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Impact of Temperature and Precipitation Anomalies on Growth Performance: A Case of Nepal

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Abstract

This paper examines the role of climate variability in determining the volatility of economic growth in Nepal by analyzing the correlations between temperature and precipitation variability and the economy's overall performance. We compared 1990-2024 data using Vector Autoregression (VAR) and Vector Error Correction Model (VECM), and used four significant variables: GDP growth, temperature anomalies, precipitation anomalies, and government debt. In our strategy, climate factors are viewed as inputs to production, alongside the traditional macroeconomic indicators. The results indicate several significant trends. Although the association between temperature changes and decreased GDP growth appears positive, it is not significant enough to conclude that a temperature rise impairs Nepal's economic performance. Nevertheless, the study found a statistically significant, close correlation between temperature variation and higher government debt. It noted that climate pressures are likely to affect Nepal's economy not only through direct productivity losses but also through fiscal channels. Precipitation is the primary climatic phenomenon influencing changes in the economy. The variance decomposition indicates that rainfall variation explains around 19 per cent of GDP changes, far more than the roles of temperature variations or debt levels. This highlights Nepal's specific susceptibility to monsoon patterns, as it relies on rain-based agriculture and hydropower. Interestingly, a negative relationship is observed between precipitation and GDP growth in the long-run analysis, which could be counterintuitive. This is probably indicative of extreme rainfall resulting in floods and infrastructure damage, or of a complex adaptation process underway over a long period of time. The implications of these findings are significant to policymakers, and the first is that climate concerns should be incorporated in fiscal planning and macroeconomic forecasts. The results underscore the need to establish fiscal resilience through climate-sensitive contingency funds and acknowledge that rainfall variability is a critical factor driving economic instability in Nepal.

Keywords: Climate change, Economic growth volatility, Temperature anomalies, Precipitation variability

JEL Classification: Q54, O47, E32

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Introduction

Climate change is increasing rapidly internationally, and developing economies are especially vulnerable due to their geographic positions, economic organization, and adaptive capabilities (Stern, 2007). The topography of Nepal is diverse, with plains on one side and the high Himalayas on the other, a typical example of such vulnerabilities. Agriculture, hydropower, and tourism are climate-dependent sectors in the country, and the country is highly vulnerable to environmental shocks that could cause notable economic volatility. Nepal can serve as an interesting case study of how climate can affect economic growth and stability, as it is ecologically diverse and relies on agriculture. Geographic challenges in the country form intricate patterns of climate exposure that influence economic performance in various ways. These issues demand empirical complexity in explaining how climate variability is translated into macroeconomic instability, as highlighted by recent frameworks that distinguish between direct and indirect economic effects of climate events. This paper measures the impact of climate variability on economic growth volatility in Nepal and empirically demonstrates how temperature and precipitation anomalies affect macroeconomic performance. We analyze the effects of temperature and precipitation variation on economic development in Nepal, explore the dynamic links and time lags between climate shocks and economic responses, and determine the extent to which Nepal's economic multivariance can be explained by climate variability relative to other macroeconomic variables.

The study of these relations is not only of theoretical interest. The economy of Nepal has been characterized by significant volatility over the last 30 years, with periods of healthy growth and, at times, massive contractions. Climate change has been found to affect most major sectors of Nepal, such as agriculture, hydroelectricity, food security, and tourism, and climate-induced hazards, such as floods, droughts, and landslides, directly affect the economy and livelihoods of the people. It is important to establish how much this volatility is climate-related and how much is caused by other macroeconomic variables to devise effective stability-oriented policies. Moreover, as Nepal enters a period of sustainable growth amid growing climate uncertainty, making relationships in the climate economy measurable is crucial for adaptation planning and macroeconomic management. The paper is based on the body of existing literature exploring associations between climate and the economy in developing countries (Dell et al., 2012; Burke et al., 2015; Diffenbaugh and Burke, 2019), but it fills a significant gap in quantitative measurements of climate effects on economic volatility in Nepal.

Although the current literature has reported climate vulnerabilities in Nepal through case studies and sectoral analyses, few studies have adopted rigorous econometric methods to estimate the economy-wide impacts on growth volatility. Climate change adaptation studies in Nepal have increased in recent years, with more than 235 peer-reviewed articles published since 2010. Still, there is a dearth of impact assessment studies by macroeconomists examining growth volatility. Research indicates that about 62 percent of the total population in Nepal has been engaged in agricultural activities, and the agriculture sector contributes about one-third of GDP, which is why any potential effects of climate change on the farming industry are of special concern to overall economic performance. In the Fourth Assessment Report, the IPCC identified the Himalayan region, which also includes Nepal, as a white spot due to insufficient scientific studies. Studies that have been conducted recently show that the temperature in Nepal rises at a higher rate than that of the world and the country is more vulnerable than its neighbors because of a fragile ecosystem, uneven terrain, high reliance on agriculture and hydro electricity production, and low GDP.

