

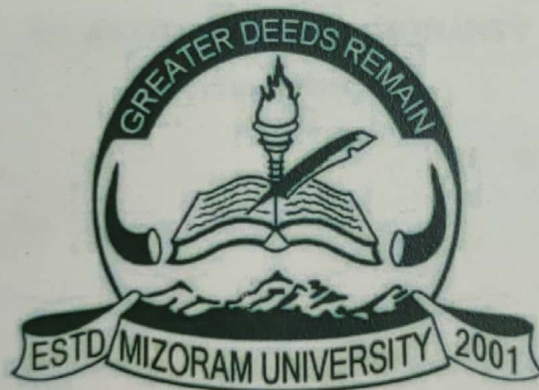
**ENVIRONMENTAL IMPLICATIONS OF FOREIGN DIRECT
INVESTMENT FOR SOUTH ASIA AND ASEAN COUNTRIES**

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF DOCTOR OF
PHILOSOPHY**

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**SCHOOL OF ECONOMICS, MANAGEMENT & INFORMATION
SCIENCE**

SEPTEMBER, 2025

**ENVIRONMENTAL IMPLICATIONS OF FOREIGN DIRECT
INVESTMENT FOR SOUTH ASIA AND ASEAN COUNTRIES**

DECLARATION

I, the undersigned, do hereby declare that the thesis titled "Environmental Implications of Foreign Direct Investment for South Asia and ASEAN Countries" submitted by
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has been written by me and is the original work of mine and has not been
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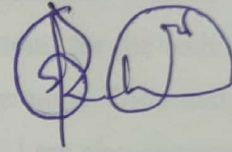
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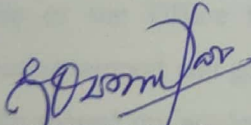
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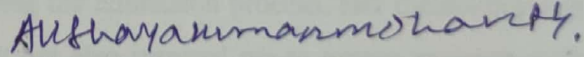
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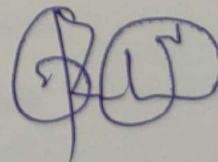
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"Embraced by spirit and grace, Mizoram is a land where love and culture intertwine, her hills carry timeless stories; her people sing songs of tradition, unity, peace and resilience, captivating the heart and soul"



(MD. MAZNUR RAHMAN)
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CONTENTS

	Page No
Certificate	I
Declaration	II
Acknowledgement	III-IV
Contents	V-XIII
List of Tables	XIV-XVI
List of Figures	XVII
List of Abbreviations	XVIII-XX
CHAPTER 1	INTRODUCTION
1.1	1-29
Introduction	1-3
Study Related to Environmental Implications or	
Degradation	3-4
Study Related to Climate Change on the	
Environment	5-6
Study Related to FDI and Impact on the	
Environment	6-8
Importance of FDI for Developing Countries	8-10
Study Related to Sustainable Development	10-11
Study Related to Economic growth	11-13
Study Related to Energy consumption and	
Renewable Energy Consumption	13-14

1.9	Study Related to Tourism	14-16
1.10	Study Related to Technological Innovation	16-18
1.11	Study Related to capital formation and Labor force	18-19
1.12	Study related to Environmental Sustainability	19-20
1.13	Study Related to STIRPAT Model	20-21
1.14	Statement of the Problem	21-22
1.15	Significance of the Study	22-24
1.16	Scope of the Study	24-25
1.17	Objective of the Study	25-25
1.18	Hypotheses	26-26
1.19	Methodology	26-27
1.2	Chapterisation	27-28
1.21	Conclusion	28-29
CHAPTER 2	LITERATURE REVIEW	30-71
2.1	Introduction	30
2.2	Literature Review on The Environmental Impact	30-33
2.3	Review of Literature on Economic Growth	33-34
2.4	Review of Literature on Foreign Direct Investment (FDI)	35-36
2.5	Literature Review on Technological Innovation	37-38
2.6	Literature Review on Tourism	38-39

2.7	Literature Review on Energy Consumption and Renewable Energy Consumption	39-40
2.8	Literature Review on the Relationship between Environmental Degradation and Foreign Direct Investment (FDI)	40-44
2.9	Literature Review on the Relationship between Environmental Implications and Energy Consumption	44-46
2.10	Literature Review on the Environmental Implications and the Economic Growth Relation	47-50
2.11	Literature Review on the Environmental Implication and The Tourism Relation	50-52
2.12	Literature Review on the Environmental Implication and the Technological Innovation Relation	52-53
2.13	Literature Review on the Environmental Implications, Capital Formation, and Labor Force Participation Rate Relation	54-58
2.14	Empirical Literature Review	58-62
2.15	Theoretical Framework Review	63-65
2.23	Literature Gap	65-71
CHAPTER 3	THEORETICAL FRAMEWORK, DATA COLLECTION, AND METHODOLOGY	72-97
3.1	Theoretical Framework	72-75
3.2	Data, Source and Model Specification	75-77
3.2.1	Data Source	76-77
3.2.2	Estimation Methodology	78-88

3.3	Empirical Methodology	89-97
3.3.1	Slope Homogeneity Test:	89-90
3.3.2	Cross-sectional Dependence (CSD)	90-91
3.3.3	CIPS Unit Root Test	91-92
3.3.4	Kao Cointegration Test	92-94
3.3.5	Parameter Estimation: PMG-ARDL Approaches	94-95
3.3.6	FMOLS Test:	95-96
3.3.7	Granger Causality Test:	96-97

CURRENT SITUATION ANALYSIS:
CHAPTER 4 GLOBAL, SOUTH ASIA AND ASEAN
COUNTRIES CO2 EMISSION 98-127

4.1	Introduction	98
4.2	CO2 Emissions in the World, ASEAN, and South Asia	98-104
4.3	FDI Trend in ASEAN and South Asian Countries	104-110
4.4	Trend of Tourism Development	110-112
4.5	Trend of Gross Domestic Product (GDP)	112-115
4.6	Trend of Capital Formation	116-118
4.7	Fossil Fuel and Renewable Energy Consumption	118-121
4.8	Labor Force Participation Rate	121-124
4.9	Technological Innovation	124-127

