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Health Impacts of Smog and Climate Change in South Asia: An In-depth Analysis of its Determinants

Zahra Aslam[1, *], *Talah Numan Khan*[1], *Tanvir Ahmed*[1]

Affiliations
1. Forman Christian College (A Chartered University)

*Corresponding Author Email: 223588637@formanite.fccollege.edu.pk

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Abstract
Every region of the world has been impacted by climate change or is expected to be impacted in the future. One of the area's most susceptible to climate change is South Asia. Extreme weather occurrences in 2022 provided a stark warning of the devastation that climate change can cause to the area. According to the World Bank, the floods in Pakistan caused eight million people to be evacuated, many casualties, and damages of USD 30 billion. This paper explores the effect of climate change in term of CO2 emission and smog under the framework of the Environmental Kuznets Curve for South Asia Region. The specific goal of this study is to manage the distinct socio-economic, environmental, and policy environments of South Asian countries while concentrating on global or regional trends and to suggest policy guidelines for the improvement of climate change. The study utilized data from two separate sources: WDI, and the KOF Index. Fixed effect regression model is used for the method of estimation. From 2000 to 2020, four South Asian nations are examined in this study: India, Pakistan, Bangladesh, and Iran. The findings of the analysis show that economic growth has a positive and noteworthy impact on carbon dioxide emissions. The findings of the analysis of foreign direct investment show that the region of South Asia has negative and insignificant effects on CO2 emissions. The government should strengthen fuel efficiency and emission standards for vehicles, with a focus on reducing NOx and volatile organic compounds (VOCs). Support for electric vehicles (EVs) should also be increased through financial incentives, subsidies, and the expansion of charging infrastructure.

Keywords: *Climate Change, CO2 Emissions, Smog, Fixed effect*

JEL Classification: *044, 040, Q53, C21*

1. Introduction

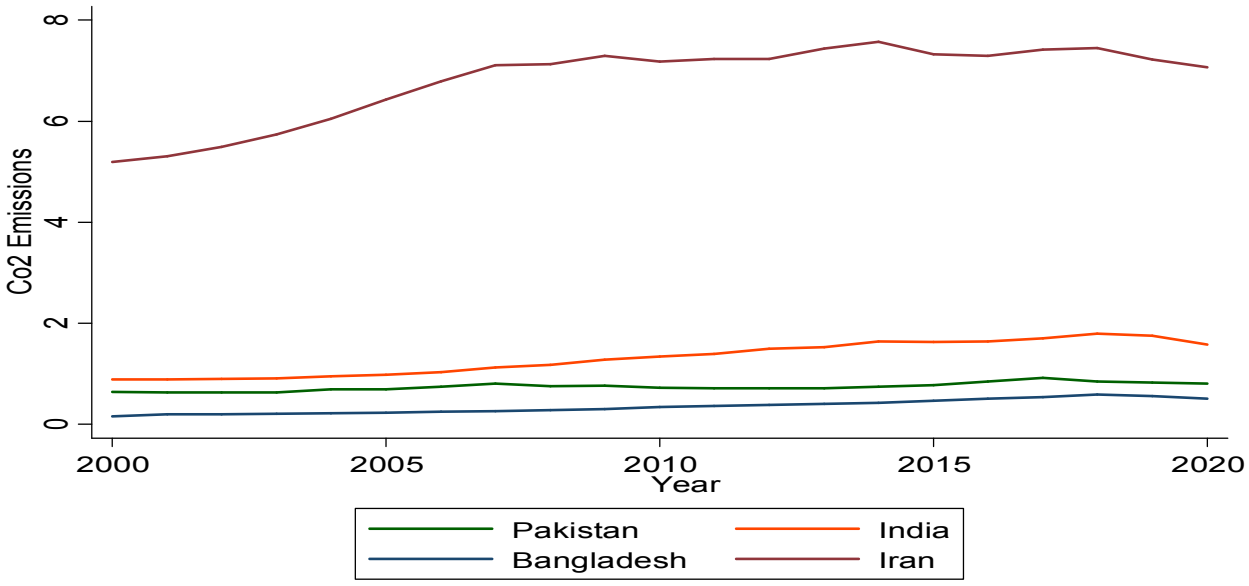
The major pivotal collaborator to rising environmental disruption and climate change has been determined to be carbon dioxide (CO2), which makes up a significant portion of greenhouse gases (GHG) (IPCC, 2014). Furthermore, it is anticipated that CO2 will continue to have an impact on global warming in future generations. Although there has always been some degree of climate change on Earth, the rapidity of evolution and increase in temperature since the middle of the 20th century is unprecedented. Eight cycles of warmer times and glaciers have arisen in the previous 800,000 years; nevertheless, the termination of the last glacial period, around 11,000 years ago, signed the start of human culture and the present phase of climate. The present trend of global warming in the context of contemporary climate is ascribed to human evolution and events starting in the 1800s (IPCC 2023, 36). One of the main causes of the rising rate of global warming is a rise in atmospheric CO2 levels. The primary method of producing CO2 is the exploitation and combustion of fossil fuels, such as natural gas, coal, and petrol (NASA 2023).

According to World Bank (2022), the floods in Pakistan caused eight million people to be evacuated, many casualties, and damages of USD 30 billion. According to Butt (2022), India also had flooding in the Indian states of Madhya Pradesh, Andhra Pradesh, Telangana, and Maharashtra, and droughts in West Bengal, Bihar, and Uttar Pradesh.

The primary cause has been identified that the major root of these crises is climate change. During the four-month monsoon season, the area normally receives 80% of its yearly rainfall. However, according to the Asian Development Bank (2014), climate change has severely disturbed this pattern, resulting in extreme rainfall happening in shorter periods, producing floods, and protracted dry spells, bringing droughts. Climate change is exerting a considerable influence on South Asia, and although it was not their fault, they now have to cope with and find solutions for it. The study focuses on India, Pakistan, Bangladesh, and Iran, the key nations in the region being investigated.

According to the World Bank (2021), these countries account for 8.6% of global emission rates for greenhouse gases, with India accounting for 7.1% of that total. South Asia has the world's largest population, and its percentage of global GDP is gradually growing due to consistent economic development. As a result, South Asia's absolute CO2 emissions and percentage of global CO2 emissions are expected to rise in the coming years. South Asian countries are increasingly designated as lower-middle-income countries (LMICs), posing the issue of growing their economy while reducing their influence on climate change. To do this, they must identify the causes of the CO2 emissions.

Figure 1: CO2 Emissions Over Time



Source: World Bank (2022)

Lately the researchers and scientists have pivoted their interest towards the carbon footprint of a nation or even of each individual. Various steps are being taken in this direction on micro and macro level to minimize the carbon footprint. If we look at Pakistan, India and Bangladesh there Co2 emission is somewhat linear over these years and in recent years they are trying to halt it even further by shift to full electric vehicles, using solar energy instead of traditional coal plants to generate electricity and mass plantation projects. But in case of Iran its completely opposite Iran is heavily dependent on oil and gas and also extract that in heavy quantity. They still use traditional ways to produce electricity and have not shifted towards hybrid or electric cars so they are still burning a lot of fuel daily because of that the emission is higher compared to other countries in the region. South Asian countries have the most significant environmental issues, including forest destruction, management of water and degradation of landscapes, smog, and climate change. According to the RECAI research, India is anticipated to be the world's third-largest consumer and producer of energy from renewable sources by 2020.

