, and environmental factors do not operate in isolation; their collective impact depends on policy coherence, institutional strength, and governance efficiency. Without integrated policymaking and effective implementation, economic growth alone cannot secure long-term sustainability.

A key takeaway from the empirical analysis is the growth–sustainability trade-off. While higher GDP growth and literacy enhance SDI performance, persistent trade deficits and environmental degradation offset these gains. This calls for a stronger institutional framework to ensure that economic expansion aligns with environmental sustainability and social inclusiveness. The findings also indicate that governance quality and regulatory enforcement are pivotal in shaping sustainable outcomes—an aspect often overlooked in traditional sustainability models.

- **Policy Implications**

Based on these insights, several policy recommendations emerge. Policymakers should prioritize sustainable economic growth by promoting trade diversification and export competitiveness while reducing dependence on imports. Investments in education must be expanded to enhance literacy and technical skills, supporting human capital development. Environmental reforms should focus on reducing CO_2 emissions through renewable energy adoption, improved energy efficiency, and reforestation initiatives to restore ecological balance. Strengthening institutional governance is equally critical—sustainability goals must be integrated into national development planning, supported by transparent monitoring and accountability mechanisms.

❖ Limitations and Future Research

Despite the robustness of the FA and Newey–West regression methodology, this study acknowledges certain limitations. The sample size (n = 11) restricts the generalizability of results and limits statistical power. However, this limitation arises from the unavailability of consistent national-level data, and for a decade-long macroeconomic analysis, these are the most reliable observations available. Additionally, SDI construction assumes linear relationships among indicators. Future studies may employ dynamic panel data models or machine learning–based composite indices to capture nonlinear sustainability dynamics and improve predictive accuracy.

In summary, the empirical findings confirm that Pakistan's sustainability outcomes are significantly influenced by economic growth, trade stability, human capital development, and environmental management. The study concludes that achieving long-term sustainability requires a balanced integration of economic, social, and environmental priorities, supported by effective governance and adaptive policy frameworks that align national development with global sustainability goals.

Conclusion

This study examined Pakistan's sustainability challenge by analyzing the balance between economic growth, social development, and environmental protection using 2014–2024 data. The findings indicate that GDP growth and human capital development—reflected through literacy contribute positively to Pakistan's sustainability, whereas trade imbalances and deforestation exert adverse effects. The mixed impact of CO_2 emissions underscores the inherent tension between industrial expansion and environmental preservation. Overall, the results affirm that sustainability in Pakistan is a multidimensional process shaped by the interplay of economic, social, and environmental forces, and contingent upon the strength of governance, institutional capacity, and policy alignment. To advance sustainability, Pakistan must adopt integrated strategies that balance economic stability with environmental stewardship and social inclusion. Policymakers should move beyond short-term growth agendas toward comprehensive frameworks that incorporate measures such as a national carbon tax, renewable energy incentives, and enforceable reforestation and emission-trading mechanisms for major industries. Future research should extend this analysis by employing provincial-level or panel

data to capture spatial variations and by incorporating qualitative methods to explore the governance and implementation challenges underlying sustainable development policies.

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