CHAPTER 5	RESULT ANALYSIS	128-198
5.1	Introduction	128
5.2	Section A: South Asian Countries	129-166
5.2.1	Descriptive Statistics	129-131
5.2.2	Correlation Analysis	132-133
5.2.3	Slope Heterogeneity Test:	134-135
5.2.4	Cross Sectional Dependency (CD) Test:	135-138
5.2.5	CIPS Unit Root Test	138-141
5.2.6	Kao Cointegration Test	141-142
5.2.7	Lag Selection Criteria	142-144
5.2.8	Regression Output of Economic Growth Model	144-147
5.2.9	Results of Basic Environmental Implications Model 1	147-150
5.2.10	Results of Environmental Implications of Population and Affluence (IPA) Model 2:	152-153
5.2.11	Results of Environmental Implications of Affluences and Technological Innovation (IAT) Model 3	153-156
5.2.12	Results of STIRPAT or Environmental Impact for Population, Affluences, and Technological Innovation Model 4:	156-159
5.2.13	Results of Pairwise Panel Causality Tests	162-164
5.3	Section B: Results for ASEAN Countries	164-192
5.3.1	Descriptive Statistics	165-166

5.3.2	Correlation Between the Variables in ASEAN Countries	167-169
5.3.3	Slope Heterogeneity Test:	169-170
5.3.4	Cross Sectional Dependency Test:	170-173
5.3.5	CIPS Unit Root Test	173-175
5.3.6	Kao Cointegration Test and Lag Order	175-176
5.3.7	Regression Results for ASEAN Countries Growth Model	176-178
5.3.8	Output of ASEAN Basic Environmental Implications Model 1	178-180
5.3.9	Results of ASEAN Environmental Implications of Population and Affluence (IPA) Model 2	180-182
5.3.10	Results of Environmental Implications of Technological Innovation and Energy (ITE) Model 3	183-185
5.3.11	Results of ASEAN Environmental Impact for Population, Affluences, and Technological Innovation (STIRPAT) Model 4	185-188
5.3.12	Causality Tests	188-192
5.4	Section C: Country Wise Environmental Implications	192-198
5.4.1	South Asian Countries	193-195
5.4.2	ASEAN Countries	195-198
CHAPTER 6	FINDINGS AND DISCUSSION	199-253
6.1	Introduction	199
6.2	To Investigate the Impact of FDI on Environmental Degradation in South Asia and ASEAN Countries.	200-210

6.2.1	Theoretical Explanation (Environmental implications of Foreign direct investment for South Asia)	200-201
6.2.2	Empirical Explanation ((Environmental implications of Foreign direct investment for South Asia)	201-203
6.2.3	Theoretical Discussion (Environmental Implications of Foreign Direct Investment for ASEAN)	203-204
6.2.4	Empirical Discussion (Environmental implications of Foreign direct investment for ASEAN):	204-208
6.2.5	Environmental implications of Foreign direct investment for South Asia and ASEAN Countries Comparison:	208-210
6.3	To estimate the impact of FDI on economic growth in South Asia and ASEAN countries	210-221
6.3.1	Theoretical Discussion: FDI and Its Implications for Economic Growth in South Asia	210-211
6.3.2	Empirical Analysis: FDI and Its Implications for Economic Growth in South Asia:	211-214
6.3.3	Theoretical Discussion: FDI and Its Implications for Economic Growth in ASEAN Countries	215-216
6.3.4	Empirical Discussion: FDI and Its Implications for Economic Growth in ASEAN Countries	216-218
6.3.5	Combine Discussion on Economic Growth in South Asia and ASEAN Countries:	218-221
6.4	To Investigate the Impact of Capital Formation and Labor Force on Environmental Degradation.	221-227
6.4.1	To Investigate the Impact of Capital Formation on Environmental Degradation in South Asia	221-222
6.4.2	To Investigate the Impact of Labor Force on Environmental Degradation in South Asia	222-224
6.4.3	Capital formation and labor force Impact on	224-227

	environmental degradation in the ASEAN	
	To compare the results between the panel group	
6.5	South Asia and ASEAN countries by considering economic, social, and environmental views	227-239
6.5.1	Economic Views	227-231
6.5.2	Social Views	231-234
6.5.3	Environmental Views:	234-238
6.5.4	Integrated Economic, Social, and Environmental Views: South Asia vs. ASEAN	238-239
6.6	Other factors Impact on Environmental Implications in South Asia and ASEAN Countries	239-247
6.6.1	Economic Growth	239-241
6.6.2	Technological Innovation	241-242
6.6.3	Renewable Energy Consumption	242-243
6.6.4	Energy Consumption	243-245
6.6.5	Tourism	246-247
6.7	To analyses the impact of the variables on environmental degradation in South Asia and ASEAN countries, country-wise	247-253
6.7.1	South Asian Countries	247-249
6.7.2	ASEAN Countries	249-253
6.8	Conclusion	253
CHAPTER 7	SUGGESTIONS OR RECOMMENDATIONS	254-270
7.1	Introduction	254

7.2	Suggestions or Recommendations	254
7.2.1	General Recommendations	255-261
7.2.2	Empirical Suggestions for South Asia and ASEAN:	261-268
7.3	Conclusion	268-270
7.4	Limitation of the Study	270
	APPENDICES	271-286
	BIBLIOGRAPHY	287-326
	BIO-DATA OF THE CANDIDATE	327-329
	PARTICULARS OF THE CANDIDATE	330

	LIST OF TABLES	Page No.
Table 2.1	Summary of Empirical Literature Review	61-62
Table 3.1	Variables Identification and Details	77
Table 3.2	The framework of the PMG-ARDL process	89
Table 4.1	Labour Force Participation Rates in ASEAN Countries	122
Table 4.2	South Asia Labour Force Participation Rates in 2023	123
Table 4.3	Global Innovation Score in South Asia	125
Table 4.4	Global Innovation Score in ASEAN Countries	125
Table 5.1	Descriptive Statistics	130
Table 5.2	Results of Correlation Analysis	133
Table 5.3	Slope Homogeneity Test Statistic P-value	134
Table 5.4	Blomquist & Westerlund (2013) also for Testing for Slope Heterogeneity	134
Table 5.5	Result of Breusch-Pagan LM Test	136
Table 5.6	Pesaran CD Test Result	137
Table 5.7	CIPS Result	139
Table 5.8	Kao Cointegration Test	141
Table 5.9	Lag Selection Criteria	142
Table 5.10	Result of ARDL Model	144

