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ECONOMIC, ENVIRONMENTAL, AND GENDER DIMENSIONS OF SUSTAINABLE DEVELOPMENT: AN EMPIRICAL INVESTIGATION

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Abstract
The present study investigates the determinants of sustainable development in Pakistan by constructing a multidimensional Development Index (DI) and estimating its long- and short-run drivers using annual data for 1980–2023. The DI integrates three pillars economic, environmental, and gender addressing the limitations of GDP-centric metrics and penalizing imbalances across pillars to reflect intergenerational equity and inclusion. Explanatory variables comprise a Government Index (capturing expenditure composition, taxation, debt, and education), a Governance Indicators Index, Adjusted Net Saving (ANS), trade openness, unemployment, and the Gini measure of income inequality. The study employs the Autoregressive Distributed Lag (ARDL) framework with bounds testing for cointegration. Results indicate a stable long-run relationship between the DI and its determinants. Governance indicators and ANS are positively associated with sustainable development through stronger governance and the maintenance of intertemporal wealth. By contrast, the Government Index, trade openness, unemployment, and income inequality exhibit negative long-run effects, reflecting crowding-out and misallocation risks, structural vulnerabilities stemming from limited diversification and environmental pressures, underutilized human capital, and exclusionary distributions. Short-run estimates reveal transitional effects and a negative error-correction term, indicating convergence to the long-run equilibrium. The study contributes by proposing a policy-sensitive DI that embeds environmental and gender constraints, jointly modeling institutional, fiscal, savings, openness, labor-market, and distributional channels, and translating the evidence into a reform agenda: strengthen institutions; reprioritize spending toward human capital; channel genuine savings into green investment; diversify and safeguard trade; expand employment; and reduce inequality.
Keywords: *Sustainable Development, Development Index, Governance Quality, Adjusted Net Saving*

INTRODUCTION

Sustainable development has transitioned from a peripheral policy discussion to the primary coordinating principle for nations striving to balance economic expansion, social justice, and environmental preservation (United Nations, 2015). Grounded in the Brundtland Commission's framework of intergenerational equity and Amartya Sen's (1999) capability approach—which defines development as the expansion of substantive freedoms (Sen, 1999) —this study operationalizes sustainability through a multidimensional Development Index (DI). By integrating economic, environmental, and gender dimensions, the DI addresses the inherent flaws in unidimensional welfare measures, such as GDP per capita, which often overlook the depreciation of natural and human capital (Ali, 2015; Pearce & Atkinson, 2017).

Pakistan's development path is characterized by significant structural shifts and frequent external shocks, complicating the pursuit of growth that is consistent with social and environmental integrity. A longitudinal view of Pakistan's progress from 1980 to 2023 reveals a complex landscape where improvements in social indicators often collide with environmental costs. As shown in Table 1, while female labor participation and political inclusion have seen significant upward trends, the environmental cost, measured in CO2 emissions, has nearly quadrupled.

To address these imbalances, the DI in this research is designed as a multidimensional index that penalizes underperforming pillars, rejecting the assumption of "perfect substitutability" between economic income and

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ecological health. This study specifically examines how governance, savings, and trade dynamics jointly determine this multidimensional outcome. Institutional quality is expected to reduce transaction costs and foster productive investment (North & North, 1992), while Adjusted Net Savings (ANS) serves as a proxy for "authentic saving," reflecting the intertemporal investment in reproducible human and natural capital (HARTWICK, 2002). The historical performance of these independent drivers is summarized in Table 2.

Table 1: Decadal Trends in Gender, Economic, and Environmental Dimensions (1980-2023)

Period	Gender Dimension (Avg. Trends)	Economic Dimension (Avg. Trends)	Environmental Dimension (Avg. Trends)
1980–1990	FLFP: 10.6%; Primary GPI: 0.52; Women's seats: 1.6%.	Avg. GDP per Capita: $329; Domestic credit: 24.9%; Broad Money: 41.4%.	Avg. CO2 Emissions: 46.1 Mt; Renewable energy share: 57.0%.
1990–2000	FLFP: 13.0%; Primary GPI: 0.61; Women's seats: 2.3%.	Avg. GDP per Capita: $436; Discount rates: 13.9%.	Avg. CO2 Emissions: 89.6 Mt; Renewable energy share: 53.6%.
2000–2010	FLFP: 15.5%; Primary GPI: 0.77. Women's seats: 18.2%;	Avg. GDP per Capita: $831; Broad Money: 39.5%.	Avg. CO2 Emissions:136.5 Mt; Renewable energy share: 48.4%.
2010–2023	FLFP: 21.1%; Primary GPI: 0.86; Women's seats: 20.9%.	Avg. GDP per Capita: $1,399; Broad Money: 48.7%.	Avg. CO2 Emissions: 192.Mt; Renewable energy share: 44.8%.

Source: Author's calculations based on World Bank (WDI), Pakistan Economic Survey (1980–2023), and IPU.

Table 2: Trends of Independent Variables and Sustainability Drivers

Period	ANS (% GNI)	Trade Openness	Governance	Government Index
1980–1990	Low; weak capital formation.	Moderate; limited diversification.	Weak institutional framework.	Rising; inefficient allocation.
1990–2000	Gradual improvement via reforms.	Increased liberalization activity.	Reforms began; quality remained weak.	Rising spending; expanding deficits.
2000–2010	Higher; supported growth.	Increased via globalization.	Slight improvement in quality.	High infrastructure investment.
2010–2023	Fluctuating; debt pressures.	Moderate; limited diversification.	Instability weakened performance.	Rising deficits; debt constraints.

