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Article: **Temperature and Economic Growth Nexus in SAARC and ASEAN Countries**

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Temperature and Economic Growth nexus in SAARC and ASEAN Countries

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Abstract

Global warming is a pressing issue that all countries are facing today. However, it affects the productivity of every sector of the economy and hence economic growth. This study is an attempt to analyze the temperature and economic growth nexus in selected South Asian Association for Regional Cooperation (SAARC) and the Association of Southeast Asian Nations (ASEAN) countries for the time of 1996 to 2018 using Generalized Method of Moments (GMM). This study develops the theoretical framework by extending the Solow growth model by incorporating the temperature in it. The results show that temperature affects economic growth negatively through its detrimental impacts on industrial value-added, agricultural value-added, and political stability in both SAARC and ASEAN regions. However, the study predicts that SAARC countries are more vulnerable regions owing to the rise of warming and temperature than ASEAN countries. Rainfall has a positive and statistically significant effect on the growth of SAARC while this shows positive and insignificant effects in the economy of the ASEAN region. Moreover, industrial value-added and political stability show positive and significant effects on the growth of SAARC and ASEAN but they have a higher impact on the growth of ASEAN countries than SAARC countries' growth. Agricultural value-added has a positive and significant effect on the economic growth of both ASEAN and SAARC countries. Inflation slows down economic growth in ASEAN and SAARC countries. While trade openness, gross fixed capital formation, and government spending spur economic growth in both regions. To sustain the economic growth, policymakers of SAARC and ASEAN countries should take safety measures that can mitigate the emission of greenhouse gases. Moreover, reduction in excessive use of vehicles, reforestation, and environmental technological advancements can reduce

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the worse effects of rising temperature and protect the environment from degradation.

Keywords: Temperature, economic growth, industrial value-added, agricultural value-added, political stability, Inflation, Government spending, Trade openness, panel data, GMM.

Introduction

Gross domestic product (GDP) per capita growth is one of the most important indicators to see how an economy is performing over time. The factors contributing to the GDP per capita are technological progress, physical capital, human capital, infrastructure, and natural resources. In addition, there is a strong correlation exists between economic growth and global warming (Udi et al., 2020). The economic productivity of countries has significantly been influenced by climatic changes over the last fifty years. Many researchers found that temperature and a change in the degree of rainfall can have a significant impact on the growth of economies around the world (Zhang et al., 2018). Several scientists delineate that there is a direct link between warming and the emission of greenhouse gases such as carbon dioxide (CO_2) and nitrous oxides are caused by human activities like industrialization, deforestation, and burning of fossil fuels (Kais & Sami, 2016; Rosen, 2009).

If people keep adding greenhouse gases into the environment at the current rate, it would increase the average warming around the world (Goel & Bhatt, 2012). To cope with the consequences of climate change it is necessary to stabilize temperature rise below 1.5 degrees celsius (IPCC, 2018). However, the world needs to reduce its annual emissions by limiting warming to 1.5-degree celsius otherwise consequences would be worse (Hickel & Kallis, 2020).

The growth of SAARC countries is seriously affected by the adverse effects of global warming due to its demographic location (Hussin & Saidin, 2012). Moreover, it is believed that CO_2 emission is the major cause of warming in SAARC countries due to CO_2 emission. For instance, CO_2 emissions are high that is causing environmental issues in India, Pakistan, and Bangladesh (Gupta, 2019). Global warming increases sea levels in the

coastal area of Bangladesh, Sri Lanka, and India, especially the situation in the Maldives is vulnerable (Das & Bandyopadhyay, 2015). It is reported that there is1.1 metric tons per capita emission of carbon dioxide in SAARC countries in 1972, 3.6 metric tons emission in 1992, which has increased to 7.95 metric tons in 2010. These facts indicate how carbon dioxide gas emission has rapidly increased in SAARC countries and led to an increase in temperature (Pandey & Mishra, 2015). According to the IPPC report, the warming is expected to increase by 2 degrees celsius all over the year in SAARC countries and the annual gross domestic product is expected to reduce by 1.8 percent in 2050.

Moreover, ASEAN is considered among the fastest-growing economies in the world but the economic growth of this region is also affected by mounting global warming (Nathaniel & Khan, 2020). ASEAN is the largest contributor to greenhouse gas emissions and is highly affected by climate change due to CO_2 emissions between the period 1990 and 2010 (Asian development bank, 2009). ASEAN contributes one-third of the world's total carbon dioxide emissions due to the consumption of coal. Meanwhile, the average temperature in ASEAN has been increasing by 0.1 to 0.3 degrees Celsius per decade over the last five decades (IPCC, 2018). ASEAN is highly populated and blessed with a variety of resources such as ASEAN is enriched with abundant minerals and energy resources, and marine life that support the growth of the economy. Several ASEAN countries have been affected by the worse effects of warming. In Singapore, it is reported that temperature increased by 0.6°C (about $0.3^{\circ}C$ per decade) from 1987 to 2007, the annual average temperature increased by 0.7°C to $0.14^{\circ}C$ from 1951 to 2000 in Vietnam, temperature, increased by $1.04^{\circ}C$ to $1.40^{\circ}C$ per century in Indonesia and temperature increased by 1.4^{0}C in the Philippines. It is analyzed that yields of crops reduced due to an increase in temperature in Thailand. Additionally, Global warming is expected to decline the trend of rainfall in ASEAN countries especially in Thailand and Vietnam threatening to increase heat waves and melting of snow glaciers in this region.