The Bangladeshi administration hoped to achieve a 10% natural energy target by the end of 2021, while the current proportion is only 3%. At the same time, according to the NEPRA study, Pakistan's installed power generating volume is 38,700 MW, with thermal (fossil fuels) accounting for 57% of total energy, hydropower accounting for 31%, renewable resources accounting for 4%, and nuclear sources accounting for 8%. India had the biggest usage of fossil fuels in 2020. Furthermore, climate change is occurring today, and authorities are working to mitigate its devastating effects. In 2021, India's yearly CO2 was 2.71 billion tons, Pakistan's 229.51 million tons, Bangladesh's 93.18 million tons, and Iran's 710.8 million tons.

Urban agglomerations in large cities also contribute to domestic CO2 as a result of economic and urban growth, which stimulates home energy usage (Bai et al., 2019; Cui et al., 2020). The fast growth of metropolitan areas has increased power consumption in metropolises, raising difficulties related to sustainability and ecological advancement (Wang et al., 2016). As civilizations grow in magnitude and urbanization, they demand more energy overall than rural regions (York, 2007). Urban transition raises power usage significantly owing to rising housing needs, traffic systems, technological devices, food, land use, and utility services (Shahbaz et al., 2017). Increases in EC stages in cities, particularly the widespread consumption of petroleum products, have significantly increased GHG emissions. The GHG releases are thought to be one of the primary causes of worldwide environmental disruptions and, as a result, anthropogenetic climate change throughout the planet (Ali et al., 2017; Wang et al., 2018d). According to current data, cities worldwide utilize almost two-thirds of total energy consumption, accounting for 70% of global CO2 emissions.

According to Shahbaz et al. (2015) and Mishkin (2009), globalization is a pervasive spectacle that has had an influence on society, economy, and political lives throughout the world. Trade and FDI promote global economic interdependence. Shahbaz et al. (2018) discovered that globalization affects trade accessibility, financial progress, economic growth, and the natural environment throughout the world. Every nation's aim to achieve maximum financial growth through international commerce and investment, as well as industrial development and urbanization, results in ecological disruptions, which disturbs the quality of the atmosphere in every nation owing to greater reliance on outdated energy resources. According to Navarro (1998), globalization is rising; communities throughout the world are today more integrated than ever before. Globalization has a greater beneficial impact than negative impact, notably in terms of eliminating poverty and economic disparity in emerging nations, however the impact of globalization on the atmosphere is still being disputed by scholars.

This study is crucial due to the escalating public health crisis caused by smog and climate change in South Asia, one of the most polluted regions globally. The air pollution in these countries has reached dangerous levels, leading to severe health effects, especially for vulnerable groups such as children, the elderly, and those with pre-existing health conditions. Furthermore, climate change has intensified extreme weather events like heatwaves, floods, and droughts, which further increase the health risks. While awareness of these issues is growing, there is a lack of comprehensive research that specifically explores the health consequences of smog and climate change within the South Asian context. This study aims to address that gap by examining the socio-economic, cultural, and environmental factors that contribute to the region's health challenges.

Although the literature has identified economic growth, urbanization, EC, innovation, globalization, and FD as important drivers of CO2 emissions, there aren't many thorough studies that look at how these factors interact and how they specifically affect CO2 emissions in South Asian regions. This study explores to manage the distinct socio-economic, environmental, and policy environments of South Asian countries while concentrating on global or regional trends. As a result, insufficient research has been conducted on how these reasons appear in the South Asian area and how they combine to affect patterns of CO2 emissions.

This paper explores the effect of climate change in term of CO2 emission and smog under the framework of the Environmental Kuznets Curve for South Asia Region. The specific goal of this study is to manage the distinct socio-economic, environmental, and policy environments of South Asian countries while concentrating on global or regional trends and to suggest policy guidelines for the improvement of climate change.

This study offers valuable insights into the intersection of smog and climate change in India, Pakistan, Bangladesh, and Iran. South Asia, being one of the most densely populated regions, faces significant challenges due to urbanization, industrial expansion, and agricultural practices, all of which contribute to the decline in air quality. By adopting a comparative approach, the study provides an in-depth analysis of the distinct factors driving and manifesting smog in each country, taking into account their specific socio-economic, cultural, and environmental contexts.

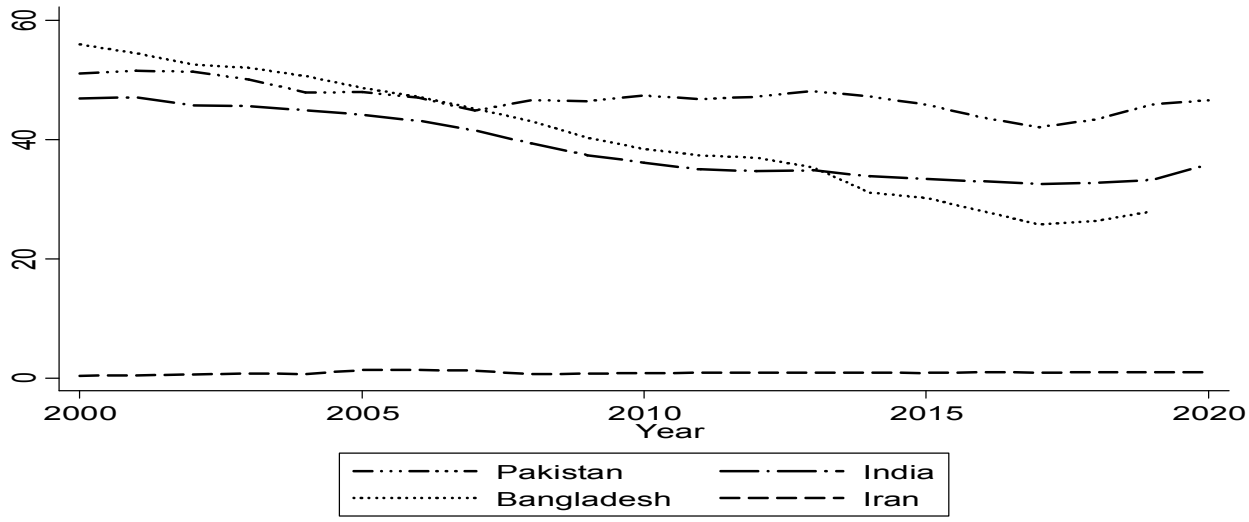
This study is organized into eight sections. Section 1 presents the Introduction, outlining the research background, objectives, and significance. Section 2 provides a Literature Review, summarizing key theoretical and empirical studies relevant to the topic. Section 3 introduces the Theoretical Framework, establishing the conceptual linkages and hypotheses. Section 4 presents the Regression Results based on the econometric analysis. Section 5 offers a Discussion of the findings in the context of existing literature. Section 6 concludes the study with a summary of the key insights. Section 7 provides Policy Recommendations based on the empirical evidence. Finally, Section 8 lists all the References cited throughout the study.

2. Literature Review

2.1 CO2 Emissions and Energy Consumption

South Asia's energy consumption is continually expanding, with demand rising by more than 50% in the previous two periods. Intensifying populace and urbanization, together with a cumulative percentage of the industrial segment in GDP, have caused in amplified mandate for energy (Chen 2022). Although energy demand is viewed as important for raising the standard of living and increasing consumption and growth, sustainable for the environment. In addition, the hypothetical situation of a large South Asian population consuming rising quantities of energy produced by fossil fuels along with other non-natural ways might cause significant environmental damage. As a result, it is critical to explore the association among energy use and CO2 discharges.