Sources: World Bank (WDI); Worldwide Governance Indicators; Pakistan Economic Survey.

Despite the global consensus on sustainable development, empirical measurement and rigorous evaluation suffer from serious limitations (Sachs, 2022). Most studies rely on unidimensional indicators like GDP per capita, which overestimate welfare by ignoring environmental degradation or gender exclusion (Ali 2018; Dasgupta, 2021). Furthermore, determinants such as institutional quality and fiscal structure are often analyzed in isolation (Qasim, Majid, & Jadoon, 2021), obscuring how they jointly determine sustainable outcomes (Ali & Bibi, 2017' Acemoglu, Johnson, & Robinson, 2005; Firdous et al., 2023). Finally, much of the existing literature utilizes static approaches that fail to capture the country-specific time-series dynamics crucial for transition economies.

This study addresses these gaps by constructing a penalty-sensitive Development Index (DI) and employing the Autoregressive Distributed Lag (ARDL) bounds testing approach to quantify the short- and long-run relationships between sustainability and its determinants. We hypothesize that while institutional quality and adjusted net savings (ANS) positively influence the DI, high fiscal deficits (Government Index), trade openness in low-diversification settings, unemployment, and income inequality (Gini Index) exert significant negative pressures. By integrating these dimensions into a single analytical framework, this study provides evidence-based diagnostics for policy prioritization in Pakistan and similar emerging economies.

REVIEW OF LITERATURE

Sustainable development is now widely understood as a multidimensional process shaped by economic, environmental, and social factors, rather than as a purely economic phenomenon. Traditional development measures that focus exclusively on income growth often overlook ecological sustainability and social inclusion.

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As a result, recent scholarship emphasizes integrated frameworks that capture these interconnected dimensions. The economic aspects of sustainable development have been extensively examined in both developed and developing contexts, with particular attention to technological progress, institutional quality, and economic openness. Tang, Hou, Fay, and Annis (2021) highlight the significance of technological integration and resource optimization in enhancing economic efficiency and sustainability, demonstrating that digital platforms can improve transparency and reduce inefficiencies. Vasylieva, Derkacz, Popp, and Horsch (2025) similarly find that stronger institutions and higher income levels facilitate the adoption of renewable energy and improve environmental outcomes. Boar, Bastida, and Marimon (2020) further demonstrate that technological innovation and resource-sharing platforms enhance production and consumption patterns, thereby supporting long-term economic sustainability. In developing countries, economic policy is shaped by structural constraints and institutional capacity. Phimphanthavong (2014) finds that reforms and foreign investment can promote sustainable development, although structural inequalities and limited technological capacity remain significant barriers. Qasim et al. (2021) examined the relationship between institutional quality, trade openness, and economic growth in selected South Asian economies. The aim was to determine whether institutional quality and trade openness are competitors or complements in promoting growth in Bangladesh, India, Pakistan, and Sri Lanka. The results showed that institutional quality has a positive and significant effect on economic growth, while trade openness alone has a negative effect. Bardy, Drew, and Kennedy (2012) emphasize the critical role of institutional quality in enabling sustainable transformation in resource-constrained environments. Evidence from Asia indicates that trade openness, infrastructure investment, and policy reforms are key determinants of development outcomes (Ali & Rehman, 2015; Kaimuri & Kosimbei, 2017; Koirala & Pradhan, 2020).

Collectively, these studies indicate that economic sustainability depends not only on growth but also on the quality of institutions, investment patterns, and global integration. Economic growth alone is insufficient if environmental degradation undermines long-term development prospects (Sajid & ali, 2018; Senturk & Ali, 2021; Mehmood et al., 2022; Ashiq et al., 2023; Ali et al., 2023). Firdous et al. (2023) examined the relationship between economic growth, environmental degradation, and public health in Pakistan. The results showed that economic growth significantly increases environmental degradation because Pakistan's industrial sector depends heavily on fossil fuels. Renewable energy consumption reduced CO_2 emissions, while environmental degradation negatively affected public health (Marc & Ali, 2017; Marc et al., 2021; Roussel et al., 2021). Overall, the study concluded that Pakistan needs sustainable growth through renewable energy investment and stronger public health spending. The environmental dimension has gained increasing prominence due to concerns about climate change, resource depletion, and ecological degradation. McGranahan and Satterthwaite (2002) underscore the importance of governance in addressing urban environmental challenges. Strezov, Evans, and Evans (2017) demonstrate that sustainable development requires a transition to cleaner energy systems, while Cramer et al. (2018) highlight the risks associated with climate change and resource scarcity, particularly in vulnerable regions. These findings reinforce the necessity of integrating environmental sustainability into broader development strategies.

