Growth Dynamics of Sulfur Emissions in case of SAARC Countries

Submitted by
Amjad Ali
Registration No: PIDE2018FMPHILENV13
M.Phil. (Environmental Economics)

Supervisor
Dr. Saud Ahmed Khan
Department of Econometrics
Pakistan institute of Development Economics
(PIDE), Islamabad

Co-Supervisor
Dr. Aneel Salman
Department of Business Management
COMSATS University, Islamabad

SUBMITTED TO
PIDE SCHOOL OF PUBLIC POLICY
PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS

Pakistan Institute of Development Economics, Islamabad

PIDE School of Public Policy

CERTIFICATE

This is to certify that this thesis entitled: **"Growth Dynamics of Sulfur Emissions in case of SAARC Countries"** submitted by **Mr. Amjad Ali** accepted in its present form by the School of Public Policy, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Environmental Economics.

Supervisor:

Dr. Saud Ahmed Khan
Chief of Research,
Pakistan Institute of Development Economics,
(PIDE) Islamabad.

Co- Supervisor:

Dr. Aneel Salman
Assistant Professor, COMSATS
Islamabad

External Examiner:

Dr. Abdul Saboor
Chairman
Department of Economics
Arid Agriculture University
Rawalpindi.

Head,
PIDE School of Public Policy:

Dr. Abedullah
Chief of Research/HOD
Pakistan Institute of Development Economics,
(PIDE) Islamabad.

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PIDE2018FMPhilENV13

Dedication

This research work, I am dedicated to my beloved Parents (Asmat Ali & Rubaba Asmat) and my Uncle Shoukat Ali Khan and Habib Mamo, who always believed in me and cheered me throughout my studies. Besides my Uncle Shoukat Ali Khan who support me a lot in every decision of life.

Declaration

I, Amjad Ali, PIDE2018FMPHILENV13 hereby declare that this thesis entitled ***"Growth Dynamics of Sulfur Emissions in case of SAARC Countries"*** submitted by me for the partial fulfillment of **Master of Philosophy** in Environmental Economics is my own tough work under the full supervision of my respected supervisor. Moreover, this thesis has not submitted concurrently to any other university for any other degree.

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Key Words

GHGs	Greenhouse Gases
SO_2	Sulfur Dioxide
$PM_{2.5}$	Particulate Matter
EPA	Environmental Protection Agency
UN	United Nations
IPCC	Intergovernmental Panel on Climate Change
GWP	Global Warming Potential
FGD	Fuel Gas Desulfurization
EKC	Environmental Kuznets Curve
SAARC	South Asian Association for Regional Cooperation
KT	Kilotons
WDI	World Development Index
IHD	Ischemic Heart Diseases
CVD	Cardiovascular Diseases
WHO	World Health Organization
GDP	Gross Domestic Product
FDI	Foreign Direct Investment
TO	Trade Openness
EEp	Electric Energy Production
POPg	Population Growth
FMOLS	Fully Modified OLS
EDA	Exploratory Data Analysis

Abstract

The impacts of climate change are very painful around the world but the developing countries are facing high vulnerability of climate change. The Greenhouse gases (GHGs) are upsurge continuously and the 100-year global warming potential of sulfur emission is very high. This study examined the relationship between Sulfur Emissions (SO_2) and economic indicators in SAARC countries. The study employed the data of SAARC countries from 1975 to 2018. In addition, the study applied panel unit root tests and all the variables are stationary at first difference level. After this, the study applied cointegration tests and the results reject the null hypothesis. The Fully Modified OLS (FMOLS) estimator used to investigate the long-run relationship between variables. The results show that GDPg has a significant negative effect on SO_2 emissions. It indicates that an increase in GDPg decreases SO_2 emissions. Meanwhile, the SO_2 emissions related positively with FDI, TO, EEp and population growth. Furthermore, the study conducts Trend Analysis to understand the monotonic trend of the data. This research provides a comprehensive policy note, where the SAARC policy negotiators raise the negative impacts of GDPg on SO_2 emissions in 26th COPs negotiation of UNFCCC. In addition, also discuss the market structure for sulfur emissions as carbon credits, where the emissions sinking countries are get benefits from it. The demand for energy is growing and used of natural resources for energy production increase like coal, natural gas and fossil fuel. These resources are environmentally degradable and needs to decrease their consumption level otherwise the subject of the environment remains unsolved. Therefore, all countries need to require sustainable growth for economic development.

Chapter No.1

Introduction

1.1 Background

Climate change is the most debatable issue and their impacts are very painful around the world. It refers to the average change in weather pattern and observed in the early 20th century due to increase in human activities. In the pre-industrialization era, the overall economic activities was upsurge, which emitted the Greenhouse gases (GHGs) such as methane, nitrous, carbon dioxide, oxide and sulfur hexafluoride. The main sources of GHGs emissions are human activities associated with economy like the combustion of gas, fossil fuels, and coal and agriculture wastes (US EPA,. 2018)[1]. These GHGs emissions increase the global average temperature of the surface and negative impacts on agriculture sectors (Husnain et al., 2018)[2]. We are living in the globalization era: where all the nations integrated with each other. So, the Global democracy of developed countries are given a vote to make in the favor of international laws and regulations for environment protection, and the amount of pollution which the industrial sectors are permitted to pledge in air. The international communities are very serious about sustainability (environment & economy) and ensure the stringency of rule and regulation related to environment protection. In 2008, the Kyoto Protocol [3]agreements were signed by 178 countries, which proposed by the United Nation (UN). The enforcement of this agreement in 2005 and committed to reduce the GHGs emission around 5.2 percent.

[1] EPA stands for Environmental Protection Agency; President Richard Nixon established in Dec 1970 in the United State and works for human and environmental protection.

[2] Husnain, M. I., Salman, A., Jan, I., & Mahmood, T. (2018). Does endogeneity undermine temperature impact on Agriculture in South Asia? *Sarhad Journal of Agriculture*, *34*(2), 334–341. https://doi.org/10.17582/journal.sja/2018/34.2.334.341

[3] The United Nation Framework Convention on Climate Change adopted the Kyoto Protocol in 1997 for reduction of GHGs emissions.

The study concerned towards sulfur dioxide emissions (SO_2) and SO_2 belongs to sulfur oxide (SO_x), which is colorless and easily reacts with other substances and soluble in water. There are two main sources of sulfur dioxide emissions. One is the anthropogenic source such as the combustion of fossil fuels, coal, and oil in the economy, refinement of sulfur containing material, metal ores and energy production. Second, the natural volcanic eruption (IPCC[4], 2015; Schmidt et al., 2018; Fioletov et al., 2016). The impacts of sulfur emissions are very harmful and noxious as compared to other GHGs emissions. When sulfur reacts with other substances to form different toxic compounds, which causes so many problems of pulmonary and respiratory systems disease and creates environmental problems like acid rain, air pollution, smog and Climate change. The effects of sulfur are very speedy and feel the worst symptoms in 10 to 15 minutes after inhaling this. In addition, the forms of sulphate aerosol which cools the earth locally in the lower atmosphere and globally in the upper atmosphere (stratosphere). Later on the impacts mostly due to large volcanic eruptions rather than anthropogenic pollution (ADEH, 2005)[5]. When the Sulfur dioxide dissolves in water to convert in sulfuric acid, sulfurous acid and sulfate particles, there are negative effects on biodiversity, forestation, crops, heritage structure and buildings (US EPA, 2017).

[4] IPCC stands for Intergovernmental Panel on Climate Change. The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. . Created by the United Nations Environment Program (UN Environment) and the World Meteorological Organization (WMO) in 1988, the IPCC has 195 Member countries. In the same year, the UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC.

[5]ADEH stands for Australian Department of the Environment and Heritage and it existed from 1998 to 2007. At its creation, the department was responsible for;

1. Environment and conservation
2. Meteorology
3. Administration of the Australian Antarctic Territory and the Territory of Heard Island and McDonald Islands
4. Natural and built heritage
5. Greenhouse policy coordination

1.1.1 Status of Global Sulfur Emissions

The total global anthropogenic sulfur emissions were around 97 m/tons in 2014, which indicates that the overall global sulfur emissions were decreasing. The trends of sulfur emissions were different in regional levels such as the trends of sulfur emissions in European and American countries were decreasing, while the trends in Asian and Africans continues were increasing.

Table No: 1.1 Total Global Sulfur Emissions

Regions	Sulfur Emissions SO_2 (Million/tons)	Growth rate of Gross Domestic Product-per capita
South America	6.56	-4.11
North America	11.79	3.18
Europe	19.79	-2.13
Asia	51.73	3.09
Africa	7.14	1.62
Total	97	0.84

Source: OECD (2014) and (Klimont et al., 2018)and J Cofala (2013)(IMF-2019)

However, the developing countries including Asia and Africa depend upon coal and fossil fuels for energy production (Klimont et al., 2018). In above table no.1.1 shows the GDP per capita growth of North America and Asia were almost same but the levels of sulfur emissions are different because North America adopted green technologies, implemented strong environmental policies, these policies leads to fuel substitutions, scrubbing and used the fuel desulfurization technology. Nevertheless, in Asia, the countries belong to the developing world and these countries are in the stage of development pace. Therefore, the energy played a key role in the development process and the main resources used for energy production were highly pollutant like fossil fuel, gas and coal. Second, the financial status of those countries cannot allow substituting and adopting green resources and technologies. Whenever the economic activities increase, the environmental quality must be degraded and increased the

concentration of pollution. The economic growth had significantly small and positive effects on Particulate Matter [6](PM2.5) concentration pollutants.

1.1.2 Status of Sulfur Emissions in Asia Region

In Asia, China and India have big economies and with the passage of time, the population size and economic activities increasing frequently and due to this, the GHGs emissions increased such as nitrous oxides, carbon dioxide, methane, and sulfur emissions. The carbon dioxide is a dominant gas in GHGs emissions but our interest towards sulfur emissions, which present in very small proportion in GHGs emissions but their impacts are very adverse because their 100-year GWP (Global Warming potential) is very high: '1-kilogram Sulfur hexafluoride is equivalent to 22.8 tons of carbon dioxide (Co_2)'. Asia is a major contributor of sulfur emissions in the present time and the most affected region from air pollution. The proportion of diseases related to air pollution are very high as compared to the rest of the world. China is 29.07 m/tons per annum and India is 10.15 m/tons per annum (Klimont et al, 2009). The total contribution of China and India in sulfur emissions by one-third of the Global sulfur emissions emitted from energy production, where the gas, coal and fossil fuels are major natural resources for energy production (CAI-Asia, 2010). The SO_2 emissions increased by 53 percent during 2000 to 2006 in China due to increasing demand of energy production for economic growth. The amount of SO_2 emissions has increased from 21.7 to 33 TG by the consumption of fossil fuels in power plants in china. In 2006, the sulfur emissions is going to decrease by the use of fuel Gas Desulfurization (FGD)[7] technology in China (Lu et al., 2005). Which means that the economic growth significantly influence sulfur emissions because of growing demand for energy and the main resource used for energy production are fossil fuel,

[6] $PM_{2.5}$ stands for Particulate Matter; PM is the complex mixture of organic and inorganic particles in air and $PM_{2.5}$ refers to the diameter is less than 2.5 micrometer in size.

[7] Fuel Gas Desulfurization technology used to remove the sulfur from fossil fuel, gasses and coal during their consumption.

coal and gas (Dasgupta et al., 2002, D. Stern. 2004, Hilton. 2006). There is a long-term relationship between SO_2 emissions and GDP growth for Philippine. The SO_2 emissions and GDP are co-integrated (-1.33) and negative relationship in long run (Puzon, 2012).

In 2006, the D. Stern used new econometric methods such as emissions frontier model, growth rate method and EKC method and compared their results. They show a significant decline by 22 percent over the time because previous study for the estimation of sulfur emissions based on technology but this study highlighted the eye of newer sources of sulfur emissions (Stern et al,. 2006). The reduction of emissions in global level by North America, Europe and East Asia but the emissions per capita of developing countries were much lower as compared to the industrial world. The relationship between environmental pollution and economic development is a monotonic in income and the reduction of emissions are associated with time. This decline referred to the reversal of trends by the Great Depression[8], the World War I and II[9], breakdown of the Soviet Union [10]and the collapse of Eastern European economies[11], financial crisis of East Asia. [12]

[8] In the1930s, "The Great Depression" occurred in the United States and the beginning of the historic economic crisis from the crashing of the Stock Market in 1929 and ended in 1933. Where the global GDP declined 26.7 percent and unemployment increased by 25 percent.

[9] World War I and II are originating "Jul 28, 1914 to Nov 11, 1918" & "Sep 1, 1939 to Apr 30, 1955"

[10] On December 25, 1991, the Soviet hammer and sickle flag lowered for the last time over the Kremlin, thereafter replaced by the Russian tricolor. Earlier in the day, Mikhail Gorbachev resigned his post as president of the Soviet Union, leaving Boris Yeltsin as president of the newly independent Russian state.

[11] The Eastern European countries follow the Soviet-Style Economies and the growth rate is positive and higher than Western European and United States. Following reasons for the collapse of Eastern European economies.

1. Exhaustion of the Capital Stock
2. Revolution of 1989, the massive invasion of electronic devices
3. Ecological collapse in Central & Eastern Europe
4. Virtual collapse of Socialist Ideology

[12] The Asian financial crisis, also called the "Asian Contagion," was a sequence of currency devaluations and other events that began in the summer of 1997 and spread through many Asian markets. The currency markets first failed in Thailand, because of the government's decision to no longer peg the local currency to the U.S. dollar (USD). Currency declines spread rapidly throughout East Asia, in turn causing stock market declines, reduced import revenues, and government upheaval

1.1.3 South Asian Association for Regional Cooperation (SAARC) Countries

The SAARC including Pakistan, India, Nepal, Sri Lanka, Maldives, Afghanistan and Bhutan are developing countries and stirring towards development growth and high vulnerable for climate change as well the a substantial portion of the world's population lives in this region (Gowdy & Salman, 2007)[13]. So, due to this the demand for energy production is very high and the use of cheap resources for energy production like fossil fuel, gas and coal but these resources are the main responsible of the GHGs emissions. However, this study does not consider Afghanistan, Bhutan and Maldives because the level of GHGs emissions are low.

Table No: 1.2 South Asian Association for Regional Cooperation (SAARC) Countries

Countries	Total SO_2 Emissions (KT)	CO_2 Equivalent of SO_2 (KT)	Population Millions	GDP per capita Growth (%)	Emission Per Capita (MT)
Bangladesh	157.9	3602229	161.4	6.7	0.000979
India	16809.9	383265948	1,352.7	5.8	0.012428
Nepal	47.2	1074446	28.1	4.5	0.001678
Pakistan	1516.4	34574536	212.2	3.2	0.007146
Sri Lanka	206.5	4709212	21.7	2.2	0.009531
TOTAL: SAARC	18738	427226371	1775.9	4.5	0.010551

Source: Author (2018)

The selection of SAARC countries based on their different dynamics such as the diseases related to air pollution are very high (WHO[14], 2018). Secondly, the contribution of sulfur emissions are also high. This panel has almost the same culture, socioeconomic, religious

[13] Gowdy, J., & Salman, A. (2007). Climate change and economic development: A pragmatic approach. *The Pakistan Development Review*, 337-350.

[14] WHO stands for World Health Organization

diversities and geographical binding. In the above table no.1.2 shows different variables of the SAARC countries like total sulfur emissions, CO_2 equivalent of SO_2, total population, GDP per capita and emission per capita and compare with each other. The emissions per capita of Bangladesh and Nepal are low but the emissions per capita of India are very high as compared to Sri Lanka and Pakistan. The total sulfur emissions of Pakistan and India are high and the total emissions of Nepal, Sri Lanka and Bangladesh are low as compared to Pakistan and India. India has the highest population size 1352.6 million in the SAARC countries and the lowest population size is Sri Lanka around 21.6 million. The GDP per capita growth of Bangladesh is high 6.73 percent and Sri Lanka is low 2.13 percent in SAARC because the total emissions of sulfur are higher according to their population size. India is the major contributor of sulfur emissions and Pakistan is the second highest country of sulfur emissions in SAARC countries. The total population of SAARC countries are 1775.9 million and the total sulfur emissions are 18737.9 kilo-tons (kt). The emissions per capita of SAARC countries are 0.010551 million tons (mt) and the average GDP per capita growth of SAARC countries is 4.5 percent annually.

The use of coal for consumption in Pakistan is very low around 7.1 to 11.6 ToE (Oil tonnes equivalent) as compare to other neighbor countries such as India 415.9-452.2 (ToE) in 2017-2018 (WDI[15], 2019). The following sources of SO2 emissions in Pakistan are vehicles, refuse burning, open dumps burning, vehicular automobiles and aircrafts. Therefore, the main source is vehicular emissions in Pakistan (Pak-EPA, 2005). However, the current major source of sulfur emissions in Pakistan is the industrial sector.

The sulfur emissions level in India is high because of low per capita income, which influences the population to pollute the environment and uses cheap resources to increase the per capita income and the population density positively influences the environment (Akhmat

[15] WDI stands for World Development Index and that is the data source of economic and non-economic variables of the World.

et al., 2014). In 2014, the study was conducted in SAARC region including Bangladesh Pakistan, India and Sri Lanka to analyze the relationship between institutions quality and environmental quality and used different models like Environment Kuznets Curve (EKC) and Dynamic OLS (DOLS) regression. The result shows that EKC[16] hypothesis exists in short and long run in the presence of institutions for both CO_2 and SO_2 but the institution reduced the SO_2 emissions in long term and reduced the CO_2 emissions in short run and long run (Imdad, 2014).

To check the relationship between international trade and environment, the study used the panel data of carbon dioxide emissions to analyze the South Asia region. There is a positive relationship between scale effects and pollution. When the scale effect increases by 1 percent, the carbon emissions increase by 2.48 percent. When the technology increases 1 percent, the pollution emissions decrease by 2.29 percent and the impacts of population density influence the pollution emissions (*Fizza and Hafsa*, 2019).

The study has conducted in 2014, which shows the natural source of sulfur emissions in Pakistan. The results were quite interesting, 70 percent of sulfur emissions (8.7 per year) increased overall in Pakistan from nature source during the period of 2004 to 2012. The main reason to increase the emissions is the natural source of SO_2 emissions after the eruption of Nabro Volcano (Khattak et al., 2014). The natural source of sulfur emissions (volcanic source) also contributes to increasing the concentration. However, the relationship of sulfur emissions and economic activities is coherent with each other in a large spin of time. The impacts of sulfur emissions on human health is very critical, which causes many problems of the pulmonary and respiratory systems. The literature shows that the cost of healthcare was very high as compared to other diseases. In 2018, the study has conducted in the USA (Lin, C. K et

[16] EKC stands for Environment Kuznets Curve; it shows the inverted-U-shaped relationship between different pollutants and per capita income.

al. 2018), measured the cost of healthcare due to sulfur emissions was 656 billion US dollar and that cost had projected to 1208 billion in 2030. The United States adopted different methods to decrease the sulfur emissions. The study shows that when 10 percent decrease in SO_2 emissions from coal-fired power plants, the Ischemic heart diseases (IHD) and cardiovascular diseases (CVD) decrease by 0.75 percent. It means that there is a direct relation between sulfur emissions and diseases. The CVD reduction in women was high as compared to men in the USA.