Figure 2: CO2 Energy Consumption Over Time



Source: World Bank (2022)

According to Sharma's (2011) research, energy usage reduced CO2 emissions when measured by Overall primary energy usage and per person electricity consumption. In developed nations, per capita energy use is a highly significant predictor of CO2 emissions. Furthermore, per capita EC—as determined by per capita total

primary EC and electric power consumption—does not significantly affect CO2 discharges in middle-class and lower-class nations.

Alam et al. (2007) proposed that Pakistan's economic expansion increases energy use and discovered a substantial correlation between GDP growths—a proxy for economic growth—and EC, which in turn results in increased CO2 emissions. A study that was published in Energy & Environment evaluated information for South Asian nations between 1972 and 2017. The results showed a positive correlation between EC and CO2 emissions at a country wide as well as a significant association between both variables in Bangladesh, although not in other nations (Khan et al. 2021). The negative coefficient associated through the GDP variable's squared term further supports the EKC theory for the area, according to the research. The model might also include the usage of renewable energy.

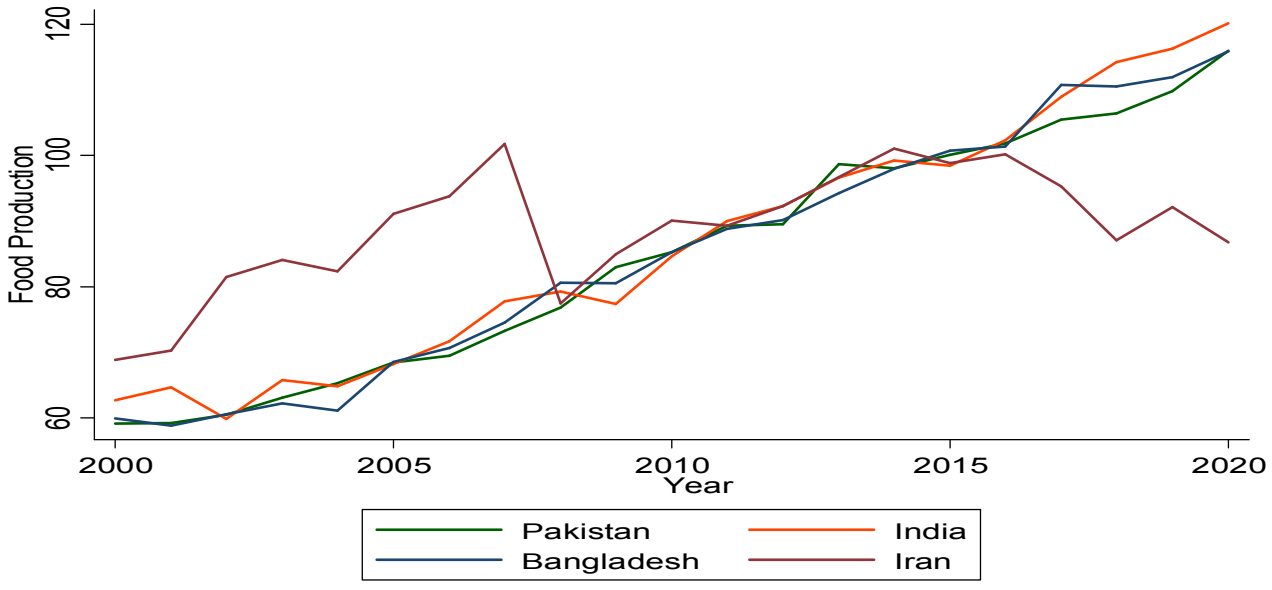
2.2 CO2 Emissions and Agricultural Production

Agriculture is a major supplier to greenhouse gas emissions, specifically CO2 emissions. Ten percent of the country's CO2 emissions are ascribed to agriculture, as per the US Environmental Protection Agency (US EPA 2015). Similarly, according to Aryal (2022), of all the areas in the world, East Asia has the largest percentage of greenhouse gas emissions that come from agriculture.

Regional investigations have been conducted in the literature about the association between agricultural productivity and CO2 emissions; nevertheless, a definitive correlation between the two variables has not been found. Most people have viewed the research primarily in the context of how rising agricultural productivity drives rising agricultural produce, which raises energy consumption, intensifies agricultural production and ultimately results in higher CO2 emissions. Understanding how agricultural output affects CO2 emissions is crucial because it enables us to understand the properties of energy consumption and other elements that are either directly or indirectly connected to the impact of agriculture on CO2 emissions in South Asia.

Research by Korkut (2021) used data from 1971 to 2016 to examine the factors influencing environmental impact and CO2 emissions in BRIC countries (Brazil, Russia, India, and China), except of Russia, where data is available from 1990 onwards. An association between CO2 emissions and agriculture—measured by agricultural value-added as a percentage of GDP—was deemed to be unsupported by the research's findings.

Figure 3: Food Production Over Time



Source: World Bank (2022)

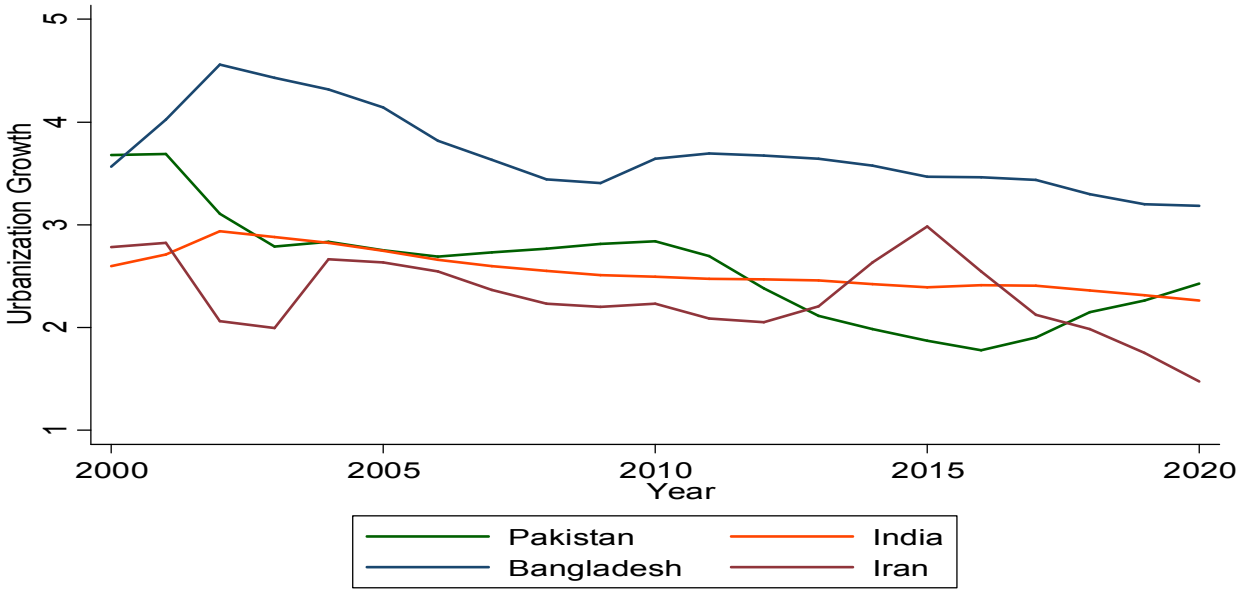
Pakistan, India and Bangladesh have been improving their food Production from day 1. The geographical location and supporting atmosphere help this country in cultivation process making their land suitable for getting higher yield. Scientific experiments helped farmers gain more yield from same amount of land. As the population in this country increased with time the food production also increased. It can be seen clearly that with time it's still increasing. On the other hand, Iran was also highest among all till 2008 after that the graph fell due to various reasons such as economic turmoil and international sanctions. Till date Iran is the lowest food producing country as compared to other 3.