Gender equality constitutes a critical determinant of sustainable development. Disparities in education, employment, and political participation diminish the effective utilization of human capital and constrain inclusive development. Kaltenborn, Krajewski, and Kuhn (2020) contend that gender equality enhances social participation and institutional effectiveness, thereby advancing sustainable development goals. Agarwal (2018) and Dhar (2018) demonstrate that gender inclusion increases economic productivity and social welfare, particularly in developing countries. Collectively, these studies suggest that social inclusion and gender equality are indispensable alongside economic and environmental progress. Despite these contributions, much of the existing literature examines economic, environmental, and social factors in isolation. Many studies rely on single indicators, such as GDP per capita, which do not adequately reflect environmental sustainability or social inclusion (Marc et al., 2022). Cross-sectional and panel approaches frequently fail to capture country-specific dynamics or long-term relationships. These methodological limitations impede a comprehensive understanding of the interactions among economic, institutional, and social factors over time (Arshad & Ali, 2016). Recent research addresses these gaps by employing composite indices that integrate multiple dimensions of development. Such indices enable a more holistic assessment of sustainable development by capturing the interplay between economic, environmental, and social factors and penalizing imbalances (Marc et al., 2022). Building on this approach, the present study constructs a composite Development Index for Pakistan that incorporates economic, environmental, and gender dimensions. The analysis examines institutional quality, fiscal structure, adjusted net savings, trade openness, unemployment,

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and income inequality as key determinants. By integrating these dimensions within a unified empirical framework and applying time-series econometric methods, this study provides a comprehensive and policy-relevant analysis of sustainable development, addresses critical gaps in the literature, and offers new insights into the economic, institutional, and social drivers of sustainable development in Pakistan.

CONCEPTUAL FRAMEWORK

The theoretical foundations of sustainable development originate in early conservation theory, which emphasized responsible use of natural resources to ensure their long-term availability. Initial frameworks, such as those by the International Union for Conservation of Nature, focused on ecological preservation and sustainable resource utilization. However, these perspectives largely overlooked economic and social dimensions. The World Commission on Environment and Development broadened this definition, conceptualizing sustainable development as meeting present needs without compromising future generations' ability to meet theirs. This multidimensional approach integrates environmental sustainability with economic progress and social welfare. Modern development theory further emphasizes that sustainable development requires not only economic growth but also environmental stewardship and social inclusion. Sen (1993) capability approach underscores that development should expand human freedoms and capabilities rather than focus solely on income. This perspective underpins the composite Development Index (DI) employed in this study, which integrates economic, environmental, and gender dimensions.

Fiscal policy theory highlights how government actions influence sustainable development. Keynesian theory posits that government expenditure on infrastructure, education, and public services stimulates economic activity and supports long-term growth. Musgrave's public finance theory emphasizes the allocative and developmental role of government in promoting welfare (Musgrave, 1959). Conversely, the crowding-out hypothesis suggests excessive public borrowing may reduce private investment, while public choice theory warns that inefficiencies and rent-seeking can undermine development. These perspectives indicate that the impact of fiscal policy depends on the efficiency and effectiveness of public resource allocation. Institutional quality is central to development. New Institutional Economics, pioneered by Douglass North, views institutions as formal and informal rules shaping economic interactions and incentives (Douglass, 1991). Strong institutions protect property rights, reduce transaction costs, and enhance policy effectiveness. Empirical evidence by Acemoglu et al. (2005) and Rodrik, Subramanian, and Trebbi (2004) demonstrates that institutional quality is a key determinant of long-term economic performance. However, political economy perspectives caution that weak governance and elite capture may limit the benefits of institutional reforms. Savings and capital accumulation underpin sustainable development. The Solow growth model emphasizes the role of savings in promoting capital formation and long-term growth (Solow, 1957). The Hartwick rule extends this by asserting that sustainability requires reinvestment of resource rents into productive capital (Hartwick, 2017; Marc & Ali, 2017). Adjusted net savings operationalizes this principle by accounting for investments in physical, human, and natural capital, as well as resource depletion. Higher genuine savings preserve the economy's productive capacity and support sustainable outcomes. International trade theory provides insights into economic openness and development. Classical theory highlights efficiency gains from specialization, while modern approaches emphasize technology diffusion and productivity growth. Structuralist and dependency theories warn that developing economies reliant on primary commodities may face structural disadvantages, and the Dutch Disease effect shows how external integration can distort competitiveness. Thus, trade's impact on sustainability depends on structural characteristics and the capacity for economic diversification. Labor market theory connects employment with sustainable development. Keynesian theory views unemployment as the underutilization of productive capacity, thereby reducing welfare. Empirical evidence, including Okun's law, shows unemployment negatively affects output. High unemployment limits income, human capital formation, and inclusive development, constraining long-term development. Inequality influences long-term development. The Kuznets curve posits that inequality rises in the early stages of development before declining (Barro, 2000). Recent evidence, however, shows persistent inequality undermines sustainable development by restricting access to education, reducing social mobility, and weakening institutions. Banerjee and Duflo (2003) argue that inequality reduces human capital investment, limiting inclusive growth. These theoretical perspectives indicate that sustainable development results from the interplay of fiscal policy, institutional quality, savings behavior, trade openness, labor market conditions, and income distribution. Efficient fiscal management, strong institutions, and genuine savings are expected to support development, while unemployment and inequality may hinder it.

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DATA, MODEL AND METHODOLOGY

DATA DESCRIPTION

This study uses annual time-series data for Pakistan from 1980 to 2023, obtained from the World Development Indicators (WDI). The variables used in the study include the Sustainable Development Index (SDI), the Governance Indicators Index (GII), the Govt Index, Income Inequality, Adjusting Net Saving (ANS), Unemployment, and Trade Openness. The analysis is done using Stata 17.0. ARDL is a technique that examines both long-run and short-run dynamics(Iqbal, Arif, Jadoon, & Rana, 2023). relationships. Diagnostic tests are used to assess the model's robustness, including tests for serial correlation, heteroscedasticity, Normality, multicollinearity (VIF), and stability tests (CUSUM and CUSUMSQ).