Adaptation research in Nepal to climate change shows geographic differences, with more than 40 percent of research conducted in central Nepal, indicating that a more detailed assessment of the nation is needed. This paper uses Vector Autoregression (VAR) and Vector Error Correction Model (VECM) to analyze annual data from 1990 to 2024. The methodology used successfully in climate-economy studies by Bastianin and Manera (2018) and Kahn et al. (2021) enables us to estimate multi-dimensional dynamic interrelationships between climate variables and economic indicators whilst removing the effects of significant macroeconomic variables. The methodology not only allows the short-term response to be ascertained, but it also allows the long-run equilibrium between climate and economic variables to be ascertained (Enders, 2015; Lutkepohl, 2005). The study will fill critical gaps noted in the literature on the measurement of climate effects on economic volatility in developing nations. Existing methodologies do not sufficiently represent dynamic vulnerability situations and exchanges among several climate hazards. Our econometric method performs better at quantifying the effects of climate on economic volatility in Nepal, in response to international bodies' demand for better modeling tools to quantify climate-economy relationships. By analyzing the relationship between climate variability and economic growth volatility, the study can help develop Nepal-specific economic models that more closely reflect the uncertainties associated with climate, which is also a major research direction noted in recent literature reviews. The article is organized as follows: Section 2 provides a literature review of the relationship between climate and the economy, especially in developing

economies and in Nepal. Part 3 presents the theoretical framework, outlines our data sources, and describes our methodology. Section 4 shows our empirical findings, impulse response functions, and variance decomposition analysis. Section 5 discusses policy implications and concludes with key findings and suggestions for future research.

Literature Review

The impacts of climate change on developing economies are complex and mainly felt in countries with low capacity to adapt to changes. Burke et al. (2015) demonstrate that rising temperatures harm economic growth in poor countries, and Dell et al. (2012) conclude that each degree of warming reduces economic growth by approximately 1.3 percentage points in developing countries. These studies give reasonable grounds to believe that climate change unequally imposes economic burdens on the rest of the world. As shown by Diffenbaugh and Burke (2019), global warming has further divided the rich and poor nations, and developing countries suffer the most. Hallegatte et al. (2016) describe that climate risks are higher in developing economies due to their geographic positions, economic systems, and limited resources for adaptation.

Nepal is particularly prone to climate change due to its geography and economy. According to the World Bank, Nepal is one of the countries in the world that is most susceptible to climate. This varied terrain of the country, ranging from lowland plains to high mountains, coupled with the high frequency of monsoons, steep terrain, and glacial lake outbursts, exposes the nation to various natural catastrophes such as floods, landslides, droughts, and glacial lake outbursts. Nepal's economic structure aggravates these risks. The majority of its population (79 percent) is rural, with 66 percent employed in agriculture, which accounts for approximately a third of the national GDP. This over-reliance on weather-sensitive operations greatly exposes them to weather fluctuations.

According to the Asian Development Bank, affects climate change struck several sectors of the Nepalese economy simultaneously. Agriculture is the most exposed to the threat of climate change among the economic sectors in Nepal. Researchers consistently record declines in agricultural productivity resulting from changes in temperature and precipitation. These effects spread throughout the economy because agriculture is the source of employment to so many people and it is a significant contribution to the GDP. The impact of climate on agriculture would be reduced economic growth, increased food import costs, and higher prices for basic commodities.

Another significant way climate impacts the Nepalese economy is through infrastructure damage. Extreme weather kills transport systems, energy infrastructure, and communication systems. These shocks ripple throughout the economy, affecting trade, investment, and government finances. The mountainous terrain of Nepal and the lack of backup infrastructure predispose the country to supply chain shortages, particularly.

Hydropower production is experiencing mounting confusion due to changing weather patterns and extreme weather. As Nepal relies heavily on hydroelectric power to serve local and international markets, climate effects on water resources have pervasive economic impacts. The alterations in the monsoon cycle and melting ice sheets influence seasonal energy supply as well as long-term power generation planning.

Tourism that generates a considerable amount of foreign exchange is susceptible to climatic catastrophes and long-term alterations to the mountain surroundings. The industry relies on favorable weather and the availability of mountainous areas, both of which are subject to mounting climatic pressures. Weather conditions, including temperature and precipitation, influence trekking seasons, mountain visibility, and tourist safety.

