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Assessing the Impact of Economic Dynamics on Sustainable Development: A Nepalese Perspective

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Abstract

Nepal strives to achieve the Sustainable Development Goals (SDGs). This commitment requires the assessment of the existing economic, social, and environmental dynamics to ensure that development is both inclusive and sustainable. Despite the urgent call for action, the factors affecting sustainable development are not adequately studied. This paper aims to analyze the economic aspects by identifying the effects of key economic variables on sustainable development. Specifically, the research empirically examines the impacts of nonrenewable energy consumption, government size, financial development, urban population, and interest rate on Adjusted Net Savings (ANS) recognized by the World Bank as an indicator of sustainable development. The research employs an ARDL bounds testing approach to cointegration on annual data for Nepal from 1994 to 2021. The data are sourced from the publications of the World Bank, the International Energy Agency and Nepal Rastra Bank. The result of the ARDL bounds test confirmed the existence of cointegration. Further, the estimated long-run coefficients of the ARDL model indicate a negative and statistically significant effect of energy consumption and financial development on ANS. Government size has a positive impact. However, the urban population and interest rate are negative but insignificant. Nepal should make productive energy use through manufacturing, promote hydropower as a sustainable energy source and implement regulations for financial institutions to encourage productive *investments and discourage unproductive consumption. Additionally, the government should allocate funds toward sectors like infrastructure, education, agriculture, and renewable energy sources to promote long-term sustainable growth.*

Key words: *Adjusted Net Savings (ANS), ARDL, Energy consumption, Government expenditure, Interest rate, Money Supply (M2), Urban* population

Introduction

The global economy has witnessed an average annual growth rate of 3.5 percent since 2020 (World Bank, 2022), yet sustainability challenges persist across multiple dimensions. CO_2 emissions from energy use and manufacturing amounted to 36.3 Gt in 2021, a 6 percent rise from 2020 (IEA, 2021). FAO (2020) estimated deforestation at 420 million hectares since 1990 with an annual loss of estimated 10 million hectares from 2015 to 2020. WWF (2020) reports a 68 percent decline in the Living Planet Index since 1970, indicating severe biodiversity loss. Over 2.2 billion population are deprived of clean water, around 712 million people live in extreme poverty (World Bank, 2022), and severe income inequality persists, with the Gini coefficient reaching 0.63 in countries like South Africa (World Bank, 2022). This suggests that the traditional use of GDP as a measure of economic progress is inefficient to account for the long-term consequences of unchecked development.

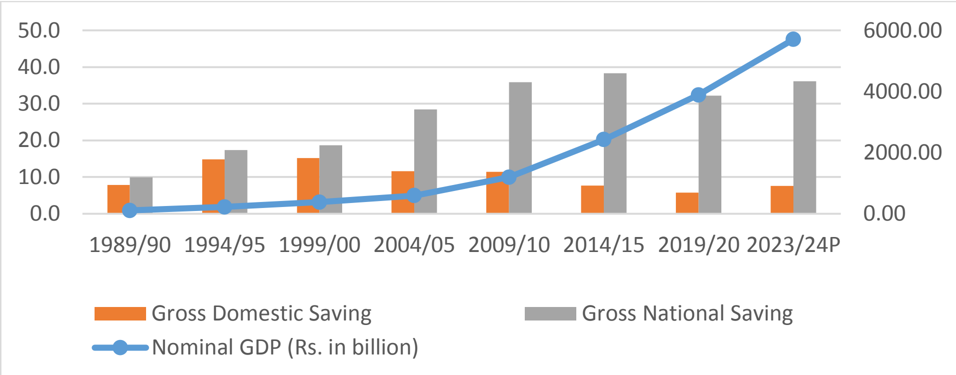
The rapid emphasis on economic growth has led to increased resource consumption, pollution, and pressure on natural resources. Various countries have implemented innovative strategies to address sustainability threats. However, persistent disparities in resource distribution and gaps in policy implementation hindered progress, stressing the critical need for enhanced global cooperation. Nordhaus (2019) pointed that sustainability requires cooperative multinational approaches, as individual nations often prioritize their own interests, while cooperation benefits other nations. In this context, the UN adopted the Sustainable Development Goals (SDGs) in 2015, establishing a comprehensive framework for sustainability incorporating 17 goals and 169 specific targets.

Nepal aspires to achieve these SDGs (NPC, 2017). Achieving sustainable growth requires integrating environmental protection, efficient resource use, and social inclusivity into development strategies. Nepal has the potential to fulfil all its energy needs through clean hydroelectricity and even export surplus power with a pipeline of large projects expected to generate over 10,000 MW within the next decade (NPC, 2017). As a national priority, this sector offers economic growth and environmental sustainability.