Table 3: Brief Explanation of Variables

Variables	Proxies	Symbol	Unit	Data source
Development Index	Composite Index constructed from: Economic Index, Environment Index and Gender Index	DI	Index constructed through PCA	Author's Calculation
Govt Index	Composite Index constructed from: General Government Consumption Expenditure Military Expenditure Education Expenditure Debt, and Tax Revenue	Govt Index	Index constructed through PCA	Author's Calculation
Governance Indicators Index	Composite Index constructed from: Voice and Accountability Political Stability Government Effectiveness Regulatory Quality Rule of Law and Control of Corruption	GII	Index constructed through PCA	Author's Calculation (These sub indicators taken from WGI and then merged through PCA)
Adjusted Net Savings	Adjusted Net Saving (Excluding particulate emission damage, % of GNI)	ANS	% Of GNI	WDI
Trade	Trade (% of GDP)	TRADE	% Of GDP	WDI
Unemployment	Unemployment (% of labor force, modeled ILO estimate)	Unemployment	% Of labor force	WDI
Gini	Income Inequality	GINI	Index (0–100)	WDI

The study employs a multidimensional framework in which sustainable development is measured by a composite Development Index (DI) constructed via Principal Component Analysis (PCA). This index integrates economic, environmental, and gender dimensions, providing a more comprehensive measure than traditional indicators such as GDP per capita.

The key explanatory variables include institutional, fiscal, economic, and social factors. The Government Index (GOVTINDEX), constructed through PCA, captures fiscal policy stance using government consumption, military expenditure, education expenditure, public debt, and tax revenue. The Governance Indicators Index (GII), also developed using PCA, reflects institutional quality through six dimensions: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption.

Adjusted Net Savings (ANS), expressed as a percentage of GNI, represents long-term sustainability by accounting for investments in physical and human capital while adjusting for resource depletion. Trade openness (TRADE), measured as a percentage of GDP, captures economic integration and its potential effects on growth and sustainability. Social factors include unemployment (percentage of labor force) and income inequality (Gini index), both of which influence inclusive and balanced development.

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METHODOLOGY

INDEX CONSTRUCTION

To capture multidimensional constructs, three indices (DI, GOVTINDEX, GII) are constructed using Principal Component Analysis (PCA). This method transforms correlated variables into uncorrelated components while retaining maximum variance.

The construction process involves three steps: (i) selection of relevant indicators based on theory and data availability, (ii) standardization of variables to ensure comparability, and (iii) extraction of principal components. The first principal component is used as the representative index because it explains the greatest variation in the data. This approach improves efficiency and reduces multicollinearity.

UNIT ROOT TESTING

To avoid spurious regression, the stationarity properties of all variables are tested using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The ADF test accounts for serial correlation through lagged differences, while the PP test corrects for heteroskedasticity and autocorrelation.

The null hypothesis in both tests assumes the presence of a unit root. Using both methods ensures robust identification of the order of integration, which is essential for selecting an appropriate econometric model.

The minimum configuration of the ADF test is as follows.

$$X_t = \mu + \alpha X_{t-1} + \gamma t + \varepsilon_t \quad (1)$$

Subtracting Xt –1from both sides give:

$$\Delta X_t = \mu + (1 - \alpha)\, Xt_{-1} + \gamma t + \varepsilon_t \quad (2)$$

Dickey-Fuller (DF) test is widely employed to detect unit roots in a time series data. Nonetheless, it has one of the weaknesses in that it assumes that the error terms are not correlated over time, which may not be so. This renders it unreliable in some situations. To avoid this problem, the Augmented Dickey- Fuller (ADF) test incorporates the lagged differences of the variable in the equation and thus provides a better control of the serial correlation. Substituting (1 - a) with r transforms the equation into a more reliable ADF test in terms of evaluating stationarity

$$\Delta X_t = \mu + \rho X_{t-1} + \gamma\tau + \sum_{i=1}^{\rho} \emptyset_i \Delta X_{t-i} + \varepsilon_t \quad (3)$$

Here, Δ denotes the first difference operator, which quantifies the change between time periods, and Xt denotes the value of the series at time t. The parameters μ, γ, $\emptyset$ need to be estimated, whereas εt represents the random error term, which captures unpredictable oscillations in the data.

ARDL MODEL SPECIFICATION

The Autoregressive Distributed Lag (ARDL) model is employed to estimate both short-run and long-run relationships. The ARDL approach is suitable for small sample sizes and accommodates variables with different integration orders, including I(0) and I(1).

The ARDL equation is follow as:

$$SDI_t = \alpha_0 + \sum_{i=1}^{3} \alpha_i\, SDI_{t-i} + \sum_{j=0}^{3} \beta_j\, GII_{t-j} + \sum_{j=0}^{3} \gamma_j\, GOVTINDEX_{t-j} + \sum_{j=0}^{3} \delta_j\, ANS_{t-j} + \sum_{j=0}^{2} \theta_j\, trade_{t-j} + \sum_{j=0}^{3} \kappa_j\, Gini_{t-j} + \sum_{j=0}^{3} \mu_j\, UMEMPLOYMENT_{t-j} + \varepsilon_t$$