The climate vulnerability in Nepal has a strong social dimension that shapes economic outcomes. Gentle and Maraseni (2012) record the impact of climate change on poor and marginalized populations, particularly on communities that rely on natural resources to earn their living. These vulnerability patterns lead to larger economic problems, including reduced worker productivity, increased demands on social protection, and the likelihood of social unrest.

Mountain communities in rural areas have special problems. Aryal et al. (2014) examine the effects of climate change on the traditional herding community in the Himalayas, which threatens their way of life. Such transformations accelerate rural-to-urban migration trends, which influence labor markets and generate urbanization pressures. Climate change usually drives vulnerable populations to migrate, resulting in additional economic and social pressure.

Women are also especially vulnerable to climate risks because they participate in agriculture and the management of natural resources. Although Nepal has gained ground in political empowerment, there are still wide loopholes in economic involvement and education which influence the capacity to accommodate climate change.

Studies find some strategies to develop economic resilience to climate shocks in countries such as Nepal. One of the strategies that comes up to lessen reliance

on climate-sensitive sectors is economic diversification. Yet, diversification entails substantial investment in human capital, infrastructure, and institutions.

Water resource management is one of the key spheres of developing resilience. Combined strategies to benefit agriculture, hydropower, and disaster reduction have the potential to increase the economy's overall resilience. Pradhan et al. (2015) show innovations in local water management that improve the sector's unique resilience and also add to the economy's stability.

Resilience strategies are marked with institutional capacity development. Climate adaptation needs to be coordinated at sector and scale levels, and thus, sound governance systems are required. Regmi and Bhandari (2013) identified institutional obstacles to climate adaptation and suggested governance reforms to improve coordination. Research focuses on integrating climate considerations into development planning to make economic investments climate-resilient.

The latest policy analysis indicates that there has been an increasing incorporation of climate adaptation in agricultural policies in Nepal, after the Nepal National Adaptation Programme of Action in 2010 and the Constitution of Nepal in 2015. Nonetheless, there are still gaps in implementation, especially in the development of holistic capacity-building programs to suit the local conditions.

International studies provide valuable background information on climate vulnerability in Nepal in the context of a broader trend among developing nations. Berlemann and Wenzel (2018) examine the growth effects of rainfall based on data collected on more than 150 countries, and they conclude that there is wide evidence of negative growth effects of rainfall deficits in poor countries over long-term perspectives. Their study will present valuable methodological antecedents for econometric research on the association between climate and growth.

The linkages of the climate economy are becoming key in development planning in the eyes of international development organizations. The Country Climate and Development Reports by World Bank analytics for 74 economies focus on the use of integrated strategies that apply to both climate and development goals.

Although there is an increasing body of literature on climate vulnerability in developing countries, there are still numerous gaps in research on quantitative measures of climate-economy relations. The majority of the literature available is on individual sectors or effect/impact channels, and there exist gaps in information about economy-wide effects and between-sector effects. The existing methods

tend to under-record dynamic vulnerability scenarios and the interplay between various climate risks.

In the case of Nepal, the research gaps includes: fewer quantitative examinations of economy-wide climate effects, limited knowledge about threshold effects and tipping points, and limited knowledge about the effectiveness of adaptation. The research topics for the future would focus on building more region-specific economic models that leverage climate uncertainties more effectively and on investigating new financing options to enhance climate resilience.

The sources demonstrate the intricate interplay between climatic risks and economic organization and institutional abilities in shaping the vulnerability outcomes. It is consistently found that there are several channels of transmission through which climate effects are experienced in economic performance, with the agriculture, infrastructure, and energy sectors being the most susceptible in Nepal. Resilience-building strategies focus on economic diversification, infrastructure strengthening, institutional capacity building, and risk management systems. Nevertheless, considerable gaps remain in the field of quantifying interactions between the complex climate economy and the development of situation-specific economic designs. With countries such as Nepal rising and falling in climate and development issues at the same time, it is necessary to conduct further studies on the measurement and mitigation of macroeconomic vulnerability to environmental shocks to provide sustainable developmental paths.

Methodology

Theoretical Framework

Before discussing the empirical strategy, the study establishes the theoretical foundation for our analysis. This study adopts a production function approach where climate variables serve as inputs to production alongside traditional factors. Following the climate economy literature pioneered by Dell et al. (2012) and Burke et al. (2015), we model economic output as a function of climate variables.

The basic production function can be expressed as: $Y = f(L, K, T, P, Z)$

Where Y represents economic output (GDP), L is labor, K is capital, T represents temperature conditions, P represents precipitation conditions, and Z captures other factors affecting production.