Temperature is the main factor of a climatic or environmental crisis that affects economic growth. Here, the study identifies channels through which temperature affects economic growth and this is the contribution. The

temperature affects economic growth by affecting agricultural output, industrial output, and political stability (Dell et al., 2012). These impacts are substantially bigger and more significant in developing countries than in developed countries. As Malikov et al. (2016) argue that agriculture plays a significant role in the growth of an economy. Less rainfall creates water shortage for irrigation, and this affects agricultural productivity (George et al., 2016). High temperature also affects the productivity of the crops and thereby reduces the agricultural output (Eboli et al., 2010). As most of the SAARC countries are agricultural countries and they depend on the agricultural sector for growth, employment creation, and poverty alleviation. Moreover, industrial output also counts on the agriculture sector. For example, in the textile industry; cotton is obtained from the agriculture sector. Hence, a worse performance of the agriculture sector also reduces the growth of the industrial sector and affects the overall growth of an economy.

Manufacturing output reduces significantly at high temperatures because when the average temperature increases, the output of individual firms decreases. High temperature also affects both labor productivity and capital productivity. Capital productivity may reduce by lowering the machine performance and labor productivity may reduce because of discomfort, fatigue, and cognitive power in workers at high temperatures.

High warming leads to political instability, owing to irregular change of national leaders and the political instability reduces growth rates in the poor economies. Political instability is associated with the decline in economic growth and there is significant empirical evidence that riots and protests are more likely to cause warm weather. Mostly high temperatures are concerned with political irregularities in poor countries. Moreover, the temperature has direct effects on political instability, which in turn affects the growth of the economy, or whether the temperature has indirect effects on economic growth, which in turn affects political instability (Dell et al., 2012).

Drought (low rainfall below threshold) increases riots which in turn leads to more democratic change. Riots and unrest are mostly triggered by adverse economic shocks or droughts that lead to political transition and institutional change. In poor countries, negative weather shocks can lead to

large population movements that may trigger riots and induce democratic institutions. In the face of drought, food subsidies could be used to mitigate the incentive to riot and social unrest (Aidt & Leon, 2016).

Global warming has become the most serious issue and hampered economic growth in developing countries. Therefore, this study aims to examine the impact of temperature on economic growth over the time period 1996-2018. We hardly found any empirical study which takes the ASEAN and SAARC regions together to study the impact of temperature on economic growth. Countries are selected based on the availability of data for both regions. This study uses the System GMM to take into account the problem of endogeneity.

The remainder of the study is organized as follows. Section two provides the reviews of the literature on the relationship between temperature and economic growth. Section three represents the theoretical framework. Section four describes the methodology and data, construction of variables Whereas Results and discussion are presented in section five while section six presents conclusions and policy implications.

Literature Review

Global warming is a pressing issue all over the world that is bringing out horrible changes in the environment and leading to loss of economic growth (Chakraborty & Maity, 2020). Temperature impact is not only confined to agriculture it has also a significant effect on industrial manufacturing products and political instability from the period 1900 to 2006. In poor countries, a 1°C rise in temperature in a given year reduced economic growth by 1.3 percent while in rich countries temperature did not have a significant and strong effect on economic growth (Dell et al., 2012). Similarly, Temperature affects GDP growth rate using the channel of total factor productivity. Temperature impacts on poor and rich countries in a different way on poor countries the effect has been stronger and more significant. The temperature has a significant impact on rich countries, and poor countries had been significantly and negatively affected by the fluctuation in temperature. The poor countries have less potential and don't have strong adaptation policies to temperature anomalies (Henseler & Schumacher, 2019).

Khawar (2014) empirically investigated the relationship between temperature and GDP per capita from the time period 1965 to 1990 and found that there is a negative relationship between high temperature and economic growth. Thus, temperature matters in the growth of economies even though the relationship between temperature and GDP per capita is difficult to show its significant impact on output and economic development (Hickel & Kallis, 2020). The temperature affects economic growth through life expectancy, extreme heat causes diseases and affects labor productivity and services in industries.

Changes in temperature and rainfall have significant effects on economic growth in African countries. Economic growth has been declined due to a 1°C increase in temperature. Shocks in rainfall also reduce the growth of the economy; thereby economic growth declines by 6.7 percent by the 1 percent change in rainfall (Lanzafame, 2014; Odusola & Abidoye, 2015). Temperature changes have a non-linear and significant impact on both rich and poor countries. Moreover, future warming is expected to decline the global output of the economy (Burke et al., 2015).

Newell et al. (2021) investigated the non-linear relationship that exists among temperature and GDP levels and assessed that global GDP decline by 1-2 percent by 2100. This study found that temperature has a less statistically significant effect on rich countries whereas a statistically significant relationship exists for poor countries (Acevedo et al., 2020). Evidence has been found that greenhouse gases are likely to increase in warming, hurricanes, and severe storms in the United States. In the year 2005 hurricane Katrina damage the most vulnerable economic area and made landfall in the United States (Nordhaus, 2006).