1.2 Research Gaps

The impacts of sulfur emissions are very injurious on human health and environment quality. The major sources of emissions are the combustion of fossil fuel, natural gas and coal and volcanic eruptions contributes to increase the sulfur emissions. This study work on sulfur emissions and their dynamics, which is very important to explore it. The study deploy the new econometric estimators, new data sets and variables for analysis. In addition, to prepared the comprehensive and smart policy gaudiness for the reduction of sulfur emissions in SAARC countries.

1.3 Problem Statement

Economic development plays a vital role to improve population living standards, increase the national income and increase productivity of the economy. The overall economic activities leads to increase the production and consumption of goods and services. These economic activities also increase the concentration of GHGs emissions and other harmful aerosols like Particulate Matter ($PM_{2.5}$), Particulate Matter (PM_{10}) in the air. Due to this, so many human health and environmental issues associated with them, such as air pollution and GHGs emissions. In 2004, the World Commission on Environment highlighted that the economic growth was the basic feature for sustainable development. The composition of GHGs emissions like CO_2, NO_x, CH_4 and SO_x but our interest towards sulfur dioxide emissions. The

sulfur emissions are very harmful as compared to other GHGs emissions (ADEH, 2005). In the previous studies, the relationship between economic activities and sulfur emissions shows both positive and negative (Stern et al., 2015). The main sources of sulfur emissions are the combustion of fossil fuel, natural gas and coal but the natural volcanic eruption increased the emissions (Khattak et al., 2014). In South Asia, the diseases related to air pollution is higher as compared to other regions (WHO, 2018). Moreover, the sulfur dioxide is more responsible for these diseases. However, the environmental quality and human health has adversely affected from sulfur emissions. This study investigated the growth dynamics of sulfur emissions in the SAARC countries. In Asia, less than 8 percent of people live breathing clean air and 4 billion people still live in injurious levels of air pollution. The air pollution discussion in the Asian countries is a debatable issue between them. The governments and high authorities want to talk and already take different initiatives to combat the air pollution through strong implementation of rules and regulations.

1.4 Significance of the study

The air pollution has very harmful impacts on environmental quality and human health. The consequences of air pollution are very serious associated with the quality of life, acidification, and depletion of the ozone layer and increased the cost of health care. According to the World Health Organization (WHO), every year seven million people die from air pollution around the world (World Bank, 2018). The concern of this study, to scrutinize the long run impact of sulfur emissions in the SAARC countries with different economic indicators. The effects of air pollution are very damaging on environmental quality and human health but the study focus on sulfur emissions and their consequences. This study used the data of sulfur emissions taken from the Community Emissions Data System (CEDS) for SAARC countries. The findings of the study provide a comprehensive outcomes for policy makers and researchers to formulate the policies, rules and regulations to combat and reduce the impacts

of climate change because the climate change policies only focus on CO_2 emissions and ignored the others GHGs emissions like sulfur emissions because the sulfur emissions 100-year GWP are very high. In 2010, the Pak-EPA make drafted of National Environmental Quality Standard (NEQS) for ambient air quality such as SO_2, NO_x, O_3, SPM, $PM_{2.5}$, lead and CO, which approved by PEPC[17] but still in Pakistan have no proper policy related to sulfur emissions in climate change policy. In addition, other SAARC countries somehow follow the environmental protection measurements.

1.5 Research Question

1) What are the impacts of gross domestic product (GDP growth), foreign direct investment (FDI), trade openness, energy production, and population growth on sulfur emissions in SAARC countries? In addition, how much a sulfur emissions will change, when the economic indicators will change?

1.6 Objective of the study

1) To understand the impacts of GDP growth, FDI on SO_2 emissions in SAARC countries.
2) To understand the impacts of trade openness, energy production and population growth on SO_2 emissions in SAARC countries.
3) To provide a comprehensive policy gaudiness related to sulfur emissions for SAARC countries, the policy should be helpful to reduce the sulfur emissions and to combat the impact of air pollution.

[17] The Pakistan Environmental Protection Council (PEPC) was set up in accordance with the legislation of 1983. The major functions of the Council include enforcement of the 1983 Ordinance and formulation of comprehensive national environmental policy. The PEPC has recommended creating a Pakistan Environmental Fund and an Environmental Bank. The PEPC is also responsible for setting up pressure groups and environmental clubs at workplaces and factories, in order to raise awareness and improve the environment.

1.7 Organization the Study

The organization of the study has divided into six chapters. The first chapter is an introduction of the study and discusses the topic, problem statement and objectives of the study. Second chapter of the study is literature review and shows the previous literature related to this topic. Third chapter of study based on data and research methodology, where the study explains about theoretical framework, study area, data collection, empirical results of the data and econometric model of the study. The fourth chapter is about the exploration data analysis for the in-depth analysis of the data trends over the time. The fifth chapter is results and discussion of the study. The last chapter six is the conclusion and recommendation of the study.

Summary:

Economic growth is essential for development, to improve the life standards and increase the national income of the country. The economic growth increase the overall human activities, which leads to upsurge the GHGs emissions and the global average temperature of the world. The major source of GHGs and sulfur emissions is the combustion of natural sources like coal, natural gas and fossil fuel, which increase the concentration of air pollution. The climate vulnerability indices of developing countries are comparatively higher than developed countries due their low bouncing back capacity. In South Asia, the ratio of air related diseases are very high as compare to other region; the sulfur emissions are more responsible for this. The impacts of sulfur emissions are very harmful on human beings and environment quality. The purpose of this study, to explore the dynamics of sulfur emissions on economic indicators in SAARC countries and analyze how much the economic growth indicators change the sulfur emission from 1975-2018.

Chapter No.2

Literature Review

2.1 Economic growth and Sulfur Emissions

Economic growth is the key indicator of economic development and for a healthy economy. Which means that to increase the population living standards and raise the national income and total expenditures of government. Economic growth enables to increase the productivity of the economy and as a result, the production of outputs in the industrial sector increases. Consequently, with the increasing production and consumption of goods and services, the environmental cost is also associated in form of GHGs emissions like CO_2, NOx SO_2 emissions, which causes environmental damages and affects human health badly. To determine the relationship between economic growth and sulfur emissions, the study needs to support different previous studies. In 2005, the study was conduct in China, using panel data and trying to explain how the economic growth increased sulfur emissions during 2000 to 2006. The amount of SO_2 emissions increased from 21.7 to 33 TG by the consumption of fossil fuels in power plants. The share of fossil fuels in the energy sector is 78 percent for GDP growth that means the coal and fossil fuel were the key resources of energy production (Lu et al., 2005). The past trend of the Global SO_2 emissions is dramatically changed (Smith et al., 2001) and the trend of sulfur emissions are shifted towards the southern region to eastern region, especially the contribution of China and India is 1/3 of global SO_2 emissions because of the economic size and population growth is continuously increasing (Stern, 2005). It means that when economic growth increases, the sulfur emissions also increases due to growing demand of energy for economic growth.

There is a long-run relationship between SO_2 emissions and GDP in Philippine. SO_2 emissions and GDP are co-integrated (-1.33) and negative relationships due to large shares of

the service sector. As the manufacturing of the service sector was highly less pollution intensive of the SO_2 emissions. The economic structure of Philippine was depends upon the services sector, where the share in the economy is around 44.3 percent. The GDP growth was not responsible for SO_2 emissions in Philippine (Puzon, 2012). The economic growth has significant positive small effects on $PM_{2.5}$ concentration pollutants. Since 2017, the Stern used a new long run growth rate model for trajectories, which allows tests of competing explanations for emissions trajectories and nested the prior model of (Brock & Taylor, 2010; Ordás Criado & Grether, 2011), and the EKC. The study finds that the impact of income growth on emissions is positive but the GDP per capita cannot explain the per capita emissions. The emissions-income elasticity of higher income countries is low and they concluded that there was no practical importance of EKC's for CO_2 and SO_2 samples. The growth and convergence impacts are important to analyzed the emissions (Stern et al., 2017; (Brajer et al., 2011); Hao and Liu et al., 2016). The results are highly related to Keene & Deller (2015) and their findings are higher interrelated for U.S. countries (Stern, 2016).

The SO_2 emissions of China were starting to decrease due to intervention of new FGD technology for desulfurization (Dasgupta et al, 2002), (Stern. 2004; Hilton. 2006); (Stern, 2006). The effects of EKCs are positive for industrial GHGs emissions and zero for the non-industrial GHGs. The zero affects economic growth at the mean income level for $PM_{2.5}$ concentration but is highly positive significant for all the emissions variables. The time effects are highly negative for sulfur emissions in both the industrial and non- industrial but that variable is insignificant for CO_2 and $PM_{2.5}$concentration (Stern et al, 2015).

China and India are big emitters of anthropogenic SO_2 emissions in the world and dominant in the Asia region. The coal consumption of both countries are the major source of anthropogenic SO_2 emissions due to coal-fired power plants. The reason is the population and economy size is increasing frequently. The anthropogenic SO_2 emissions rate of India is greater

than China in the upcoming decade because China adopted the Fuel-Gas desulfurization technology (FGD) to decrease current emissions (Li et al., 2017).

The relationship between economic growth and sulfur emissions are both (positive and negative). If the government will adopt strong implementation of rules and regulations, and to use environment friendly inputs for the production process. Their impacts are positive and overall GHGs emissions reduced. On the other hand, the use of dirty technologies for production processes have negative effects on the environment as well as also increase the sulfur emissions.

2.2 Foreign Direct Investment and Sulfur Emissions

Foreign direct investment (FDI) is a backbone for economic growth in developing countries. It enables to creates employment opportunities, improve the physical structure of the economy, to increase the productive capacity as well as enhance the labor skills through technological transformation. The most comprehensive outcome of FDI is to integrate the global and domestic economy. The increase in FDI leads to increased economic activities but their environmental consequences also in the form of positive and negative externalities. If the allocation of FDI in clean technology and environmental friendly, then impacts on the environment is positive. On other hand, if the allocation of FDI in old and dirty technology, then the impacts on the environment is negative.

The impacts of sulfur emissions associated positively with FDI and shows negative relationship between FDI and SO_2 emissions in case of Pakistan. In addition, the GHGs, CO_2 of solid fuel are positive related with FDI and increased the pollution emissions (Nadeem et al, 2020). The consequences of FDI on environment quality are very worse and the different studies shows their positive and negative relationship. Moreover, the findings of the study shows inverse relationship between FDI and environmental pollution like CO_2 and SO_2

emission (Demena & Afesorgbor, 2020; Adamu et al, 2019). Second, when the inflow of FDI is increase the spending related to pollution control equipment also increase because the investors were motivated towards clean technology (Sharma, 2014).

The impact of FDI on SO_2 emissions is significantly positive but the value is very small. When the FDI capital stock increased by 1 percent, the changing response in industrial SO_2 emissions is 0.099 percent increase. In China, it seems a comprehensive increase in environmental regulations and that affects the FDI inflow due to different restrictions. In addition, the composition transformation influences FDI dominated by the inflow of foreign capital pursing, which provide a good environment for investment (J. He, 2006). The inflow of FDI in the developing nations has quite increased in the last few decades. The relationship between FDI inflow and pollution is negative in case of new industries set up because of environmental regulations and more advanced technologies, which emitted less pollution. At the same time the relationship between both the variables are positive by the existing old industries setup that caused the sulfur emissions in Mexico. The consideration is very important for national and international firms, when the firm makes decisions related to FDI (Waldkirch et al, 2008). The previous literature escapes the theoretical dependency of emissions across trans-boundary decomposition, where the host country emissions are less than the foreign countries contribution in emissions. The EKCs exist for a long period in the European countries for SO_2 emissions. The spatial lag showed and tracked the per capita emissions characteristic of transboundary of the per capita income level irrespectively (Maddison, 2007).

To check the relationship between FDI and SO_2 emissions in the Beijing-Tianjin-Hebei region China. The results suggest that the impacts of FDI on SO_2 emissions are negative and refers to the results of (Kirkukulak et al., 2011), that means the FDI reduces SO_2 emissions. If the FDI increases by 1 percent, the SO_2 emissions decreases by 0.84 percent. In addition, if the government implements proper environmental regulations and encourages clean and more

energy efficient industries to sustainable economic growth (Zhu et al, 2017). FDI stocks have a positive relationship with pollution in Latin America. When the FDI increases by 1 percent, the pollution increases by 0.036 percent because the FDI is the backbone of the developing countries in the eyes of economic growth (Sapkota & Bastola, 2017).

Recently the study had conducted in China to show the nexus between regional corruption, FDI and environmental degradation. Further, it shows significant longitudinal clusters results in environmental pollution. The results of panel data models disclose that the FDI coefficient is extensively negative and FDI inflow of China minimizes environmental pollution. The Regional corruption proved that which increased and contributed further to environmental degradation. The interaction term of FDI and regional corruption is substantially positive, indicating that the regional corruption reduces the environmental advantages derived from FDI. In addition, the regional variations in spatial consequences verify that regional corruption additionally reduces the environmental overall performance of FDI in the central region. Meanwhile, the regional corruption increases the environmental aggravation results of FDI in the eastern location but weakens it in the western region (Tang et al., 2020). However, the FDI has influenced the pollution in both (short & long) run in case of sulfur and carbon dioxide emission in China (Jun et al., 2018).

The FDI is like a power engine of economic growth for the developing nations but the environment is also important. The government must increase the inflow of FDI but also needs to establish and implement such as effective policies, rules and regulations for environment protection that cannot discourage the FDI inflow in the host country.

2.3 Trade Openness and Sulfur Emissions

Trade openness is the combined volume of imports and exports of the country. Trade openness creates many opportunities to establish sustainable economic growth, creates many job opportunities for employment, and increases the foreign capital inflow. The integration of global economies is the powerful tool to raise economic growth, improve the living standard and reduce poverty and hunger. Trade is playing an important role to achieve the Sustainable Development Goals (SDGs)[18]. Whenever the trade volume is high, the environmental degradation is also high. The relationship between trade and environment is the critical issue in the eye of trade policy that has the most debatable topic. The impacts of international trade having significantly small changes in SO_2 concentration. When trade liberalization increases, the GDP per capita increases by 1 percent and pollution decreases almost 1 percent. There is an indirect relationship between them and positive impacts on the environment. The income growth has a positive impact on the environment because the country adopted clean and green technologies (Antweiler et al., 2001).

The previous literature shows positive and negative relationships between trade liberalization and environmental degradation. In 2017, (Shahbaz et al, 2012) explored the linkages between trade openness and GHGs emissions especially CO_2 have positive and reduced levels of emissions. If the transformation of technology has clean and environment friendly, and their impacts are positive otherwise negative. The SO_2 emissions caused by the population distribution and regional collection of socioeconomic activities. The overall SO_2 emissions are decreasing but the emissions of developing provinces are increasing. When economic growth is increased, the SO_2 emissions and other GHGs emissions are starting to be

[18] The Sustainable Development Goals (SDGs), also called the Global Goals, were adopt by all the United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030.

reduce due to increasing the demand for a clean environment. In addition, the relationship between SO_2 emissions and economic growth is inverse due to technical progress and advancement in technologies. Further, the industrial structure changes have significant effects on SO_2 emissions (Zhou et al., 2017).

The positive relationship between manufacturing share of GNP[19] and environment quality and the high level of per capita income does not affect the environment quality. The dirty imports have negative impacts and exports are significantly positive. It suggests that the production of pollution intensive goods is decreasing in the Southern Region. However, the exports have positively influenced the SO_2 emissions levels. In OECD countries, the linkages between trade openness and environment are positive, which elaborate the trade openness decrease the emissions level because of adaptation of clean technologies transformation (Cole, 2004).

The impacts of North American Free Trade Agreement (NAFTA) on environmental quality depends upon the overall mass of economic activities, technology change for production of goods & services, and inter-sectoral composition economics activities. The sulfur dioxide emissions are lower with trade liberalization and there are no statistically effects between trade and environment. NAFTA negatively affects environmental quality and creates pollution in the USA and Mexico (Yu et al., 2011). They found that GHGs emissions are increases due to NAFTA[20] between Mexico and the USA. In 1995, after the implication of NAFTA, the GHGs emissions of Canada decreased and the USA and Mexico increased the GHGs emissions. The per capita emissions of Mexico are lower and higher in the USA and

[19] GNP stands for Gross National Product

[20] The North American Free Trade Agreement (NAFTA) was implemented in order to promote trade between the U.S., Canada, and Mexico. The agreement, which eliminated most tariffs on trade between the three countries, went into effect on January 1, 1994. Numerous tariffs–particularly those related to agriculture, textiles, and automobiles–were gradually phased out between January 1, 1994 and January 1, 2008.

Canada before NAFTA. The results suggest that the FTA's amongst the developing nations are improving the environmental quality but the overall trade affects the environment. The FTA[21]' between developed to developing nations increases the GHGs emissions (Nemati et al., 2019).

Trade is necessary for economic development because without trade openness, the countries cannot increase economic growth and to improve living standards. The environment is an important subject in case of GHGs emissions, which increase global warming and climate change as well as damage natural biodiversity. We needs sustainable economic growth and an environment because both are essential for human beings.

2.4 Electric Energy Production and Sulfur Emissions

In the developing world, the common resources used for energy production are coal, gas and fossil fuel. The linkages between economic growth and environment is so long axiomatic. Economic growth increases as resulting in the demand for energy also increased. The dominant resources used for energy production are highly degradable and affect environmental quality badly. All these natural resources are the main source of anthropogenic sulfur emissions. The SO_2 emissions per energy use are decreasing due to desulfurization technology such as oil and natural gas by adopting the less ambient air pollution technologies like FGD. They also convert the more pollutant technology in low sulfur fuel. The SO_2 emissions trend in China has not shown any changes over the time. Where the country decreases the total emissions while Japan decreases 75 percent over 20-years by environmental regulations. The SO_2 emissions volume of China in 1999 is three times higher than Japan in 1975 due to the tightening of environmental regulations. There are negative impacts of past per capita GDP on emissions when Japan adopted the environmental policy for reduction of

[21] A free trade agreement (FTA) is a pact between two or more nations to reduce barriers to imports and exports among them.

emissions. There are no effects neither on per capita income nor past energy consumption on SO_2 emissions factors and energy consumption for both countries (Yaguchi et al., 2007).

The impact of energy intensity is positive on SO_2 emissions. The marginal impacts of population on SO_2 emissions are increasing trend. Greater the population level leads to increased SO_2 emissions and non-linear effects of total population size on SO_2 emissions (Cole et al., 2004). During 1990-2015, the consumption of total energy increased as a result 4 times in China, 3 times in India and 2 percent increased GHGs emissions in Japan at the level of the 1990s. The SO_2 emissions are increasing because the coal power plants play a vital role in economic growth. In the 2005s, the SO_2 emissions declined by the intervention of environmental regulations and adopted the Fuel-Gas desulfurization (FGD) technologies but still the emissions of India shows an increasing trend (Rafaj et al., 2018).