2.3 Urbanization and Co2 Emissions

Many academics have additionally observed at the association between CO2 emissions and urbanization because of the effects that urbanization has on energy consumption, vehicle usage, and the consumption of more goods that are produced using methods that increase CO2 emissions. Sharma (2011) looked at the effects of urbanization in high-income, middle-income, and lower-income nations as well as globally. The impact of urbanization on per capita CO2 emissions was shown to be statistically insignificant in nations with lower, medium, and higher incomes. Overall statistics, however, pointed to a detrimental effect of urbanization. Alam et al. (2007) discovered that Pakistan experienced a rise in CO2 emissions due to urbanization between 1971 and 2005.

Last but not least, a comprehensive study conducted in 14 MENA (Middle East and North African) nation-states between 1996 and 2012 examined the relationship between urbanization, proxies measured by the proportion of urban residents, and CO2 emissions. The study originates that urbanization had a positive influence on the region's ecological footprint, but that the influence within particular nations was not of statistical significance.

Figure 4: Urbanization Growth (%)



Source: World Bank (2022)

Initially in all 4 countries the urbanization was increasing as because of low education and health facilities in rural areas. With time people started to move to urban areas and over the years the urban centers have become so populated and there is a lot of burden on hospitals, schools and other offices in that their efficiency started to decrease. Governments have focused on this issue and released funds for rural developments which

resulted in decrease in urbanization. As now people can get good health care in rural areas, the roads are paved and educational institutes are there. This trend is noticeable in the above graph. In case of Pakistan in recent years urbanization has increased again due to corruption at district government level which is not focusing on rural development projects.

2.4 Smog and its Impact

Smog, as its most often described, is a combination of smoke and fog within common air. After World War 2, the first use of the term smog was in 1950s London its primarily used in London dictionaries (Allaby, M. (2014). Smog is a word describing dense air which has vast amount of water in it and is polluted. Climate and anthropogenic actions and gases are the components that determine the presence of smog. Shift of construction colonies, burning coal in industries, agriculture burning, industrial construction, and brick making however are the destructive ones. Vehicle and aircraft emissions addition is a significant reason American cities are experiencing greater smog pollution than ever before (Lodhi et.al, 2009). Climate conditions during summer months change other air pollutants into smog-like particles.

Table A: Pollutants and its Effects

Pollutants	**Effects**
Nitrogen oxides	This poses significant risk of lungs and heart and also minimize the immune system against diseases.
Volatile organic compounds (VOCs)	• Eye inflammation • Respiratory distress • Cancer-causing agent
Ozone	• Irritative cough and High-pitched breathing • Scratchy eyes • Asthma-related respiratory symptoms
Peroxyacetyl nitrate (PAN)	• Tired eyes • respiratory difficulties

Table 1: Types of Smog

Character	**London Smog (Sulfurous Smog)**	**Polish Smog**	**Photochemical Smog (Los Angeles Smog or Summer Smog**	**Natural Smog**	**References**
Definition	Resultant from sulfur oxide atmospheric contamination.	Pollutants accumulate in low-hanging cloud as temperatures drop.	Created via photochemical oxidation of nitrogen oxides and VOCs.	This phenomenon is triggered by volcanic activity and plant-based hydrocarbon emissions.	Czerwi and Wielgosi (2020), Vecchiato et.al.2017), Zia-UL-Haq and Modhi (2021), Tofte and Barnes (2017)
Occurrence	The combination of cold temperatures and humidity contributes to this.	Occurs predominantly during the winter season.	Found in areas with warm weather, little rain, and plenty of sunshine	Common in tropical summer climates.	Czerwi and Wielgosi (2020), Vecchiato et.al.2017), Wang et.al. (2020), Yin eta.al. (2019)
Effects	Adverse effects include eye irritation, bronchitis, and lung complications.	Associated with respiratory and cardiovascular diseases, including asthma.	Associated with eye irritation, chronic respiratory disease, cardiovascular pathology, and asthma	Can lead to dry cough, eye redness, breathing issues, and asthma.	Read and parton (2021), and Yu et.al (2020)

This is concentrated over Los Angeles: photochemical smog. Smog is best known in Los Angeles as a form or compound of ozone (Zhang and Oanh 2002). In many cases, people might be affected through exposure to hazardous elements that can be a smoke Heit'sj factors contributing to respiratory disorders include several variables (Sati and Mohan 2014). Smog is a liquid in the atmosphere which can be in yellow or black coloration and is hard to breathe through as it leads to diseases of the upper and lesser breathing system and even viral infections because of the irritation of the lung muscles leading to thoracic pain, coughing and itchy eyes, and its ecological impact comprise hazy condition. The entire populace of the smog zone is got infected but the old aged, children and some whose are suffering from cardiac and respiratory disorders are at more risk (Sati and Mohan 2014). Photochemical or 'summer' smog' is referred to the response of sunlight with nitrogen oxides and explosive biological mixtures in the air which discharges the suspended particulates and ground-level ozone (Zhou et.al.2015). Four -only those who have surnamed gas rakehell water are not known to a filled gas but also carries things about environmental facet, health of human beings at various levels and even effects diverse materials.

The presence of air smog has adverse effects on human health, causing many diseases that result in high mortality and morbidity rates, especially in developed nations, where human beings have been more prone to various toxins. The introduction of other measures into nutrition such as organic plant food products may maintain different systems in the body from the adverse effects of air pollution. One thing that is clear is that air pollution is hazardous on the breathing system. When elements floating in the lung air are inhaled, the airways are the first structural barriers to be breached. Having researched the correlation of environmental factors with health, and a range of lung ailments, the researcher are of the opinion that aggravating factors should be evaluated comprehensively and included in preventive efforts. This is especially true for lung disorders that are experienced as a result of development of both primary and secondary elements.

3. Methodology and Model

The Environmental Kuznets Curve (EKC) concept has drawn significant interest concerning respect to the link between income and emissions. As per this hypothesis, the correlation between income and pollution levels, or environmental degradation, can be represented by an inverted U curve. This implies that while pollution levels rise in the beginning phases of a country's development, they tend to decrease beyond a certain threshold. Put another way, it is predicted that as an economy grows, the quality of its environment will initially deteriorate before improving. Initially, studies focused exclusively on the bivariate causal relationship. However, in recent years, plenty of researches have included EC (as an intermediary variable to clarify and explain the bivariate causality) to carry out a triradiate evaluation. Many research study has also included a variety of control variables to account for particular aspects of the economies under investigation, such as urbanization and trademark innovation.