A temperature has a significant impact on the economic growth of sub-Saharan Africa. A one percent rise in temperature has been a 0.13 percent decline in economic performance. Precipitation and rainfall are considered to be very important for crops production in the agriculture sector (Nordhaus, 2006). Due to the increase in industrialization in Tunisia emission of CO_2 is increasing. The high living standard of the people leads to energy consumption in cars, air condition, and household equipment, and in turn, emits greenhouse gases. In Tunisia, the main cause of emissions of

greenhouse gases in the energy sector contributed 53.4 percent of total emissions (Borhan et al., 2012).

In South Asian economies, agriculture plays a major role in the survival and livelihood of people. Agriculture production is the major source to eliminate the poverty from rural areas in the agricultural-based economy and raise the GDP while in urban areas agriculture has insignificant effects (WDI report, 2008). About 60 percent of people are confined to an agricultural product, temperature affects crops. High temperature and low precipitation caused significant loss of rising production at the end of the growing season. Agriculture is the major cause of an increase in the emission of greenhouse gases and the most emitted gases are methane and nitrous oxide which are emitted by fertilization, livestock, and rice production. Deforestation is also an indirect source of emitted carbon dioxide gas. The South Asian government should focus on clean technology to be used in agriculture to reduce emissions and developed countries should reduce the consumption of meat to reduce emission from livestock (Singh et al., 2014). In the next 30 years, a temperature rise damaged the manufacturing industry owing to productivity losses in the South Asian region (Dottori et al., 2018). In the next three decades, South Asia could lose an average of 16 percent of its current labor capacity due to a rise in heat stress. Singapore and Malaysia are predicted to drop in productivity at 25 percent and 24 percent respectively and estimated that by 2045 the number of hot days rises from the current 335 to 364, while in Indonesia there will be 355 heat stress days from the current 303 (Mateo-Márquez et al., 2021).

Moreover, government instability and political unrest lead to risks in economic development. Irregularities of government have created uncertainties among foreign investors about policymaking and it hurts economic growth (Alesina et al., 1996). Bollfrass and Shaver (2015) reported a significant and positive association between high temperature and conflict. They identified the cause of conflict within Africa, crop yield affected by higher temperature and this led to drop in agricultural output and rise in food prices. Rising temperature decreases agricultural output in two ways by an increase in crop evapotranspiration and quickly crop growth and this reduces crops yield by 10 % to 30% with a rise in per degree Celsius

of temperature. They also found that areas with higher temperatures have experienced more violence than cooler areas.

Political instability creates uncertainty among future economic policy and it has a worse effect on investment and capital accumulation. In this uncertain condition, foreign and domestic investors do not invest in both physical capital and human capital. Total factor productivity is the major channel through which political instability reduces economic growth from 52.13 percent to 5.80 percent and this has a significant negative impact on economic growth, physical capital accumulation affects 22.59 to 28.71 percent of the total effect, and human capital affects 17.08 percent to 21.11 percent of the total effect (Aisen & Veiga, 2011).

There is a highly negative and significant impact of higher prices on political stability. In low-income countries increase in food prices has an adverse effect on the political institution. Higher food prices may be lead to conflict and unrest in a nation against the current government (Arezki & Bruckner, 2011). Above mentioned literature uncovered facts that a wide range of empirical studies have been done on temperature and economic growth nexus. The studies concluded that temperature affects overall economic growth. In precise, temperature change has a negative as well as a positive impact on economic growth in both direct and indirect ways. The one key message which can be drawn from the past studies is that there is no hardly any study available that has studied the impact of temperature on the economic growth of SAARC and ASEAN. Therefore this study contributes to the literature by examining the nexus between temperature and economic growth in selected SAARC and ASEAN countries using the channels of industrial value-added, agricultural value-added, and political stability.

Theoretical Framework

The traditional production function is given as

$$Y_{it=}f(L_{it},K_{it}) \quad (1)$$

Whereas Y_{it} represents the output of country i in time t, L_{it} and K_{it} represent labor and capital respectively for country 'i' in time 't'. However, Solow (1956) argued that technology is also considered necessary to produce

output, and sustainable growth is possible only through technological progress. We can write the following production function as

$$Y_{it=}f(K_{it\,,}AL_{it}) \qquad (2\acute{})$$

Where 'AL' is an effective unit of labor and A is for technology also called Solow residual. Its Cobb-Douglas form is specified as

$$Y_{it\,=}\,(A_{it}L_{it})^{\beta}K_{it}^{\alpha} \qquad (3)$$

Here α and β represent output elasticity of capital and output elasticity of labor respectively and A is for total factor productivity compromising technological progress and knowledge. Individually, in the Solow model capital and labor follow decreasing return to scale. But in aggregate form, the production function follows a constant return to scale. According to Solow, growth is caused by some explicit factors called exogenous factors. Mankiw et al. (1992) presented the Augmented Solow model by the inclusion of accumulation of human capital as well as physical capital. The presence of human capital accumulation increases the impact of physical capital accumulation on incomes. In this model human capital (H) depreciates at the same rate as physical capital.