$$SDI_t = \alpha_0 + \alpha_1\, SDI_{t-1} + \alpha_2\, SDI_{t-2} + \alpha_3\, SDI_{t-3} + \beta_0\, GII_t + \beta_1\, GII_{t-1} + \beta_2\, GII_{t-2} + \beta_3\, GII_{t-3} + \gamma_0\, GOVTINDEX_t + \gamma_1\, GOVTINDEX_{t-1} + \gamma_2\, GOVTINDEX_{t-2} + \gamma_3\, GOVTINDEX_{t-3} + \delta_0\, ANS_t + \delta_1\, ANS_{t-1} + \delta_2\, ANS_{t-2} + \delta_3\, ANS_{t-3} + \theta_0\, trade_t + \theta_1\, trade_{t-1} + \theta_2\, trade_{t-2} + \kappa_0\, gini_t + \kappa_1\, gini_{t-1} + \kappa_2\, gini_{t-2} + \kappa_3\, gini_{t-3} + \mu_0\, UMEMPLOYMENT_t + \mu_1\, UMEMPLOYMENT_{t-1} + \mu_2\, UMEMPLOYMENT_{t-2} + \mu_3\, UMEMPLOYMENT_{t-3} + \varepsilon_t \quad (4)$$

This framework captures dynamic adjustments and long-run equilibrium relationships simultaneously.

COINTEGRATION AND ERROR CORRECTION MODEL

The ARDL Bounds Testing approach is employed to determine whether a long-run relationship exists. Cointegration is established when the F-statistic exceeds the upper-bound critical values.

Following confirmation of cointegration, the Error Correction Model (ECM) is applied to capture short-run dynamics and the rate at which the system returns to equilibrium. The error correction term quantifies the speed of adjustment. A negative and statistically significant coefficient indicates model stability.

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DIAGNOSTIC AND STABILITY TESTS

Several diagnostic tests are conducted to evaluate the model. The Breusch-Godfrey LM test assesses serial correlation, the Breusch-Pagan test evaluates heteroskedasticity, and the Shapiro-Wilk test examines normality. Multicollinearity is assessed using the Variance Inflation Factor (VIF).

Model stability is assessed using the CUSUM and CUSUMSQ tests, which evaluate the consistency of model parameters over time. These tests demonstrate whether the model satisfies econometric assumptions and produces reliable results.

RESULTS AND DISCUSSIONS

This chapter presents the empirical findings of the study using the ARDL (Autoregressive Distributed Lag) approach to examine the significant factors influencing sustainable development in Pakistan from 1980 to 2023. The primary focus of this analysis is the Sustainable Development Index (SDI), a comprehensive measure of long-term economic, social, and environmental well-being. The explanatory variables include the Government Index (GOVTINDEX), Governance Indicators Index (GII), Gini coefficient, Adjusted Net Savings (ANS), trade openness, and unemployment. Both short-run and long-run dynamics are explored, and diagnostic tests are conducted to ensure the model's robustness and validity.

DESCRIPTIVE STATISTICS

Table 1 summarizes the descriptive statistics of all variables used in the study. The SDI has a mean of 0.409 and a standard deviation of 0.114, indicating relatively steady progress in sustainable development over the study period. The minimum and maximum values of 0.221 and 0.569, respectively, show that the SDI did not experience extreme fluctuations.

The Governance Indicators Index (GII) has a mean value close to zero (0.009) and a standard deviation of 1.002, with values ranging from -1.822 to 1.088. This reflects the significant variability in institutional quality in Pakistan, suggesting periods of both deterioration and improvement in governance. Similarly, the Government Index (GOVTINDEX) shows an average of -0.013 with a standard deviation of 0.966, highlighting substantial variations in government performance over time.

Economic factors show a considerable variation as well. Adjusted Net Savings (ANS) average at 5.202 with a standard deviation of 1.874, ranging from 1.149 to 8.821, reflecting the fluctuating investment in resources and sustainability practices. Trade openness has a mean of 31.36% of GDP with moderate variability (standard deviation 4.376), suggesting a relatively stable trade environment over the years. The Gini coefficient averages at 30.659 with limited variation, indicating that income inequality has remained fairly persistent in Pakistan. Unemployment, however, shows greater instability, with an average of 4.104% and a standard deviation of 2.082%, reflecting fluctuations in labor market conditions over time.

Table 4: Summary Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
SDI_t	44	0.409	0.114	0.221	0.569
GII_t	44	0.009	1.002	-1.822	1.088
$GOVTINDEX_t$	44	-0.013	0.966	-2.345	1.45
ANS_t	44	5.202	1.874	1.149	8.821
$Trade_t$	44	31.359	4.376	21.46	38.499
$Gini_t$	44	30.659	1.813	27.77	33.95
$Unemployment_t$	44	4.104	2.082	0.398	7.83

Source: Author's estimations using Stata 17.0

CORRELATION ANALYSIS

The correlation matrix (Table 2) offers an initial understanding of the relationships between the variables. Notably, the SDI is negatively correlated with the Governance Indicators Index (GII) (-0.622) and the Gini coefficient (-0.629), suggesting that lower institutional quality and higher income inequality are associated with lower sustainable development outcomes in Pakistan. Conversely, SDI shows a positive correlation with Adjusted Net Savings (0.240), highlighting the importance of investment and resource sustainability for long-term development.

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Trade openness is strongly positively correlated with GII (0.679) and GOVTINDEX (0.424), indicating that good governance and institutional quality facilitate trade expansion. However, trade exhibits a negative relationship with SDI (-0.430), implying that unregulated trade may have adverse consequences on sustainable development, likely due to environmental pressures and unequal distribution of benefits. The unemployment rate also exhibits a negative correlation with SDI (-0.268), highlighting the detrimental effect of high unemployment on sustainable development outcomes.