However, Nepal continues to lag behind on various development indicators. The country ranks 143rd on HDI, with 17.5 percent of its population living in poverty and an additional 17.8 percent vulnerable to multidimensional poverty (UNDP, 2023). While Nepal's GHG emissions is only 0.027 percent of global emissions (MoPE, 2016), they have been growing at an average annual rate of 5.8 percent from 1990 to 2017 (UNFCCC, 2019). Additionally, Nepal ranks 125th out of 185 nations in the 2021 ND-GAIN Index, underscoring its sensitivity to the effects of climate change, influenced by a mix of political, topographical, and societal factors (ADB, 2024).

Nepal struggles with remittance dependency, a growing trade deficit, and climate vulnerability. NRB (2024) reports a significant trade deficit of Rs 1,440.60 billion for FY 2023/24. The country urgently needs adaptation measures to address the threats of glacial melting and natural disasters. Furthermore, Nepal faces significant challenges in implementing sustainable initiatives due to resource constraints, limited access to advanced technologies, financial limitations, and a less developed regulatory framework. NPC (2018) estimates an annual average investment shortfall of Rs. 585 billion over an annual requirement of Rs. 2,025 billion to achieve the SDGs. Explicitly mentioned in economic theories, more savings provide the resources necessary for investment.

Figure 1: Savings as a Share of GDP



Source: NRB, 2024

Figure 1 presents the Gross Domestic and National Savings as a share of the GDP of Nepal alongside nominal GDP. The gross domestic and national savings remains at a significant average of 8.1 percent and 35.6 percent, respectively over the past 15 years. Starting in the mid-1990s, while Gross Domestic Savings (GDS) generally declined, Gross National Savings (GNS) continued to rise. It reached as high as 38.30% in 2014/15 and maintained 36.15% in FY 2023/24. This divergence suggests that while domestic savings have been on the decline, national savings have increasingly relied on remittances. Further, the overall GDP remains low, which limits the potential for higher investment.

This raises a serious question whether or not the economic variables support economic growth, especially considering the declining trend in domestic savings and the reliance on external factors to boost national savings. More importantly, are these variables aligned with the SDGs as outlined by the National Planning Commission (NPC) in its various publications?

Based on this backdrop, the basic objective of this study was to analyze the effect of key economic variables identified as non-renewable energy supply, government size, urban population, financial development and interest rate on Adjusted Net Savings (ANS). As measure of sustainability, ANS provides a more inclusive perspective to sustainable development by incorporating economic, human and environmental aspects. ANS accounts for net national savings, education expenditure, and adjustments for environmental factors. This research expects to provide a deeper insight into development from a sustainability standpoint. Additionally, it aims to contribute to the global commitment to sustainability by providing insights into how Nepal can align its economic policies with the SDGs.

The research paper is organized as follows: The second section reviews the literature and includes the conceptual framework for the study. The third section outlines the research methodology, covering data and methods. The fourth section presents the empirical findings. The final section provides a summary, conclusion, policy recommendations, and discusses the study's limitations and suggestions for future research.

Review of Literature

The concept of sustainability first emerged as a critique of orthodox economic views from the ecological standpoint. During the early 70s, the notion of “degrowth” was advocated as a solution to environmental issues influenced by rapid industrialization. The perspective called for resource consumption and economic activity reduction to achieve ecological sustainability and social well-being. In the same period, Meadows et al. (1972) called for restricting consumption and growth in light of the environment's tolerance. The seminal work of Meadows et al. (1972), "Limits to Growth," forecasted the adverse consequences of unprecedented economic and population expansion within the earth's finite resource limits. Later numerous economists including Daly (1990), Mills and White (2009), Raymond (2004), Solow (1993), Stern (2007) stressed the need for the inclusion of ecosystem services in the traditional economic models.

Empirically, the effect of income on environment sustainability was first empirically studied by Grossman and Krueger (1991), identifying an inverted "U" shape relationship between environment deterioration and economic growth. This relationship was widely recognized as the Environmental Kuznets Curve (EKC). Later, ample studies used emissions as an indicator of environmental quality to identify the effect of economic expansion. Khan et al. (2020) investigated the effects of nonrenewable energy consumption and economic growth on CO_2 emissions in Pakistan from 1965 to 2015. Long-run ARDL estimates suggested an increase in CO_2 emissions from rising energy consumption and economic growth. Likewise, Ugur (2022) found that the economic expansion, foreign direct investments and energy use had a significant positive relationship with CO_2 emissions. The ARDL model with a structural break confirmed this relationship in Turkey's economy from 1974 to 2015. Similarly, Ozturk et al. (2024) analyzed five South Asian countries from 1971 to 2018. The findings suggested that the energy consumption led to an increased ecological footprint while the financial development supported reducing the environmental pressure.