For this study panel data analysis is used from 2000-2020. The following Table provides a detailed discussion of each variable. The World Bank (2018) provides statistics for CO2, ECFF, URPG, FD, FDI, GDPPC, and INNV. The KOF Index of Globalization (Dreher, 2006) provides data for the Globalization Index, which measures Economic, Political, and social globalization. This study's variable selection process was based in the evaluation of the impact of economic growth on CO2 emissions conducted by Sekantsi et al. (2016), Kayhan et al. (2010), and Khan et al. (2019). Çoban and Topcu (2013) and Shahbaz et al. (2016a) looked at the relationship between financial development and environmental deterioration. The relationship between environmental deterioration and globalisation has been investigated by Antweiler et al. (2001), You and Lv (2018), Shahbaz et al. (2016b), and Solarin et al. (2017a, 2017b). The impact of financial growth and energy consumption on environmental degradations has been explored by Shahbaz et al. (2018), Abbasi and Riaz (2016), Charfeddine and Khediri (2016), Sadorsky (2011), Frankel and Romer (1999), and Dasgupta et al. (2001). Khan et al. (2018) explored at how various urban population characteristics affected CO2 emissions. The effects of trade and FDI on environmental degradations have been reviewed by Lau et al. (2014), Narayan and Narayan (2010), Saboori et al. (2012), Shahbaz et al. (2013a, 2013b), Farhani et al. (2014), and Jalil and Mahmud (2009). The relationship between innovation and pollution was examined by Potepa and Welch (2018), Dauda et al. (2019), Gotsch and Hipp (2014), and Flikkema et al. (2015).

3.1 Empirical Model

The analytical model, derived from the literature, takes the following form:

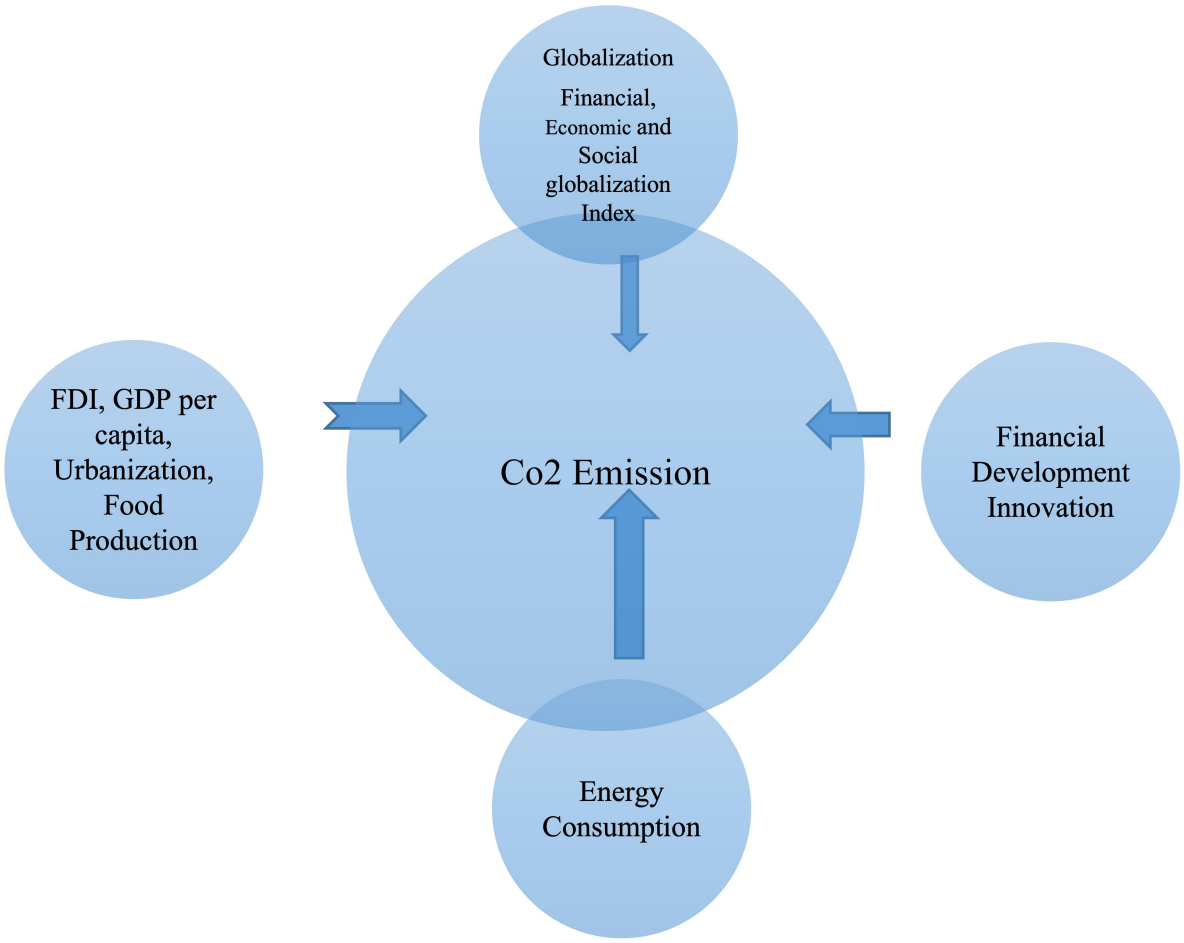
$$C = f(Y, U, G, E, INN, A, FD, FDI) \quad (1)$$

Above equation states that GDP (Y), urbanization (U), globalization (G), energy consumption (E), innovation (INN), agricultural production (A), financial development (FD), and foreign direct investment can potentially determine CO2 emissions (C). As our study is a panel study, we must consider both time and individual (country) effects in the mathematical model, leading to the following equation:

$$CO2\ emissions_{it} = \beta0 + \beta1\ GDP_{it} + \beta2\ urbanization_{it} + \beta3\ globalization_{it} + \beta4\ energy\ consumption_{it} + \beta5\ innovation_{it} + \beta6\ agricultural\ production_{it} + \beta7\ financial\ development_{it} + \beta8\ foreign\ direct\ investment_{it} + \epsilon it \quad (2)$$

Where i represents country (in our study, we have 4 countries), t represents time (our time frame is 2000–2020).

Figure 3: Flow Diagram



The overall regression model for panel data can be expressed as follows:

$$CO2_{it} = \beta0 + \beta1\ EC + \beta2\ UP_{it} + \beta3\ FD + \beta4 FDI_{it} + \beta5 GDPPC_{it} + \beta6 INN_{it} + \beta7 PLGL_{it} + \beta8 ECGL_{it} + \varepsilon it \quad (3)$$

Table 2: Variables and its Description

Symbol	Variable Description	Units of Measurements	Data Source
CO2	Carbon dioxide emissions	Metric tons per capita	WDI
EC	Energy Consumption	% of total final energy consumption)	WDI
UP	Urban Population growth	% of annual	WDI
FD	Financial development	Insurance and financial services (% of commercial service imports)	WDI
FDI	Foreign direct investment	Foreign direct investment, net inflows (BoP, current US$)	WDI
GDPPC	GDP per capita	constant 2015 US $	WDI
INN	Innovation	Trademark applications, nonresident, by count	WDI
SCGL	Social globalization index: It is gauged by direct interaction, the exchange of information, and cultural proximity.		KOF Index
PLGL	Political globalization index: It is assessed based on the number of embassies in foreign countries, membership in international organizations, participation in UN Security Council mission meetings, and the count of treaties signed with other nations.		KOF Index
ECGL	Economic globalization index: It is evaluated based on trade flows with other countries, foreign direct investment (FDI), portfolio investments, and the restrictions placed on these inflows and outflows.		KOF Index
Agriculture Production	Food Production Index		WDI

4. Results and Discussion

The table 3 presents the summary of the main features of the dataset. It offers insights into the central tendency, dispersion, and distribution of the data.