Table 5: Correlation Matrix

Variables	SDI_t	GII_t	$GOVTINDEX_t$	ANS_t	$Trade_t$	$Gini_t$	$Unemployment_t$
SDI_t	1						
GII_t	-0.622	1					
$GOVTINDEX_t$	-0.112	0.545	1				
ANS_t	0.24	-0.231	-0.087	1			
$Trade_t$	-0.43	0.679	0.424	-0.535	1		
$Gini_t$	-0.629	0.507	0.139	0.068	0.219	1	
$Unemployment_t$	-0.268	-0.101	-0.352	0.213	-0.339	-0.12	1

UNIT ROOT TESTS

The stationarity of the variables was assessed using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) methods (Table 3). The findings indicate that most variables are non-stationary at level but become stationary after first differencing, demonstrating mixed orders of integration, I(0) and I(1). The Government Index and Adjusted Net Savings are stationary at level, which supports the application of the ARDL model for analysis, as it accommodates variables with different integration orders.

Table 6: Unit Root Tests

Variables	ADF (P-value)	PP (P-value)
	I(0)	I(1)
SDI_t	0.697	0.000***
GII_t	0.372	0.000***
$GOVTINDEX_t$	0.003***	0.000***
ANS_t	0.000***	0.000***
$Trade_t$	0.1895	0.000***
$Gini_t$	0.7727	0.000***
$Unemployment_t$	0.1543	0.000***

*** shows the significance level of the variable at the 1% level.

ARDL BOUND TEST

The ARDL bound test indicates a long-term relationship between the variables. The F-statistic (11.799) is much higher than the upper-bound critical values at all significance levels (10%, 5%, 2.5%, 1%), so the null hypothesis of no cointegration is rejected. This means that economic, social, and political factors affect sustainable development in Pakistan over the long run.

Table 7: ARDL Bound Test Results

Significance	I(0) Bound	I(1) Bound
0.1	2.12	3.23
0.05	2.45	3.61
0.025	2.75	3.99
0.01	3.15	4.43

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*ARDL F-statistic = 11.799***, Source: Author's estimations using Stata 17.0**

ARDL LONG-RUN ESTIMATES

The long-run ARDL estimates (Table 5) indicate that governance, economic savings, trade, inequality, and unemployment exert significant effects on sustainable development in Pakistan. The Governance Indicators Index (GII) demonstrates a positive association with the Sustainable Development Index (SDI) (coefficient = 0.068, $p < 0.01$), underscoring the role of robust institutions in promoting long-term development. Conversely, the Government Index exhibits a negative long-term effect (coefficient = -0.048, $p < 0.05$), suggesting that weak fiscal policies, elevated debt levels, and mismanaged expenditures impede sustainable development.

Adjusted Net Savings is positively associated with SDI (coefficient = 0.042, $p < 0.01$), highlighting the significance of resource conservation and investment for intergenerational equity. In contrast, trade openness demonstrates a significant negative relationship with SDI (coefficient = -0.018, $p < 0.01$), indicating that unregulated trade may undermine environmental and social sustainability. Income inequality, measured by the Gini coefficient, exerts a negative effect on SDI (coefficient = -0.062, $p < 0.01$), supporting the view that unequal wealth distribution impedes inclusive growth. Unemployment also negatively affects SDI (coefficient = -0.036, $p < 0.01$), underscoring the importance of job creation for sustainable development.

Table 8: ARDL Long-Run Estimates

Variables	Coefficient	Std. Error	t-Statistic	P-Value
GII_t	0.068	0.022	3.11	0.008***
$GOVTINDEX_t$	-0.049	0.018	-2.64	0.019**
ANS_t	0.042	0.006	6.89	0.000***
$Trade_t$	-0.018	0.003	-6.37	0.000***
$Gini_t$	-0.062	0.008	-7.78	0.000***
$Unemployment_t$	-0.036	0.007	-5.18	0.000***

Source: Author's estimations using Stata 17.0

ARDL SHORT-RUN ESTIMATES AND ERROR CORRECTION MODEL

The short-run ARDL results capture the immediate effects of changes in the explanatory variables on the Sustainable Development Index (SDI) in Pakistan. The Error Correction Model (ECM) indicates how quickly deviations from long-run equilibrium are corrected in subsequent periods. The estimated ECM coefficient is -0.762 ($p < 0.01$), showing that approximately 76% of deviations from the long-run sustainable development equilibrium are corrected within one year. This high adjustment speed underscores that Pakistan's sustainable development responds relatively quickly to policy, governance, and economic shocks.

In the short run, the Governance Indicators Index (GII) continues to show a positive influence on SDI (coefficient = 0.051, $p < 0.01$), suggesting that even temporary improvements in institutional quality, such as enhanced rule of law, reduced corruption, or better political stability, immediately benefit sustainable development outcomes. Similarly, Adjusted Net Savings (ANS) maintains a positive short-term impact (0.031, $p < 0.01$), implying that current investments in resource conservation and sustainable projects have immediate effects on the development index.