Climate variables affect economic output through multiple channels:

Direct productivity effects: Temperature and precipitation directly affect agricultural productivity, worker efficiency, and industrial processes

Capital productivity effects: Climate conditions affect the productivity of physical capital, particularly in climate-sensitive sectors

Fiscal transmission effects: Climate shocks create fiscal pressures through disaster response costs and revenue impacts

This theoretical foundation justifies our empirical approach of examining relationships between climate variables and economic growth while controlling for fiscal variables that capture transmission mechanisms of climate impacts.

Data and Variables

The proposed study employs annual data from 1990 to 2024 for Nepal, which includes variables covering not only climate but also macroeconomic variables. The primary indicator of a country's economic performance is Real GDP Growth (GDPG), which is calculated as the annual percentage change in real GDP, obtained from Nepal Rastra Bank and the Central Bureau of Statistics. Temperature Anomaly (TEMP) is a measure of the difference in degrees Celsius of the average temperature in 1980-2010 compared to the base year average temperature, which is obtained via the World Bank Climate Change Knowledge Portal, which is a standard measure of temperature change. Precipitation Anomaly (PRECIP) is defined as the percentage change in annual precipitation relative to the 1980-2010 average, as obtained from the World Bank Climate Change Knowledge Portal, to account for precipitation variability. Using the production function approach and to control for the transmission channel of climate-related fiscal impacts, we are adding Government Debt as a Percentage of GDP (DEBT), which is the fiscal aspect of macroeconomic stability, obtained from the Ministry of Finance.

To make the anomaly-based model consistent with our model for analyzing climate variables, we convert the debt variable into deviations from the entity's long-term average. Before analysis, we ran stationarity tests based on Augmented Dickey Fuller and Phillips Perron tests, which showed that GDP growth and climate variables are stationary at the level, and the deviation variable of debt is stationary after first differencing, indicating I (1) processes. These results directed our later methodological decisions, especially the use of both VAR and VECM models.

Table 1: Descriptive Statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
GDPG	4.402	4.533	8.977	-2.370	2.190	-0.716	4.686
PRECIP	-1.003	-2.700	12.400	-12.600	6.281	0.161	1.897
TEMP	0.585	0.540	1.240	-0.250	0.438	-0.128	2.181
DEBT_DEV	0.000	-4.882	17.858	-16.906	13.399	0.059	1.360

The descriptive statistics show that GDP growth (GDPG) exhibits a mean of 4.40% with moderate variability, ranging from -2.37% to 8.98%. Precipitation (PRECIP) shows substantial variability with values representing percentage deviations from the baseline average, reflecting Nepal's exposure to monsoon variability. Temperature (TEMP) demonstrates relatively low dispersion around the mean anomaly value. The debt deviation variable (DEBT_DEV) has a zero mean by construction, representing deviations from the long-term debt-to-GDP ratio.

Empirical Methodology

The study employs a Vector Autoregression (VAR) framework to analyze the dynamic relationships between climate variables and economic indicators. The VAR approach treats all variables as potentially endogenous, allowing for feedback effects between climate factors and economic outcomes.

VAR Model: $Y_t = C + \sum_{i=1}^{p} A_i Y_{(t-i)} + \varepsilon_t$ ... (1)

Where Y_t is a vector containing our variables, C is a vector of constants, A_i are coefficient matrices, p is the lag length, and ε_t is a vector of error terms assumed to be white noise.

For lag length selection, the study applies multiple information criteria. Given our sample size constraints with annual data, these criteria consistently support a lag length of one (p = 1), balancing model parsimony and explanatory power.

Vector Error Correction Model (VECM): To address the mixed integration order of our variables and capture potential long-run equilibrium relationships, we implement a VECM framework:

$\Delta Y_t = \Pi Y_{(t-1)} + \sum_{i=1}^{p-1} Y_i \Delta Y_{(t-i)} + \varepsilon_t$ ... (2)

where $\Pi = \alpha\beta'$ contains the long run relationships, with β' representing the cointegrating relationships and α containing the adjustment coefficients.

The study determines the number of cointegrating relationships using Johansen's trace and maximum eigenvalue tests, with both tests indicating the presence of one cointegrating relationship at the 5% significance level, justifying our VECM specification with rank(Π) = 1.

Analysis Methods

To analyze dynamic interactions between variables, the study computes orthogonalized impulse response functions (IRFs) and forecast error variance decompositions (FEVDs). The IRFs trace the response of each variable to a one standard deviation shock in another variable over a ten-period horizon. We construct two standard error confidence bands using Monte Carlo integration with 1,000 replications to assess statistical significance.

Variance decomposition analysis quantifies the relative contribution of each shock to the forecast error variance of GDP growth at different time horizons, directly addressing our research question regarding the attribution of economic fluctuations to climate variability.