However, these studies primarily focused on environmental degradation, neglecting broader aspects of sustainability. According to Pearce and Atkinson (1993), a sustainable economy requires Genuine Savings (GS), an indicator from the Solow-Hartwick sustainability model to be positive. Hartwick (1977) proposed that the investment in artificial capital should equal the rent from natural resource exhaustion. Solow-Hartwick sustainability model suggests measuring utility with consumption keeping capital stock constant (Hartwick, 1977). Similarly, the World Bank proposed ANS as a comprehensive framework to sustainability combining economic, human and environmental aspects. The ANS framework ensures sustainable conversion of the natural capital from forests and minerals into physical and human capital supporting sustainable economic growth and employment generation (Henstridge et al. 2013).

Atkinson and Hamilton (2003) used Genuine saving (GS) adjusted for resource depletion as a proxy for sustainable development to identify the existence of the resource curse hypothesis. Using cross-country regressions of 18 years for 115 countries, the study analyzed the relationship between growth and saving, identifying the effect of institutional variables and resource surplus. Economic growth and age dependency ratio was a significant determinant of GS while institution variables showed corruption as a significant determinant of low GS.

Asici (2012) investigated the linkage between economic expansion and environmental pressure measured by the depletions of energy, mineral and net forest alongside carbon emissions in US$. The study used Adjusted Net Savings data for 213 countries from 1970 to 2008. The findings from fixed-effects and fixed-effects instrumental-variables regressions revealed a positive relationship between environmental pressure and economic growth. The extent of pressure was significantly higher in middle-income countries. The study further suggested a positive relationship between environmental pressure with FDI and a negative relation with the extent of the rule of law.

Pardi et al. (2015) utilized the VECM to confirm that inflation rate, financial development and minerals export share positively affect sustainable development in the long-run. The study was conducted in the Malaysian economy from time series data spanning 1971 to 2011. From the study, income negatively affected the Adjusted Net Saving Rate (ANSR), while the other determinants had a positive impact in the long-run.

Similarly, Koirala and Pradhan (2019) employed a random-effect model to identify the determinants of ANS. The study utilized data from 1990 to 2014 for 12 Asian economies. The findings revealed that income and financial development positively and significantly affected ANS. The estimated coefficient of inflation, natural resource rent, and time was negatively significant. In the context of energy consumption, Noor et al. (2024) found that non-renewable and renewable energy use had significant long-term positive impacts on sustainability. The study was conducted employing panel ARDL technique in the South Asian region between 1995 and 2019.

Kaimuri and Kosimbei (2017) explored the factors influencing sustainable development in Kenya from 1991 to 2014. The ARDL estimates revealed that household consumption negatively influenced ANS in the long-run, while unemployment rate and energy efficiency had a negative impact only in the short-run. Similarly, Ogunyemi (2024) found that per capita income and natural resource rents positively affected sustainable development. The study adopted a Fully Modified Ordinary Least Squares (FMOLS) method, using ANS as a measure of sustainability in the Nigerian economy from 1981 to 2022.

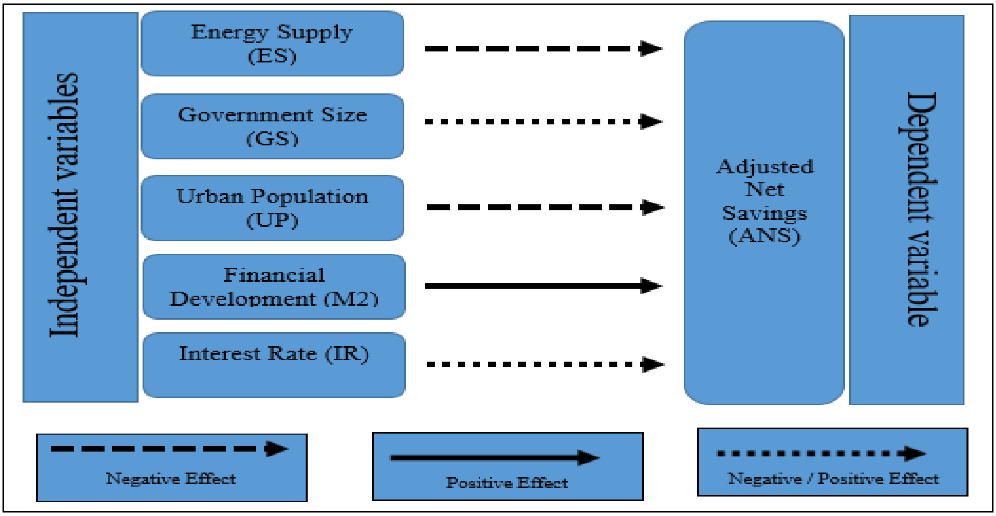
Kpegba et al. (2024) found that public expenditure and institutional quality positively and significantly affected economic sustainability. The research employed Pooled OLS and System GMM econometric techniques over a 20-year longitudinal dataset from 48 Sub-Saharan African (SSA) countries. The findings further revealed that institutional quality negatively moderated the association between public expenditure and sustainable economic growth.