$$Y\,=\,Y_{it}\,=K^{\alpha}H_{it}^{\beta}(A_{it}L_{it}\,)^{1-\alpha-\beta} \qquad (4)$$

Output per effective unit of labor is given as

$$y = k^{\alpha}h^{\beta} \qquad (5)$$

The change of physical stock is equal to the investment less effective rate of depreciation $(\sigma + n + g)$

$$\dot{k} = s_k y - (\sigma + n + g) \qquad (6)$$

σ is the rate of depreciation. This equation implies that 'k' converges to the steady-state position. Human capital per effective unit of labor is given as

$$\dot{h}\,=\,s_h y - (\sigma + n + g)h \qquad (7)$$

In steady-state $\dot{k}\,=\,\dot{h}\,=0$. By solving the equations simultaneously

$$h^{*} = [\frac{s_h^{1-\alpha}s_k^{\alpha}}{\sigma + n + g}]^{\frac{1}{1-\alpha-\beta}} \qquad (8)$$

$$k^* = [\frac{s_k^{1-\beta} s_h^{\beta}}{\sigma + n + g}]^{\frac{1}{1-\alpha-\beta}} \quad (9)$$

Putting equations (8) and (9) in equation (5)

$$y = \frac{Y}{L_t} = A_{(t)}. s_k^{\frac{\alpha}{1-\alpha-\beta}} s_h^{\frac{\beta}{1-\alpha-\beta}} [\frac{1}{n+\sigma+g}]^{\frac{\alpha+\beta}{1-\alpha-\beta}} \quad (10)$$

According to the neoclassical model, technology exponentially grows at the rate of 'g' i.e. $A = A_{\circ} e^{gt}$. Technological progress is the main component of total factor productivity and total factor productivity depends upon several factors such as human capital, physical capital, trade openness, government spending (Hsiang, 2010; Solow, 1956) and temperature change (a climatic variable). Several studies found that human capital is mostly affected by short-run changes in temperature there is a statistically significant relationship between temperature changes on human capital as temperature increase the cognitive performance decline and long-run analysis expose that there is no significant relationship between temperature anomalies and human capital (Graff Zivin et al., 2018; Hsiang, 2010; Letta & Tol, 2019; Zhang et al., 2018).

The temperature affects economic growth through industrial value-added, agricultural value-added, and political instability. On the agriculture side supply of crops may be reduced by excess heat and in turn increase in prices of agricultural goods leads to unrest and strike (Bollfrass & Shaver, 2015). In the light of the above equation, "A" is evolved as

$$A(\mathrm{t}) = A(0) e^{gt+\theta lnT} Where \theta > 0$$

The constant 'A' captures the total factor productivity and that is interpreted in broad manners, as Zhang et al. (2018) suggested that the decline in total factor productivity in response to high temperature is one of the major channels that leads to a reduction in output. Here "T" is for temperature change. Where $'\theta'$ represents output elasticity of temperature respectively and g is a parameter that denotes the technology progress at an exogenous rate.

$$y = A(0) e^{gt+\theta lnT} s_h^{\frac{\beta}{1-\alpha-\beta}} [\frac{1}{n+\sigma+g}]^{\frac{\alpha+\beta}{1-\alpha-\beta}} \quad (11)$$

By taking the natural log

$$lny = lnA(0) + gt + \theta lnT + \frac{\alpha}{1-\alpha-\beta} lns_k + \frac{\beta}{1-\alpha-\beta} lns_h - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+\sigma+g)$$

As ln e=1. We assume that technological progress (g) is constant for each country, $\ln(A_O)+gt = \alpha_0 + \mu_{i,t}$ where $\alpha_0$is for intercept and $\mu_{i,t}$ is the error term.

$$lny = \alpha_0 + \theta lnT + \alpha_1 lns_k + \alpha_2 lns_h - \alpha_3(n+\sigma+g) + \mu_{i,t} \quad (12)$$

Data and Methodology

Based on the previous theoretical model the following equation is estimated by using the panel data of the selected SAARC and ASEAN countries for the time period 1996- 2018.

$$y_{it} = \alpha_o + \beta X_{it} + \theta T_{it} + \phi Z_{it} + \mu_{it} \quad (13)$$

Where i is the cross-section of countries, t is the time period, "y_{it}" represents our dependent variable that is GDP per capita, "T_{it}" is temperature, X_{it} is for other explanatory variables such as rainfall, agricultural value-added, industrial value-added and political stability, Z_{it} is the vector of control variables such as trade openness, inflation, gross fixed capital formation, and government spending. $\alpha_o, \beta, \theta, and\ \phi$ are the vector of the parameter to be estimated whereas μ_{it} is the error term.