Diagnostic Tests and Limitations

The study conducts comprehensive diagnostic tests to ensure model validity. The Lagrange Multiplier test for serial correlation, White's test for heteroskedasticity, and Jarque-Bera tests for normality are applied. We verify that all roots of the characteristic polynomial lie inside the unit circle, confirming VAR model stability.

This methodology has limitations, including the use of annual data, which limits observations, a focus on temperature and precipitation without extreme weather events, and a linear model structure, which may not capture potential nonlinear effects in climate economy relationships.

Empirical Results

VAR Estimation Results

Table 2 presents key coefficient estimates from our VAR model. The coefficient for TEMP(-1) on GDPG is -2.21, indicating that a 1°C increase in the temperature anomaly is associated with a 2.21 percentage-point decrease in GDP growth in the following year. However, this coefficient is not statistically significant at conventional levels (t-statistic = -0.67). The correct interpretation is that there is no statistically significant evidence that temperature has a negative impact on GDP, though the sign aligns with theoretical expectations.

Table 2: VAR Coefficient Estimates (Selected Variables)

Variable	GDPG	TEMP	PRECIP	DEBT_DEV
GDPG(-1)	-0.192	0.014**	-0.703	-0.173
	(-1.028)	(2.262)	(-1.445)	(-0.600)
TEMP(-1)	-2.213	0.853***	-1.825	13.630***
	(-0.667)	(8.031)	(-0.211)	(2.655)
PRECIP(-1)	0.067	-0.002	-0.477***	0.044
	(1.036)	(-0.779)	(-2.809)	(0.433)

Note: t-statistics in brackets; *** p<0.01, ** p<0.05, * p<0.1

The results show that lagged precipitation (PRECIP(-1)) has a positive but statistically insignificant effect on GDP growth (coefficient of 0.067). Most notably, lagged temperature anomalies (TEMP(-1)) exhibit a strong positive and highly significant effect on the deviation of government debt (coefficient of 13.630, significant at the 1% level), providing evidence that warming temperatures create substantial fiscal pressures for Nepal.

VECM Results

The VECM estimation identified one cointegrating relationship among our variables, indicating a long-run equilibrium relationship. The cointegrating equation coefficients indicate a significant long-run relationship between precipitation and GDP growth, with a coefficient of -0.618 that is highly significant (t-statistic = -6.42).

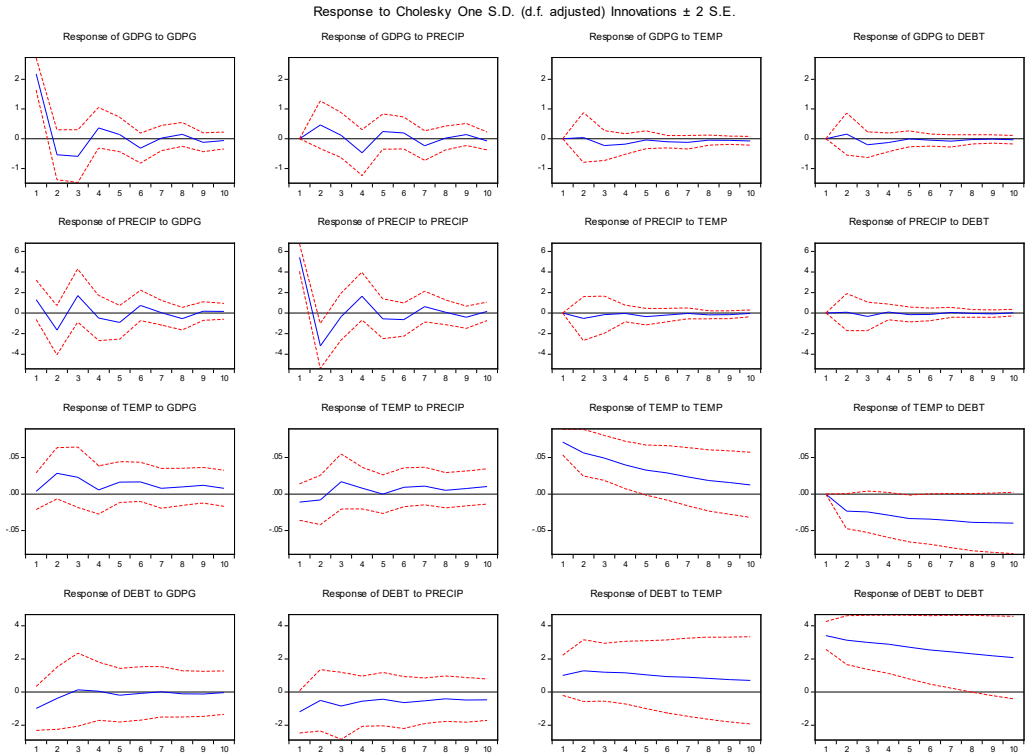
Table 3: Cointegrating Equation

Variable	Coefficient	Std. Error	t-statistic
GDPG(-1)	1.000	-	-
TEMP(-1)	-2.084	2.655	-0.785
PRECIP(-1)	-0.618***	0.096	-6.420
DEBT_DEV(-1)	0.016	0.061	0.258
C	-8.151	-	-