Ullah et al. (2024) examined the impact of financial development, institutional quality, and the size of the earning population on sustainable development across 64 countries participating in the BRI from 2005 to 2020. Utilizing a two-step generalized method of moments (GMM) the study revealed that financial development and institutional quality significantly positively affected sustainable development. In contrast, the size of the earning population significantly negatively affected sustainable development.

While the effect on environmental sustainability is extensively discussed in the literature, few studies have considered broad sustainability indicators such as Genuine Savings (GS) or Adjusted Net Savings (ANS). Further, to the researcher's understanding, a research gap exists in this study area from the Nepalese perspective, despite the global commitment to meet the SDGs. Hence, to fill this gap, this empirical research is deemed necessary. The paper is expected to add value to formulating relevant economic policies.

A conceptual framework illustrating the effects of the key economic variables on ANS is presented in Figure 2.

Figure 2: Conceptual Framework



Source: Author's creation, 2025

The explanatory variables are Energy Supply (ES), Government Size (GS), Urban Population (UP), Financial Development (M2) and Interest Rate (IR). It was expected that the effects of ES and UP would be negative. M2 was anticipated to have a positive impact, while the effects of GS and IR could vary, being either negative or positive depending on the economic dynamics of Nepal. An overview of these variables is presented in the following section.

Research Methodology

The research was based on Nepal's annual data from 1994 to 2021 obtained from the World Bank, the International Energy Agency and Nepal Rastra Bank. This section describes the dependent and independent variables and the methodology adopted for the analytical analysis. The summary of variables notation, level of measurement, source and expected coefficients of the explanatory variables is presented in Table 1.

Dependent Variable

Adjusted Net Savings (ANS)

The traditional growth theory ignores the impact of resource depletion and human development in their growth model. Costanza et al., (2017), Daly (1990), Dasgupta (2021), Nordhaus (2019), Solow (1993), and Stern (2007) advocated for the incorporation of environmental and human considerations into the models of global economic growth. In this context, the World Bank has suggested using ANS as a holistic approach combining economic, human and environmental aspects. Hence, ANS was selected as the proxy for sustainable development. The data for ANS was extracted from the World Bank's open platform. The value of ANS was available in US$, which was converted to local currency based on the exchange rate published by NRB.

Independent Variables

Energy Supply (ES) $\boldsymbol{\beta_2 < 0}$

Energy supply is the total energy demand that includes the energy use by sectors itself, including transformation and distribution losses. The present study focused on non-renewable energy supply. In Nepal, energy consumption is primarily driven by household and transportation needs rather than industrial production, leading to higher resource depletion without proportional economic gains. Hence, ES was anticipated to exhibit a negative coefficient. The secondary data were extracted from the International Energy Agency (IEA).

Government Size (GS) $\beta_3 > 0$ or $\beta_3 < 0$

Government spending focused on long-term investments, such as infrastructure development, education, healthcare, and renewable energy, can boost economic growth, productivity, and national savings. For example, investment in hydropower and agriculture can increase output and income alongside supporting environmental sustainability. However, if a significant portion of government expenditure is directed toward recurrent costs (such as public sector wages, subsidies, and debt servicing), it could lead to fiscal deficits and reduce overall savings.

Urban Population (UP) $\beta_4 < 0$

Nepal has experienced significant demographic shifts in recent years with rural-urban migration reshaping its economic structure. This shift has contributed to the decline of agriculture and raw material supply for industries, weakening domestic production and increasing reliance on imports. The strain on urban resources, rising living costs, and environmental degradation further weakens sustainability. A negative coefficient on ANS was expected from the impact of this migration-driven urbanization in Nepal.

Financial Development (M2) $\beta_5 > 0$

Following Levine (1997), the proxy for financial development has been used as the monetization ratio or broad money relative to GDP. NRB defines broad money as the sum of narrow money (currency in circulation and demand deposits) and time deposits. A higher ratio suggests better access to financial resources, promoting investment, economic growth, and overall financial stability. Financial development was expected to have a positive coefficient.

Interest Rate (IR) $\beta_6 > 0$ or $\beta_6 < 0$

Higher interest rates encourage savings, which can increase ANS, but reduce borrowings for productive investments, potentially slowing economy. Conversely, reduced interest rates foster investments and economic activities but discourage savings and lead to fiscal imbalances. The overall effect depends on how interest rate changes influence financial stability, investment efficiency, and long-term sustainability. The interest rate was represented by the annual weighted average rate on 91 days treasury bills.