Table 5.11	Results of FMOLS Method	146
Table 5.12	ARDL Output of Basic Environmental Implications Model 1	148
Table 5.13	FMOLS Output of Model 1	149
Table 5.14	ARDL Output of IPA Model 2	151
Table 5.15	ARDL Output of Basic Environmental Implications Model 1	152
Table 5.16	ARDL Output of Model 3	154
Table 5.17	FMOLS Output of Model 3	155
Table 5.18	ARDL Output of Model 4	157
Table 5.19	FMOLS Output of Model 4	158
Table 5.20	Pairwise Panel Causality Test Results	160
Table 5.21	Descriptive Statistics	166
Table 5.22	Correlation Test	168
Table 5.23	Slope Homogeneity Test Statistic P-value	169
Table 5.24	Blomquist & Westerlund (2013) also for Testing for Slope Heterogeneity	170
Table 5.25	Result of Breusch-Pagan LM Test	171
Table 5.26	Pesaran CD Test Result	172
Table 5.27	CIPS Result	174
Table 5.28	Kao Cointegration Test	175
Table 5.29	Lag Selection Criteria	175

Table 5.30	Result of ARDL Model	176
Table 5.31	Results of FMOLS Method	177
Table 5.32	ARDL Output of Basic Environmental Implications Model 1	178
Table 5.33	FMOLS Output of Model 1	179
Table 5.34	ARDL Output of IPA Model 2	181
Table 5.35	FMOLS Output of Model 2	182
Table 5.36	ARDL Output of Model 3	183
Table 5.37	FMOLS Output of Model 3	184
Table 5.38	ARDL Output of Model 4	186
Table 5.39	FMOLS Output of Model 4	188
Table 5.40	Pairwise Panel Causality Test Results	189
Table 5.41	Country Based Results in South Asian Countries	194
Table 5.42	Country Based Results in ASEAN Countries	297

LIST OF FIGURE

Page No.

Figure 2.1	Theoretical Framework of the Study	64
Figure 4.1	Global, South Asia and ASEAN Countries CO2 Emissions	100
Figure 4.2	CO2 Emission in ASEAN Countries	102
Figure 4.3	South Asia Countries CO2 Emissions	103
Figure 4.4	Foreign direct investment in ASEAN, South Asia and World, net inflows (% of GDP)	104
Figure 4.5	Foreign Direct Investment in South Asian Countries, net inflows (% of GDP)	105
Figure 4.6	Foreign Direct Investment in ASEAN Countries, net inflows (% of GDP)	107
Figure 4.7	FDI Flows to Developing Countries in Asia And Subregions, 2020-2021 (Billions of Dollars)	108
Figure 4.8	South Asian International Tourism	110
Figure 4.9	International Tourism, Receipts in ASEAN Countries	111
Figure 4.10	Gross Domestic Product (GDP) of the ASEAN (<i>in billion U.S. dollars</i>)	113
Figure 4.11	South Asia GDP Growth Rate 1961-2022	115
Figure 4.12	Gross capital formation % of GDP (South Asia)	116
Figure 4.13	Gross capital formation % of GDP (ASEAN Countries)	117
Figure 4.14	Emission Growth in the ASEAN's Electricity Generation and Power Sector Emissions has been Driven by Fossil Fuels	119
Figure 4.15	South Asian Energy Consumption	120

LIST OF ABBREVIATIONS

AIC	Akaike information criterion
ASEAN	Association of Southeast Asian Nations
BDS	Brock-Dechert-Scheinkman test
BRI	Belt and Road Initiative
BRICS	Brazil, Russia, India, China and South Africa
CDIAC	Carbon Dioxide Information Analysis Centre
CICC	China International Capital Corporation
CIPS	Cross-Sectionally Augmented Im-Pesaran-Shin
COP	Conference of the Parties
COVID 19	Coronavirus Disease Of 2019
CPEC	China-Pakistan Economic Corridor
CS-ARDL	Cross Sectional- Autoregressive Distributed Lag
CSD	Cross-sectional Dependence
D-ARDL	Dynamic Autoregressive Distributed Lag
ECM	Error Correction Model
ECT	Error Correction Term
EKC	Environmental Kuznet Curve
ELGH	Export-Led Growth Hypothesis
ESG	Environmental, Social And Governance
FIR	First Information Report
FMOLS	Fully Modified Ordinary Least Squares
FPE	Final prediction error
GARMA	Generalized Autoregressive Moving Average
GCF	Greatest Common Factor
GDP	Gross Domestic Product
GGGI	Global Green Growth Institute
GII	Global Innovation Index
GLS	generalized least squares
HQ	Hannan-Quinn information criterion

IEA	International Energy Agency
IET	Impact of Energy and Technology
ILO	International Labour Organization
IMF	International Monetary Fund
IPA	Impact of Population and Affluences
LFP	lithium ferrous phosphate or lithium iron phosphate
LNCF	Natural logarithm of Capital Formation
LNEG	Natural logarithm of Economic Growth
LNENRC	Natural logarithm of Energy Consumption
LNENV	Natural logarithm of environmental Degradation
LNFDINIF	Natural logarithm Foreign Direct Investment Net Inflow
LNLF	Natural logarithm of Labor Force
LNRENRC	Natural logarithm of Renewable Energy Consumption
LNTAI	Natural logarithm of Technological Innovation
LNTRM	Natural logarithm of Tourism
LR	Likelihood Ratio
MNCs	Multinational Company
N-11	Next Eleven Countries (Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, The Philippines, South Korea, Turkey, and Vietnam)
NARDL	Nonlinear Autoregressive Distributed Lag
NDCs	Nationally Determined Contributions
NEMESIS	New Econometric Model of Evaluation by Sectoral Interdependency and Supply
NESCAP	United Nations Economic and Social Commission for Asia and the Pacific
OECD	Organization for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PHH	Pollution Haven Hypothesis
PMG-ARDL	Pooled Mean Group-Autoregressive Distributed Lag
PQR	Panel Quantile Regression

PPP	Public and Private Partnerships
R&D	Research and Development
SAARC	South Asian Association for Regional Cooperation
SC	Schwarz Information criterion
SDG	Sustainable Development Goals
SEZ	Special Economic Zone
SH	Slope Homogeneity
STIRPAT	Stochastic Impacts by Regression on Population, Affluence, and Technology
TLGH	Tourism-Led Growth Hypothesis
TNC	Transnational Corporation
TNC	Transnational Corporations
TVAR	Time-Varying Autoregressive
TVECM	Threshold Vector Error Correction Model
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNWTO	World Tourism Organization
UNWTO	United Nations World Tourism Organization
VECM	Vector Error Correction Model
VECM	Vector Error Correction Model
WCU	World Conservation Union
WDI	World Development Indicator
WTTC	World Travel And Tourism Council

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

In recent years, economists' research has become increasingly concerned with the environment due to growing awareness of the numerous relationships and impacts of economic activities on the environment. The development of an economy involves the contributions of individuals, organizations, government institutions, and technological advancements. For the distinguished development economists Schumpeter and Backhaus (2003), development is a gradual, complex process of social, economic, political, environmental, and cultural advancement of either an individual or a society. As per the Nobel laureate economist Amartya Sen, Sen (2000), development means improving the quality of life of people, which depends on their education, health, longevity, and many other things. Increasing income is just one way to reach that goal. According to him, the issue of human rights or entitlements to income growth or production should be taken seriously.