The previous literature shows that there are two sources of air pollution such as anthropogenic and natural sources. The major anthropogenic sources are fossil fuel, oil and gas combustion. The sources of SO_2 emissions are different for every country suppose that in Bangladesh are vehicles, bricks, pulp, paper industries, and sulfuric acid production plants. In Bhutan households and in India the major source of SO_2 emissions are refineries, textile, pulp, paper and industrial chemicals contribute 87 percent sulfur emissions. Nevertheless, in Pakistan and Nepal the sources of SO_2 emissions are vehicles because the coal usage in both countries is less as compared to their neighboring countries (CAI-Asia, 2010).

The air pollution in Asia has accelerate dramatically throughout the last six decades, but situations had been different amongst countries and regions. Due to China's rapid economic growth in current years, it is a relative largest contribution of emissions in Asia. However, most pollutant species reached their peaks through 2015 and the increase rates of different species decreased or nearly zero. The air pollutant emissions from India showed a nearly continuous

growing trend. As a result, the relative ratio of emissions of Asia have multiplied recently. The style located in Japan was once distinctive from the rest of Asia. In Japan, emissions expanded rapidly for the duration of the 1950s-1970s, which reflected the financial state of affairs in this period; however, most of emissions reduced from their top values, which were about 40- years ago, due to the introduction of rules and laws for air pollution. In the case of other Asian countries, air pollutant emissions typically show an expansion alongside financial boom and motorization (Kurokawa & Ohara, 2019).

The economy and population size of India is continuously increase and the biofuel is the major source for energy consumption in India and around 87 percent households use the biofuel. During 1985-2015, (World Resource, 1993) the wood fuel is the only source predicted to increase in India. These biofuel dramatically change the concentration of SO_2 and NO_x in India (Gadi et al., 2003). The projection shows that the sulfur emissions in Asia might increase to 80-110 TG by 2020. However, the SO_2 emissions in China and Japan are going to decrease and the decomposition of acid will diminishing. The health problems related to SO_2 emissions are declining because of the advancement of technology but the global warming expectancy is increasing (Carmichael et al., 2002).

Energy plays a key role for economic growth in developing countries and natural resources such as coal, gas and fossil fuel are the main resources used for energy production in developing nations. The use of these resources have moreover their environmental consequences in the form GHGs emissions. It needs a sustainable energy production system to maximize and overcome the demand for energy such as renewable energy sources like hydro, solar and nuclear.

2.5 Population Growth and Sulfur Emissions

Population plays an important role in the development process of the country. According to Adam Smith, population growth is the basic element of wealth. In addition, some of the other world leaders argue that the relationship between population growth and economic development is a very complex issue in the early decades. If the growth of population increased, the number of working population also increased and led to a massive labor force. Second, the increasing population means that the market size increased for goods and services. There are also some negative consequences of increasing population. The growth of population builds pressure on natural resources and economic resources of the countries. The relationship between population and GHGs emissions are very close to each other. Empirical studies, which explicitly examine the link between population and pollution in a systematic quantitative manner are very few in number. Cramer (1998, 2002) and Cramer and Cheney (2000) examine the impact of population levels on air pollution in California and conclude that population is closely associated with some sources of emissions but not with others. The relationship of population growth is positively associated to GHGs emissions and other pollution (Cole & Neumayer, 2004; Shikwambana & Tsoeleng, 2019).

2.6 Natural Source of Sulfur Emissions

The main sources of sulfur emissions are two such as anthropogenic and volcanic eruptions. The literature shows so many studies to find out the relationship between volcanic eruptions and sulfur emissions. The natural source of SO_2 emissions are volcanic eruptions, which also contribute to global emissions. Their percentage is 30 percent and anthropogenic is 70 percent contribution in total SO_2 emissions (Shen et al., 1975). The concentration of SO_2 emissions varies in stack gases. The SO_2 emissions depends upon the amount of sulfur contained in substances and other compounds where the sulfur is present. Fossil fuel and coal combustion is the main source of SO_2 emissions and highly degrades biodiversity.

In 2004, the study shown the impacts of volcanic eruption on sulfur emissions to used satellite based data. The result shows significant impacts of volcanic eruption on sulfur emissions. The SO_2 column density temporal trend has increased 70 percent (8.7 per year) overall in Pakistan by the period of 2004 to 2012 by the eruption of Nabro Volcano. Which means that humans are not only responsible for the global sulfur emissions but nature also contributes to it (Khattak et al, 2014). There are 491 sites identified around the world, where both the anthropogenic and natural sources of SO_2 emission trajectories release 30 kty^{-1} to 4000 kty^{-1} per year. The volcanic sources are 7 and 279 sites of power plants; smelters are 5 and 65 sites of oil & gas industries identified. The emissions of the power plants and smelters reduced over time but the emissions of the oil and gas industries are quite constant. Almost 30 percent of sulfur emissions from volcanic eruption and the remaining 70 percent is the anthropogenic source. The SO_2 emissions of the USA decreased by 80 percent in the period of 2005-2014 but the emissions of India doubled in this period (Fioletov et al, 2016).

The impacts of SO_2 emissions are very adversely on human health. If the SO_2 emissions decrease by 10 percent from coal-fired power plants, the cardiovascular diseases (CVD) decreases by 0.75 percent. It means that there is a direct relation between them. The CVD reduction in women is high as compared to men. The health cost of sulfur emissions related diseases is very high as compared to adopting the Fuel-Gas Desulfurization (FGD) technologies for desulfurization. In monetary terms, the profit margin for coal-fired power plants is less the cost of health due to sulfur emissions (Lin et al., 2018).

The humans are responsible for the increasing trend of sulfur emissions but according to David Stern (ADEH, 2008); later on, the natural source is increased sulfur emissions. The forms sulphate aerosol that cools the earth locally if in the lower atmosphere and globally if in the upper atmosphere (stratosphere). In addition, mostly sulfur emissions will be produce due to large volcanic eruptions rather than anthropogenic pollution.

Summary:

The economic growth is the key indicator of healthy economy and easily guess the life standard of their population and other indicators the economy. However, the increasing GHGs emissions also associated with these activities. When the economic activities increase, the production and consumption of good and services leads to increase. The demand of energy is increase and the main inputs used for energy production are natural resources in SAARC countries including coal, natural gas and fossil fuel. These resources are highly environment polluted and increase the concentration of sulfur emissions as well as air pollution. The relationship between economic growth and sulfur emissions are unidirectional. The existing literature support both the relationship (positive and negative) among variables and there is many factors, which determined the relationship between them. The relationship between other economic indicators also influence the sulfur emissions. Whenever, the trade liberalization and FDI volume increase or decrease, the sulfur emissions will be change and the increasing population should be increase sulfur emission and other GHGs emissions. In addition, the increasing population build pressure on natural as well as economics resources. We need to explore the new avenues for investment and economic growth, where we sustain the growth and environment both.

Chapter No.3

Data and Methodology

3.1 Theoretical Framework

Economic development is very important for every nation to improve the living standards' of population and to increase the national income. Whenever economic activities upsurge as a result GHGs emissions and other harmful pollutants increase, which change the global average temperature. The increasing temperature treats the survival of human beings and other species. The sulfur emissions are mainly produce by the combustion of natural resources including fossil fuel, coal and natural gas and their resources are use as inputs for energy production in economy. When the population increase, the economic activities also increase and GHGs emissions are highly associated with economic activities. Therefore, the sulfur emissions is the function of economic indicators.

$$Y = f(\ Ei, P)$$

Y shows the total sulfur emissions, E_i shows the economic indicators, which are GDPg, FDI, Trade Openness and energy production. P shows the population growth rate.

3.2 Study Area

This study conducts in SAARC countries such as Pakistan, Bangladesh, India, Sri Lanka and Nepal but we exclude Afghanistan, Bhutan and Maldives due to low level of sulfur emissions and other economic indicators data. The purpose of this study to scrutinize the relationships between the sulfur emissions and economic indicators like GDP growth, FDI, trade openness and energy production (EEp) and population growth (POPg).

3.3 Data Sources

This study examined the relationships between SO_2 emissions and economic indicators like GDP growth, FDI, trade openness, population growth and energy production (EEp) in

SAARC countries. The study used panel data for SAARC countries from 1975-2018. Some economic indicators data collected from the World Development Index (WDI). In addition, the study used data of sulfur emissions taken from the Community Emissions Data System (CEDS) for SAARC countries from 1975-2014 shared by third party David Stern[22]. However, the study further extend the data to 2018 through trend value. The total observations are 220 for the SAARC countries and 44 observations for each country.

3.4 Methodology

3.4.1 Estimation Strategies

Panel Unit Root Tests

To check the stationarity of the data series (SO_2, GDPg, FDI, TO, POPg, and EEp) through Panel Unit Root Tests such as LLC, IPS and Breitung unit root tests. According to Pedroni (1999), when panel data exceed the fifteen years, then characteristic of panel data converted into time series nature that's why the unit root is an essential to investigate the integration order of the underlying all series. Secondly, used the panel cointegration tests to investigate the long-run relationship amongst variables. If the results reject the null hypothesis is. H_0, which means that there is cointegration amongst variables.

To check the stationarity of the variables by using the panel unit root tests. The previous literature used different unit root tests for panel data, but this study used Levin-Lin-Chu (2002)[23], Im, Perasan and Shin (2003) and Breitung (2000) for panel unit root tests. The table no.3.2 shows the results of three different panel root tests with constant and trend. The initial results suggest that all the data series are statistically insignificant at level but statistically significant at first difference of level.

[22] David Stern is a professor in the Crawford School of Public Policy at The Australian National University.

[23] Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. Journal of Econometrics, 108(1), 1–24. https://doi.org/10.1016/S0304-4076(01)00098-7

Table: No 3.1 Results of Panel Unit Root Tests

		I(0)			I(1)		
Variables		**LLC**	**IPS**	**Breitung**	**LLC**	**IPS**	**Breitung**
SO_2	Constant	-0.2659	2.5284	-	-14.6824*	-13.221*	-
		(0.395)	(0.994)		(0.000)	(0.000)	
	Constant	-0.7876	-0.2720	-1.2012	-14.1636*	-12.6881*	-9.5984*
	and Trend	(0.2155)	(0.392)	(0.1148)	(0.000)	(0.000)	(0.000)
GDP_g	Constant	0.5922	1.1149	-	15.255*	23.1895*	-
		(0.7232)	(0.1324)		(0.000)	(0.000)	
	Constant	1.2217	-1.9331	-0.3659	13.3768*	23.0994*	-11.0365*
	and Trend	(0.8891)	(0.1266)	(0.3572)	(0.0168)	(0.000)	(0.000)
FDI	Constant	1.2234	0.7896	-	9.3827*	-10.7806*	-
		(0.110)	(0.2149)		(0.000)	(0.000)	
	Constant	-0.5975	-0.3574	-1.0482	8.0143*	-9.8530*	-3.4723*
	and Trend	(0.2751)	(0.3604)	(0.1472)	(0.000)	(0.000)	(0.000)
TO	Constant	0.3277	0.2002	-	-12.8538*	-12.1808*	-
		(0.3718)	(0.5793)		(0.000)	(0.000)	
	Constant	0.4419	0.5872	-0.5072	-11.9878*	-11.3488*	-5.9556*
	and Trend	(0.6708)	(0.7215)	(0.3606)	(0.000)	(0.000)	(0.000)
EE_p	Constant	2.0317	-0.6796	-	-15.2715*	-15.2051*	-
		(0.4789)	(0.2484)		(0.000)	(0.000)	
	Constant	-1.2394	1.2551	0.78621	-15.2513*	-15.2423	-8.9279*
	and Trend	(0.1107)	(0.8953)	(0.2159)	(0.000)	(0.000)	(0.000)
POPg	Constant	0.2006	0.8052	-	-7.4315*	-5.3664*	-
		(0.5795)	(0.7906)		(0.000)	(0.000)	
	Constant	1.6939	-0.2513	2.1197	-7.4591*	-2.9986*	-3.3646*
	and Trend	(0.9549)	(0.4008)	(0.9830)	(0.000)	(0.001)	(0.004)

Note: *, ** and *** indicate level of stationarity 1%, 5% and 10%.

The study used the Pedroni cointegration tests for long run relationships. (Pedroni, 1999, 2004)[24] suggested seven different cointegration panel tests and the results of cointegration tests are reported in below table no 3.2. The cointegration tests are statistically significant; six tests are significant out of eleven tests. It means that the variables are highly

[24] Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Econometric Theory, 20(3), 597–625. https://doi.org/10.1017/S0266466604203073.

cointegrated with each other. There are long run relationships between economic indicators and sulfur emissions.

Panel Cointegration Tests

Table No: 3.2 Result of Pedroni Cointegration Tests

Panel Statistic	**Statistic**	**Prob.**	**Statistic**	**Prob.**
Panel v-Statistic	-0.308	0.620	-0.979	0.836
Panel rho-Statistic	0.739	0.770	0.890	0.813
Panel PP-Statistic	-3.061	0.001*	-1.909	0.028**
Panel ADF-Statistic	-2.633	0.004*	-2.034	0.020**
Group Statistic	**Statistic**		**Prob.**	
Group rho-Statistic	2.312		0.989	
Group PP-Statistic	-2.868		0.002*	
Group ADF-Statistic	-1.862		0.031**	

Note: *, ** and *** indicate level of stationarity 1%, 5% and 10%.

Figure No. 3 Schematic Diagram of Econometric Model

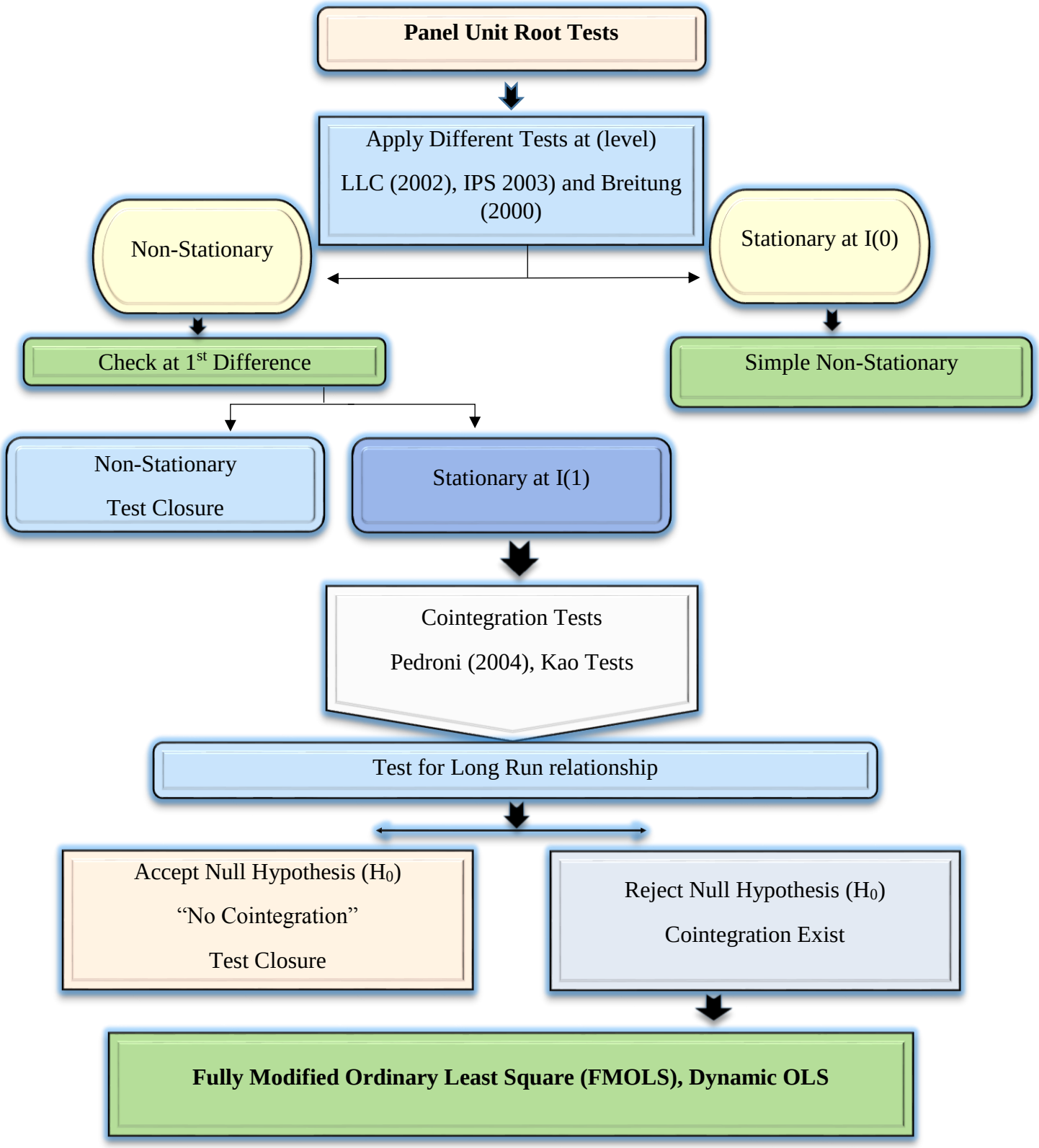

Table No.3.3 Econometric Models

Models	References
ARDL	(Mugableh, 2013; Teame, 2017; (Demena & Afesorgbor, 2020; Ullah & Awan, 2019)
FMOLS	(Al-mulali & Foon, 2013; Nemati et al, 2019; Pedroni, 2004; Ullah & Awan, 2019; Zandi & Haseeb, 2019; *Fizza & Hafsa*, 2019; Salman, 2018; Canan et al, 2015; Intisar et al, 2020)
GMM	(Al-mulali & Foon, 2013; Perkins & Neumayer, 2008; Sapkota & Bastola, 2017; Ullah & Awan, 2019; Zandi & Haseeb, 2019; He, 2006)
DOLS	(Adamu et al, 2019; Imdad, 2014; Nemati et al, 2019)
EKC	(Fosten et al, 2012; Llorca & Meunié, 2009; Sapkota & Bastola, 2017; Stern & Crawford, 2015; *Fizza & Hafsa*, 2019; Cole, 2004; Yaguchi et al, 2007)
PVECM	(Nemati et al, 2019; Adamu et al., 2019; P. He et al, 2019; Ullah & Awan, 2019)

Source: Author

The above table no.3.3 shows the different econometric models, which used in literature in case of panel data analysis. The aims of this table just mention the previous studies, which used different model estimators for analysis.