Table 1: Variables, notation, level of measurement, source and expected coefficients

Variables	Variables Type	Notation	Level of Measurement	Source	Expected Coefficients
Adjusted Net Savings	Dependent	ANS	Natural log	World Bank	
Energy Supply	Independent	ES	Natural log	IEA	-ve
Government Size	Independent	GS	Ratio of Govt. expenditure to GDP	NRB	+ve / -ve
Urban Population	Independent	UP	% of total population	NRB	-ve
Financial Development	Independent	$M2$	Ratio of M2 to GDP	NRB	+ve
Interest Rate	Independent	IR	Yearly average 91 days T-bills rate	NRB	+ve / -ve

Model Specification

The long-run relationship between Adjusted Net Savings (ANS) and Energy Supply (ES), Government Size (GS), Urban Population (UP), Financial Development (M2) and Interest Rate (IR) was quantitatively analyzed using ARDL bounds test approach proposed by Pesaran et al. (2001). The method allows short and long-run parameters with appropriate asymptotic inferences using OLS. The test can be applied to the variables regardless of whether they are I(0) or I(1). Further, the test can be applied even if the explanatory variables are exogenous (Pesaran et al., 2001)). The ARDL model takes the following general form;

$$Y_t = \delta + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_k Y_{t-p} + \gamma_1 X_t + \gamma_2 X_{t-1} + \cdots + \gamma_q X_{t-q} \qquad (1)$$

From equation 1, the long-run relationship is expressed as;

$$\Delta lnANS = \delta + \sum_{i=1}^{p} \beta_1 \Delta lnANS_{t-i} + \sum_{i=0}^{q1} \beta_2 \Delta lnES_{t-i} + \sum_{i=0}^{q2} \beta_3 \Delta GS_{t-i} + \sum_{i=0}^{q3} \beta_4 \Delta UP_{t-i} + \sum_{i=0}^{q4} \beta_5 \Delta M2_{t-i} + \sum_{i=0}^{q5} \beta_6 \Delta IR_{t-i} + \gamma_1 lnANS_{t-1} + \gamma_2 lnES_{t-1} + \gamma_3 GS_{t-1} + \gamma_4 UP_{t-1} + \gamma_5 M2_{t-1} + \gamma_6 IR_{t-1} + \mu_t \qquad (2)$$

Where, Δ represents the first difference operator and δ denotes the drift component. Variables γ_1 *to* γ_6 represents long-run coefficients while β_1 *to* β_6 represents short-run dynamics. μ_t is a random disturbance term.

The long-run cointegrating relationship was tested using bounds test (F-Version). ARDL bounds test follows non-standard distribution based on F-statistics or Wald test. Within the ARDL bounds test, the lower critical value corresponds to I(0), and the upper critical value corresponds to I(1). The null hypothesis suggests of no cointegration where, $H_0 = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = 0$. If the test statistic exceeds the upper critical value, null hypothesis is accepted. If the test statistic falls below the lower critical value, null hypothesis is rejected. However, if the test statistic lies between the two critical values, the result remains inconclusive. Akaike Information Criterion (AIC) was used to determine the order of the ARDL $(p, q_1, q_2, q_3, q_4, q_5)$ and the number of lags.

Likewise, short-run dynamic parameters were estimated using the error correction model (ECM) specified as;

$$\Delta lnANS = \delta + \sum_{i=1}^{p} \beta_1 \Delta lnANS_{t-i} + \sum_{i=0}^{q1} \beta_2 \Delta lnES_{t-i} + \sum_{i=0}^{q2} \beta_3 \Delta GS_{t-i} + \sum_{i=0}^{q3} \beta_4 \Delta UP_{t-i} + \sum_{i=0}^{q4} \beta_5 \Delta M2_{t-i} + \sum_{i=0}^{q5} \beta_6 \Delta IR_{t-i} + \lambda EC_{t-1} + \mu_t \qquad (3)$$

Here, EC is the error correction term that represents the long-run residual and λ is the speed of adjustment. The Error Correction Term EC is given as;

$$EC_t = lnANS_{t-1} - \emptyset_1 lnES_t + \emptyset_2 GS_t - \emptyset_3 UP_t - \emptyset_4 M2_t - \emptyset_5 IR_t \qquad (4)$$

Where, $\emptyset_1 = -(\gamma_2/\gamma_1)$, $\emptyset_2 = -(\gamma_3/\gamma_1)$, $\emptyset_3 = -(\gamma_4/\gamma_1)$, $\emptyset_4 = -(\gamma_5/\gamma_1)$, $\emptyset_5 = -(\gamma_6/\gamma_1)$ are the OLS estimators from equation (1). The coefficient of lagged values provides short-run dynamics in the equilibrium path. Negative λ implies cointegration.