Note: *** p<0.01, ** p<0.05, * p<0.1

The negative coefficient on precipitation in the long-run relationship indicates that lower precipitation is associated with higher GDP growth. This counterintuitive finding may reflect threshold effects in which excessive precipitation causes flooding and infrastructure damage that outweigh agricultural benefits, or structural economic changes and adaptation measures over longer time horizons.

Impulse Response Analysis



The impulse response functions show clear trends in the reaction of the Nepalese economy to climate and fiscal shocks over time. The growth of GDP is strongly mean-reverting, returning to its long-run path within 2-3 periods after the shock, indicating economic resilience at the output level. The most vivid conclusion, though, is the government's response to temperature shocks, which is positive, increasing over time, and statistically significant. This provides strong evidence that temperature changes impose significant, long-term fiscal burdens on Nepal by damaging infrastructure, increasing disaster response costs, and diminishing earnings potential.

By contrast, effects of precipitation exhibit wave-like behavior, which is ultimately dissipated, indicating that Nepal has a seasonal monsoon system, whereas effects of temperature on debt exhibit cumulative behavior, not disruptive. Such trends have significant policy significance for Nepal's climate adaptation policy. The sustained and increasing fiscal consequences of temperature shocks imply that conventional countercyclical fiscal policy might not be effective in mitigating the economic stresses associated with climate, and that superior, specific fiscal policy is needed that addresses the cumulative

quality of climate effects. The comparatively rapid reversion in GDP growth and the enduring fiscal impact show that climate adaptation investments must focus on fiscal sustainability rather than short-run growth stabilization. Fiscal buffers and climate contingency funds may be more significant than output-fluctuation policies, and the oscillatory nature of precipitation means that seasonal fiscal planning and water resources may also alleviate some climate-related fiscal strains.

Variance Decomposition

Table 4 presents the forecast error variance decomposition for GDP growth at various forecast horizons.

Table 4: Variance Decomposition of GDP Growth

Period	GDPG	TEMP	PRECIP	DEBT_DEV
1	100.00	0.00	0.00	0.00
2	79.99	0.62	17.14	1.57
5	78.20	0.81	18.54	1.70
10	77.21	0.96	18.95	2.01

The results show that after 10 periods, approximately 19% of the variance in GDP growth can be attributed to precipitation shocks, while temperature shocks account for about 1%. The relatively higher contribution of precipitation to GDP fluctuations underscores the sensitivity of Nepal's economy to rainfall patterns. Government debt accounts for approximately 2% of the variance in GDP after 10 periods.

Diagnostic Tests

Comprehensive diagnostic tests support the validity of our VAR model. The LM test for serial correlation yielded a p-value of 0.6380, indicating no significant serial correlation in the residuals. The heteroskedasticity test yielded a p-value of 0.8004, indicating homoskedastic residuals—all roots of the characteristic polynomial lie inside the unit circle, confirming model stability.

Discussion

The results of this empirical study demonstrate significant findings regarding the relationship between climate economics in Nepal that are both consistent with and inconsistent with the current literature. Although there is a negative relationship between temperature changes and GDP growth, it is not significant compared to other studies, such as Dell et al. (2012), who found a significant

negative impact in poorer countries. Nevertheless, the strongest result is the recognition of fiscal transmission as one of the key directions, and that temperature anomalies exert significant pressure on state debt. Such a fiscal channel seems to be more significant than the direct impacts of agricultural productivity, which were previously reported in studies of Nepal by Malla (2008) and Gurung and Nayava (2010).

This preponderance of the effect of precipitation over temperature (19% and 1%, respectively, of the GDP variance) indicates the specific susceptibility of Nepal to rainfall variability, confirming the findings of Sujakhu et al. (2022) on the effects of rainfall on agriculture. The negative long-run correlation between precipitation and GDP growth is counterintuitive. It may indicate that it is driven by threshold effects of excessive rain, leading to flooding and damage to infrastructure. Such results suggest that the climate adaptation policy in Nepal must focus on establishing fiscal buffers and disaster response mechanisms rather than sectoral ones. The notable fiscal transmission effects are in line with the demands of international organizations to have integrated climate and development planning methods. Yet this analysis has limitations, such as the annual frequency of data collection, which might not capture significant seasonal changes. Future studies on spatial variation and threshold processes are necessary.