3.4.2 Descriptive Statistics

Table no.3.4 contains the detailed summary of each variable. The values of mean and median are almost near to each other in all variables. The average value of SO_2 emissions is 5.37 with a standard deviation of 2.09. The maximum and minimum values of SO_2 emissions are 9.72 and 2.17, the maximum value shows the countries where the SO2 emissions are very high, and the minimum value shows the countries where the SO_2 emissions are low in panel countries. The maximum value of the GDP around 5.02 percent and minimum value is -2.97 percent, which indicate the negative growth of the economy in panel countries. The maximum

and minimum value of FDI is 3.66 and -0.09 percent, which again shows the negative growth. The trade openness have maximum value 88.63 and minimum value 10.99 percent. The maximum value of EEp is 99.94 percent of the total energy production from coal, natural gas and fossil fuel in the panel countries. The population growth rate maximum value is 3.36 percent per year, where the fertility rate is very high as compare to death rate.

Table No.3.4 Descriptive Statistics

Variables	**LNSO2 (KT)**	**GDPG (%)**	**FDI (%)**	**TO (%)**	**EEP (%)**	**POPg (%)**
Mean	5.374851	5.072443	0.653911	39.74436	51.44581	1.849841
Median	4.822294	5.026404	0.478691	35.32827	60.67374	1.986906
Maximum	9.729724	10.21570	3.668323	88.63644	99.94158	3.363941
Minimum	2.176344	-2.977406	-0.098375	10.99563	0.005950	-0.266960
Std. Dev.	2.090013	2.074914	0.713012	18.28704	33.87098	0.764519
Observations	**220**	**220**	**220**	**220**	**220**	**220**

Source: Author

3.5 Econometric Model

Econometric model based on the results of unit root tests and cointegration tests. The result shows that the entire series are stationary at first level and highly cointegrated with each other. Therefore, the study used a fully modified OLS estimator for the analysis. The FMOLS model is a semi-parametric model and captures both the effects of linear and non-linear. In literature, different econometric models used in case of panel data. The above table no. 3.3 shows different models such as (Canan et al, 2015) used Fully modified OLS and DOLS method to analyzed the long run relationship between primary energy consumption and economic growth for central Asia Turkish Republics and Turkey because the OLS estimator is biased after apply the cointegration test. In this case, the Pedroni (1995) suggest the DOLS and

FMOLS (Zandi & Haseeb, 2019) for a long run relationship. (Salam, 2018)[25] also used the FMOLS[26] to investigate the long run relationship between the FTA and environmental pollution for Pakistan.

3.6 Mathematical Model

According to previous literature the sulfur emissions is the function of GDPg, FDI, TO and the energy production and population growth added in the model (Stern et al., 2017)[27].

$$(lnSO_{2it}) = \beta_1 GDPg_{it} + \beta_2 FDI_{it} + \beta_3 TO_{it} + \beta_4 EEP_{it} + \beta_5 POPg_{it} + \mu$$

Where LN is the log of variables, *i* indicate the countries and t = time.

Variables	Explanation and Units
$lnSO_2$	*Sulfur Dioxide Emission (Percentage)*
GDP_g	*GDP growth (Annual Percentage)*
FDI	*Foreign Direct Investment (Percentage of the GDP)*
TO	*Trade Openness (Percentage of the GDP)*
EEP	*Electric Energy Production (Percentage of total energy)*
POPg	*Population growth rate (Percentage)*

3.7 Description of Variables

1. **Sulfur Emission (SO_2):**

Sulfur emissions data is the annual basis for each country of the SAARC. The SO_2 emissions is a dependent variable and the unit of measurement is kilotons (KT). The source of data is third party David Stern[28], the paper of Steven Smith (Klimont et al., 2018).

[25] Salman, A., Sethi, B., Aslam, F., & Kahloon, T. (2018). Free Trade Agreements and Environmental Nexus in Pakistan. *Policy Perspectives*, *15*(3), 179-195.

[26] Zandi, G., & Haseeb, M. (2019). *The Role of Trade Liberalization in Carbon Dioxide Emission : Evidence from Heterogeneous Panel Estimations*. *10*(5). https://doi.org/10.5430/ijfr.v10n5p228

[27] Stern, D. I., Gerlagh, R., & Burke, P. J. (2017). Modeling the emissions–income relationship using long-run growth rates. *Environment and Development Economics*, 1–26. https://doi.org/10.1017/S1355770X17000109

[28] David Stern is a professor in the Crawford School of Public Policy at The Australian National University. He is a research associate in CAMA and CCEP, and a participant in the Energy Change Institute. Interest area Energy economics, Economic growth, Economic history, Climate change, Meta-analysis, Bibliometric. https://anu-au.academia.edu/DavidStern/CurriculumVitae

1. **Gross Domestic Product Growth (GDPg):**

Gross domestic product growth is the overall economic activities in a country. The GDPg is an independent variable and the unit of measurement is percentage yearly. The data source of GDPg is the world development index (WDI).

2. **Foreign Direct Investment (FDI):**

FDI is the total inflow of capital made by an individual, firm and country for business interest with other countries. The FDI is an independent variable, the unit of measurement is percentage of GDP, and the data source of FDI is the World Development Index (WDI).

3. **Trade Openness (TO):**

Trade Openness is the total volume of imports and exports of the country and the contribution of imports and exports positively on economic growth. The trade openness is independent variables, the unit of measurement is percentage of the GDP yearly and the data source is WDI.

4. **Electric Energy Production (EEp):**

Energy plays an important role in economic growth of the country and most of the developing world uses coal, gas and fossil fuel for energy production. The EEp is an independent variable; the unit of measurement is the percentage of the total energy production.

Population Growth (POPg):

Population growth shows the growth rate of population increased, which means that the total number of individuals increased within the country. The population growth is independent variables, the unit of measurement is the annual percentage and the data source is WDI.

Chapter No.4

Exploratory Data Analysis (EDA)

Exploration data is the initial step to summarize the data by means of statistical and visualization techniques used for the better understanding of data.

4.1 Sulfur Emissions and SAARC Countries

South Asia is the fastest growing economic growth, population size, urbanization, modernization and industrialization, which leads to increased demand for energy consumption. The primary sources of energy production are coal, fossil fuel, natural gas, hydro, nuclear, biomass and other renewable resources. The combustion of thermal resources is the major source of energy production, which increase the GHGs emissions and affects the environmental quality as well as human health. The share of coal usage for energy production is very high because coal is cheap as compared to other resources and all the graphs of sulfur emission shows in graph no.4.1.

The trend of sulfur emissions in India is increasing and their sulfur emissions are high in the SAARC countries. The main source of sulfur emissions are the combustion of fossil fuel and coal in industrial and energy sectors. The economic growth and population size is rapidly increase, which leads to increase the sulfur emissions over the time. Pakistan is a developing nation and the population size is increasing but the economic condition is not much impressive and highly vulnerable for climate change in national and district levels (Rahman & Salman, 2013). The trend of sulfur emissions increased over the time from 1975-2018. The major source of sulfur emissions are vehicles. The share of fossil fuel and coal are high for the energy production by the increasing demand of energy consumption, which contributes to increase the sulfur emissions.

The population size, population density and economic growth of Bangladesh is high in SAARC countries and these factors leads to increase the level of sulfur emissions. The increasing demand of energy consumption also increases the sulfur emissions in Bangladesh. The primary sources for energy production are natural gas, coal etc. which contribute to 57.37 percent of the total energy. Therefore, the trend of sulfur emissions increased from 1975-2018. The share of sulfur emissions are low as compared to other SAARC countries. The main source of sulfur emissions are coal and petroleum products, which increased to the level of sulfur emissions in Nepal and Sri Lanka.

4.2 Gross Domestic Product Growth (GDPg) and SAARC Countries

The role of economic growth is very important in the development process for the improvement of living standards and increasing the national income of the country. Growth is also important to stabilize the macroeconomic indicators of the economy. The higher growth leads to increased income for government spending. The following factors which increase the growth such as natural resources, physical capital, productive labor force and human capital, technology and law & order and other factors which deaccelerate the growth rate like poor education and health, limited infrastructure, crowding out, political instability and no proper institutional framework as well as the World Trade Organization (WTO)[29]. The growth of South Asia is growing very fast as compared to other regions. The overall growth of South Asia declined 1.1 percent in the fiscal year of 2019 around 5.9 percent. Graph no.4.2 shows the GDP growth of the SAARC countries.

The Pakistan economic history is not impressive over the time. Pakistan is a high populous country in South Asia and most of the population rely on agriculture income as well

[29] The World Trade Organization (WTO) is the only global international organization dealing with the rules of trade between nations. At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations and ratified in their parliaments. The goal is to help producers of goods and services, exporters, and importers conduct their business

as agriculture based industrial sector. After 1947, Pakistan was known as an agrarian economy and the share of agriculture in GDP was 53 percent from 1947-50's. Around 65 percent of labors engaged in agriculture sector and the agriculture output share in exports was 99.2 percent and 90 percent of foreign exchange earned for that sector (SBP[30], 2010; Zaidi, 2005; Anjum & Sgro, 2017). Since the 1950's was known as the transformation era of traditional economy into industrialization. Pakistan launched the Colombo Plan in 1951 and adopted the imports substitutional policy. In the fifties' "*the Korean War*[31]*"* increased the demand of private and public trade, which accelerated the industrialization process but still increased dependency on foreign aids around 500 million USD from 1955-1958. In the late 50's and early 60's the total exports of Pakistan was decreased due the Pak-Indo War of 1965, which badly hit the economic growth of both the countries to create a huge gap in balance of payment. In the 60's the total poverty level decreased by 4.6 percent and the average GDP growth rate was 6.7 percent per annum due to the large scale of the manufacturing sector of Pakistan. The era called Socialism, the economic growth was in a worse position and the poverty level increased by 55 percent in the 70's. At the same time the Global crisis of oil, floods, failure of cotton crop and high level of inflation, which increased the fiscal deficit and trade deficit. The historic mistake made by Socialist regime to adopt the nationalization policy, which extremely affected the foreign and local investors. Interestingly, at that time the large economies preferred to privatization policies to sustain the growth. The military regime revised the policies and adopted the denationalization, deregulation and privatization policies. The era so-called revival of the Pakistan economy is the 1980's and the average GDP growth 6.3 percent per annum. The ratio of poverty also decreased about 29.1 percent and unemployment decreased by 3.7 percent in

[30] SBP stands for State Bank of Pakistan

[31] The Korean War began on June 25, 1950, when some 75,000 soldiers from the North Korean People's Army poured across the 38th parallel, the boundary between the Soviet-backed Democratic People's Republic of Korea to the north and the pro-Western Republic of Korea to the south.

the 80's. Again, Pakistan faced a debt crisis in 1990's due to political instability and the foreign remittances declined. Since the 2000's, the situation was almost same, Pakistan faced economic crisis due to many factors but global crisis of 2009-2010 and terrorism was one of them. The journey towards industrialization was very expensive for Pakistan because the agriculture sector continues ignoring over the time and the contribution of agriculture around 18.5 percent in 2019. One reason for the declining share of the agriculture sector is that farmers cannot consider climate change as a potential threat to agriculture (Salman et al, 2018). The GDP growth is 2.4 percent the fiscal year of 2019.2020. The present regime sincerely worked to maintain and to increase the GDP growth but still failed to overcome these problems.

India is one of the big economies in the world and third ranked in Purchasing Power Parity (PPP). India also the member country of BRICS[32] and G-20[33] (Anand, 2014). The population of India is very large and the good thing about the population is around 700 million people are young age (World Population Prospects, 2018). Since 1947, the average GDP growth is 3 percent per annum and the era of the 1960's and 70's was called "*Hindu rate of growth*[34]" (Arvind Virmani, 2005). The government of India faced two main problems such as poverty and lack of resources. The economic growth of India grew in the late eighties' and 6 percent growth per annum from 1990-2005. India achieved too much in the past 50 years and now the economy is more stable and more integrated with global economies. By increasing the growth, many sectors like agriculture, services and industrial, which rose the productivity of

[32] BRIC is an acronym for the developing nations of Brazil, Russia, India, and China - countries believed to be the future dominant suppliers of manufactured goods, services, and raw materials by 2050.

[33] The Group of 20, also called the G-20, is a group of finance ministers and central bank governors from 19 of the world's largest economies, including those of many developing nations, along with the European Union. Formed in 1999, the G-20 has a mandate to promote global economic growth, international trade, and regulation of financial markets.

[34] The term 'secular' rate of growth (which connotes long-term trend growth) is well established in literature of development economics. (It is use in the sense of a religious belief, practice and process of the State). In distinctive contrast, 'Hindu' rate of growth was coin to refer to the phenomenon of sluggishness in the growth rate of Indian economy (3.5 per cent observed persistently during 1950s through 1980s).

labor and total production. According to the India Reserve Bank, the GDP growth was 8.8 percent per annum in 2004-2008. The foreign direct investment played an important role to boost the growth of the economy. The current GDP growth of India is around 5 percent against an estimated 6.8 percent in the previous year.

Bangladesh is one of the country, which create the most successful economic story in the world. The population is very high, most of the population depend upon agriculture, 77 percent population lived in rural areas, and agriculture is the main source of income (Mohajan, 2014). After the independence war with Pakistan, the physical capital of Bangladesh had completely abolished. Bangladesh was faced number problems in his basket like natural disaster, poverty and the biggest center of refugees in the world nearby 750,000 refugees due to *Myanmar religious conflicts*[35]. Despite all these, the economic growth is growing fast in the South Asia region and the annual growth rate of GDP is 6 percent per annual, will still increase around 7-7.8 percent in 2019-2020. In 1990's era the new civilian government revised the economic policies and established the concept of free market limited government intervention in economic activities, adopted the privatization policy and trade openness and transformation of technology. The policies initiatives motivate the foreign and local investors for investment and the remittance played a vital role in economic growth around 15 billion USD in 2018 (Bangladesh bank, 2019). The government taken many initiatives to improve the economy further like "Digital Bangladesh" [36] in 2009 and established the economic zones. The poor physical capital, inflation and political instability deaccelerated the economic growth of

[35] The Rohingya conflict is an ongoing conflict in the northern part of Myanmar's Rakhine State (formerly known as Arakan), characterized by sectarian violence between the Rohingya Muslim and Rakhine Buddhist communities.

[36] The Concept of Digital Bangladesh in 2009 refers to the Information and Communication Technologies (ICTs) being recognized as a powerful tool for socio-economic development. With appropriate policies, supplemented by realistic strategies, ICTs are known as to have brought tremendous welfare to people in terms of better access to information.

Bangladesh. The status of Bangladesh has changed in United Nations criteria, so called "least developed nation in 2024.

Sri Lanka is a developing nation and the main source of income is agriculture. The economic picture was not much shining over the past 50 years and we divided in three different era's. First, the 1948-1970's era, where this time the political regime adopted the mix of economic policies and development programs and against open economic policies (Henegedara, 2002). When the United National Party (UNP) regime came into power, they adopted the open economic policies but the same pattern of restriction on imports due to the limited exchange reserve of Bangladesh. In the late 60's, the new regime adopted the liberalization and nationalization policy and nationalized many private companies and firms. Second, the era called the "protectionist regime", which imposed restrictions on agriculture inputs and import of food items. The government tried to ensure food sufficient status (Henegedara, 2002). All these policies pushed the economic growth of Sri Lanka and the average growth around 6.1 percent per annum. After the civil war in Sri Lanka, which ended in 2009, was badly hit the growth of the economy and growth was record negative in this era. The GDP growth in 2019 is 2.6 percent due to terror attacks in Sri Lanka (Aslam et al, 2018)[37] and the growth have recover slowly and increase (ADB[38], 2019).

The objective of economic growth and social development to reduce poverty, increase national income and to improve the quality of life. Nepal is a small developing country and agriculture the major source of income. There are following factors which affected the economy of Nepal such as political instability, poor industrialization, energy crisis, limited flow of investment in the private sector, which sluggish the economic growth over the time.

[37] Aslam, F., Rafique, A., Salman, A., Kang, H. G., & Mohti, W. (2018). The impact of terrorism on financial markets: evidence from Asia. *The Singapore Economic Review*, *63*(05), 1183-1204.

[38] ADB stands for Asian Development Bank

The average growth rate of GDP in Nepal was 4 percent for the past decade (Government of Nepal, 2013). The role of agriculture is very important in the Nepal case, where most of the population is based on agriculture income and the agriculture growth around 3 percent from 2003-2013 (Bajracharya & Ph, 2014). The growth of Nepal was low over time due to low productivity, stagnation, high cost of transportation and energy crisis, which cannot provide the desired environment for investment. Tourism is the rising sector of the economy and contributed around 9.4 percent in Nepal GDP in 2012 and the current share is 7.9 percent in GDP. Second, the remittance share in GDP is around 33 percent in Nepal and 8.1 billion USD in 2018 (GON, 2013, 2018). The government of Nepal set the GDP growth target of 7 percent in 2022; the growth of Nepal was 4.2 percent on average during 1947-2012. Additionally, the growth was positive in the 80's and 90's but declined 4 percent due to civil conflicts. The GDP growth for 2019 is 6.2 percent and expected 6.3 percent in 2020 (ADB, 2019; Basnett et al, 2014).

4.3 Energy Production and SAARC Countries

Energy plays a vital role to increase the economic growth of the developed and developing nations. The primary resources for energy production in both the developed and developing nations are coal, gas, fossil fuel, nuclear energy and wind energy and solar energy used around the world. The natural resources like fossil fuel, gas and coal are the cheap resources used for energy production in the developing world. These resources are environmentally polluted resources and have adverse impacts on the environment and human health in the form of Greenhouse Gases (GHGs) emissions. However, those GHGs emissions create many problems such as climate change and global warming. Graph no.4.3 shows the energy production of SAARC.

Pakistan as a developing country always faced crisis related to energy. The primary resources used for energy production are coal, gas, and fossil fuel and nuclear power plants. In

the 1980's, almost 86 percent of energy was produced domestically and 14 percent imported from the rest of the world but now the mix is changing. The energy demand-supply gap increased in 2000's around 41 percent (Ghafoor et al., 2006). In addition, that gap decreased 18 percent in 2005. After the 1947's, Pakistan produced only 60 MW of the total production of energy. The established Water and Power Development Authority (WAPDA) in 1959. The capacity of energy production is 119 MW (Ministry of Finance Pak, 2019). After this Karachi Electric Supply Company (KESC) was working as a private firm producing and distributing energy in Karachi. However, the GOP controlled KESC in 1952 and added 30 MW energy in the existence system. In the 1966's the GOP established Pakistan Atomic Energy Commission (PAEC) for nuclear energy production and contributed 137 MW but the reactor is small. Since in 1980's the GOP added more 3000 MW electricity in the system Due to the construction of *Tarbela Dam* in 1976. In the early 1990's, Pakistan was able to produce 7000 MW electricity. In 1997, Pakistan established as NEPRA. The aims toward NEPRA to enhance the capital formation, improve the efficiency, settle the price, and developed competition strategic plans for private firms.