We use the Generalized Method of Moment (GMM) to estimate equation (13) to tackle the problem of endogeneity. GMM is suitable for estimation due to the following reasons. (i) In our model there is a problem of endogeneity, (ii) reverse causality, and (iii) omitted variable bias. For instance, high temperature leads to declining economic growth, and in reverse economic growth causes a rise in temperature (Amiri & Zibaei, 2012). Similarly, higher-income tends to cause the emission of CO_2 and in turn, causes fluctuations in the temperature. The temperature of the earth has increased by one degree Celsius, the reason is that the black exhaust released by industries and other emission contains, carbon dioxide, nitrous oxide, methane, and water vapours which form a blanket, in which the heat

of the sun is trapped which causes the temperature to increase. Deforestation is also caused by global warming; hence forestation is necessary for the balance of oxygen. These all studies show that there is reverse causality between temperature and economic growth. These results lead to the problem of endogeneity.

Some variables simultaneously affect temperature and economic growth for instance Industries which may also lead to economic growth and the combustion of fuels from industries leads to a rise in temperature. In the presence of the above problems, GMM is the better solution to overcome the problem of endogeneity (Arezki & Bruckner, 2011; Kais & Sami, 2016). There are two types of GMM. First difference generalized method of moments (GMM) which is introduced by Arellano and Bond (1991) and system GMM (Arellano & Bond, 1991; Blundell & Bond, 1998). Here we use system GMM which is a hybrid of GMM at level and difference GMM. System GMM is consistent if there is no second-order serial correlation in the residuals and they stated that the dynamic panel model is valid if the estimator is consistent and instruments are valid. For the sake of addressing this problem, this study utilizes two tests which are proposed by (Arellano & Bond, 1991). The first is the Sargan test to check the validity of the instruments and test the null hypothesis of validity of instruments. AR2 test is used to detect the autocorrelation in a specified model. This study used GDP per capita as a dependent variable by following previous studies (Borhan et al., 2012; Dell et al., 2012; Hsiang, 2010; Newell et al., 2021).

Temperature is an objective measurement of how hot or cold an object is, a measurement in degrees showing the heat of something such as air or water. In this study the variable of interest is temperature. Temperature is the essential climatic variable, and the current study uses the average annual temperature in degree centigrade. Several empirical studies investigate that there is a significant relationship between temperature and economic growth of a country (Dell et al., 2012; Khawar, 2014; Newell et al., 2021; Nordhaus, 2006). The amount of precipitation in the form of raindrops that falls in a specified place and time. Many research studies have found that rainfall is a significant determinant of economic growth (Mateo, 2015). This study collected the monthly rainfall data and converted it to annual rainfall in millimeters. Rainfall is considered an important environmental change variable because it causes floods and droughts that have a greater

impact on economic growth. Political stability plays an important role in promoting economic growth and it has a statistically significant and positive impact on economic growth. Trade openness is defined as an economy that trades with the rest of the world, or there exist economic activities such as imports and export for a country. Inflation is a general increase in the overall price level of the goods and services in the economy. Inflation is the percentage change in the consumer price index (CPI). High inflation creates uncertainty among investors for future profit and in turn leads to less investment. Gross fixed capital formation GFCF is the net increase in physical assets within the given time period it does not include consumption or depreciation of fixed capitals. Gross fixed capital formation as an addition in stock of capital assets sets. It gains from saving accumulation which gives positive effects to private savings accumulation, in other words, contributes more savings. Capital formation is a prerequisite to an increase in the physical capital stock of a country with investment in social and economic infrastructures; a nation needs a capital formation or capital accumulation to meet its objective of economic development. Government spending or expenditures means the distribution of total income or revenues received by the government on different programs related to health, education, and infrastructure for the welfare of citizens which are assumed to have a positive effect on economic growth. In this study, government expenditure is used as a percentage of GDP. Agricultural value-added, and industrial value-added are used as control variables

In this study panel data is used for selected SAARC and ASEAN countries. The study used secondary data that has been taken from the secondary official sources for the time period 1996 – 2017. Data of Gross domestic product, Inflation, trade openness, government spending, gross fixed capital formation, and industrial value-added, agricultural value-added have been taken from the World development index (WDI). Where the data of temperature and rainfall is taken from World Climate Change. Data for political stability are taken from the World Governance Indicators.

Result Discussion

This study has attempted to examine the impact of temperature on economic growth using panel data for the selected SAARC and ASEAN region. In

this study, the temperature is our variable of interest while economic growth is our dependent variable. In the first step, we have estimated the impact of temperature on economic growth with control variables. While in the second step, we have analyzed the impact of rainfall on economic growth with control variables. Table 1 presents the empirical results of temperature and economic growth for the SAARC countries while table 2 presents the empirical results for the ASEAN countries.

Temperature and Economic Growth (SAARC countries)

Table 1 shows temperature has a negative and significant effect on economic growth. One degree Celsius rise in temperature reduces the GDP growth by 1.169 percent. The reason may be that temperature reduces the manufacturing sector output by affecting the performance of machines. High temperature also reduces labor productivity by lowering the worker's ability as the high temperature affects the labor's health. This results in a major loss in industrial sector productivity and thus reduces economic growth. This result is consistent with the previous findings (Dell et al., 2012; Newell et al., 2021; Nordhaus, 2006).