The global temperature is rising amid an expanding economy. Nearly a 1°C increase in Earth's temperature over the past century is linked to addressing SDG Goal 13, Climate Action. We must act swiftly and plan to tackle the climate crisis. The latest UNEP emissions gap report states that even if all Nationally Determined Contributions (NDCs) are fully implemented, we are on track for a 2.6°C rise by 2100. This would exceed the targets set by the Paris Agreement. To meet the Paris Agreement's objectives, which is a vital international climate accord, countries have committed to acting in their own best interests. These include keeping the global temperature increase well below 2°C above pre-industrial levels and preventing harmful human-induced disturbances to the climate system. Countries are also striving to limit warming to 1.5 °c (Change, 2015). This is not merely a scientific or political goal but an urgent necessity for the planet's future. The Sharm el-Sheikh Implementation Plan, reaffirmed during COP27 in Egypt, emphasizes this commitment and recognizes that it is no longer just an environmental goal but a moral duty.

However, climate change is a significant contributor to the alarming problem of global warming. The environmental impact of greenhouse gas (GHG) emissions extends beyond rising global temperatures. It affects many aspects of our daily lives and the decisions we make. Environmental sustainability has become increasingly critical for the health of our planet and all its inhabitants, both now and in the future. Recent evidence includes melting ice, rising average global temperatures, higher ocean levels, and record-breaking temperatures in both summer and winter. All these events are linked to global warming, which is mostly caused by human actions. According to numerous studies, such as (Rahman et al., 2023), (Wu et al., 2023), (Ozden et al., 2023), Rahman et al. (2021) state that, the use of non-renewable energy sources like coal, oil, and gas to produce electricity is to blame for climate change because these types of burning fossil fuels are the primary causes of rising CO₂ emissions in the atmosphere. But the use of renewable energy sources can disprove the existence of global warming. Most of the radical environmental pollution has arisen from carbon dioxide releases (Rehman et al., 2022).

In contemporary times, countries worldwide are placing considerable emphasis on FDI inflows due to their substantial contributions to economic growth and development. Such investments offer benefits to both the recipient and investing economies (Camarero et al., 2018; Wang & Wang, 2015). Globally, FDI has witnessed significant growth, increasing from \$330 billion in 1995 to \$1.43 trillion in 2017, as reported by UNCTAD in 2018. The FDI expects a critical work in monetary improvement when there is a lack of homegrown venture reserves (Ahmad et al., 2022). FDI has emerged as the fundamental wellspring of external resource streams to horticultural countries all through the long haul and has turned into a tremendous piece of the capital improvement in these countries, despite their proposal in the overall dissemination of FDI, continuing to remain pretty much nothing or regardless, declining (Xinye, 2022).

Similarly, tourism has positive impact on economic growth and development (Rasool et al., 2021; Selvanathan et al., 2021). International tourism has been recognized as a

potential solution to counter balance excessive trade imports in the balance of payments by fostering job creation and development, among other factors (Lanza et al., 2003). Moreover, beyond simply driving growth within the sector itself, tourism also serves to stimulate broader economic development (Lee & Chang, 2008). Many governments have taken steps to promote tourism as a means of achieving greater economic prosperity. However, it's important to acknowledge that due to the simultaneous production and consumption of tourism at the destination, the industry is intricately linked to its environmental impact.

The study serves the purpose of highlighting the very real and relatively unexplored link between FDI and the environment, which is the focus of this analysis. As FDI in South Asia and ASEAN countries continues to rise, it is imperative to understand the true nature of such investments, particularly the environmental impact in the region, for governments, businesses, and societies. The goal of this study is to find out how much FDI changes environmental practices, resource management, and the health of ecosystems in these areas, which often have a lot of different kinds of plants and animals and ecosystems that are easily damaged. The study enables strategies which favor positive or negative impacts and discourage or encourage adverse ones that can be adopted by policymakers to ensure sustainable investments with the generation of regulatory frameworks. Finally, these results help inform a more nuanced understanding of how to balance economic development with environmental stewardship, confirming that moderate benefits stemming from FDI can be harnessed for prosperity without compromises on ecological integrity and public health in South Asia and ASEAN countries.

1.2 STUDY RELATED TO ENVIRONMENTAL IMPLICATIONS OR DEGRADATION

Environmental implications refer to the changes that occur in the natural or built environment as a result of human activities, which can have either positive or negative impacts on the ecosystem, including air, water, land, plants, animals, and

overall biodiversity. These implications encompass both direct and indirect effects, such as pollution, contamination, resource depletion, or habitat destruction, and are often described as environmental degradation when harmful. Climate change's effects on the natural world are referred to as its environmental implications.

The environmental issues are so pressing that it is climate change, one of the greatest and most serious challenges. Climate change" here refers to long-term changes in the climate, or to long-term changes in average weather conditions. The main cause of global warming is human activities like burning fossil fuels, deforestation, and industrial processes which raise the concentration of greenhouse gases (GHGs) in the air. An increasing concentration of GHGs alters the climate system of the planet as a whole with, inter alia, increasing global temperatures, rising sea levels and more frequent and more severe weather extremes. Climate change is an incredibly thorny global challenge with deep environmental, social, and economic ripple effects.

In light of the escalating crisis of climate change, countries across the globe have done their best to outdo each other in pledges to reduce their GHG emissions and shift to more sustainable practices. Despite divergences in pace of economic progress, virtually every country is working to reduce its impact on the environment. The 26th United Nations Climate Change Conference (COP26) in 2021 emphasized the severity about facing climate change and the way we behave to have a more sustainable lifestyle, and also prevent those environmental disasters. And they refocus on resource management across the supply chain, from logistics to mining to freight, and green technologies that reduce emissions. This has been unambiguously recognized by the international community, realizing that if there is no substantial action taken collectively across the globe, impacts of climate change will be further aggravated and would continue to threaten not just various ecosystems but even the entire human race.