Table No.4.1 Energy Mix of Pakistan (percentage of the total energy)

Year	1990/91-2004/05	2013-14	2018-19
Thermal Source	64	64.2	63.55
Hydro Source	33	30.7	25.1
Nuclear Source	3	4.9	7.95
Other Source	-	0.2	3.4

Source: Ministry of Energy, Hydro center Development Institute of Pakistan, 2019

Pakistan heavily depends upon the thermal source of energy production; the cost of production is high. The share of hydro energy production was around 25.1 percent in 2019 but in the 1990's the share was 33 percent of total energy production of Pakistan. The cost of hydro source energy is very low comparatively and the potential of hydro energy power is very high

but the GOP have failed to produce more energy form this and shows a decreasing trend over the time. Pakistan produced 3.4 percent of energy from nuclear sources of the total energy production. The government needs to increase their capacity for nuclear energy and build new dams for energy production to decrease the demand-supply gaps and to overcome the energy crisis in Pakistan. The government must control the losses related to the energy sector like technical losses, illegal connection of electricity and minimize the inefficiency of power management systems.

India is the third largest consumer of energy in the world after China and the United State due to their growing economic growth dynamics and population size. The demand for energy increases day by day in India and they import energy from other countries. The production of energy is around 75 percent of the total energy in India (UN, 2015). The primary resources for energy production in India are Coal and fossil fuel. After independence in 1947's, the energy power sector of India was growing very fast and the total energy production capacity in this era was 1363 MW but that increased about 267 GW in 2015. The relationship between energy consumption and economic growth are highly coherent with each other. The energy mix of India over the time has changed. The use of coal is very high in India because most of the energy production based on coal-fired power plants.

Table No.4.2 Energy Mix of India (percentage of the total energy)

Years	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**
Thermal Source	92	70	70	75.4	64	62.8
Hydro Source	5	15	14	1.4	13	12.4
Nuclear Source	1	2	2	1.1	2	1.9
Renewable Source	2	13	14	22.1	21	23.4

Source: BP Statistical Review of World Energy, 2016; Renewable Energy Ministry of India, 2015; International Energy Agency, 2014, 2018; Energy Statistic, 2019.

The coal-fired power plants are the major source of anthropogenic sources emissions and India sulfur emission in SAARC countries is very high. The above table no.4.2 shows the energy mix of India from 2015-2019. The thermal source (gas, coal & oil) of energy production in India is very high. The cost of production is very cheap compared to other resources. In 2014, the share of thermal sources of energy production was 92 percent of the total energy production in India but that decreased to 62.8 percent. It means the dependency on thermal sources of energy is very high in India. India is also trying to increase the production from hydro sources and the share of the hydro sources is 12.4 in 2019. The trend of renewable energy sources is increasing over time, which is a positive indicator to decrease the dependence on thermal sources of energy.

Bangladesh is one of the most populous and high population density countries in the world around 164.6 million people live. Most of the population of Bangladesh depends upon agriculture. In the era of globalization, modernization and urbanization, every individual used the electric devices in daily life, which increased the demand for energy. The migration towards rural-urban in Bangladesh is very high, which increases the consumption of energy.

Table No.4.3 Energy Mix of Bangladesh (percentage of the total energy)

Years	**2013-14**	**2016-17**	**2017-18**	**2018-19**
Natural Gas Source	64	66.44	63.51	57.37
Furnace Oil Source	19	17.37	17.3	25.16
Diesel Source	7	4.59	7.21	7.23
Coal Source	3	1.76	2.7	2.75
Hydro Source	2	1.71	1.64	1.37
Power Imported	5	8.13	7.63	6.12

Source: (Annual Report BPDB, 2018) Bangladesh Power Development Board, 2019

Second, the average economic growth of a country is high, about 7 percent per annum as compared to SAARC countries. In the 1960's, Kapati Hydro power with the capacity of 40 MW. After independence of the 1971's, Bangladesh had only 3 percent access to electricity. Since 2012, one-third of the population still have no access to electricity in Bangladesh. The demand of energy increasing on average is 10 percent per annum over the time. In the above table, no.4.3 shows the energy mix of Bangladesh from 2013-2019. The major resource used for energy production in Bangladesh is natural gas and the share of gas in energy production is 57.37 percent in the fiscal year 2018-19. The share of furnace oil shows is 25.16 percent and shows an increasing trend during 2013-19. The share of diesel for energy production has fluctuated over the time in Bangladesh. However, the country's dependency on imported energy is increasing and the government of Bangladesh focused on increasing the share of renewable energy in the upcoming decade for energy production.

The average economic growth of Sri Lanka is 6.4 percent per annum and the fastest growing emerging economy in South Asia. The economic growth and modern urbanization increased the demand for energy in Sri Lanka. The primary source of energy production is coal, petroleum and biomass sources.

Table No.4.4 Energy Mix of Sri Lanka (percentage of the total energy)

Year	**2011-12**	**2013-14**	**2015-16**	**2017-18**
Petroleum Source	43	37	38.9	43.9
Biomass Source	44	43	39	36.5
Hydro Source	9	13	9	6
Coal	3	4	10	11
Others Source	2	3	3	3

Source: Ministry of Power and Renewable Sri Lanka, 2018

In the 1970's, biomass and petroleum were the dominant primary resources for energy production in Sri Lanka. However, the increasing demand of energy consumption built pressure in imported sources of energy (coal, petroleum) and reached 49 percent of the total energy production (World Bank, 2017).The above table no.4.4 shows the energy mix of Sri Lanka from 2011-2017. The share of petroleum and biomass energy sources dominate in the total energy production. In 2017, the share was 36.5 percent of the total and 44 percent in 2010. Therefore, it shows the decreasing trend over time. The share of coal used for energy production is increased and around 11 percent of the total energy.

Nepal is a very small country and almost hilly. The primary energy resources are biomass, hydropower, and coal and petroleum products for energy production. The biomass, especially the wood resource is very rich and there are no significant reserves of petroleum, coal and gas in Nepal. The government of Nepal imported the energy resources from other countries like coal, petroleum etc.

Table No.4.5 Energy Mix of Nepal (percentage of the total energy)

Years	**2010-11**	**2014-15**	**2017-18**	**2018-19**
Biomass Source	88	80	72	71
Hydro Source	1	3	4	2
Oil/Petroleum Source	9	12	14	18
Coal Source	-	4	7	5
Electric Source	2	1	3	2
Other Source	-	-	-	2

Source: SAARC Energy Outlook-2030 Annum Report, 2019

The above table no.4.5 shows the energy mix of Nepal from 2010-2018. The share of biomass energy sources is very dominant in the total energy production. The energy production

from biomass is 71 percent in 2018 and comparatively low as per the fiscal year of 2010 around 88 percent. The trend of biomass is decreasing and that shifted towards oil/petroleum sources and their shares in total energy is increasing around 18 percent in 2018. The other sources of energy are wind and solar and the share is only 2 percent in the total energy production.

4.4 Trade Openness and SAARC Countries

Trade Openness plays a vital role to promote the economic growth, increase national income and economic development of the countries. The expansion of exports is the major contributor to increase the economic growth of the developed world and most of the countries generate so many benefits from international trade like creation of employment opportunities, increase the volume of foreign exchange earnings etc. The trade within the South Asia countries is only 5 percent of the regional trade. In October 28, 2018 the report published by World Bank *"A Glass Half Full: The Promise of Regional Trade in South Asia*[39]*"* addressed the basic problems of trade within South Asia like non-tariff barriers, connectivity issues due to high cost, trust deficit and border tax alterations and the policymakers must address these problems to promote regional trade. South Asia recognized the world fastest growing region as compared to other regions to set the growth rate around 7 percent in 2019 and 7.1 percent in 2020-2021 expected growth rate (World Bank, 2019). To sustain that growth needs to increase the volume of exports and increase the integration with the rest of the world and multi international market and that is the key to sustainability in the growth rate of South Asia.

Pakistan always adopted economic reforms to decrease the imports of the country and expand the exports of the country but the results are very critical because those reforms lead to increase the trade deficit and bust up the gap in Balance of Payment (BoP) account. In the initial years, after the independence and 1950's to 1960's, the Government of Pakistan (GOP)

[39] The World Bank's recent report, A Glass Half Full: The Promise of Regional Trade in South Asia clearly illustrates the gaps between current and potential trade in South Asia.

introduced the imports substitutional policy and followed the different tools to improve the export flow like overvalued the exchange rate, introduced multi-exchange rate and trade bonus scheme. In addition, in the era of 1970's GOP adopted three kinds of policies to decrease the anti-export biases such as closure of export bonus scheme, ending of licensing system and devaluation of currency but that are not effective to decrease the biasness.

However, in the eighties the GOP struggled to restore the business in the country because after *Nationalization Policy*, their impacts are very worse because the domestic enterprises lost their confidence to run their business in Pakistan. The government introduced the Structural Reforms with aims of deregulating the economy and creating a liberal trade environment for local and international investors. The process of liberalization is continuing from the 1990's and in this era, GOP has decreased the tariffs and non-tariffs barriers on international trade (Ahmed et al., 2018). The policy of trade in 2000's are supports the export culture in the country. In 2010, the Pakistan current account went in surplus due to the high level of remittance received by the government of Pakistan and the exports of primary goods also increased in the textile and leather sectors of Pakistan (Umer, 2014). The impacts of trade liberalization are positive on the service sector of Pakistan (Khan, 2016). Since 2012-2015, the government introduced the *"Strategic Trade Policy Framework (STPF)*[40]*"* by the ministry of Commerce of Pakistan and ratified by the cabinet in 2013. The impacts of that policy are not significant and domestic producers faced losses due to market competition (Ahmed et al, 2018). The total volume of exports around 30.8 billion USD (United State Dollar) and the volume of imports are 74.1 billion USD in 2018 (WDI, 2019).

[40] The Pakistan Business Council (PBC) notes the Ministry of Commerce's ambition to enhance exports, as embodied in the recently issued Strategic Trade Policy Framework (STPF) 201518. A single stakeholder's ambition however, cannot be a strategy! A pragmatic and achievable strategy requires buy-in from all stakeholders. The Ministry of Commerce is to be lauded for leading the thought process. Unfortunately, in Pakistan's context, it is not the sole stakeholder in trade (especially exports) nor adequately resourced or empowered to deliver the ambition.

India faced a very serious macro-economic crisis in 1991 and that is the turning point of India, where they started moving towards economic development. Most of the trade liberalization policies and other economic reforms adopted in this era. India opened many sectors for foreign direct investment and built a comprehensive investment policy regime. Due to these policies, the Indian government increased the integration and volume of trade. They totally focused on integrating with global economies. That means greater trade openness leads to increased integration with other countries and reduced tariffs on international trade. The trade openness increased four times in the India economic history at the time of 1987-88 to 2012-13 (Roy et al, 2014; Singh, 2015). Recently in 2015, India announced Foreign Trade Policy under the administration of Modi's government in April-2015. The impact of that policy was quite good to improve trade and foreign investment towards the country. The total volume of exports of India is around 558.4 billion USD and the total imports are 694.9 billion USD in 2018 (WDI, 2018).

Trade is the prominent force for economic growth and directly correlated with FDI, foreign exchange rate, imports and exports. Bangladesh adopted very restricted policies after independence in the 1971's and these policies are highly based on tariffs and non-tariffs barriers on trade (Raihan & Selim, 2012). The government of Bangladesh followed different policies like overvalued the currency to support the import substitutions policy for the protection of local producers and to improve the BoP position of the country (Bhuyan & Rashid, 1993). However, in the 1980s, they adopted the moderate trade liberalization policies. Therefore, in the early 1990's, the government implemented a large scale of trade openness policy, which led to increased trade and also played a vital role in increasing economic development (Afzal, 2012). The trend of trade openness increased in Bangladesh over the time 1975-2018. The total exports of Bangladesh around 67.9 billion USD and the imports volume around 44.3 billion USD in 2018 (WDI, 2019).

Sri-Lanka is a good geographical location in Indian Ocean, which supported international trade and expanded the exports of the country. Since the 1977's, the government of Sri-Lanka adopted the trade liberalization policy. The outcomes of this policy was highly significant and positive on economic performance and the economy of Sri-Lanka moving towards betterment. The second phase of trade liberalization in 1990's and the growing infrastructure development in rural sectors promoted the Small and Medium-sized enterprises (SME's) under the new set of policies. The integration of Sri-Lanka within South Asia is very limited due to the lack of connectivity. The insufficient connectivity and trade tariffs in the region affect trade as well as also increased the cost of trade. The total exports of Sri-Lanka are 20.5 billion USD and imports are 29.5 billion USD (WDI, 2019; Herath, 2018).

Nepal is a small economy and landlocked country and located between two big economies India and Bangladesh, where the speed of economic growth is very fast and high (World Bank, 2019). In South Asia, Nepal is much liberalized and totally depends upon trade, but the status of international trade is not balanced because the volume of imports are higher than exports volume, which increases the trade deficit. The main reason for increasing the trade deficit is less exports and the profit margin is much lower as compared to other countries exports. In the early 1960's, the Nepal government adopted import substitution policies and exports diversification. In addition, they further took initiatives to introduce a dual exchange rate system in the 1970's. According to (Santos-paulino et al., 2004), the impacts of trade liberalization policies are negative in all developing countries, who adopted those policies and Nepal is one of them. The liberalization era started in Nepal during 1980's to 1990's. In the initial stage Nepal did trade with two countries India and Tibet but the trade relationship of

Nepal was shrike in *Rana Regime*[41]. In 2018, Nepal total exports around 3.3 billion USD and imports 15.3 billion USD (WDI, 2019).

4.5 Foreign Direct Investment and SAARC Countries

Foreign direct investment (FDI) is very important for developing nations to stabilize economic growth and it is working like a fuel of an engine for economic growth. Pakistan always faced the financial crisis over the time and was looking for International Monetary Funds (IMF) programs for the past few decades. Pakistan is an emerging economy and emerging economies faced so many problems related to low level of capital, low level of per capita income, and poor rate of saving, deprived industrialization, foreign loan burden and fiscal deficit. To overcome these problems, the FDI plays a vital role in economic growth. The FDI trends of Pakistan is increasing from 1975-2018. The history of the FDI in Pakistan is not impressive like others developing nations of the world. Since the 1980's, the average inflow of FDI has been 42 million USD per annum (SBP, 2005) and 1.4 percent of the Gross Domestic Product (GDP). The inflow of FDI in 2007 increased by 9 billion USD and recorded the highest inflow of FDI in Pakistan history (SBP, 2008). In 2019, the inflow decreases 540 million USD as compared to FY 2018. That was very hard to convince those investors, who left the country and the Board of Investment (BoI) of Pakistan is responsible to motivate and mobilize as well as regulate the FDI. Nevertheless, the good thing is the fundamentals of FDI are effective in Pakistan (Azam & Khattack, 2005). Pakistan needs to take some serious measurements, to sustain the FDI inflow under the growing Small Medium Enterprises (SME's) especially in the

[41] **Rana era**, (1846–1951) in Nepal, the period during which control of the government lay in the hands of the Rana family. Jung Bahadur (1817–77) seized power in 1846 and made himself permanent prime minister. He was given the hereditary title of Rana. Under the Ranas, Nepal maintained relations with the British, who provided it with support. When the British withdrew from India in 1947, the Rana family was exposed to new dangers. They faced a revolution in 1950, and in 1951, under pressure from India, Nepal's King Tribhuvan took the throne with restored sovereignty.

eye of European market and other new avenues of FDI. Second, Pakistan needs to formulate an effective foreign policy to attract the foreign investors (Pakistan & Gulf Economist Feb 12, 2020).

The economy size of India is much larger than other SAARC countries. The total volume of GDP is 2.72 trillion USD in 2018 (Reserve Bank of India, 2018). The importance of FDI for developing countries is excessive, because they provide a strong financial backup to the economies. The FDI inflow of developed countries towards developing countries has significantly increased (Rao, 2018). In addition, the FDI is non-debt financial resources and a growing large source of finance for the developing countries to minimize the technological gap between developed and developing countries. The investment policies of India played a vital role to encourage and attract the FDI inflow after 1991 balance of payment (BoP) crisis (*Riken,* 2012).

Therefore, the FDI inflow in 2009 was around 36.6 billion USD, which is 2.7 percent of the GDP but in the initial seven months of 2010, the inflow declined by 24 percent around 12.5 billion USD. There are following factors to decrease the FDI inflow of India like policy reforms, new land acquisition that hits the industrial sector, global financial crisis and negative publicity of Commonwealth Games (Reuter May 29, 2009). In 2014, India launched a campaign to attract the FDI *"Make in India"* [42]and there are four basic pillars of this campaign such as new processes, new mindset, new sectors for investment and new infrastructure. These initiatives provide the highest FDI inflow around 157,546 million USD from 2014-2018 (RBI, 2018). The current inflow of FDI is 64.37 billion USD received by India reported by the Department of Promotion of Industry and Internal Trade (DPIIT, 2019).

[42] Make in India is a major new national program of the Government of India designed to facilitate investment, foster innovation, enhance skill development, protect intellectual property and build best in class manufacturing infrastructure in the country.

Bangladesh also needs the foreign direct investment (FDI) like other developing nations for economic development. The FDI trends of Bangladesh is increasing but not consistent. Since 2012, according to the Bangladesh Bank, the total inflow of FDI in 2004-05 was 803.78 million USD but we observed many difficulties in the FDI flow. There are so many reasons for these fluctuations in the FDI trend of Bangladesh such as poor infrastructure system, political instability and macroeconomics environment. The good things of Bangladesh are their labor force because the labor cost is very low as compared to other SAARC countries, which influence the foreign investors for investment (Sultana & Akhter, 2013).

The FDI inflow of Bangladesh in 2018 around 3.61 billion USD according to UNCTAD's World Investment Report [43]and the total stock of FDI is 17 billion USD, which is 5.9 percent of the GDP. The government of Bangladesh takes initiatives to open a PayPal facility for international consumers and investors, who use Bangladeshi products. There are such good things of Bangladesh economy, who favors to increase the FDI stock like good macroeconomics stability in the economy, which leads to increase the growth rate 7.1 percent in 2017. Second, the low labor cost which motivates the foreign investors because the production costs are low, where the profit margin is very high. Third, market size, effective monetary policies and foreign policies to continue attracting the foreign investors (Hossain et al, 2018; Mahmood, 2018).

In the present time, Sri Lanka also faced so many problems in the development process like high level of fiscal deficit in the economy, low level of foreign reserves and incompetence to return the foreign debt in form of loan. These all factors pushed Sri Lanka towards debt trap (ADB, 2016). In 1970's, the Sri Lanka government introduced such comprehensive liberalization policies and these policies played a key role in increasing the FDI inflow and

[43] The ***World Investment Report*** focuses on trends in foreign direct investment (FDI) worldwide, at the regional and country levels and emerging measures to improve its contribution to development.

economic growth. However, in the late 1980's, due to political instability "*the outbreak of 1983 War*"[44], which hit the FDI inflow and decreased the economic growth (Velnampy et al, 2013). The annual FDI inflow in 2010 was 955.91 million USD and declined by 681.24 USD in 2015 (UNCTAD's, 2016). Sri Lanka adopts different policies to attract FDI inflow to open new sectors for investment and friendly environment for foreign investors (Samantha et al, 2017).