Conclusion

This paper explore the association between economic growth volatility and climate variability in Nepal by conducting a thorough VAR and VECM analysis of the data between 1990 and 2024, as hard evidence of the impact of climate variables on the Nepalese economic performance, and with significant implications about the nature of climate economy associations in a developing economy.

The result of the analysis shows that, although the positive correlation between temperature and GDP growth is present, it is not significant at standard levels and, therefore, there is not enough evidence to support the probability that temperature influences GDP growth negatively in Nepal despite the direction of the coefficient coinciding with theoretical predictions of the research, such as the one conducted by Dell et al. (2012).

The statistically strongest result is connected with the channels of fiscal transmission, in which the temperature anomalies have a significant positive and significantly high impact on government debt, which provides strong evidence of warming temperatures imposing significant fiscal strains on Nepal

and defines fiscal vulnerability as a significant dimension of climate economy interrelationships that has been little explored in the past literature.

The analysis of variance decomposition demonstrates that the changes in the precipitation can explain about 19 percent of the fluctuation in the GDP, which is much more than the effects on temperature. It indicates that Nepal is especially vulnerable to changes in rainfall patterns, implying the country's reliance on rain-fed agriculture and the generation of hydropower.

The VECM findings indicate a negative and counterintuitive long-run relationship between precipitation and GDP growth, which possibly shows threshold effects of excessive rainfall that lead to flooding and damage to infrastructure or intricate adaptation processes that take up more extended periods of time.

These results have several implications for economic policy formulation in Nepal, indicating that policymakers need to create institutionalized fiscal buffers explicitly designed to absorb climate shocks by establishing specific climate contingency funds or risk insurance systems, and that rainfall variability should be systematically modeled in macroeconomic forecasting and planning frameworks.

The study is also a contribution to the methodology, as the authors employ rigorous econometric methods to quantify climate-economy relations within Nepal. The finding of one cointegrating relation indicates that the Nepalese economy re-equilibrates after climate shocks. Still, the processes involved in the adjustment must have had dire short-run economic impacts.

These limitations of the analysis are that annual data has been used, which limits observations, seasonal effects, in addition to the fact that it concentrates on temperature and precipitation, and omits extreme weather events, and the form of the linear model structure may not include maximum or minimum effects in climate economy relationships.

Future studies ought to focus on climate sensitivities and possible threshold impacts across individual sectors, examine the mechanisms through which climate shocks affect fiscal variables, and include geographic aberration in Nepal to provide insight into spatial variations in climate impacts and adaptation capacity.

With the ongoing climate change, this economic dimension will gain more significance in developing nations such as Nepal, and this research would be a basis for evidence-based policies recognizing the interconnectedness of the

climate economy and also evidence on the importance of rigorous quantitative approaches in informing climate adaptation and economic development practices in the vulnerable developing economies.

References

Aryal, S., Cockfield, G., & Maraseni, T. N. (2014). Vulnerability of Himalayan transhumant communities to climate change. *Climatic Change*, *125*(2), 193-208. https://doi.org/10.1007/s10584-014-1157-5

Asian Development Bank. (2024). *Climate risk country profile: Nepal*. https://www.adb.org/sites/default/files/publication/677231/climate-risk-country-profile-nepal.pdf

Bajracharya, S. R., Maharjan, S. B., Shrestha, F., Guo, W., Liu, S., Immerzeel, W., & Shrestha, B. (2018). The glaciers of the Hindu Kush Himalayas: Current status and observed changes from the 1980s to 2010. *International Journal of Water Resources Development*, *34*(6), 849-862. https://doi.org/10.1080/07900627.2018.1445176

Bastianin, A., & Manera, M. (2018). How does stock market volatility react to oil price shocks? *Macroeconomic Dynamics*, *22*(3), 666-682. https://doi.org/10.1017/S1365100516000353

Berlemann, M., & Wenzel, D. (2018). Hurricanes and economic growth: The case of missing data. *World Development*, *112*, 279-295. https://doi.org/10.1016/j.worlddev.2018.08.008

Burke, M., Hsiang, S. M., & Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature*, *527*(7577), 235-239. https://doi.org/10.1038/nature15725

Carnegie Endowment for International Peace. (2023, January). *Economic development in an era of climate change*. https://carnegieendowment.org/research/2023/01/economic-development-in-an-era-of-climate-change

Dell, M., Jones, B. F., & Olken, B. A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics*, *4*(3), 66-95. https://doi.org/10.1257/mac.4.3.66

Diffenbaugh, N. S., & Burke, M. (2019). Global warming has increased global economic inequality. *Proceedings of the National Academy of Sciences*, *116*(20), 9808-9813. https://doi.org/10.1073/pnas.1816020116

Enders, W. (2015). *Applied econometric time series* (4th ed.). John Wiley & Sons.