On the other hand, the Government Index exhibits a negative short-run effect (-0.032, $p < 0.05$), consistent with the long-run findings, indicating that fiscal mismanagement, rising debt, and inefficient government expenditure continue to hinder short-term development outcomes. Trade openness negatively affects SDI in the short term (-0.014, $p < 0.01$), likely due to environmental pressures and social disparities associated with rapid trade expansion without proper regulations. Income inequality, as measured by the Gini coefficient, significantly reduces SDI (-0.045, $p < 0.01$), reinforcing that even temporary rises in inequality can negatively impact the social and economic dimensions of sustainable development. Similarly, unemployment negatively influences SDI (-0.028, $p < 0.01$), highlighting the immediate socio-economic consequences of rising joblessness on development outcomes. These short-run results indicate that Pakistan's sustainable development is highly sensitive to both economic and institutional changes. Policies targeting improved governance, investment in sustainable savings, and social inclusion can produce tangible benefits even within a few years.

5.7 Diagnostic Tests

To ensure the reliability and robustness of the ARDL model, several diagnostic tests were conducted. The Breusch-Godfrey Serial Correlation LM test indicates no evidence of serial correlation, confirming that the residuals are

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uncorrelated over time. The Breusch-Pagan-Godfrey test suggests constant error variance, confirming the absence of heteroskedasticity. The Ramsey RESET test indicates no omitted variable bias, while the Jarque-Bera test confirms that residuals are normally distributed. Together, these results provide strong evidence that the estimated ARDL model is well-specified and the results are statistically reliable.

Table 9: ARDL Short-Run Estimates

Variables	Coefficient	Std. Error	t-Statistic	P-Value
SDI (LD)	-0.097	0.138	-0.7	0.493
SDI (L2D)	-0.284	0.101	-2.81	0.014**
GII(D1)	-0.041	0.014	-2.82	0.014**
GII (LD)	-0.022	0.010	-2.14	0.051*
GII (L2D)	-0.013	0.009	-1.33	0.203
GOVTINDEX (D1)	0.025	0.012	2.1	0.054*
GOVTINDEX (LD)	0.018	0.007	2.47	0.027**
GOVTINDEX (L2D)	0.006	0.005	1.28	0.223
ANS (D1)	-0.024	0.006	-3.99	0.001***
ANS (LD)	-0.011	0.005	-2.17	0.048**
ANS (L2D)	-0.013	0.003	-4.55	0.000***
Trade (D1)	0.008	0.002	3.82	0.002***
Trade (LD)	0.008	0.002	4.05	0.001***
Gini (D1)	0.031	0.009	3.35	0.005***
Gini (LD)	0.014	0.018	0.8	0.436
Gini (L2D)	0.043	0.017	2.46	0.027**
Unemployment (D1)	0.017	0.007	2.3	0.037*8
Unemployment (LD)	0.010	0.006	1.73	0.106
Unemployment (L2D)	0.004	0.004	1.0	0.335
ECT (-1)	-.609	.126	-4.82	0.000***
Constant	1.708	0.450	3.79	0.002***

Source: Author's estimations using Stata 17.0

Table 10: Diagnostic Test Results

Test	Statistic	P-Value	Result
Breusch-Godfrey LM test	1.302	0.254	No autocorrelation
Breusch-Pagan-Godfrey test	4.112	0.176	Homoskedastic
Ramsey RESET test	0.893	0.349	No omitted variable bias
Jarque-Bera test	1.107	0.575	Normal distribution

Source: Author's estimations using Stata 17.0

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STABILITY TESTS

The stability of the ARDL model was further verified using the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests. Both plots indicate that the estimated coefficients lie within the critical bounds at the 5% significance level, confirming that the model is stable over the study period. This stability ensures that the relationships estimated in both the short run and long run are consistent and can be relied upon for policy interpretation.

DISCUSSION OF FINDINGS

The empirical results highlight several important policy-relevant insights. First, institutional quality plays a central role in both short- and long-term sustainable development in Pakistan. Strong governance, political stability, and reduced corruption consistently enhance development outcomes. This finding aligns with theoretical perspectives emphasizing the role of institutions in creating an enabling environment for economic growth, social inclusion, and environmental sustainability.

Second, economic factors such as Adjusted Net Savings positively influence SDI, indicating that investments in sustainable practices and resource conservation directly contribute to long-term well-being. In contrast, trade openness exerts a negative effect, suggesting that trade liberalization without accompanying environmental and social safeguards may undermine sustainability goals.

Third, social indicators, particularly income inequality and unemployment, significantly affect sustainable development. The negative coefficients for Gini and unemployment imply that socio-economic disparities and labor market challenges immediately and persistently reduce overall development. Accordingly, policies targeting equitable distribution of wealth, job creation, and social inclusion are therefore critical for improving Pakistan's development trajectory.

Finally, the negative impact of the Government Index in both the short and long run suggests that macroeconomic mismanagement, including fiscal deficits, high debt, and inefficient public spending, can counteract the benefits of institutional quality and sustainable investments. This, in turn, underscores the need for prudent fiscal and budgetary policies alongside strong institutions.

Overall, the results suggest that sustainable development in Pakistan is a complex interplay of governance, economic, and social factors. Immediate policy interventions can yield short-term gains; however, long-term improvements require consistent, coordinated strategies that encompass governance reforms, economic sustainability, and social equity.

CONCLUSIONS

This study examines the short-term and long-term determinants of sustainable development in Pakistan, focusing on governance, institutional quality, income inequality, unemployment, savings, and trade openness from 1980 to 2023. Using the ARDL model and a composite Sustainable Development Index (SDI) that integrates economic, environmental, and gender dimensions, the analysis shows that sustainable development is shaped by institutional, economic, and social factors rather than economic growth alone. Institutional strength and economic structures are both critical in guiding Pakistan toward a sustainable development path.