The key role of FDI to raise the national income creates different opportunities for employment and increases the level of wages rate. The Nepal government has failed to attract and increase the FDI inflow due to some factors, which smash the inflow of FDI in Nepal like political instability, energy crisis and labor conflicts (Pyakurel, 2018). The history of FDI of Nepal is very poor as like other SAARC countries. The peak era of FDI inflow in the mid of 1990's and after that the trend of FDI is decrease due to "*Civil War of Maoist Insurgency*"[45]. After 2013, the trend of FDI increased still to 2018. Recently the Nepal government approved "Foreign Investment and Technology Transfer Bill 2019" and "Public-Private Partnership and Investment Bill 2019. The expectation of the Nepal government is rational after this legislation; they may be increasing FDI inflow towards Nepal.

4.6 Population Growth Rate and SAARC Countries

In the Napoleon era, the world population was less than a billion but after the Second World War, the average increase in population was a billion over every 12-15 years. Now the figure of the population is double. The last projection of the World population around 9.7 billion in 2050 and still increase 10.9 billion in 2100. The following factors, which increase the population growth rate such as the high fertility rate, declining mortality rate and awareness related to family planning etc. The factors, which decrease the population growth like low

[44] The Tamil Tigers declared the "First Eelam War" (1983-87) with the aim of creating a separate Tamil state in northern Sri Lanka called Eelam.

[45] The Maoist Insurgency or the Maoist Revolution was a civil war in Nepal fought between the Communist Party of Nepal (Maoist) (CPN-M) and the government of Nepal from 1996 to 2006.

fertility rate and increase the literacy rate and strong execution of family planning programs to control the population size. The increasing trend of population builds pressure on natural resources and the world faces so many socio economic issues like global migration, poverty, unemployment etc.

In South Asia, 59.76 percent of the population of the world living and the first ranked in regional level. The South Asia region has the largest population as compared to other regions of the world. After poverty and economic growth, the increasing population is very critical in South Asia.

Pakistan is the most populous country in the world. According to the 2017 census, the total population of Pakistan is around 207.8 million. The population growth rate is 2.4 percent per annum, which is the highest in the South Asia region (Bongaarts et al, 2013); (Z. Sathar, 2001). The ranking of Pakistan is 6^{th} in 2013 but that ranking up towards fourth in the world according to population (M. A Wazir, 2013). In the initial period after independence, 34 million people according to the 1951 census and the 132 million, 184 million population in 1998 and 2012. The average growth rate of population is 3 percent per annum during 1950-1985. However, the growth rate is declining around 2.6 percent per annum from 1998-2010. The trend of growth rate is decreasing but the population size is still increasing. The government of Pakistan used different sources and set the projection of population to calculate them such as the United Nations, National Institute of Population Studies (NIPS) and Population Council (PC). The projections of all the sources are slightly different with each other due the fertility rate, where each source takes its different value for projection. The massive increase in population caused serious problems of socio-economic issues. The following issues are increasing poverty level, unemployment, poor health condition and rural to urban migration for job searching and to avail better opportunities to improve the standard of life. The population

growth rate is decreasing in Pakistan due to decreasing the fertility rate, increasing the literacy rate and implementing family planning programs.

India is the second highest populous country after China in the world. The total population of India is around 1.38 billion and the population growth rate is 1.08 percent per annum in 2019 (UN, World Population Prospects, 2019). According to the United Nations Fund Population (UNFPA, 2014), 78 crores people increased in every year in the world population and India contributed one-fifth of the total world population. The continuous increase in population builds pressure on natural resources, where the depletion of natural resources are very high and adverse impacts on the environment, especially those developing countries where the most of the population is based on agriculture. The impacts of population growth on a country's economy have big debates and most of the time their impacts are not favorable for the economy because they increase the socioeconomic issue in the country. In 2015, (Sethy & Sohoo; Tumwebaze & Ijjo, 2015) finds that the relationship between population growth and per capita income is positive but that relationship is negative for China and Australia (Banerjee, 2012).

The population growth rate of India declined after the 1981 census but the population of the country increased 21.5 percent from 1991-2001. The basic reason for the declining trend in India is due to the falling fertility rate. In 1971, the average fertility rate was 5.2 children per woman in India but that fell down in 2017 to 2.2 children per woman. The Prime Minister Neranda Modi publicly discussed and warned about the growing population size of India. The government of India strictly implemented the policy of population controlling.

The Bangladesh population and density of the population are very high as compared to other developing countries. The density of the population of Bangladesh is 1115.6 people per kilometer square and 8th ranked in the world (World Population Prospects, 2019). The total

population of Bangladesh is estimate to be around 164.69 million in 2019 and the population growth rate is 1.02 percent per annum. The last census of Bangladesh officially conducted in 2011 and the total population was around 142 million. Since the 1960's, 1970's, the growth rate of the population is the highest in the world and after the 1980's, the growth started decreasing due to the fertility rate decreasing. The current fertility rate in the country is 2.4 children per woman and due to high-populated cities in Bangladesh so called *"City State country".*

Sri Lanka's population was very small in the 19th century. The first census conducted in 1871s was by the British Government and the total population was around 2.8 million. In this era, the British Government migrated thousands of Tamils workers to Sri Lanka for plantation and that 40-70 percent of the population increased in the 1900's. After the independence, the first official census was conduct by the Sri Lanka government in 1981 and estimated the total population to be 14.8 million. Since the 1953's, the fertility rate is 5.3 percent and continuously decreased the growth rate of the population in Sri Lanka by the implementation of different policies to improve the standards of life and health conditions. In 1994, the government of Sri Lanka adopted the International Conference on Population Development (ICPD) for the betterment of population health and the life standard. The results are very significant to improve the life expectancy, decrease the fertility rate, also increase the women empowerment, and increase awareness related to small family planning (Anulawathie Menike, 2017). The total population of Sri Lanka is 21.22 million and 21.38 million in 2020 and the ranked country is 58th in the world. The population growth rate is 0.48, 0.45 and 0.42 in 2018, 2019 and 2020. It shows that the trend growth rate is decreasing.

In the past three decades, the fertility rate, mortality rate and population growth rate significantly decreased in Nepal, which improved the life expectancy rate, increased awareness of contraception and decreased infant diseases. Over the time, the fertility rate of Nepal is

decreasing and half of the rate is decreasing after compared with years. The fertility rate decreased by 2.32 children per woman in 2015, 5.62 children per woman in 1980's (Baral, 2016; Regmi, 2015). In 2010, the Nepal government conducted the 10th census and estimated the population to be around 23.21 million and the average annual growth rate of the population was 2.3 percent in 2010. The current population size is around 28.6 million and will still be 36.45 million in 2051 (UN, World Population Prospects, 2019).

4.7 Trend Analysis

Trend analysis refers to analyzing and describing the trend and pattern in a "Noisy[46]" data set over the time spin. Whether, the trend is increasing or decreasing in the data set. In economics trend analysis used for market trading and forecast the future scenario on the previous trend. Different tools and tests parametric and non-parametric used for the trend analysis such as Autocorrelation, Kwiatkowski–Phillips–Schmidt–Shin (KPSS) and Mann-Kendall test. The study used Mann-Kendall test for trend analysis in SAARC countries.

4.7.1 Mann-Kendall Test

Mann-Kendall test used to check the trend of sulfur emissions data series over the time with the null hypothesis H_0: there is no trend in data series and the alternative hypothesis H_1: there is monotonic trend (increasing or decreasing, constant) in data series. This test is nonparametric used for climatic time series and also deals with the missing value and value under detection limit (Gavrilov et al, 2016)[47].

[46] Noisy data is data that has a relatively signal-to-noise ratio. When data is collected, humans tend to make mistakes and instruments tend to be inaccurate, so the collected data has some error bound to it. This error is referred to as noise.

[47] Gavrilov, M. B., Tošić, I., Marković, S. B., Unkašević, M., & Petrović, P. (2016). Analysis of annual and seasonal temperature trends using the Mann-Kendall test in Vojvodina, Serbia. *Idojaras*, *120*(2), 183–198.

Table No.4.6 Mann-Kendall trend test (Two Tailed)

Countries	Tau-Value	Hypothesis accepted α = 5 %	P-Value
Pakistan	0.922*	Ha	(0.000)
India	0.994*	Ha	(0.000)
Bangladesh	0.837*	Ha	(0.000)
Sri Lanka	0.854*	Ha	(0.000)
Nepal	0.957*	Ha	(0.000)

Note: *, ** and *** indicate level of stationarity 1%, 5% and 10%.

The above table no.4.5 shows the Mann-Kendall[48] trend test results, it shows that the p-values of sulfur emissions data series of SAARC countries are highly significant and reject the null hypothesis. There is a significant monotonic trend in the series of sulfur emissions; so, accept the alternative hypothesis.

To further identify the trends are increasing or decreasing in the data series. Makesens used two types of statistical tests, if the number of data if less than 10 then used the S-statistic test and if the data numbers exceed for 10 go for Z-statistic test. Following equations used to calculate the s-statistic and z-statistic test.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} Sgn(x_j - x_i) \qquad (i)$$

Where x_i and x_j are the annual data of the series j and i, j>i, n is the data number and calculate for this equation;

$$Sgn(x_j - x_i) = \begin{cases} 1 \; if \; x_j - x_i > 0 \\ 0 \; if \; x_j - x_i = 0 \\ -1 \; if \; x_j - x_i < 0 \end{cases} \qquad (ii)$$

[48] Drápela, K., & Drápelová, I. (2011). Application of Mann-Kendall test and the Sen's slope estimates for trend detection in deposition data from Bílý Kříž (Beskydy Mts., the Czech Republic) 1997-2010.

If the s-statistic values are positive and negative, that shows the upward and downward trend in the series sulfur emissions. When the number of data is more than 10 so, the literature suggests z-statistic tests to check the monotonic trend of the data and equation are.

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var\ (s)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \dfrac{s-1}{\sqrt{Var\ (s)}} & if\ S < 0 \end{cases} \qquad (iii)$$

The z-statistic results demonstrate that whether there is a monotonic trend in the data, if the z-statistic values are positive and negative, the trend of data is upward and downward. The results of z-statistic in below table no.4.7 shows that there is an increasing trend in all the data series of sulfur emissions in SAARC countries over the time from 1975-2018. The sulfur emissions are the dependent variables.

Summary:

To understand better the trend of economic indicators, this study conduct the EDA and trend analysis for SAARC countries and to find out some common facts and problems, which effects the trend of variables.

- The economics policy almost similar in all SAARC countries, like trade liberalization, import-substituting policy etc.
- The sources of sulfur emissions are almost same in SAARC countries (combustion of fossil fuel, gas and coal) due to growing demand of energy and these resources are the main inputs for energy production.
- Political Instability and war & terrorism.
- Issues (High poverty level, unemployment, limited resources, high fiscal deficit and trade deficit).
- Trade (Non-tariffs barriers, connectivity issues, high transportation cost, trust deficit, border tax alteration).
- The consistency of policies are depends upon the new ruling party government.
- Increasing population, which build pressure on natural and economic resources.
- Climate change Vulnerability risk increased over the time.
- SAARC as an organization has failed to build the mutual trust amongst members of SAARC for regional development and facilitate with each other.
- The trend of sulfur emissions in SAARC countries are increasing over the time.

Chapter No.5

Results and Discussion

Results of Panel FMOLS for SAARC Countries

The below table no.5.1 shows the panel data results of long-run relationship between sulfur emissions (SO_2) and different economic and social demographic indicators through FMOLS method. The findings of this study confirm the relationship between variables and all the variables are highly significant at the level of p-value (0.00). The GDP growth has statistical significance at the level of 1 percent and the relationship between GDP growth and SO_2 emissions is negative. The findings highly related to (Zhou et al, 2017; Puzon, 2012; Wu, 2019). It shows that 1 percent increase in GDP growth leads to decrease SO_2 emissions by 2 percent. First, it means that the GDP growth of SAARC countries could not reach to their optimal level where the GDP growth increased the SO_2 emissions. Therefore, that is why there is an inverse relationship between GDP growth and SO_2 emissions. If the GDP growth will raise and achieve the optimal level, that is positively related to environment quality (Teame, 2017).

Second, all the countries of SAARC are emerging economies, where the economic activities are comparatively low and GDP growth cannot influence the increase in SO_2 emissions. It means that the manufacturing sector participation in GDP growth is low and the inputs used in this sector are less than the pollution level of SO_2 emissions in these countries. In addition, the inverse relationship between SO_2 emissions and economic growth shows the technical progress and advancement in technologies. Further, the industrial structure changes have significant effects on SO_2 emissions (Antweiler et al, 2001). Third, the economic structure of the SAARC countries depends upon the services sector and that sector provides different intangible facilities like customer services, management skills and provides some professional

experience. In addition, the share of this sector is large in all countries as compared to other sectors of the economy and more than 50 percent share of services sector in GDP of SAARC countries except Nepal, because Nepal highly depends upon the agriculture sector around 60 percent.

Table No.5.1 Panel FMOLS Results for SAARC Countries

Dependent Variable: Sulfur Dioxide (SO_2) Emissions				
Variable	**Coefficient**	**Std. Error**	**T-Statistic**	**P-Value**
GDPG	-0.022*	0.003	-7.023	(0.00)
TO	0.010*	0.001	8.610	(0.00)
FDI	0.051*	0.018	2.800	(0.00)
EEP	0.003*	0.001	2.780	(0.00)
POPG	0.137*	0.036	3.723	(0.00)
R-squared: 0.62				

Note: All the variables are significant at the level of 1 %, indicates 1 % of significance*

Trade Openness is statistically significant at the level of 1 percent significance. Trade openness has a positive relationship with SO_2 emissions in SAARC countries. The finding of this study shows that 1 percent increase in trade openness leads to an increase of 1 percent in SO_2 emissions and these findings related to (Zhou et al, 2017) for Gulf Cooperation Council (GCC)[49] countries. Trade openness refers to the movement of different goods between two more countries and where the production of goods in one country and their consumption in another country. In addition, when the domestic production of goods expands, that called scale

[49] The Cooperation Council for the Arab States of the Gulf, originally known as the Gulf Cooperation Council, is a regional intergovernmental political and economic union consisting of all Arab states of the Persian Gulf except Iraq, namely: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates

effects and the impacts of scale effects on the environment are negative to increase the level of SO_2 emissions.

Whenever the trade liberalization increases, the level of SO_2 emissions and other GHGs emissions are increasing due to the increasing volume of dirty imports and exports. In case of developing countries, when the trade openness increases the inflow of imports are high as compared to exports because the trade structure of developing countries is skewed towards imports. In SAARC countries the volume of dirty imports are high such as fossil fuel and other petroleum products. In addition, fossil fuel and other petroleum products are the major source of anthropogenic SO_2 emissions.

To increase the trade openness means that to minimize the restriction levels on trade, which influence the pollution levels. The increasing volume of trade without imposition of environmental policies leads to increased SO_2 emissions and other GHGs emissions. When the trade openness increase by percent, the CO_2 emissions increase by 0.86 percent for Pakistan (Salman, 2018)[50]. If the trade between developed to developed countries, decreases the pollution and if the trade between developed to developing countries might be increased the environmental pollution (Nemati et al, 2019).

The coefficient of foreign direct investment (FDI) has statistically significant and positive related to SO_2 emissions in SAARC countries and the results are closely associated to (J. He, 2006); (Waldkirch & Gopinath, 2008); (Nadeem et al, 2020). The finding shows that 5 percent increase in SO_2 emissions are associated with the 1 percent increase in FDI. The change in sulfur emissions is high in SAARC countries. The previous literature shows unidirectional relationship of SO_2 emissions and FDI and shows different dynamics of increasing SO_2

[50] Salman, A., Sethi, B., Aslam, F., & Kahloon, T. (2018). Free Trade Agreements and Environmental Nexus in Pakistan. *Policy Perspectives*, *15*(3), 179-195.

emissions. The positive relation refers to the investment in different sectors of the economy in SAARC countries such as investment in energy sectors, new industries installations and old technology transformation.

In the energy sector, the natural resources are the main inputs used for energy production like coal, gas and fossil fuel in emerging economies and these all resources are highly sulfur polluted (EPA, Air quality fact sheet, 2005). Second, the installation of new industrial set up and where the use of technologies not updated in the industrial sector. The technologies transformation are not innovative and environment friendly because they have limited capital resources, where they countries invest in clean technology. Third, the lack of environmental regulations and policies against FDI due to increased inflow of FDI towards the country. The host country compensated the foreign investors for investment and created a friendly environment for investors to shrink the mass of environmental rules and regulations. The main reason for shrinking the regulations is the importance of FDI in economic growth and it plays a vital role as backbone of the economy.

The coefficient of Electric Energy Production (EEp) is statistically significant. The relationship between EEp and SO_2 emissions is positive. The change in EEp coefficient is very small. The finding shows that 1 percent increase in EEp leads to an increase of 0.3 percent in SO_2 emissions and is highly related to (Rafaj & Amann, 2018; CAI-Asia, 2010; Cole & Neumayer, 2004). The positive relationship between EEp and SO_2 emissions depends upon different factors of energy production. First, the energy production sector, which totally depends upon natural resources used as inputs and the major resources are coal, natural gas and fossil fuel in SAARC countries. According to the Environmental Protection Agency in 2009, the consumption of coal, natural gas and fossil fuel are main sources of anthropogenic SO_2 emissions. When looking at the energy mix of all SAARC countries, the proportion of thermal energy resources (coal, gas & fossil) used are very high for electric energy production.

Especially coal consumption in coal fired power plants for energy production, because coal is a cheap resource in developing countries and SAARC countries are marked in the list of developing countries. The quality of coal is very poor; it means that the amount of sulfur is high in coal and more sulfur emissions by the consumption of that coal. Third, the transport sector of the countries where the consumption of fossil fuel is very high. In addition, the most countries like Pakistan, Nepal and Bangladesh the primary source of SO_2 emissions are the transport and industrial sector (CAI-Asia, 2010).

The population growth is statistically significant and positively related to SO_2 emissions. The results of the study related to different studies like pollution (Cole & Neumayer, 2004); (Shikwambana & Tsoeleng, 2019). The finding of the study shows that 1 percent increase in population growth leads to 13 percent increase in SO_2 emissions. It means that when population increases the GHGs emission and other pollutants must increase but the following factors of population growth, which influence the emissions growth. First, to link the population emissions with economic growth and positive relations with each other. However, when the population increases, the economic activities also increase due the increasing demand for goods and services. Second, to link the population emissions with energy production; the increasing population increases the demand for energy consumption and the energy production totally depends upon thermal resources. Moreover, those resources are extremely polluted, the major source of SO_2 emissions in SAARC countries.