1.3 STUDY RELATED TO CLIMATE CHANGE ON THE ENVIRONMENT

Ecosystem disorder, growth of temperature, macroeconomic challenges, institutional constraints, technical limitations and environmental and economic vulnerabilities are only some of the problems induced by climate change and climate variability (Begum et al., 2020; Raihan et al., 2021a; Raihan and Tuspekova, 2022a). So, environmentalists are trying to figure out what could help the environment to become healthier. Combustion of coal, oil and natural gas emits more carbon dioxide (CO₂) out of the atmosphere, which circulates in the ecosystem because of fast industrialization and urbanization.

Environmentally, we live in a time of climate instability. And it's one of the biggest risks to the future of human society. It's humans that are doing the most to cause climate change. It has many awful consequences like raising sea levels, changing weather patterns, reducing the overall crop yield, etc. The only way to slow climate change down is by cutting back on CO₂ emissions. This is only possible through significant technological progress and the scaled implementation of clean technologies that enhance the productivity of clean energy. But climate change is to blame on the terrifying issue of global warming. However, climate change is to charge for the alarming problem that is global warming. And this warm increases the ice melting, an increase in the global average temperature, rising sea levels, and the hottest summer and coldest winter. According to numerous studies, such as Rahman et al. (2023), Voumik et al. (2023) and Rahman et al. (2021) state that, the use of non-renewable energy sources like coal, oil, and gas to produce electricity is to blame for climate change because these types of burning fossil fuels are the primary causes of rising CO₂ emissions in the atmosphere. But the use of renewable energy sources can disprove the existence of global warming.

Climate change and the consequences of greenhouse gases have drawn more attention from the international community in recent decades. For instance, the three strategies outlined in the Kyoto Protocol are intended to reduce six greenhouse gases. A reduction in greenhouse gas emissions is not required of Non-Annex I Parties under the agreement. The "migration" of filthy industries to developing nations may

have this as a contributing component. Carbon Dioxide Information Analysis Center (CDIAC) rated countries by their per capita fossil-fuel carbon dioxide emissions in 2009 to put the disparity between emissions from industrialized and developing countries perspective. Hence, rich nations like Australia, the United States, and Canada created 4.98, 4.64, and 4.16 metric tons of carbon, respectively, whereas underdeveloped nations like Mali, Chad, and Burundi produced only 0.01 metric tons of carbon each.

Carbon dioxide (CO₂) emissions have a huge impact on the environment, mostly because of how they contribute to climate change. One greenhouse gas that traps heat in the Earth's atmosphere is carbon dioxide, which causes global warming and a host of other negative environmental effects.

1.4 STUDY RELATED TO FDI AND IMPACT ON THE ENVIRONMENT

Following the OECD (1996), Foreign Direct Investment (FDI) is characterized as an investment that is investing in a business in another country with a lasting interest and significant control. Here the investor is called as parent company. As per the IMF (2004), Foreign Direct Investment (FDI) related to global investment within either the financial or non-financial corporate sectors of an economy, where the non-resident investor acquires a stake of 10 percent or more in the voting rights of a legally incorporated enterprise, or holds equivalent ownership in an enterprise operating under a different legal framework.

Foreign direct investment (FDI) is important for promoting economic growth, creating jobs, and bringing advanced technologies to the countries (Demena & Van Bergeijk, 2019). The globalization of the world economy has led to both the liberalization and increased expansion of foreign direct investment (FDI) inflows worldwide. Consequently, policymakers have been compelled to carefully evaluate the profound implications of this significant economic transformation and its impact on the natural environment.

FDI is just one of several potential causes of declining environmental quality. Because of the weak regulation of the environment in developing nations,

industrialized countries transfer their polluting industries and establish offices there, adding to environmental degradation in the host developing countries. FDI is thought to have a negative relationship with environmental quality.

The environmental consequences of those investments, however, have become a major issue. Note that, in some cases, this FDI may bring technological transfer and better manufacturing processes but may as well increase environmental degradation (Jenkins & Nicholls, 2010) given that supervision of such processes is not made under sustainable criteria. As an example, pollution, deforestation, and biodiversity loss are frequently caused by industries such as manufacturing and extractive industries practices, especially in countries with weaker environmental regulations (Baker et al., 2018).

On the other hand, in South Asia, India and Bangladesh experienced some of the highest levels of industrialization through FDI in the world, triggering some alarming environmental metrics, including air and water pollution (Kumar & Singh, 2019). In a similar vein, ASEAN countries (and notably Indonesia and Vietnam), are experiencing environmental degradation associated with foreign investments in agriculture and forestry (Li et al., 2019); Roe & Mardiasmo, 2019).

However, with the increased pace of industrialization, environmental issues have been occupying most of the salient debate in such a context of the relationship between FDI and environmental pollution has been debated to a great extent. Inflows of FDI may lead to the improvement of environmental conditions of a country as FDI might bring environment-friendly technologies to less or weak developed countries which help to mitigate pollution (Atici & Gursoy, 2012; Kirkulak et al., 2011; Lan et al., 2012). Inflows of FDI are likely to be source of pollution as they generate the conditions of investment and growth of local circumstances and pollution which contributes positively in environmental degradation (Barman & Biswas, 2022; Cole & Elliott, 2005; Wang et al., 2013). Conversely, some findings show that the connection between FDI and CO₂ emissions is negative, as cited by these sources (Atici & Gursoy, 2012; Kirkulak et al., 2011; P. Romer, 1993; P. M. Romer, 1986)

The objective of this research is to analyse the environmental effects of FDI in South Asian and ASEAN countries in order to gain insights into these countries' ways of using foreign investments while protecting their natural environment. This means that policymakers who are concerned with formulating strategies to balance FDI and environmental protection are in need of understanding the implications of FDI and its environmental effects (Zhang et al., 2020).

1.5 IMPORTANCE OF FDI FOR DEVELOPING COUNTRIES

The significance of Foreign Direct Investment (FDI) for developing countries is undeniable. It not only injects capital but also brings in managerial expertise, marketing knowledge, and advanced technologies, thereby creating employment opportunities in the host country. Additionally, FDI offers various other potential benefits such as fostering employment generation, augmenting investment levels, improving infrastructure, transferring advanced technology, contributing revenue to the government, and enhancing labor productivity (Bhasin, 2012).