Table 3: CO2 Emissions

Variables	Countries	Mean	Standard Deviation	Minimum	Maximum
C02 Emission	Pakistan	0.7432	0.0799	0.626	0.9184
	India	1.3159	0.3260	0.8837	1.7955
	Bangladesh	0.3533	0.135	0.160	0.5861
	Iran	6.8070	0.7704	5.194	7.57

According to descriptive statistics, Iran is the highest co2 emission as compared to other selected economies. Iran's energy demands are mostly met by fossil fuels, especially oil and natural gas. Conversely, the energy mixes of nations like Bangladesh, Pakistan, and India are more varied and include sizable amounts of renewable energy sources including solar, wind, and hydroelectric electricity. Iran uses a comparatively larger amount of coal than these other nations, which is another significant source of CO2 emissions. The industrial

sector in Iran, which includes petroleum products, and oil and gas production, is heavily dependent on fossil fuels and energy-intensive processes, which contribute significantly to CO2 emissions. Although Bangladesh, Pakistan, and India all have sizable industrial sectors, they may have adopted cleaner technology or more ecological regulations to reduce emissions.

Analysis shows that Bangladesh has the lowest CO2 emissions when compared to a few other chosen countries. Although Bangladesh has an industrial sector, it is not as dependent on fossil fuels as nations like Pakistan, India, and Iran are. Furthermore, a sizable percentage of Bangladesh's industrial sector is made up of light manufacturing sectors, which generally need less energy and produce less emissions than heavy industries like petrochemicals and steel.

The government of Bangladesh has put in place a number of laws and programmers that are meant to encourage environmentally friendly growth and lower greenhouse gas emissions. These include the Bangladesh Climate Change Strategy and Action Plan and the National Sustainable construction Strategy, which place emphasis on the construction of climate-resilient infrastructures energy conservation, and energy from renewable sources.

Table 4: Descriptive Statistics of Renewable Energy Consumption

Countries	Mean	Standard Deviation	Minimum	Maximum
Pakistan	47.10	2.4995	42.1	51.54
India	38.63	5.38	32.57	47.11
Bangladesh	41.334	10.7421	25.79	60.2
Iran	0.924	0.2464	0.44	1.4

Pakistan uses a comparatively larger amount of renewable energy than Bangladesh, India, and Iran. Pakistan has a lot of potential for hydropower because of its hilly geography and plenty of major rivers like the Indus. In Pakistan, hydropower is a prominent renewable energy source that accounts for a sizeable amount of the country's electricity production. Pakistan has also made investments in wind energy projects, especially in the coastal regions where breezes are ideal for producing power.

Through regulatory support and incentives, the government has aided in the building of wind farms, increasing the nation's use of renewable energy. International organizations and funding agencies have provided Pakistan with support for activities aimed at strengthening capacity and promoting renewable energy. This partnership has made it easier to share knowledge, transfer technologies, and provide funding for the nation's infrastructure to support renewable energy sources.

There are a number of reasons why Iran uses less renewable energy than nations like Bangladesh, Pakistan, and India. The production and sale of gas and oil are vital to Iran's economy. Fossil fuels are the main source of energy for the nation's transportation, industry, and power generation. The advancement and widespread use of renewable energy technologies have been impeded by this reliance on conventional energy sources. Iran's access to technology, capital, and experience in the development of renewable energy has been hampered by political isolation and international sanctions. The imposition of these sanctions has limited international participation and investment in Iran's energy industry, encompassing renewable energy initiatives.

Table 5: Descriptive Statistics of Urbanization Growth Rate

Variables	Countries	Mean	Standard Deviation	Minimum	Maximum
Urbanization growth rate	Pakistan	2.5841	0.5284	1.779	3.690
	India	2.5473	0.1861	2.2636	2.9377
	Bangladesh	3.6964	0.3885	3.1870	4.560
	Iran	2.3041	0.3773	1.4737	2.9841

For a variety of reasons, Bangladesh has had a comparatively faster pace of urbanization expansion than India, Pakistan, and Iran. Over the past few decades, Bangladesh's economy has grown significantly thanks to sectors including manufacturing, textiles, and apparel. Due to job possibilities brought forth by this economic expansion, rural migrants seeking work have been drawn to metropolitan regions

The government of Bangladesh has made investments in the construction of homes, schools, healthcare facilities, and transportation systems in urban areas. Urbanization has been aided and urban life has become more appealing due to improved infrastructure in town and city centers. Bangladesh has a little amount of arable land and is among the most overcrowded nations globally. Because of the burden this high population density puts on rural regions, people are migrating to cities in pursuit of better facilities, services, and economic possibilities.

There are several reasons behind Iran's slower pace of urbanization expansion when compared to a few other chosen nations. In many regions of Iran, traditional rural lifestyles and agricultural methods are still widely used, especially in rural areas where farming and raising animals are important sources of income. Strong familial ties and links to rural customs may discourage migration to metropolitan areas. People's decisions to move to or remain in rural regions may be influenced by social and cultural variables, such as connections to agricultural areas, ethnic background, and lifestyle preferences. Different patterns of urbanization may be found throughout Iran due to the country's rich cultural history and regional identities.

Table 6: Descriptive Statistics of Social Globalization

Variables	Countries	Mean	Standard Deviation	Minimum	Maximum
Social Globalization	Pakistan	83.46	2.2525	79.41	85.75
	India	88.17	6.459	63.36	92.76
	Bangladesh	69.30	3.093	64.12	72.75
	Iran	75.36	4.838	65.86	79.88

There are several reasons why India has a comparatively greater level of social globalization than Bangladesh, Pakistan, and Iran. With a vast variety of languages, religions, customs, and ethnic groups coexisting inside its boundaries, India is renowned for its wide range of cultures. Social globalization is aided by this variety, which promotes social connections, exchanges, and integration amongst various populations. India, which has a thriving IT sector and extensive access to mobile and internet technology, has been at the center of the global ICT revolution.

This has promoted social globalization by making it easier to interact, communicate, and engage in social networking both domestically and internationally. Iran's population, which is primarily Shia Muslim and Persian, may be less diverse culturally than that of nations like India, which is home to a wide variety of languages, faiths, and ethnic backgrounds. There may be fewer social encounters and exchanges with other populations worldwide as a result of this rather homogeneous cultural landscape. The primary language used in Iran is Persian (Farsi), which is also spoken in several of its neighbors, but is not as commonly used as languages like English, which is more common in Pakistan and India. Communication and cultural interaction with non-Persian speaking populations may be hampered by language obstacles.

4. Results and Discussions

Table 7 reports the results of Pooled OLS model, shedding light on the effects of independent variables on the dependent variables.

Table 7: Results of Pooled OLS

Dependent Variable: CO2 Emissions			
Variables	**Coefficients**	**Standard Error**	**t-value**
UP	0.07050	0.076	0.98
FD	-0.00039	0.0062	-0.06
FDI	0.0288	0.0934	0.31
GDPP	0.0017**	0.0000845	20.22
Innovation	-1.14 e -06	1.31e-06	-0.87
PLGL	0.035**	0.0072	4.88
SCGL	0.0164**	0.016	0.0029
ECGL	-0.013**	0.0053	-2.54
EC	0.004128	0.0056	0.73
Food Production	-0.0220**	0.00190	-11.62
Constant	-2.9091**	0.816	-3.56
R- Square	0.9961		
Adjusted R-Square	0.9955		
Root MSE	0.1785		
Prob > F	0.000		

The table 8 presents the estimation results of fixed effect regression model.