Chapter No.6

Conclusion and Policy Recommendations

6.1 Conclusion

The study found out the relationship between sulfur dioxide (SO_2) emissions and economic indicators in SAARC countries: Pakistan, India, Bangladesh, Sri Lanka and Nepal from 1975-2018. The study confirmed the relationship between sulfur dioxide (SO_2) emissions and economic indicators like GDPg, Trade Openness, FDI, Energy Production and Population Growth. The study conducts exploration data analysis for in-depth analysis and trend analysis use to explore the monotonic trends of all the variables. In addition, the study used Mann-Kendall test to check the trend of series data over the time. The study used panel unit-root test [51]for stationarity and the panel cointegration test[52] to figure out the relationship among the variables. The fully modified Ordinary least Square (FMOLS) estimators used for the evaluation of variables relationship, how much the response of dependent variable due to change is independent.

The results of the study shows that there is a negative relation of GDPg with SO_2 emissions. The GDPg of SAARC countries reduces the SO_2 emissions because the growth of GDP has not maximized the optimal level where the growth influences the sulfur emissions. The value of GDPg coefficient is 0.022, which is positive. The relation of trade openness is positive SO_2 emissions. The trade liberalization increases the sulfur emissions because of the increasing volume of dirty imports and exports, which is not environmentally friendly. The coefficient of trade openness is 0.01. It means 1 percent increase in trade openness leads to 1 percent increase

[51] Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. Journal of Econometrics, 108(1), 1–24. https://doi.org/10.1016/S0304-4076(01)00098-7

[52] Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Econometric Theory, 20(3), 597–625. https://doi.org/10.1017/S0266466604203073.

in SO_2 emissions. The absence and limited environment protection rules and regulations also influence the SO_2 emissions.

FDI positively influences the SO_2 emissions in SAARC countries because the transformation of technology is environment friendly. The inflow of FDI in developing countries mostly in the energy sector, infrastructure and industrial sector and that is also one of the factors, which increase SO_2 emissions. The use of technology is not Green and clean in all the above sectors and other factors like limited capital stock and lack of research & development. The electric energy production (EEp) is positively associated to SO_2 emissions because the inputs used to energy production are coal, gas and fossil fuel, which is highly polluted. The coefficient of EEp is very small and increases SO_2 emissions less than 1 (0.03) percent. The main source of SO_2 emissions is the consumption of coal in power plants for energy production. The relationship between population growth and SO_2 emissions and 1 percent increase in population growth rate leads to 13.7 percent increase in SO_2 emissions. The increasing growth rate of population also increases the overall population size, which builds pressure on economic and natural resources of the countries.

In conclusion, the SAARC countries raise GDPg in the table of COPs negotiation in the 26^{th} UNFCCC held on (9^{th} to 20^{th}) November 2020 in Glasgow, Scotland because their impact is negative on sulfur emissions. Furthermore, also discuss the market structure as carbon credits for sulfur emissions, where the emissions sinking countries get benefits from this. The demand for energy is growing over time in SAARC countries and the energy production still highly depends upon natural resources like coal, natural gas and fossil fuel. The economic growth of all countries based on energy consumption and the subject of the environment remains unsolved. Therefore, all countries need to require sustainable growth for economic development.

6.2 Recommendations

This study provides comprehensive policy applications for SAARC countries. The following suggestions and recommendations are:

Recommendations for SAARC countries:

1. The policy negotiators of SAARC countries must raise the GDP growth in the table of COPs negotiation of UNFCCC because the GDP growth has not influenced the GHGs emissions.
2. The transformation of technology should be clean and environment friendly in industrial and energy sectors in SAARC countries and motive toward the new technologies like hybrid vehicles in transport sectors and fuel-Gas Desulfurization Technology in energy sectors because the share of both sectors in sulfur emission is high.
3. The SAARC countries needs to change the goods mix in trade means to decrease the volume of dirty imports and exports with market-based policy like cap-trade. The countries used Green technology and environmental friendly inputs for production.
4. All countries need to decrease the dependency on fossil fuel, coal and natural gas in energy sectors and to adopt renewable energy sources like hydro, solar, wind and nuclear energy.
5. All countries need to improve the standards of environment protection and increase the reinforcement of environment protection policies. The existing policies are not sufficient for the reduction of sulfur emissions and other GHGs emissions.

Recommendations for Pakistan:

1. The government of Pakistan adopts market based environmental regulations and policies such as pollution abatement (green R & D), emissions tax and cap-trade in different sectors of the economy. The government should impose a Green tax on the cement industries and transport sector because most of the sulfur emissions are produce from those sectors.
2. The government must be focus on hybrid technology in transportation sector of Pakistan, introduce a sustainable transport system to reduce the sulfur emissions and the main of sulfur emissions is vehicles emissions.
3. Government of Pakistan adopts Desulfurization technology in cement industry because the natural coal is the major input for energy production, the coal quality of Pakistan is very poor because the amount of sulfur is very high.
4. The National Climate Change Policy of Pakistan totally focused on Carbon dioxide (CO_2) emissions. The other GHGs emissions are not consider in national policy but only the carbon emissions are not responsible for global warming, the other GHGs emissions like (SO_2, methane and nitrous oxides) are also caused. The government must consider sulfur emissions in NCCP of Pakistan and Pakistan's Vision 2025 because the 100-year GWP is very high as compared to GHGs emission (IPCC-AR4, 2007).
5. The government needs to adopt green technology policy, motivate the investors like hybrid vehicles, and to change the fuel type into green fuel (high-octane). The implementation of these policies is very important and to ensure the sustainability of economic growth.
6. Pakistan needs to produce the electricity from renewable energy sources like nuclear and hydro energy because Pakistan has a great potential of electricity production from those sectors.

7. The population growth rate of Pakistan is very high as compared to other SAARC countries. The government needs to reduce the population growth rate and implement some effective policies to control the growth and to increase the awareness related to family planning in the population.

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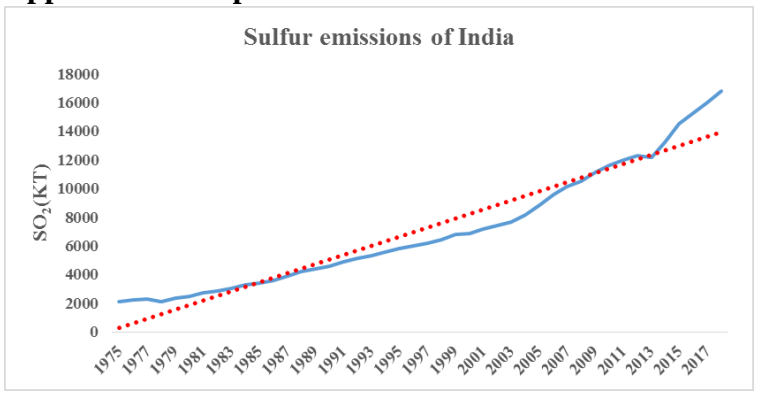
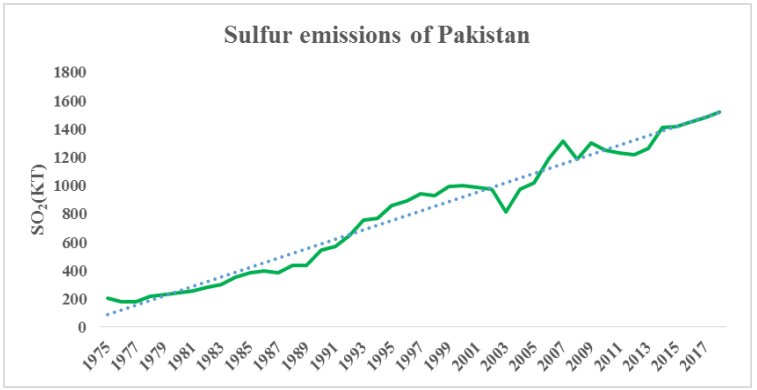
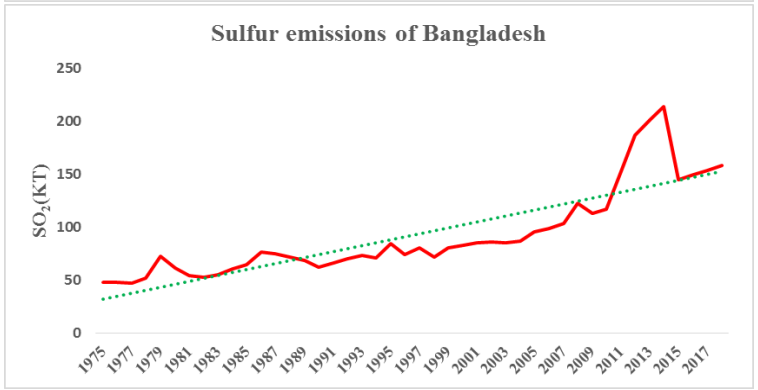
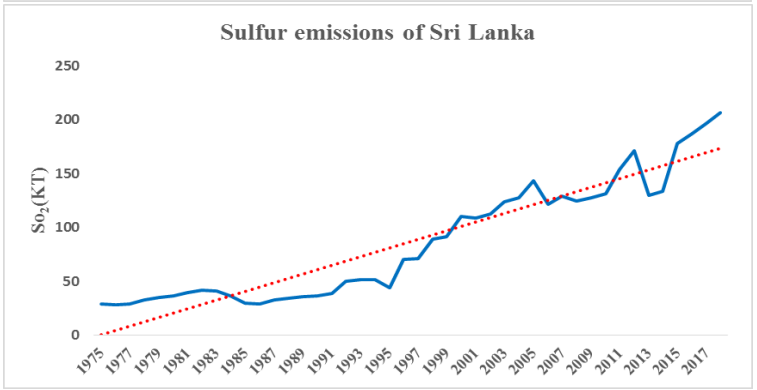
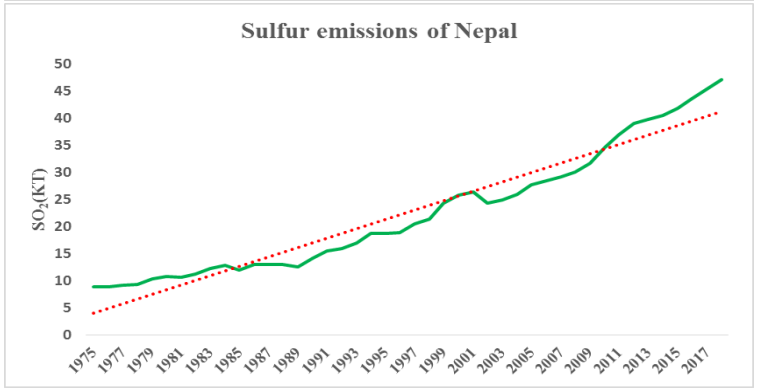
Appendix Graph No.4.1 Sulfur emissions of SAARC Countries



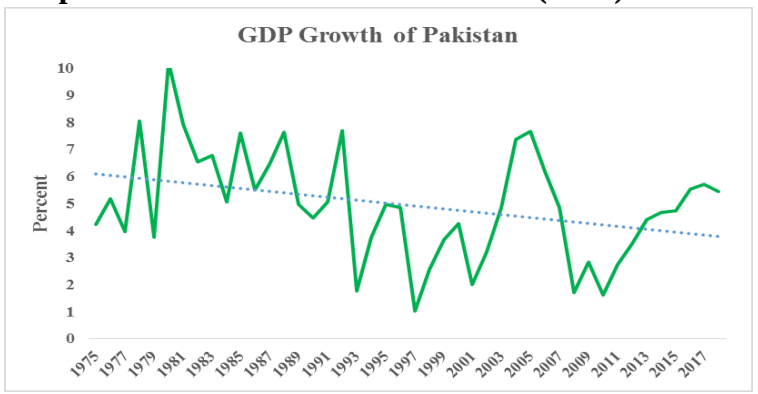


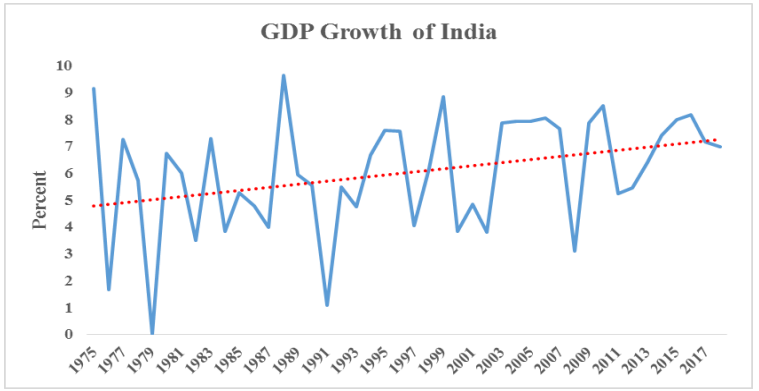


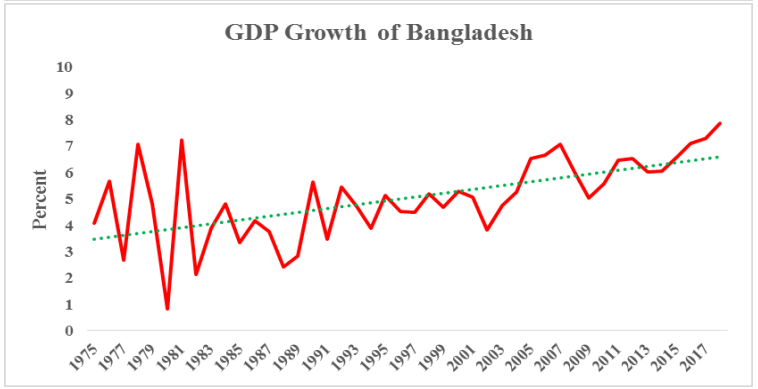


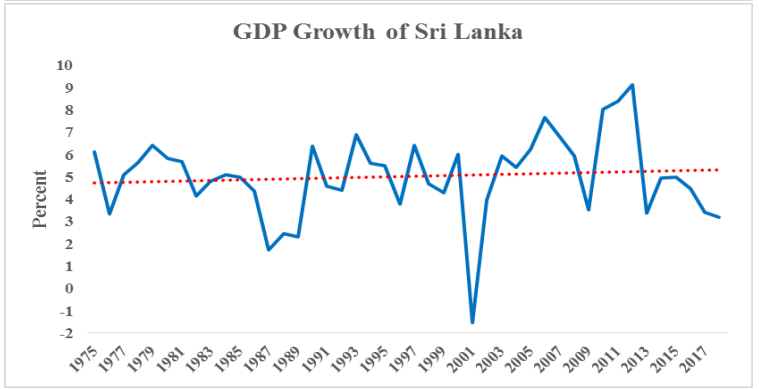


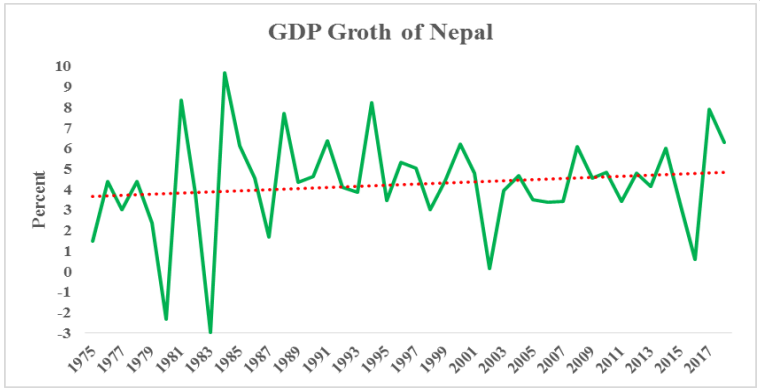
Graph No.4.2 Gross Domestic Product (GDP) of SAARC Countries



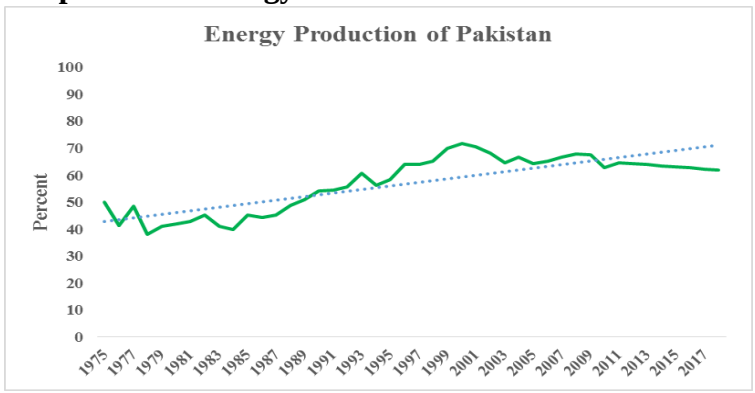


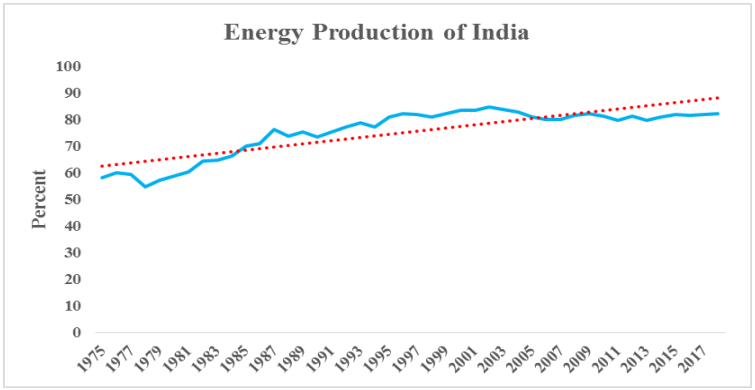


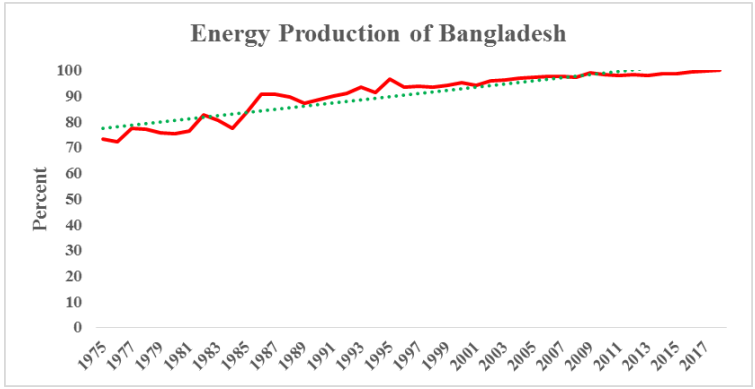


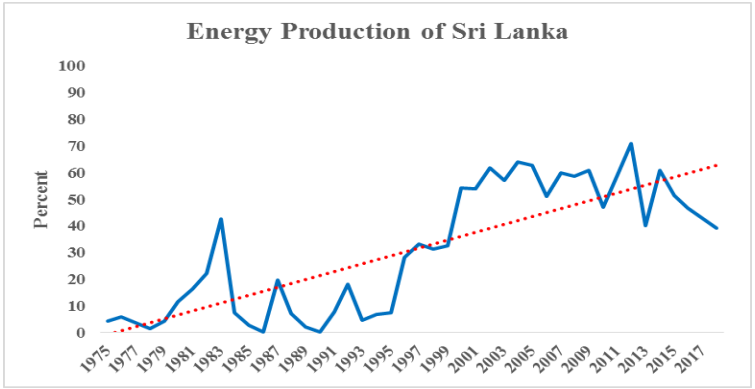


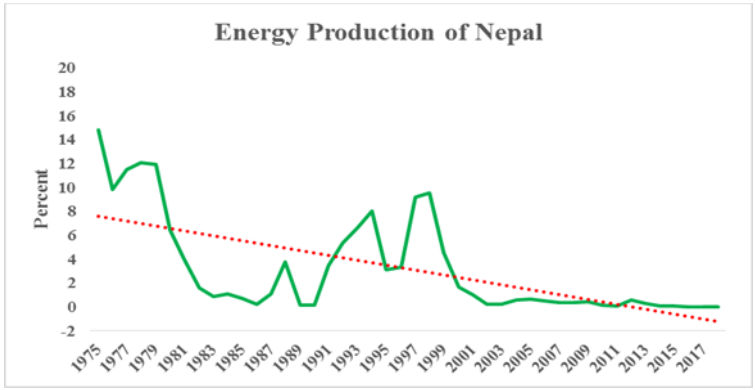
Graph No.4.3 Energy Production of SAARC Countries