FDI has consequently become an important engine for growth and development in South Asia and ASEAN countries. These regions have been the recipients of large inflows of FDI due to their strategic geographical location, abundant natural resources, and growing consumer markets (UNCTAD, 2021). South Asia, a region with a cumulative foreign direct investment (FDI) of around \$787.32 billion (CICC Research, CICC Global Institute, 2024), has been a renowned symbol of the continent for the last two decades. In the same year, ASEAN received 229.8 billion US dollars of FDI, with Singapore ranked first, followed by Indonesia and Vietnam. Both regions are major investment centers, particularly in manufacturing and R&D. Significant growth has been observed in key sectors like IT services, automobiles, tourism, communications, electronics, sustainable energy, transportation, and pharmaceuticals. While many sectors that drive economic growth are expanding, they are also responsible for a substantial fraction of the world's carbon dioxide emissions.

FDI benefits South Asia and the ASEAN countries, in terms of capital inflows, technological transfer, employment and competition and impact on institutional quality. Injection of capital for the growth of the economy; FDI (foreign direct investment) is critically important for South Asian and ASEAN countries, which suffer from low capital accumulation and insufficient domestic savings. Large economies such as India, Indonesia, and Vietnam have updated their infrastructure and grown in a sustainable and modern manner, thanks partly to FDI.

Technology transfer and innovative content; FDI facilitates the diffusion of sophisticated technologies from foreign firms to domestic firms in South Asian and ASEAN nations. Such transfer doesn't involve only equipment. New production processes, organizational systems and practices of innovation increase productivity and the competitive power.

Job creation and human capital formation; FDI plays a big role in generating employment in South Asia and ASEAN, thereby significantly increasing employment in South Asia and ASEAN due to the creation of employment opportunities in various sectors (manufacturing, services, and technology, etc). For countries like India and Indonesia, which have a large percentage of young people who may struggle to find employment, foreign investment is particularly important. Of course, apart from jobs directly created, FDI also generates employment in the ecosystem, ranging from logistics to marketing and construction. It imparts employability skills to local personnel through training and exposure to contemporary business practices.

Balance of payment and institutional development; FDI enhances the balance of payments position of both South Asian and ASEAN nations by facilitating a stable flow of capital that can finance imports without borrowing from abroad. This has been especially useful for economies such as the Philippines and Vietnam, where the trade balance has benefited from FDI in export sectors. Foreign direct investment also leads to gradual institutional reform. Governments are forced to improve their regulatory system and to introduce a better governance system in order to attract and retain capital. These streams of reforms make the business environment more

transparent, efficient and predictable for both domestic and foreign companies, contributing to lasting economic stability as well.

1.6 STUDY RELATED TO SUSTAINABLE DEVELOPMENT

The concept of sustainability means fulfilling the needs of people without compromising future generations' ability to fulfil theirs. People use raw natural resources, and we need social and economic resources. Then, sustainability is much more than environmental protection, which includes social justice and economic development in most definitions of sustainability. Sustainable development is a broad, complex and changing concept that seeks to balance progress with the needs of future generations. It is based on the premise that the economy, the environment and society must go hand in hand. The realization is that the traditional development process is focusing merely on economic growth instead of comprehensive wellbeing that are resulting in degradation of environment, depletion of resources and widening of social inequalities which gave birth to this idea.

At its heart, sustainable development aims at establishing a future in which economic activities do not overexert natural resources or cause harm to the environment, and where social systems are equitable and provide opportunities for every human being to prosper. While addressing the issues of poverty, education, health, social justice and gender equality it should ensure that the environmental resources of current ecosystems, such as the elements of clean air, water, and biodiversity are conserved for future generations. The three pillars of sustainable development are to addressing economic, environmental, and social effects. The economic side is about building developments which will be an economic heavy weight in the long run. The environmental dimension seeks to minimize ecological footprint, reduce emissions and waste, protect ecosystems and biodiversity, and ensure sustainable and responsible resource use. The social pillar is centered on fairness, inclusivity, and equity, improving quality of life for all people including vulnerable and marginalized groups.

In other words, sustainable development entails a change in how policies are made, business is conducted, and humans consume and utilize the natural resources. It demands incremental implementation of sustainable practices in agriculture, energy, industry and urban planning. This can include switching to renewable energy, leveraging energy saving technology, advancing circular economies, encouraging sustainable agriculture, investing in social services to create a more equitable society for all parties.

Moreover, it takes into account globalization and instability on education for sustainability. It also highlights that education is important for sustainable development for the global goals on urgent issues like climate change, biodiversity, and waste. However, efforts to reduce carbon emissions, promote climate-resilient agriculture, and enhance ecosystems are all integral to a sustainable future. Such initiatives need collaboration across governments, industries, and civil society for the development of policies and frameworks that incentivize sustainable practices over time. But at its core, sustainable development is about building an economy that pays and a society that will be alive and well for the generations to come. It is a living process that must continue to be assessed, redesigned and adjusted to meet new challenges.

1.7 STUDY RELATED TO ECONOMIC GROWTH

Economic growth has brought declines in certain types of pollution for high-income countries, some developing economies, particularly in South Asia and ASEAN and elsewhere, have been unable to reconcile economic growth with environmental sustainability. Economic growth monitors how many goods and services the economy is producing over the course of a year, and it is commonly measured by economists using gross domestic product (GDP). In 2012, most of the world's emergent and rapid-growth markets were in the Asia-Pacific, and the population figure of its ASEAN community was about 600 million (Ahmed et al., 2017). This is US\$63,987b (Singapore), US\$11,136b (Malaysia), US\$7,791b (Thailand), US\$4,163b (Indonesia), US\$3,294b (The Philippines) and US\$2739b (Vietnam)

respectively in 2019 (IMF 2019). (ASEAN) For the most part of Association of South East Asian Nations (ASEAN) ,5.2% is a growth rate. (Nasir et al., 2019). Despite being home to only one in four of the world's people, South Asia remains reduced living standards; per capita income in the region falls below that for the world. South Asia's GDP per capita was 1,842.25 USD in 2017, while East Asia and the Pacific's was 10,368.48 USD and Europe and Central Asia's was 23,422.19 USD (Islam, 2020). Nonetheless, compared to many other Asian regions, South Asia's economy is expanding more quickly. In that year, South Asian Countries growth rate was 6.53%, higher than East Asia and the Pacific at 4.55%, and much higher than Europe and Central Asia at 2.61% (World Bank, 2020).{Citation}

The trade-off between economic growth and environmental quality has been debated extensively by scholars. The bigger the people make their system, the more the people are creating the ecosystem and running down natural capital, but then people increase carbon dioxide (CO₂). Among these, the Environmental Kuznets Curve (EKC) is the most well-known, according to which pollution (output of low quality environment) increases (decreases) with economic growth, at the initial stages of the growth process (for OECD), whereas it decreases (increases) at higher levels of income after taking on an inverted U-shape form. According to EKC, at lower levels of development, environmental degradation rises with growing industrialization and energy consumption. But once it has passed a threshold of economic development, one that seems to come with higher income levels, a move to cleaner technologies and better environmental policies takes hold. Based on the EKC, in the early stages of industrial development, the social development path is the greater emission of pollutants, and then the period of a certain level of increased income, can accept environment friendly technology and implementation of a more stringent control(Dong et al., 2020).