Table 8: Results of Fixed Effect Regression Model

Dependent Variable: CO2 Emissions			
Variables	**Coefficients**	**Standard Error**	**t-value**
UP	0.104247**	0.0480	2.17
FD	0.011*	0.0056	1.97
FDI	-0.035	0.05953	-0.60
GDPP	0.00071**	0.00015	6.22
Innovation	3.97e-06**	1.09e-06	3.65
PLGL	0.05335**	0.01320	4.06
SCGL	0.0031	0.0036	0.87
ECGL	0.0067*	0.0037	1.78
EC	0.0147**	0.0038	3.86
Food Production	-0.0042*	0.0021	-2.00
dPak	-5.22**	0.608	-8.58
dInd	-4.999**	0.6448	-7.75
dBang	-4.7174**	0.510	-9.24
Constant	-0.47	0.8439	-0.57
R- Square	0.9986		
Adjusted R-Square	0.9983		
Root MSE	0.1103		
Prob > F	0.000		

In this analysis, the F statistic was employed to choose between the pooled and fixed effect models. The critical value at a 5% significance level is 4.34, while the computed value was 4.04. Since the calculated value is lower than the tabulated value, the null hypothesis is not rejected, suggesting that the fixed effect model is the more suitable option

The White test is applied to check for heteroskedasticity. The outcome shows that the ² value with 83 degrees of freedom is 84.00, while the p-value is 0.448. Since the p-value exceeds 0.05, the null hypothesis (H_0) cannot be rejected, suggesting that heteroskedasticity is not a concern. The Wooldridge correlation test is conducted to detect autocorrelation. The calculated F statistic was 56.620, with a p-value of 0.0049. Since the p-

value is below 0.05, the null hypothesis (H_0) is rejected, supporting the alternative hypothesis and indicating the presence of serial correlation.Robust standard errors are calculated to ensure unbiased results in the presence of heteroskedasticity and autocorrelation. The table 9 presents the outcomes of the fixed effect regression model using robust estimation.

The findings of the urbanization analysis show that there have been notable and beneficial belongings on CO2 discharges in South Asian regions. The results show that a 1% rise in urbanization will result in a 0.1042 metric ton rise in CO2 emissions per capita, all other things being equal. Due to a higher demand for transport services, urbanization usually leads in a rise in the ownership and usage of automobile. As a result, vehicles such as automobiles, trucks, buses, and motorbikes emit more CO2 and other pollutants, which increases air pollution and greenhouse gas emissions. In contrast to rural regions, urban areas have higher energy needs for industrial, commercial, and residential uses. combustion conventional sources like coal, oil, and natural gas are a communal way to meet the growing demand for power like climate control, heating, and electricity as urbanization increases. Power plants and other energy-intensive operations emit more CO2 as a result.

Table 9: Results of Robust Estimation

Dependent Variable: CO2 Emissions			
Variables	**Coefficients**	**Standard Error**	**t-value**
UP	0.104247**	0.051	2.04
FD	0.011*	0.0051	2.17
FDI	-0.035	0.0513	-0.69
GDPP	0.00071**	0.00010	6.70
Innovation	3.97e-06**	1.05e-06	3.45
PLGL	0.05335**	0.01720	3.15
SCGL	0.0031	0.0032	0.97
ECGL	0.0067*	0.0037	1.78
EC	0.0147**	0.0032	4.58
Food Production	-0.0042*	0.0024	-1.72
dPak	-5.22**	0.58	-8.99
dInd	-4.999**	0.630	-7.93
dBang	-4.7174**	0.540	-8.73
Constant	-0.47	1.120	-0.43
R- Square	0.9986		
Root MSE	0.1103		
Prob > F	0.000		

The findings of the analysis showed that the primary factor having a favorable influence on China's environmental degradation is urbanization. Wang et al. (2016) and Wang et al. (2016) studied the connotation between urbanization and EU and CO2 discharges. The results of the analysis exhibited that the root causes of

environmental pollution are energy use and urbanization. Urbanization has a favorable influence on CO2 discharges, according to Martinez-Zarzoso and Maruotti (2011), Ponce de Leon Barido and Marshall (2014), Adusah-Poku (2016), Erdoğan (2013), Zhang and Lin (2012), and Martinez-Zarzoso and Maruotti (2011). The outcome of the analysis showed that while urbanization has a favorable outcome on CO2 releases economically advanced and upper-middle-income countries, it has a undesirable influence on environmental degradations in lower-, middle-, and upper-class economies.

The projected financial development outcomes (a proxy for insurance and financial services) show that the South Asian area has seen positive and noteworthy improvements in CO2 emission in metric tons per capita. The findings show that a 1% rise in insurance and financial services will result in a 0.011 CO2 emission metric tons increase per capita, assuming all other factors remain the same. Numerous financial organizations and insurance firms make reserves in the coal, gas, and oil industries. The exploration, extraction, and use of conventional fuels—which, when burnt for energy, are significant sources of CO2 emissions—are supported by these investments. Projects financed by fossil fuels have the potential to maintain dependency on carbon-intensive energy sources and impede the shift to greener alternatives. Insurance providers serve a wide range of businesses and pursuits, including high-carbon industries like production, transport, energy generation, and construction. Insurance firms indirectly promote activities that raise CO2 emissions by funding projects and operations that promote reforestation and shifts in land use, or that extensively depend on fossil fuels. The following writers disagree with the financial development outcomes that were analysed. According to studies by Tamazian and Rao (2010), Kim and Park (2016), Lin et al. (2014), and Tamazian et al. (2009), the rise in financial activity boosts the renewable energy industry by funding energy initiatives that lessen environmental degradation.

The findings of the analysis of FDI show that the region of South Asia has negative and insignificant effects on CO2 emissions. According to the analysis's findings, every 1% increase in FDI will result in 0.035 metric tons less carbon dioxide emissions. Renewable energy sources including green energy, air energy, water power, and organic energy may be developed and expanded with the help of foreign direct investment (FDI). To fund and build renewable energy infrastructures foreign investors may bring in resources, expertise, and technology. This would replace conventional based energy sources and lower CO2 discharges related to the production of electricity.

The FDI results under examination are consistent with those of earlier studies by Solarin et al. (2017a, 2017b), Sun et al. (2017), Zakarya et al. (2015), and Behera and Dash (2017), which found that the primary industries receiving FDI from developed economies that contribute to the deterioration of the environment in emerging nations are manufacturing, mineral extraction, and electricity.

The findings of the analysis show that financial growth has a positive and noteworthy influence on carbon dioxide emissions. The findings show that a 1% rise in economic development will result in 0.00071 metric tons increase in CO2 emissions. The following researchers' findings are consistent with the researched effects of economic expansion. According to Khan et al. (2019), Dinda (2004), Acquaye et al. (2017), Sharma (2011), and Lau et al. (2014), economic growth is the root of environmental deterioration. The findings of the analysis showed that environmental deterioration is positively impacted by economic expansion. A greater GDP per capita is linked to increased consumption levels, which in turn leads to higher waste generation levels. The open burning of solid trash is one example of an insufficient waste disposal technique that can cause the atmosphere to fill with greenhouse gases, including CO2. A growth in the demand for transportation services, such as private automobiles, commercial trucks, and public transit, is usually associated with rising GDP per capita. The use of petrol and diesel fuels in automobiles is the main source of CO2 emissions from the transportation industry. People tend to buy more cars and travel more often as their salaries grow, which increases emissions.