Feriga, M., Lozano Gracia, N., & Serneels, P. (2024). The impact of climate change on work: Lessons for developing countries. *The World Bank Research Observer*, *40*(1), 104-146. https://doi.org/10.1093/wbro/lkae002

Gentle, P., & Maraseni, T. N. (2012). Climate change, poverty, and livelihoods: Adaptation practices by rural mountain communities in Nepal. *Environmental Science & Policy*, *21*, 24-34. https://doi.org/10.1016/j.envsci.2012.03.007

Government of Nepal. (2022). *Fifteenth plan (fiscal year 2019/20-2023/24)*. National Planning Commission.

Gurung, A. K., & Nayava, J. L. (2010). Impact of climate change on production and productivity: A case study of maize research and development in Nepal. *Journal of Agriculture and Environment*, *11*, 59-67.

Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., & Vogt-Schilb, A. (2016). *Shock waves: Managing the impacts of climate change on poverty*. World Bank Publications. https://doi.org/10.1596/978-1-4648-0673-5

Hsiang, S. M., & Jina, A. S. (2014). *The causal effect of environmental catastrophe on long-run economic growth: Evidence from 6,700 cyclones* (NBER Working Paper No. 20352). National Bureau of Economic Research. https://doi.org/10.3386/w20352

International Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Cambridge University Press. https://doi.org/10.1017/9781009325844

Kahn, M. E., Mohaddes, K., Ng, R. N., Pesaran, M. H., Raissi, M., & Yang, J. C. (2021). Long-term macroeconomic effects of climate change: A cross-country analysis. *Energy Economics*, *104*, Article 105624. https://doi.org/10.1016/j.eneco.2021.105624

Karn, P. K. (2014). *The impact of climate change on agriculture: A case study from Nepal* (Policy Brief). South Asian Network for Development and Environmental Economics

Lütkepohl, H. (2005). *New introduction to multiple time series analysis*. Springer. https://doi.org/10.1007/978-3-540-27752-1

Malla, G. (2008). Climate change and its impact on Nepalese agriculture. *Journal of Agriculture and Environment*, *9*, 62-71. https://doi.org/10.3126/aej.v9i0.2119

National Planning Commission. (2022). *Nepal multidimensional poverty index 2021*. Government of Nepal.

Oswald, Y., Owen, A., & Steinberger, J. K. (2024). The socioeconomic impact of climate change in developing countries over the next decades: A literature survey. *Heliyon*, *10*(14), Article e33635. https://doi.org/10.1016/j.heliyon.2024.e33635

Paudel, B., Zhang, Y., Yan, J., Rai, R., & Li, L. (2019). Farmers' perceptions of agricultural land use changes in Nepal and their major drivers. *Journal of Environmental Management*, *235*, 432-441. https://doi.org/10.1016/j.jenvman.2019.01.091

Pradhan, N. S., Sijapati, S., & Bajracharya, S. R. (2015). Farmers' responses to climate change impact on water availability: Insights from the Indrawati Basin in Nepal. *International Journal of Water Resources Development*, *31*(2), 269-283. https://doi.org/10.1080/07900627.2015.1033514

Regmi, B. R., & Bhandari, D. (2013). Climate change adaptation in Nepal: Exploring ways to overcome the barriers. *Journal of Forest and Livelihood*, *11*(1), 43-61. https://doi.org/10.3126/jfl.v11i1.8612

Shrestha, P., KC, A., Karki, D. K., Shrestha, N., Bharati, A., & Giri, S. (2024). Impact of climate change on agriculture in Nepal and strategies for farmer adaptation and economic resilience. *Journal of Multidisciplinary Research Advancements*, *2*(2), 130-137.

Stern, N. (2007). *The economics of climate change: The Stern review*. Cambridge University Press. https://doi.org/10.1017/CBO9780511817434

Sujakhu, N. M., Ranjitkar, S., He, J., Schmidt-Vogt, D., Su, Y., & Xu, J. (2022). Impact of climate change on agricultural production: A case of Rasuwa District, Nepal. *Climate Services*, *27*, Article 100329. https://doi.org/10.1016/j.cliser.2022.100329

Tol, R. S. J. (2023). A meta-analysis of the total economic impact of climate change. *Energy Policy*, *185*, Article 113922. https://doi.org/10.1016/j.enpol.2023.113922

World Bank. (2023). *Nepal: Country climate and development report*. World Bank Group. https://doi.org/10.1596/40691

World Bank. (2024). *Climate change knowledge portal: Nepal*. https://climateknowledgeportal.worldbank.org/country/nepal