Results and Findings

Unit Root Test

The initial step in applying the ARDL bounds test was to determine the order of integration. The ARDL model can be applied only if the variables are integrated in order I(0) or I(1). The Augmented Dickey-Fuller (ADF) test was used to assess the order of integration. The result is presented in Table 2.

Table 2: ADF unit root test

Variables	Level:I(0) t-Statistics	p-value	First Difference: I(1) t-Statistics	p-value	Order of Integration
ANS	-1.2521	0.6357	-6.6765	0.0000	I(1)
ES	0.5017	0.9833	-5.4339	0.0002	I(1)
GS	-1.0555	0.7181	-4.1831	0.0033	I(1)
UP	-3.1761	0.1110	-88.0013	0.0000	I(1)
M2	1.8789	0.9996	-3.5998	0.0129	I(1)
IR	-2.2523	0.1938	-4.7240	0.0009	I(1)

Source: Authors calculation using E-Views

Table 2 shows that the variables are integrated in order I(1), allowing the application of the ARDL bounds testing approach.

Lag Length Selection

Table 3 reports the optimal lags based on different criteria. In the study, the Akaike Information Criterion (AIC) was used for the selection of the optimal lags. Based on the AIC, the model selected two lags. FPE (Final Prediction Error) and HQ (Hannan-Quinn Information Criterion) also supported the result.

Table 3: VAR lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-195.629	NA	0.219337	15.50989	15.80022	15.59349
1	-35.258	234.3877*	1.67e-05	5.942923	7.975233*	6.528155
2	7.640553	42.89856	1.63e-0.5*	5.412265*	9.186555	6.499124*

Source: Authors calculation using E-Views
Note: * suggests optimal lag length

ARDL Bounds Test

The ARDL bounds test was conducted using a Wald test that imposes a zero restriction on the coefficients of the one-period lagged level form of the variables. Table 3 presents the test results of the ARDL bounds test with two lags. The optimal lag structure for each variable was identified as ARDL (1,2,0,2,0,1). The order of the ARDL $(p, q_1, q_2, q_3, q_4, q_5)$ are not required to be identical. The test results is reported in Table 4.

Table 4: Bound test (F-Version), ARDL (1,2,0,2,0,1)

Null Hypothesis: No Long Run Relationships Exist			
F-Statistics	**Significance**	**Lower Bound(I0)**	**Upper Bound (I1)**
4.27	10%	2.75	3.79
	5%	3.12	4.25
	2.5%	3.49	4.67
	1%	3.93	5.23

Source: Authors calculation using E-Views

The computed F-statistic value (4.27) exceeded the upper bound (I1) at 5 percent level of significance. Hence, the null hypothesis was rejected, confirming cointegration.

Estimation of Long-Run Coefficients

Once cointegration was established, the subsequent step involved estimating the long-run coefficients in the ARDL model. The lag length for each variable was determined as ARDL(1,2,0,2,0,1). The estimated long-run coefficients are presented in Table 5.

Table 5: Estimated Long-Run Coefficients: ARDL (1,2,0,2,0,1)

Dependent Variable : LnANS				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
ES	-7.5175	3.4806	-2.1597	0.0500**
GS	0.0620	0.0302	2.0506	0.0610***
UP	-0.2122	0.3229	-0.6572	0.5225
M2	-0.0188	0.0068	-2.7663	0.0160**
IR	-0.0306	0.0249	-1.2303	0.2404

Source: Authors calculation using E-Views

Note: **Significant at 5 percent, ***Significant at 10 percent

The Estimated Long-Run Coefficients indicate that energy supply (ES) significantly negatively affects ANS, with a coefficient of -7.5175, statistically significant at the 5 percent level. Government size (GS) positively impacts ANS, with a coefficient of 0.0620, significant at 10 percent. Financial development (M2) reflects a negative effect on ANS, with a coefficient of -0.0188, statistically significant at 5 percent. In contrast, urban population (UP) and interest rate (IR) have negative coefficients, but their effects are not statistically significant.

Error Correction Model

Table 6 presents the short-run dynamic coefficients of the ARDL (1,2,0,2,0,1) model along with the error correction term. The lag was selected based on Akaike information criterion.

Table 6: Error Correction Estimation: ARDL (1,2,0,2,0,1)

Dependent Variable: LnANS				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
CointEq(-1)*	-0.6724	0.1128	-5.9568	0.0000

Source: Authors calculation using E-Views

Note: **Variables with Zero Lags

The error correction term (CointEq(-1) = -0.6724, p = 0.0000) was negative and statistically significant, confirming that deviations from the long-run equilibrium were adjusted at a speed of 67.24 percent per period.