Column three shows that rainfall has a positive and significant relationship with economic growth. In particular, SAARC countries, which depend mainly on the agriculture sector, this study found that rainfall is significantly and positively affecting economic growth. This result is similar to the findings of previous studies (Barrios et al., 2010; Cabral, 2014). Barrios et al. (2010) briefly discuss the two important channels through which rainfall affects economic growth that is agriculture and energy resources. However, rainfall is an important input to the agriculture sector, as the agricultural products increase, and producers can sell the goods at lower prices which increases exports of agricultural products.
Energy can also be produced using water and rainfall and these are considered important sources to produce cheap electricity and thereby, increase economic growth. Industrial value-added has a positive and significant contribution to the process of economic growth. These findings are in line with the findings of previous studies (Dell et al., 2012; Maingi, 2017).

Similarly, agriculture value-added also show a positive and statistically significant association with economic growth. In developing countries, it is the main source of employment for the people of rural areas. It is also considered as playing a vital role by providing intermediate inputs to the industrial sector. In developing countries, the development in the agriculture sector increases industrial growth to keep a sustainable process of economic growth. Our results are parallel to the findings (Yusuf, 2014).

Table 1

Empirical results for selected SAARC countries

Variables	Model 1	Model 2
ln(GDPP)	0.985***	0.9881***
	(0.000)	(0.000)
ln(Temperature)	-1.169***	……
	(0.000)	
ln(Rainfall)	……	0.152***
		(0.003)
ln(Industrial value added)	0.002***	0.003***
	(0.000)	(0.000)
ln(Agriculture value)	0.031***	0.017***
	(0.000)	(0.000)
ln(Political stability)	0.021**	0.004**
	(0.032)	(0.021)
ln(Trade openness)	0.010*	0.032*
	(0.066)	(0.073)
ln(GFCF)	0.001**	0.006**
	(0.010)	(0.049)
Inflation	-0.001**	-0.001**
	(0.051)	(0.024)
ln(Government spending)	0.008**	0.003**
	(0.011)	(0.03)
Constant	0.286***	0.373***
	(0.002)	(0.000)
Sargan	0.090	0.060
AR(1)	0.015	0.055
AR(2)	0.259	0.261

Significance level at 1 percent is denoted by ***, 5 is denoted by ** and 10 percent is denoted by * respectively.

Political stability has a positive and significant relationship with economic growth. In this study, we take government stability as a proxy for political stability. Economies need to have a balanced political system to achieve higher economic growth. Our results are akin to the findings (Aisen & Veiga, 2011; Shabbir et al., 2016). A stable political environment encourages investors to invest. However, it leads to an increase in basic infrastructure, technological progress, research, and development, enhances skilled human capital, physical human capital, and reduces inflation, poverty, and social unrest (Shabbir et al., 2016).

Government spending is our control variable which shows a positive and statistically significant relationship with economic growth. To increase economic growth, it is necessary to spend more on physical infrastructure, social infrastructures like education, health, research and development, agriculture, railways, roads, electrical energy, defense, transportation, and social security. Moreover, the cost of production declines if the government spends more on the construction of roads and electricity. Government expenditures on education and health care lead to an increase in the stock of human capital and in turn rise in the physical accumulation of capital which improves the growth of an economy. Our results are in line with the findings (Maingi, 2017; Shioji, 2001).

Inflation has a negative and significant effect on economic growth. This means that high inflation is harmful to economic growth and it reduces growth through savings and investment. Inflation reduces exports because of an increase in the prices of goods and services in the international market. Inflation also reduces the per capita income and purchasing power of consumers. Moreover, high levels of prices also cause uncertainty among investors and consumers which in turn hamper the growth of an economy. Our result is in relevance with the findings of previous studies (Farooq et al., 2011).

Trade openness has a positive and significant impact on economic growth. According to comparative advantage theory, trade openness leads to specialization in factor-abundant commodities which in turn increase the size of exports. Hye (2012) analyzed that trade openness has a positive impact on total factor productivity. It would improve the allocation of resources and lead to economic growth. Our results are similar to the

findings of previous studies (Das & Paul, 2011; Keho, 2017; Kim et al., 2012; Marelli & Signorelli, 2011).

Gross fixed capital formation is positively and significantly associated with economic growth. The capital formation leads to enhance the size of national income by solving the problems of balance of payment, budget deficit, inflation, and economic activities would be expanded in low developing economies which have a significant impact on economic growth. Our results are similar to the findings of previous studies (Bal et al., 2016). Likewise in model 1, the control variables in model 2 come with the expected sign and are significantly correlated with economic growth. In the above model, the Sargan p-value indicates that instruments are correctly identified and the values of AR2 also show that there is no issue of serial correlation in the model.

Temperature and Economic Growth (ASEAN countries)

Table 2 shows the estimated results for selected ASEAN countries, the results show that the temperature is negatively correlated with economic growth in ASEAN countries. One degree Celsius increase in temperature reduces economic growth by 0.166 percent. Temperature affects economic growth through the industrial sector, agriculture sector, political stability, and labor productivity. The rise in temperature affects the manufacturing output by reducing the productivity of physical capital. Moreover, Pindyck (2011) examines that temperature affects economic growth by reducing physical and human capital accumulation, research, and development. Heatstroke causes discomfort, health problems among laborers which results in a reduction in workers' productivity which leads to affects the human capital. (Burgess et al., 2017; Burgess et al., 2014) argue that agricultural productivity also declines due to damage of major crops by a rise in temperature. Our results are parallel to the findings of previous studies (Burgess et al., 2017; Dell et al., 2012).