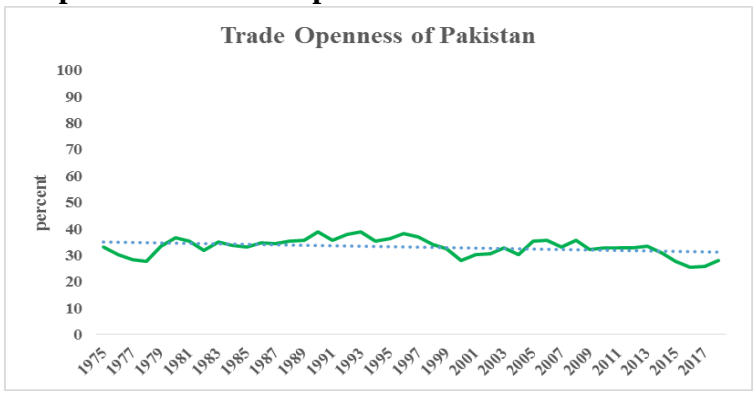


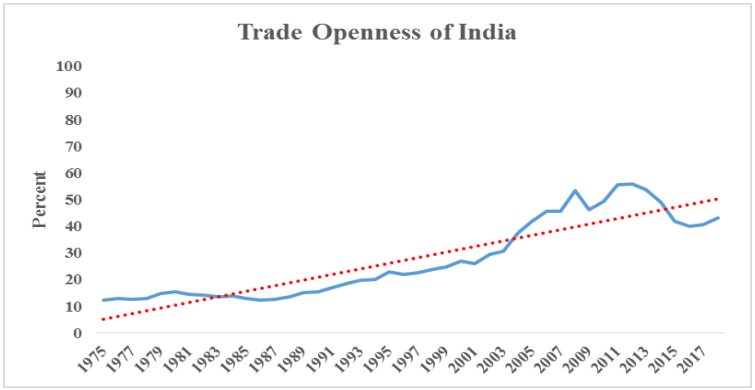


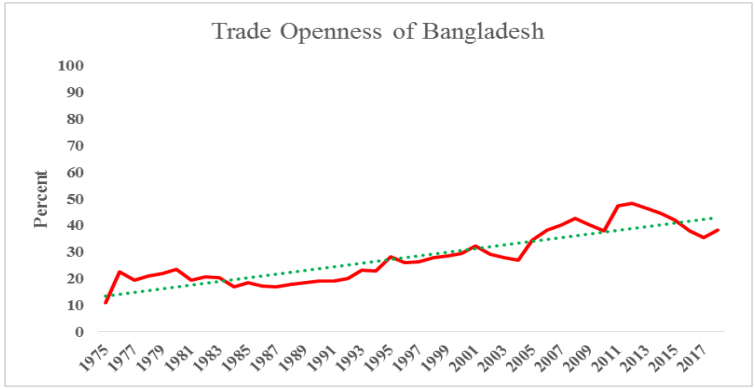


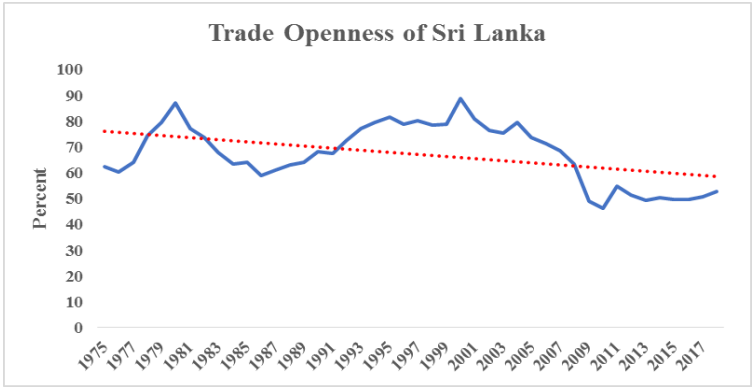


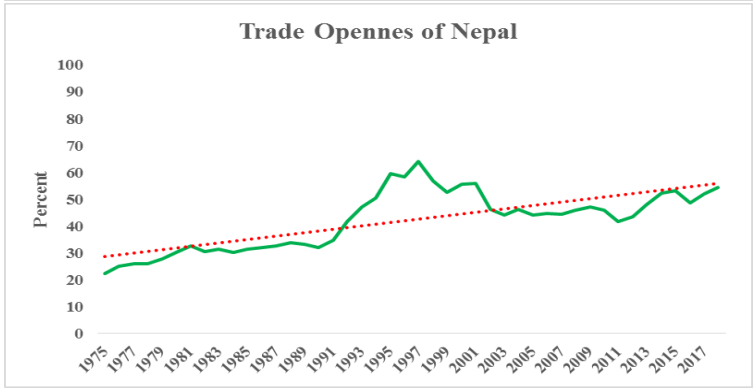
Graph No.4.4 Trade Openness of SAARC Countries



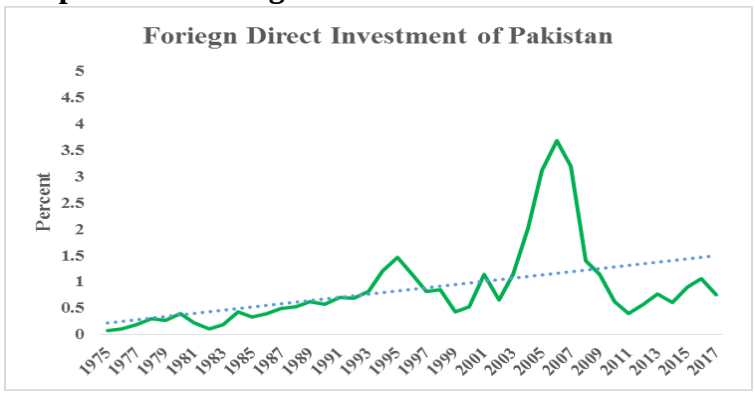


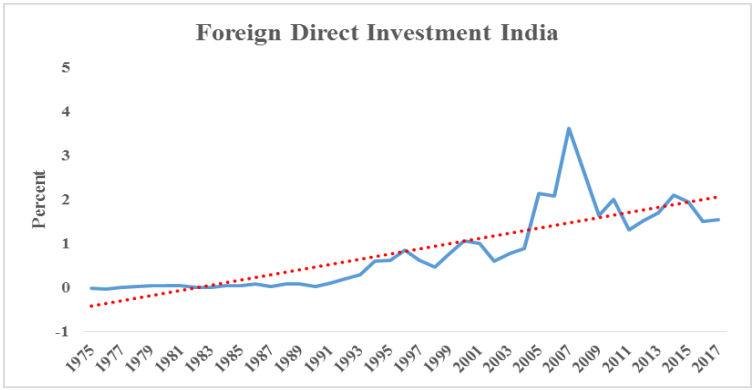


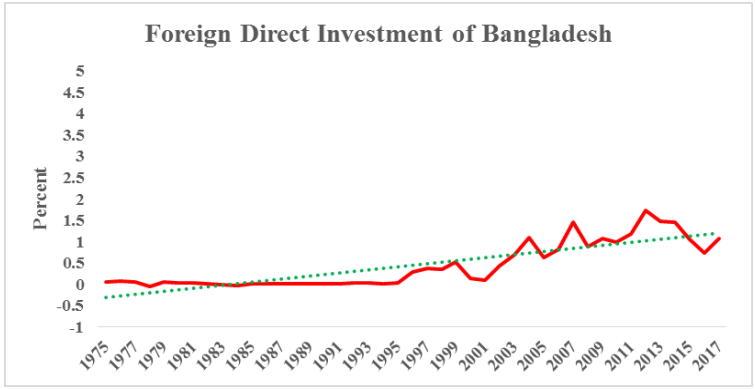


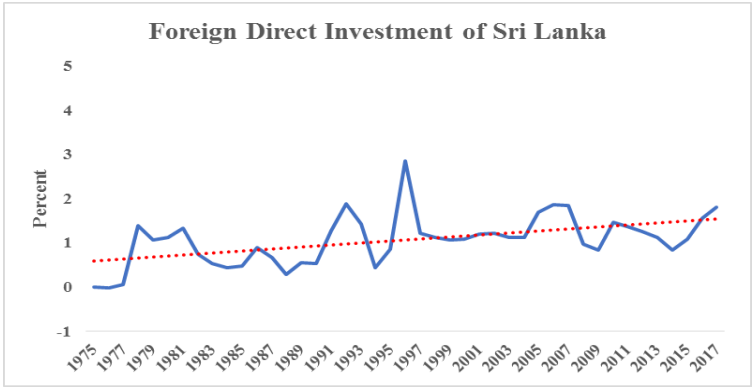


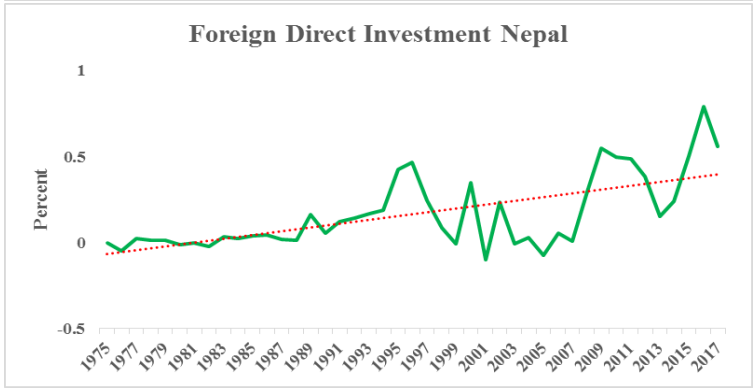
Graph No.4.5 Foreign Direct Investment of SAARC Countries



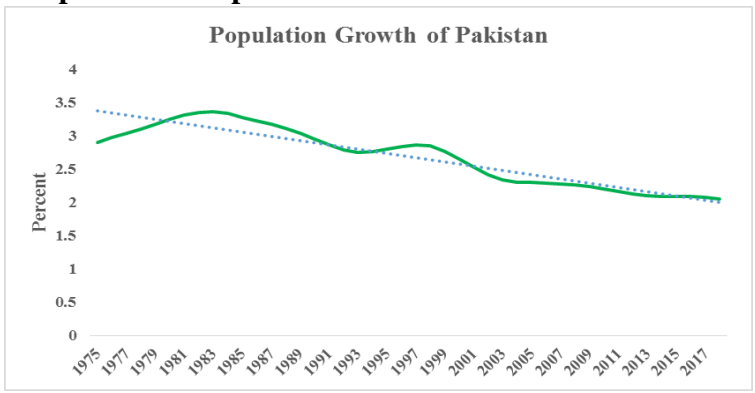


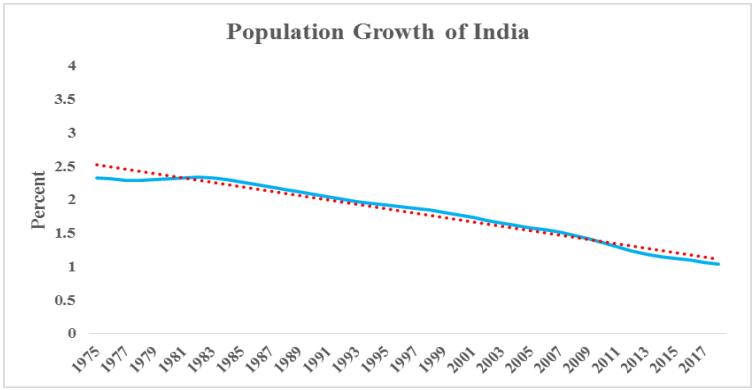


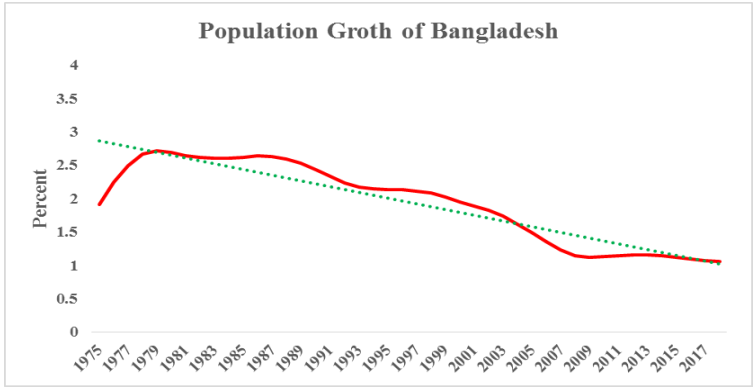


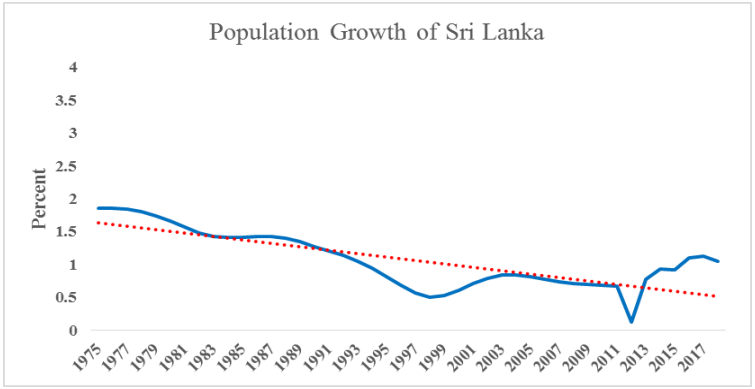


Graph No.4.6 Population Growth of SAARC Countries









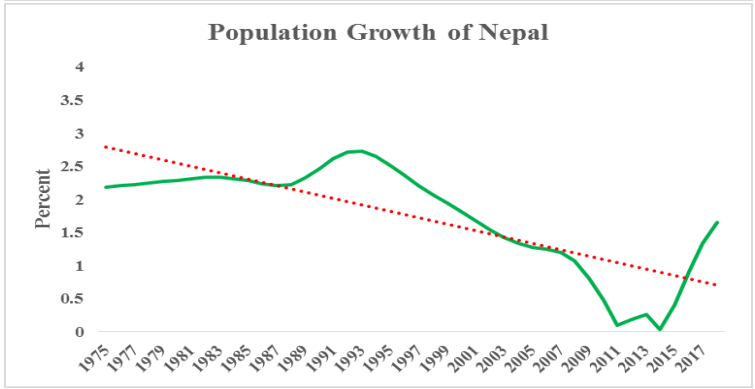


Table No.4.2.2 Results of Mann-Kendall Test (through Z-Statistic)

Year	Pakistan	India	Bangladesh	Sri Lanka	Nepal	Year	Pakistan	India	Bangladesh	Sri Lanka	Nepal
1975	-1.75678	-1.65858	-1.42817	-1.30787	-1.55196	**1997**	0.509963	0.06697	-0.14924	0.01847	0.062311
1976	-1.91696	-1.5572	-1.4364	-1.35892	-1.57246	**1998**	0.494053	0.121873	-0.4389	0.355773	0.133477
1977	-1.92489	-1.51771	-1.48096	-1.32001	-1.49379	**1999**	0.593031	0.222899	-0.15374	0.387702	0.38775
1978	-1.65745	-1.64282	-1.22901	-1.14191	-1.46639	**2000**	0.60268	0.225428	0.07813	0.671603	0.502726
1979	-1.5816	-1.4917	-0.39413	-1.02506	-1.27259	**2001**	0.5808	0.297987	0.011877	0.647296	0.541242
1980	-1.4658	-1.39466	-0.8266	-0.97475	-1.17847	**2002**	0.565162	0.352079	0.024444	0.696271	0.382536
1981	-1.39382	-1.26578	-1.12651	-0.86604	-1.19939	**2003**	0.295697	0.406278	-0.00068	0.842179	0.431264
1982	-1.25158	-1.18053	-1.20932	-0.7799	-1.10404	**2004**	0.562981	0.509129	0.046638	0.889472	0.509623
1983	-1.16187	-1.08502	-1.0845	-0.81214	-0.93076	**2005**	0.629066	0.639369	0.293061	1.061098	0.638281
1984	-0.94507	-0.95024	-0.84954	-0.96326	-0.85075	**2006**	0.862626	0.766066	0.359624	0.810831	0.687884
1985	-0.80034	-0.8985	-0.69852	-1.26625	-0.98376	**2007**	1.008147	0.859871	0.477189	0.902284	0.734535
1986	-0.76805	-0.79609	-0.2643	-1.30109	-0.83114	**2008**	0.854843	0.914985	0.912526	0.850883	0.792653
1987	-0.79739	-0.66696	-0.32322	-1.12054	-0.8175	**2009**	0.988629	1.002652	0.707331	0.884353	0.894421
1988	-0.61432	-0.55794	-0.42721	-1.07271	-0.81278	**2010**	0.931347	1.076701	0.796595	0.925473	1.067706
1989	-0.61717	-0.47392	-0.55547	-1.01656	-0.89157	**2011**	0.905777	1.127689	1.458831	1.165561	1.196149
1990	-0.29225	-0.42559	-0.77189	-0.97579	-0.64875	**2012**	0.890144	1.166771	1.961531	1.323487	1.298438
1991	-0.22465	-0.31325	-0.64481	-0.88131	-0.48245	**2013**	0.948041	1.154282	2.145366	0.914375	1.339349
1992	-0.04593	-0.2267	-0.48786	-0.497	-0.43045	**2014**	1.1081	1.281772	2.304415	0.957414	1.372982
1993	0.186291	-0.17753	-0.36817	-0.45177	-0.30706	**2015**	1.117679	1.436413	1.331268	1.377958	1.433155
1994	0.21678	-0.11064	-0.45381	-0.45748	-0.12382	**2016**	1.151025	1.514057	1.403229	1.452442	1.510623
1995	0.378968	-0.03257	-0.0253	-0.68172	-0.11831	**2017**	1.184357	1.591701	1.475189	1.526927	1.588091
1996	0.432789	0.019636	-0.34986	0.008815	0.10258	**2018**	1.216952	1.669345	1.54715	1.601411	1.665559