Environmental consideration and global warming are not particular to the people in the advanced stage of industrialization, but rather it is a problem faced by the whole globe and all communities, which any team can be confronted with. And climate change, specifically, is greatly affecting human health, biodiversity, agriculture, and

the frequency and intensity of extreme weather events. As environmental conditions continue to deteriorate, the population of individuals displaced by climate change is anticipated to increase dramatically in the decades to come. The growing number of environmental migrants and refugees has only added up to the pressure on how governments and humanitarian organizations and international organizations to address the root causes of climate change and create sustainable ways to reduce its adverse effects.

1.8 STUDY RELATED TO ENERGY CONSUMPTION AND RENEWABLE ENERGY CONSUMPTION

Energy is truly the bedrock for the development of both economies and societies toward a higher quality of life globally. It includes many types, such as chemical, thermal, electrical, mechanical, gravitational, nuclear, radiant, sound, and kinetic energy. Such structured formulae are also storable, manipulable and scalable for applications in the development of mankind. Energy from anthropogenic energy sources can be divided into three main categories such as fossil, renewable (alternative), and fissile. Fossil fuels comprise oil, coal, tar sands, natural gas, shale oil and so forth. These have provided the energy for much of our industry and transportation, but the use of them has come in for criticism for environmental reasons and because people are removing them at a finite rate.

Renewable energy sources offer promising alternatives, derived from natural processes that can be continuously replenished. Biomass, hydroelectric power, wind energy, solar power, geothermal energy, marine energy, and hydrogen are all examples of renewable energy sources. Their utilization can significantly reduce greenhouse gas emissions and dependency on finite resources.

Fissile materials, such as uranium and plutonium, are used to generate nuclear power. It is a controversial form of energy due to safety threats (such as nuclear accidents), as well as concerns about spent nuclear fuel and waste disposal. Nuclear energy makes up a significant part of the energy mix in several countries, and is

assumed to provide low-carbon electricity generate. Moving to a cleaner energy mix based on renewable energy resources along with energy efficiency is essential to abate climate change and provide for long-term energy security. People have the human intellect and the technological creativity to continue progressing to a cleaner energy future.

The rapid economic growth in the developing countries during the last decades, has been resulted in rapid increase the energy consumption, which is expected to be continued in the new century as well, as already reported (Kaygusuz & Bilgen, 2008).

1.9 STUDY RELATED TO TOURISM

Tourism is the flourishing motivation that gives rise to visitations in pursuits of nature, adventure, magnificence of life and how it is lived of traveling through cultures, people, values, and events. The growth of tourism in a particular area is the primary means of attracting visitors. It is inextricably linked to a healthy tourism business and its continued success. But as the demand for tourism increases, the necessity of ensuring that it is environmentally sustainable, which means preserving natural resources, ecosystem, and socio-cultural heritage for future generations. It is imperative.

It is holistically that when environmental sustainability becomes purpose in the future of saving the socio-cultural heritage and promoting the use of natural resources for the protection of the environmental ecosystems as one of the steps to enhancing the health wellbeing of the people and the future of economic development. Wellbeing and ecological sustainability can be unrolled in a clean and green natural landscaping, motivator for the biodiverse-rich marine beach assets, tall desert steppes, socio-cultural values, and archeological legacy which is illustrating the tourist motivation degree and the reception readiness of the local community to host the tourist. Tourism growth and Environmental sustainability is interrelated concepts in the study and, Tourism development growth and tourists inflow to

destinations directly affect the quality of sustainable and green tourism (Azam et al., 2018; Hassan et al., 2020; Sun et al., 2021).

Tourism is responsible for contributing more than 10 % of the world GDP and is also one of the emerging industries (UNWTO 2017; (Mikayilov et al., 2019). In 1950 there were 25 million international tourists; in 1970, 166 million; in 2018, 1.442 billion, with a projection of 1.8 billion in 2030. Such a weight of anti-gravitating mass of humanity is something that tends to spittle a near contaminates by pollution environment it is entered in, however good it is for employment, the creation of wealth and the economy in general. These effects may be local, such as air pollution, noise and waste disposal, or they may be regional or global, such as atmospheric pollution, deforestation, food chains, among others. In addition, the scale and quality of the environment will be greatly affected by chaotic and improper population of tourism. This results into over-extraction of natural resources, deterioration in quality of services and a skyrocketing of wastage and pollution. In contrast, tourism arrivals are not proffered more than a blessing create problems, more than anything else, i.e.: and soil erosion, depletion of natural resources, littering and air pollution, diversity threatening, degradation of social –cultural habitat, and reduction of land and sea virginity ((Kostić et al., 2018); (Shaheen et al., 2019); Andlib & Salcedo-Castro 2021).

The process of tourism development for a destination would vary in nature on the basis of what forms of tourism is referred to. There are other words that mean the same thing, like ecotourism and sustainable travel and green travel and regenerative travel. Ecotourism is the activity of visiting natural areas in a manner that conserves the environment and improves the welfare of local people, including education and interpretation (Cheia,2013). The World Conservation Union (WCU) defines ecotourism as responsible travel to natural areas, where people can enjoy and appreciate nature and cultural; features, while supporting conservation and minimizing the impact of visitors. The demands of reducing adverse environmental impact and increasing local social-economic values clearly draw the relevance of these issues.

Ecotourism controls the depletion of the destination's resources through physical, social, psychological and interactive impacts. It promotes responsible and positive action from both guests and hosts on saving all aspects of the environmental ecosystem.