Residual Diagnostics

After the estimation of the empirical model, a set of residual diagnostic tests were conducted. These include, the Wald test for joint significance, Jarque-Bera test for normality, the LM test (Breusch-Godfrey serial correlation test) for serial correlation and Breusch-Pagan-Godfrey test for heteroscedasticity. The test results are presented in Tables 7, 8, 9 and 10.

Table 7: Wald test

Null Hypothesis: Coefficients are jointly equal to zero			
Test Statistics	**Value**	**Df**	**Probability**
F-Statistics	4.4243	(5,13)	0.0142
Chi-square	22.1215	5	0.0005

Source: Authors calculation using E-Views

Wald test suggests that the coefficients are jointly significantly different from zero. The F-statistic is 4.4243 with degrees of freedom (5, 13) and a p-value of 0.0142, which was less than the 0.05 significance level, leading to the rejection of the null hypothesis.

Table 8: Normality test (Jarque-Bera test)

Null Hypothesis: The data follows a normal distribution.			
Skewness	**Kurtosis**	**Jarque-Bera**	**Probability**
-0.6481	2.6727	1.9365	0.3797

Source: Authors calculation using E-Views

The result of the normality test in Table 8 shows that the data does not significantly deviate from a normal distribution. The Jarque-Bera statistic is 1.9365 with a p-value of 0.3797, which was greater than the 0.05 significance level. This suggests that the data follows a normal distribution.

Table 9: Test for Serial Correlation (Breush-Godfrey LM Test)

Null Hypothesis: No Serial Correlation	
Test Statistics	**Value**
F-Statistics	0.7158
Obs*R-Squared	2.9941
Prob.F(2,11)	0.5102
Prob. Chi-Square(2)	0.2238

Source: Authors calculation using E-Views

From table 9, the Chi-Square test value is 0.2238 with the associated p-value of 0.2238, which was above the 0.05 percent significance. This suggests that the residuals are not serially correlated.

Table 10: Heteroscedasticity Test (Breush-Pagan-Godfrey Test)

Null Hypothesis: Homoscedasticty			
Test Statistics	**Value**	**Df**	**Probability**
F-Statistics	0.8052	Prob.F(12,13)	0.6430
Obs*R-Squared	11.0861	Prob. Chi-Square(12)	0.5215
Scaled explained SS	2.3180	Prob. Chi-Square(12)	0.9987

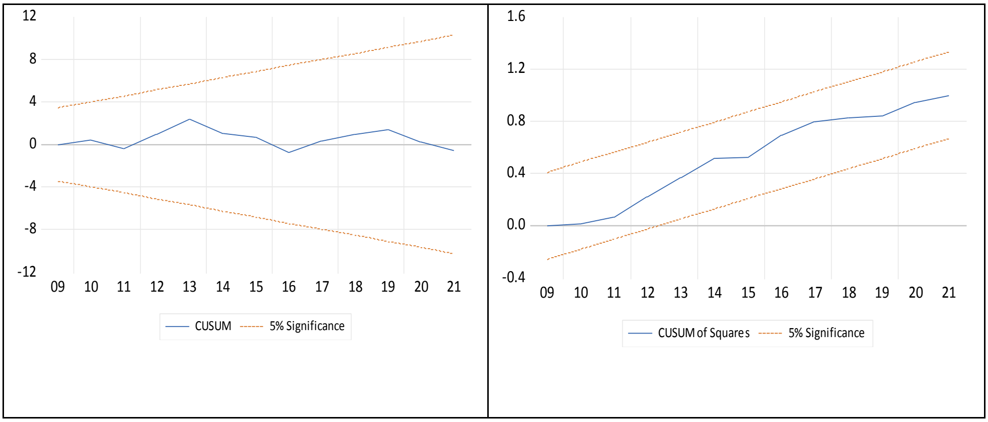
Source: Authors calculation using E-Views

The heteroscedasticity test in Table 10 suggests that there was no evidence of heteroscedasticity. The F-statistic is 0.8052 with a p-value of 0.6430, which was greater than the 0.05 significance level, leading to the acceptance of null hypothesis.

Stability Test

Finally, the stability of the long-run coefficients was tested using CUSUM and CUSUM square tests. The plots of CUSUM and CUSUMSQ statistics remained within the critical bounds at the 5 percent significance level. Hence, the null hypothesis was accepted, confirming that the long-run regression model's parameters are stable over time. Figure 3 presents the test results of CUSUM and CUSUMSQ tests.