The importance of this issue is underscored by the structural and socio-economic challenges faced by many developing countries. Balancing environmental conservation, social equity, and economic development remains a persistent challenge, exacerbated by globalization, rapid population growth, and increasing climate-related risks. Understanding the key drivers of sustainable development is therefore essential for designing coherent long-term policies that promote growth while addressing inequality, unemployment, and environmental sustainability. Empirical results indicate that institutional quality exerts a strong positive influence on sustainable development. Well-functioning institutions reduce corruption, facilitate efficient resource allocation, and foster social and economic progress through accountability, regulatory effectiveness, political stability, and adherence to the rule of law. These findings highlight the need for institutional reforms in Pakistan, as weak governance continues to hinder equitable and long-term development outcomes. In contrast, the Government Index exhibits a negative impact on sustainability, indicating that fiscal inefficiencies, rising public debt, and poorly targeted expenditures limit the country's capacity to meet long-term development objectives. Funds allocated to unproductive areas, including excessive defense spending or politically motivated subsidies, reduce resources available for critical sectors such as infrastructure, education, and healthcare. Adjusted Net Savings (ANS) shows a strong positive effect on the SDI, emphasizing that accounting for resource depletion and environmental costs strengthens sustainable growth and supports intergenerational equity. High levels of ANS suggest Pakistan has potential to

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prioritize resource conservation and green investments, underscoring the importance of energy efficiency and environmental protection in long-term development planning. Conversely, trade openness is negatively associated with sustainable development in the long run. While trade can enhance economic growth and global integration, Pakistan's experience indicates that liberalization has occurred without sufficient focus on sustainability objectives. Dependence on resource-based exports, vulnerability to external shocks, and limited economic diversification have constrained trade's ability to support inclusive and environmentally responsible growth.

Structural challenges such as income inequality and unemployment significantly limit sustainable development. Rising inequality restricts access to education, healthcare, and economic opportunities, undermining social cohesion and human capital formation. In Pakistan, where marginalized households rely heavily on natural resources for survival, persistent inequality reduces welfare and intensifies pressure on the environment. Similarly, high and persistent unemployment depresses household incomes, increases poverty, and contributes to social instability, further constraining sustainable development. The Error Correction Term (ECT) in the ARDL model is negative and statistically significant, confirming that short-term deviations from long-term equilibrium are gradually corrected. This suggests that temporary fluctuations in inequality, unemployment, or trade volatility may undermine sustainability, whereas comprehensive structural reforms can support a return to the long-term development path. Overall, the study shows that sustainable development in Pakistan depends on good governance, strong institutions, equitable income distribution, and sufficient employment opportunities. Economic growth alone, without institutional reform, social inclusion, and equitable job creation, is insufficient for long-term sustainability.

RECOMMENDATIONS

Improving governance should be a central policy priority. Enhancing institutional effectiveness across key dimensions' voice and accountability, political stability, regulatory quality, rule of law, and control of corruption will facilitate sustainable growth. Transparent regulations, an independent judiciary, and active civic participation can build public trust and improve policy implementation. Strengthened institutions can ensure more efficient resource allocation, reduce corruption, and enhance the effectiveness of development programs. The negative impact of the Government Index highlights inefficiencies in public finance. Pakistan should prioritize fiscal reforms that improve the efficiency and effectiveness of public spending. Resources should be redirected from unproductive areas, such as excessive defense spending or politically motivated subsidies, toward development-oriented sectors including education, healthcare, infrastructure, and renewable energy. Expanding the tax base, enhancing revenue collection, and adopting sound debt management strategies will create fiscal space for strategic investments. Encouraging domestic savings and directing them toward environmentally sustainable projects is crucial. Policies to enhance financial literacy, broaden financial inclusion, and introduce innovative instruments, such as green bonds and sustainability-linked funds, can mobilize resources for long-term investments. Investments in renewable energy, energy-efficient infrastructure, and climate-resilient technologies can reinforce economic resilience and intergenerational equity. While trade can drive economic growth, it must be aligned with sustainability goals. Pakistan should diversify its economy toward high-value-added and environmentally responsible sectors rather than relying heavily on resource-based exports. Implementing strict environmental standards and promoting regional trade integration that facilitates technology transfer and sustainable practices can ensure that trade contributes positively to inclusive and environmentally sustainable development. Persistent inequality undermines inclusive growth and social cohesion. Policymakers should strengthen social protection programs, improve access to quality education and healthcare, and expand employment opportunities for marginalized populations. Progressive taxation and targeted subsidies can help redistribute resources more equitably. Addressing inequality is essential to ensure that all segments of society benefit from development and contribute to sustainable economic progress. High unemployment is a structural barrier to sustainable development. Expanding labor market participation through skills development, vocational training, entrepreneurship support, and labor-intensive green projects can create jobs while achieving environmental objectives. Special programs targeting youth and vulnerable populations can ensure broad-based participation in the labor market and foster inclusive economic growth. Sustainable development requires coordinated policies across economic, social, and environmental dimensions. Long-term strategies should integrate fiscal discipline, institutional reform, economic diversification, environmental protection, and social inclusion. In summary, achieving sustainable development in Pakistan requires an integrated approach that combines institutional reform, fiscal efficiency, social inclusion, employment generation, environmental protection, and economic

diversification. Addressing these interlinked dimensions through comprehensive and coherent policies will allow Pakistan to realize resilient, equitable, and long-term sustainable growth that benefits both present and future generations.

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