Innovation has a favorable and considerable influence on CO2 discharges, according to the results of the analysis. According to the analyzed data, a 1% increase in innovations will result in a 3.97 e-06 CO2 emissions metric per tons rise. Industries like heavy manufacturing, cement manufacturing, and petrochemicals, which

have huge carbon footprints by nature, may be places where innovation happens. Even though these innovations may improve efficiency or lower emissions per unit of output, repercussions or an overall rise in production might result in net emissions rises.

The use of fossil fuels may be permitted while lowering emissions per unit of energy generated due to advancements in energy production technology like carbon capture and storage (CCS) systems and efficient fossil fuel extraction processes like hydraulic fracturing. On the other hand, if fossil fuels are used exclusively for energy generation, this might slow down the switch to renewable energy sources and increase reliance on carbon-intensive resources for energy.

There are three indicators used to quantify globalization: the political, social, and economic globalization indices. The South Asian region's environmental degradations have been positively and meaningfully influenced, affording to the outcomes of the economic, social, and political globalization index. The analyzed globalization results are consistent with earlier research.

Danish et al. (2018) and Ahmed et al. (2015) explored how globalization influenced environmental sustainability. The closely examined findings demonstrated that environmental deterioration is caused by natural resource depletion, which is a byproduct of globalization. Increased international trade has resulted from globalization, with long-distance transportation of commodities and services. When commodities are transported by trucks, ships, airplanes, and other vehicles, fossil fuels are frequently used, which results in CO2 emissions. Furthermore, industrial outsourcing to nations with cheaper labor expenses or more relaxed environmental regulations laws Could result in extended supply chains and higher transportation emissions.

CO2 discharges are positively impacted by the usage of renewable energy. The findings show that a 1% increase in the use of renewable energy would result in a 0.014% rise in CO2 emissions while all other factors stay the same. Many renewable energy methods, including bioenergy (using biomass for power generation or biofuels for transportation), might result in land use changes that increase CO2 emissions when they are implemented widely. Some of the emissions savings linked to the use of bioenergy can be countered, for instance, by releasing carbon trapped in plants and soil via cutting forests or converting agricultural land to grow biofuel feed stocks. Aziz (2023) discovered comparable outcomes.

The calculated results illustration a important and negative relationship between food production and CO2 emissions. One percentage increase in food production will result in a 0.0042% decrease in CO2 emission metric tons per capita, assuming all other factors stay the same. This finding is statistically significant, but only at the 10% significance level. There are several reasons why increasing agricultural productivity has a negative effect on CO2 releases. One reason may be the use of specific farming techniques that result in lower CO2 emissions.

One of these methods is using less fertilizer per hectare of agricultural land. Comparing East Asia and South Asia, the average fertilizer use in 2017 was 165.7 kg per hectare of arable land and 327.8 kg per hectare, respectively (World Bank Open Data 2023). Other significant factors that influence how agriculture affects CO2 emissions include the quantity and sources of energy utilized in agriculture; we have already taken these variables into account individually in the regression model. The crops chosen for cultivation may also have a role in this detrimental effect on agricultural output. The effects of different grain crops on the environment vary. For instance, methane emissions from flooded rice fields are linked to rice farming; nevertheless, wheat has been demonstrated to function as a carbon sink since it accumulates greater amounts of carbon than it discharges (Veeck et al. 2022, 901). One possible explanation for the negative impact of agricultural production on CO2 emissions in South Asia is the region's widespread wheat growing. Furthermore, growth in the agricultural sector suggests a shift in the economy away from the industrial and manufacturing sectors, which might result in larger CO2 emissions than in the agricultural sector. As a result, the net effect of agricultural output on CO2 emissions is negative.

5. Conclusion

This study aimed to provide light on the relationship between 10 key factors—food production, political, social, and economic globalization, GDP per capita, urban population, FD, and FDI—and CO2 emissions in South Asia. From 2000 to 2020, four South Asian nations are examined in this study: India, Pakistan, Bangladesh, and Iran. The study utilized data from two separate sources: WDI and the KOF Index. Fixed effects were employed for the empirical analysis.CO2 emissions are positively and significantly impacted by the usage of natural energy. The findings show that a 1% increase in the use of renewable energy would result in a 0.014% rise in CO2 emissions while all other factors stay the same. Many renewable energy methods, including bioenergy (using biomass for power generation or biofuels for transportation), might result in land use changes that increase CO2 emissions when they are implemented widely. The findings show that a 1% rise in urbanization will result in a 0.1042 metric ton increase in CO2 emissions per capita, all other things being equal. Due to a higher demand for transport services, urbanization usually leads in an increase in the ownership and usage of motor vehicles. The projected financial development outcomes (a proxy for insurance and financial services) show that the South Asian area has seen positive and noteworthy improvements in CO2 emission in metric tons per capita.

According to the analysis's findings, every 1% increase in FDI will result in 0.035 metric tons less carbon dioxide emissions. Renewable energy sources including sun energy, air energy, water power, and biomass energy may be developed and expanded with the help of FDI. The findings of the analysis show that economic growth has a positive and noteworthy impact on carbon dioxide emissions. The findings show that a 1% rise in economic development will result in 0.00071 metric tons increase in CO2 emissions. Innovation has a favorable and considerable impact on CO2 emissions, according to the results of the analysis. The South Asian region's environmental degradations have been positively and significantly influenced, according to the results of the economic, social, and political globalization index. The calculated results show a significant and negative relationship between food production and CO2 emissions. One percentage increase in food production will result in a 0.0042% decrease in CO2 emission metric tons per capita, assuming all other factors stay the same. The theoretical model developed over a comprehensive literature analysis, which outlined the potential causes and factors explaining the correlations identified between the explanatory variables and the CO2 releases, was used to analyze the data.

6. Policy Recommendation:

The primary causes of South Asian's environmental degradation are outlined above. It is recommended that South Asian policymakers use measures that incentivize foreign investors to contribute in green energy schemes as a means of promoting sustainable economic growth and environmental preservation. To protect the environment and promote economic growth, government policymakers are advised to strengthen their international, social, and economic ties with nations that are leaders in the field of renewable energy technology. The government should increase financial subsidies or investments to actively promote the development of energy infrastructure and facilitate the building of electricity networks and natural gas pipelines. Residents will have easier access to efficient and sustainable energy for their homes due to this effort.

The government should enforce more stringent regulations on industrial emissions, particularly from sectors that generate high concentrations of fine particles and nitrogen oxides (NOx), which are major contributors to smog. This can be achieved by tightening emission limits, establishing routine monitoring, fostering the shift toward cleaner technological solutions, such as scrubbers and filters. Additionally, the government should strengthen fuel efficiency and emission standards for vehicles, with a focus on reducing NOx and volatile organic compounds (VOCs). Support for electric vehicles (EVs) should also be increased through financial incentives, subsidies, and the expansion of charging infrastructure.

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