Figure 3: Stability Test



Source: Authors calculation using E-Views

Discussions

The estimated long-run energy supply (lnES) coefficients in table 5 suggested a negative and significant effect on adjusted net savings (lnANS). The findings of this study align with Khan et al. (2020), Ugur (2022), and Ozturk et al. (2024), which highlight the negative impact of increased energy consumption on environmental sustainability due to emissions. However, the study contradicts with Noor et al. (2024), which examined both renewable and non-renewable energy and suggested that energy consumption in South Asia can support sustainable development. In Nepal, a significant portion of energy consumption is for residential use, transportation, and general consumption, rather than productive sectors. As a result, the country is unable to benefit economically from energy consumption. Additionally, non-renewable energy imports, which constitute the largest share of Nepal's trade deficit, exacerbate the nation's economic challenges.

Similarly, the estimated long-run financial development (M2) coefficient is negative and statistically significant at 5 percent significance level. Financial development typically facilitates greater access to credit and encourages investment. Previous studies (Koirala & Pradhan, 2019; Pardi et al., 2015; Ullah et al., 2024) have established a positive relationship between financial development and sustainability. However, the increased money supply and credit availability are fueling a consumption-driven economy in Nepal. Many households rely on credit for consumption financed by remittances, leading to a divergence from the expected positive relationship. Additionally, the banking sector in Nepal predominantly finances import and trading businesses.

The positive relationship between government size (GS) and sustainability (lnANS) resonates with the findings of Kpegba et al. (2024), which emphasize the significant role of government expenditure in promoting sustainable development. This study provides compelling evidence that increased government spending supports sustainable development by facilitating investments in infrastructure, education, healthcare, and other critical sectors. The government of Nepal has incorporated SDGs into its policies. Investments in key sectors such as hydropower, infrastructure, and renewable energy are central to these efforts. These investments with positive institutional variables (Asici, 2012; Atkinson & Hamilton, 2003) can drive long-term economic growth and contribute to environmental sustainability and social well-being.

The estimated long-run urban population (UP) and interest rate (IR) coefficients are negative but insignificant. The rural-urban migration is a significant driver of urban population growth in Nepal. While urbanization leads to higher incomes, higher living costs and consumption offset any savings. Additionally, urban populations have greater access to credit, encouraging spending rather than saving. In Nepal, limited financial literacy and a preference for informal saving methods further diminish the impact of urbanization. In context of interest rate, factors like a preference for non-financial savings, the reliance on remittances and import dependence likely diminish the overall impact of interest rates on sustainable development.

Nepal faces significant challenges in meeting the SDGs. The reliance on non-renewable energy imports and a consumption-driven economy contribute to a large trade deficit fueled by increased access to credit. These factors hinder economic sustainability and environmental progress. Despite government investments in infrastructure and social sectors, the country struggles with balancing short-term consumption with long-term development goals. Additionally, the high reliance on remittances and limited productive sector growth further exacerbate the challenges in achieving sustainable development.

Conclusion, Limitations and Future Direction

Conclusion

The study provides valuable insights into the economic factors influencing sustainability in Nepal, highlighting challenges and opportunities for promoting sustainable development. Employing the ARDL bounds testing method, the study empirically examined the impact of nonrenewable energy consumption, government size, financial development, urban population, and interest rates on Adjusted Net Savings (ANS) in Nepal from 1994 to 2021. The results of the ARDL bounds test confirmed cointegration between the variables. Additionally, the estimated long-run coefficients from the ARDL model revealed a negative and statistically significant effect of energy consumption and financial development on ANS, while government size showed a positive effect. In contrast, the effects of urban population and interest rates were negative but statistically insignificant.

The study's findings highlight the adverse effects of energy supply and financial development on sustainability, while emphasizing the crucial role of government size in promoting sustainable development. The negative effect of energy supply on ANS reflects the detrimental impact of increased energy consumption. Nepal's energy supply relies heavily on imports, which contributes to higher costs and inefficiencies, leading to increased carbon emissions and resource depletion. Economically, this reliance on imports has strained the national budget with higher energy import costs. Similarly, financial development encourages unproductive consumption pattern rather than investment. This is evident from the substantial trade deficit of the country. Meanwhile, the positive relationship between government size and sustainability underscores the importance of strategic government expenditure in promoting sustainable development.

Based on empirical results, the study urges the government and private sector use productive energy in Nepal through manufacturing. Hydropower as a sustainable energy source should be central to the government's energy policy. Additionally, it suggests implementing regulations for financial institutions to promote productive investments and discourage unproductive consumption. The study further underscores the importance of strategic government expenditure, urging the government to allocate funds toward sectors that drive long-term economic growth, such as infrastructure, education, agriculture, and sustainable energy.

Limitations and Future Direction

The effectiveness of the outcomes derived from this study remains robust. However, there are some limitations. The study focused on economic dynamics. Future studies could incorporate environmental and social dimensions to provide a more comprehensive insight on sustainability. Similarly, the scope of this study is limited to Nepal. Further studies could consider a broader region. Additionally, further research could explore evaluating institutional quality, public policies, and governance systems to gain deeper insights into their impact on fostering sustainable development.

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