Table 2

Empirical results for selected ASEAN countries

Variables	Model 1	Model 2
ln(GDPP)	0.9905***	0.9881***
	(0.000)	(0.000)
ln(Temperature)	-0.1666***	……
	(0.000)	
ln(Rainfall)	……	0.0137
		(0.131)
ln(Industrial value added)	0.120***	0.327***
	(0.000)	(0.003)
ln(Agriculture value added)	0.0078**	0.017**
	(0.015)	(0.040)
ln(Political stability)	0.038**	0.023**
	(0.021)	(0.010)
ln(Trade openness)	0.0108**	0.00485**
	(0.023)	(0.034)
ln(GFCF)	0.075**	0.061**
	(0.049)	(0.01)
Inflation	-0.0026**	-0.014**
	(0.051)	(0.024)
ln(Government spending)	0.0068**	0.0047**
	(0.010)	(0.044)
Constant	0.6835***	0.1103***
	(0.007)	(0.000)
Sargan	0.070	0.015
AR(1)	0.214	0.119
AR(2)	0.015	0.090

Significance level at 1 percent is denoted by ***, 5 is denoted by ** and 10 percent is denoted by * respectively.

Rainfall shows a positive but statistically insignificant effect on economic growth. Rainfall affects different sectors in different ways. However, rainfall may influence the ASEAN economies differently. In Southeast Asia, many economies are dependent on the service-based sector therefore these economies are less sensitive to rainfall. Industrial value-added has a positive and significant association with economic growth. In ASEAN, the region's industrial sector is considered the engine of economic growth. Industrial development leads to the growth of an economy through technological innovations and by supplying goods in both internal and external markets. In addition, the industrial sector creates more employment opportunities which increase the income of employers and enhance the saving and investment thereby increasing the national income which improves the welfare and living standard of the population.

Similarly, agriculture value-added shows a positive and significant relationship with the growth of the economy. Agriculture is the basic source of food and creates employment opportunities for the unskilled labor force. The agriculture sector provides raw materials to agro-based industries such as textile mills, sugar mills, and numerous other factories. This sector also leads to enhance the exports of agricultural products and creates the source of foreign exchange, making the better contribution to the GDP of an economy.

Political stability is positively and significantly correlated with economic growth. Political stability plays a vital role to determine the growth of an economy. Economies with stable political structures have attained sustainable economic growth. Stabilized government leads to increase physical and human capital accumulation, attracting foreign investors to invest in the domestic market, enhancing exports, and improving technology. These all economic factor directly or indirectly depends on government stability which positively contributes to the growth of an economy. Our results are compatible with the findings of previous literature.

Gross fixed capital formation is positively and significantly correlated with economic growth. The rise in the GFCF positively contributes to an increase in the growth of the economy. Gross fixed capital formation increases investment in the stock of physical capital and leads to enhance productivity and increases the size of national output. To increase the size

of GFCF reduces the burden of foreign debt, controls the inflation rate, solves the problem of balance of payment, and makes the country self-sufficient thereby influencing the economic growth of a country.
Inflation which is our control variable has a negative and statistically significant impact on economic growth. Economic growth hampers above the threshold level of inflation affect the various economic factors such as saving, investment, capital accumulation and increase the unemployment rate.

In this study, Government spending is another control variable that has a positive and significant correlation with economic growth. If a government spends money on capital formation, healthcare, education, infrastructure, private investment, subsidy, law and order, all these factors make a favorable economic environment. Government expenditures on infrastructure contribute towards productivity and lead to growth.

Trade openness has a positive as well as significant impact on the growth of the ASEAN country's economy. If a country is more open to world trade and increases exports by producing the best-specialized products, this leads to sustainable economic growth in a country. Due to openness in the trade, a country can import only those products which are lower in cost than producing them domestically. In table 2, the Sargan p-value indicates that instruments are correctly valid and the values of AR2 also show that there is no issue of serial correlation in the model.

Comparative Analysis of the estimated results of selected SAARC and ASEAN regions.

In Table 1 the coefficient of temperature indicates it has a strong coefficient (-1.169) and is statistically significant at one percent level while in table 2 the coefficient of temperature is (-0.1666). Although it has a negative and statistically significant coefficient of both regions shows that SAARC countries experience more severe impacts of temperature due to dependency on agriculture while in ASEAN manufacturing sector is less affected. ASEAN has achieved high economic growth through industrialization. In addition, the temperature has a large negative effect on economic growth but only in less developed countries because these countries have few resources and do not set appropriate policies regarding

greenhouse gas emissions (Dell et al., 2012). SAARC is a developing region and a large number of people in South Asia live below the poverty line. The SAARC countries have low per capita income with a large and growing population and due to the emission of greenhouse effects, most of these countries are highly vulnerable (Gupta, 2019). The South Asian region faces technological and political obstacles in developing a sustainable approach to combat the negative effects of temperature. Developed countries have capacities and adaptation policies to overcome the change which has occurred due to greenhouse gas emissions. ASEAN's or East Asia leaders have actively engaged to tackle the adverse effects of warming and to ensure the protection of the environment.

Similarly, Rainfall's coefficient in table 1 shows that the SAARC region has more vulnerable to variations in rainfall than ASEAN. In SAARC it has positive and statistically significant effects on economic growth whereas in the ASEAN region it has positive but insignificant effects on the economy because in SAARC most countries are relying on the agricultural sector and it has more affected by anomalies in rainfall. The ASEAN region has achieved significant economic growth especially in the field of industry, trade, and services so the growth of ASEAN has been less affected by the variations in rainfall. The coefficient of industrial value-added in ASEAN is statistically higher than in SAARC countries this means that the industrial sector has more influence on the growth of the ASEAN than SAARC.

The coefficient of agricultural value-added in the SAARC region has greater than ASEAN countries which means that the agricultural sector has a greater contribution to the growth of the SAARC region than ASEAN. The coefficient of political stability in ASEAN has a higher magnitude than the SAARC region which means that ASEAN has more stable government policies than SAARC. The region of ASEAN is best recognized for its economic and political bond which contributed to its economic growth.
There is a minor difference between the values of the coefficient of control variables for table 1 and table 2. However, trade openness in table 1 has almost the same coefficient but in (SAARC) region trade openness indicates that it has correlated with economic growth at a 10 percent level of significance because in the case of SAARC countries exports are mostly agricultural-based and have lower international market value while in ASEAN region mostly exports are industrial based and in turn having high

international market value and results of ASEAN shows that it has correlated with economic growth at 5 percent level of significance. Whereas, other control variables gross fixed capital formation, Inflation, and Government spending in SAARC and ASEAN both regions associated with economic growth at a 5 percent level of significance. Additionally, coefficients of Gross fixed capital formation show that it has a high impact on the growth of ASEAN than SAARC countries because the amount of investment may increase in ASEAN and lead to capital accumulation, productivity, and enhance economic growth.

Conclusion and Policy Recommendations

The key objective of this study is to assess the temperature and economic growth nexus in selected SAARC and ASEAN countries. For empirical analysis, this study has developed a model and identified a channel through which temperature affects economic growth, for instance, industrial value-added, agricultural value-added, and political stability. To analyze the empirical model, this study has used the panel data set of selected eight ASEAN countries and six selected SAARC countries for the time period from 1996 to 2018. The study has used the system GMM estimation technique to overcome the problem of endogeneity in the econometric model.

The key findings of the study can be summarized as follows: Based on empirical results this study has found that temperature has a statistically significant impact on economic growth in both selected SAARC and ASEAN countries. Moreover, this study reveals that temperature has adversely contributed to economic growth and it has larger effects on growth as compared to the ASEAN region. For instance in SAARC countries as one degree Celsius rise in temperature reduces the economic growth by 1.169 while in ASEAN countries as one degree Celsius rise in temperature the economic growth reduces by 0.16 percent. Meanwhile, rainfall has a positive and significant impact in SAARC countries, and in ASEAN it shows the positive but insignificant impact reason is that ASEAN has industrial and service-based economies and it has less affected by rainfall whereas, SAARC has heavily relied on agricultural-based so rainfall has high impacts on it. Industrial value-added has a positive and significant

effect on the economic growth in both regions but in ASEAN magnitude of the coefficient is higher than SAARC. Similarly, agricultural value-added and political stability has a positive and significant effect on economic growth in both regions. Agricultural value-added has more effects on the growth of SAARC than ASEAN and political stability has a strong and significant impact on ASEAN. Correspondingly, inflation has a negative and significant impact on growth in both regions. GFCF, trade openness, government spending have expected positive signs and significantly correlate to economic growth in both ASEAN and SAARC countries.

This study reveals that anomalies in temperature or rising in temperature have adverse effects on economic growth even in ASEAN countries. Moreover, less developed countries have more vulnerable to the negative effects of temperature. For instance, the temperature has stronger impacts in SAARC countries, because these are agricultural-based economies and have limited resources to adopt the mitigation and adoption strategies to prevent the impacts which are happened through temperature. Overall this study suggests that if the temperature is not controlled it could hamper economic growth to a great extent.

Following policy recommendations can be suggested in the light of our results that can direct policymakers about the adverse effects of temperature on economic growth. Based on the empirical findings, this study recommends that more attention should be paid to mitigate the worse effects of temperature variation. To sustain economic growth the government should play its essential role and different adaptation policies should be taken to control greenhouse gases emission such as the burning of fossil fuels should be contained for the protection of the environment.

There is a need to make innovations in technologies by increasing investment in new and clean energy technologies in the energy sector to lessen the negative impacts of greenhouse gases. In addition, reduce undesirable human intervention in forests because the forest balance the greenhouse gases in the atmosphere and absorbs the greenhouse gases which frequently raise the temperature in the atmosphere. So we need reforestation, trees should be planted again to mitigate the negative effects of climate change.

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