1.10 STUDY RELATED TO TECHNOLOGICAL INNOVATION

Despite a perception that innovation represents the creation of advanced technological solutions based on cutting-edge knowledge. These advances are commonly ascribed to an educated workforce and firms investing heavily in research and development, which have long been closely connected with top scientific institutions. But it is crucial to take a broader view on innovation. One of the earliest theoretical perspectives on innovation (among others) can be found in ideas developed by Schumpeter (1934), who defined innovation as an example of entrepreneurial activity, describing that entrepreneurial activity as involving the creation of “new combinations” of existing resources. The invention or improvement of goods or services of a significantly different nature from previously existing products, process of production of the service or goods, marketing methods, or business organization are defined to be innovation. This definition is very broad and covers different innovation dimensions, not only technology.

In contrast, Manual, F. (2002) (OECD, 2002: 30) is specific on technological innovation, which refers the new or substantially improved technological goods and processes. Here, technological novelty consists of changes in the performance attributes (rather than the same old attributes in improved performance) of those products or processes. Innovations are not confined to the high-tech sector. It includes not just the development of new products or processes but also the improvement of existing ones, including in so-called low-tech businesses. These improvements have the potential to create significant aggregated economic and social value. Broadening the definition of innovation itself highlights the immense impact it has on the economy and society at large. It underscores how we need to

cultivate innovation in all kinds of industries, whether or not they're high-tech sponsored Content. So, in this vein, we also need to see the forest for the trees, and this could help us not building our poles up too high to begin with, so that people don't overlook the power of optimization in creating long-run prosperity and happiness.

Schumpeter (1934) identified five categories of new products, new processes of production, new markets, new methods of selling a product in the market and new forms of organization of the industry. In the place of innovation, one uses patent applications as proxy and (Johnstone et al., 2010a) investigate the effects of various types of policies. Now, patent data is an extremely valuable input in studies of technological progress. Patents are commonly recognized as important determinants of innovation activities (Frietsch & Grupp, 2007) because they continuously provide standardized information regarding new ideas and innovations. As a result, these elements have been central to many different tools and methodologies developed to measure innovation (Belderbos, 2003; Hanel & St-Pierre, 2006; Pilkington, 2004). Patent counts the numbers of granted patents over time, by country and inventor provide a wealth of information from the patents in many fields and allow an analysis of technological trends and patterns (Watanabe et al., 2001).

Innovation is economically agnostic and extends beyond the high-tech industry. This includes developing new products or processes as well as upgrading existing products even in so-called low-tech sectors. These improvements contribute to large cumulative economic and social gains. Acknowledging the pervasiveness of innovation emphasises the deep impact that innovation has on economic development and social progress. It stresses the need for promoting innovation in all sectors, whether they are high or low technological intensity. Such an inclusive approach credits the importance of gradual improvement and the achievement of long-term prosperity and well-being. Schumpeter (1934) classifies innovation in five types such as the introduction of new products, production methods, markets, and distribution methods, and the development of new sources of input supply. Patent numbers and patent age are frequently used as a good measure of innovation, and

Johnstone et al., (2010b) has examined the effects of different policy instruments on innovation.

1.11 STUDY RELATED TO CAPITAL FORMATION AND LABOR FORCE

There has been a close relationship between labor force expansion, especially in industrial and agricultural sectors, and environmental degradation through increased natural resources extraction and carbon emission. To realise economic growth ambition of most of the countries, a corresponding increase in workforce leads to more industrial activities, deforestation and increasing energy consumption, posing a vital role in increasing air, water and soil pollution. The informal labor sector, where there are no rigid environmental controls, contributes significantly to ecological devastation through irresponsible mining, excessive use of agrochemicals, and improper dumping of garbage, as seen in many developing countries (Shahbaz et al., 2016). Such trends underscore the need to integrate environmental considerations in labor policies and advanced active labour market policies focused on green jobs for sustainable development.

The depreciation results in declining productivity as older or overused capital requires more energy to produce less. As a result, the problem of writing is undoubtedly a part of the environmental crisis we are currently experiencing, and it has a lot to do with energy consumption, and the subsequent release of greenhouse gases, and carbon dioxide in particular. The inter relationship between how capital is used too much and labor output should not be without looking at environmental damage, does not take a lot of description to mark this an important area of research that the inputs which are very essential to economic growth can also cause environmental damages.

Gross capital formation (GCF) is one of the most crucial and one of the most challenging components. Over consumption of energy also adds on to carbon emissions, which is a major contributor of environmental damage (Ur Rahman et al., 2019). A Gross capital formation is the total new fixed assets of a unit or sector plus changes in inventories plus the purchases of existing capital goods minus the sale of

existing capital goods. Paramount research (Alshammry & Muneer, 2023) investigates those relationships involving energy exploitation and carbon dioxide diffusion, short-run or stable and correlated to other factors. According to Wood and Hertwich (2018), the total share of GCF as a share of global carbon footprint varies more among nations than GCF as a share of overall GDP.

They argue that the GCF and the environment have varying relationships for different countries, differentiated by their developmental status, because the differences between the large share of their dirty assets of developing countries and the small share of these assets of developed countries are large. East Asian countries put more emphasis on resource-intensive (albeit less sustainable) assets by purchasing industrial equipment and infrastructure, while Western countries are less involved in such purchases, but they make greater investments in software, buildings, and computer technology (González-Blanco et al., 2019). Research study must be carried out for the relationship between the gross fixed capital formation and overall emissions of carbon dioxide along with the level of economic growth.

1.12 STUDY RELATED TO ENVIRONMENTAL SUSTAINABILITY

Environmental sustainability is a center-stage issue on the international agenda across the world especially in South Asia and ASEAN countries. The most urgent calls for change also emphasize that systematic changes in economic models are the only alternative to our current trajectory, as research continues to highlight the links between the climate crisis and increased global bad situations, coupled with firsthand observations of local deterioration. Over the last few decades, the world has realized that conventional routes to industrialization and economic development are not sustainable over the long term because of their dependence on finite natural resources and their contribution to environmental degradation. In response to these challenges, in an effort to address them, governments, businesses, and civil society groups have begun to call for more sustainable practices, up to and including the use of renewable energy instead of fossil fuels, Waste reduction, and circular economic

models. The widespread agreement between the two communities for a need for transition from the linear resource-extractive economic model to a sustainable environmental stewardship model (Stern, 2006) accentuates the need.

Going forward, jointly addressing the ecological consequences of human activity has necessitated at worldwide, collaborative work. Although there has been substantial progress on several fronts, including the development of renewable energy technology and international agreements to cut emissions, far more needs to be done. The key is to overhaul economic models, invest in sustainable technology, and build a future for generations to come and live our best lives without harming the health of the planet.

1.13 STUDY RELATED TO STIRPAT MODEL

The Environmental Kuznets Curve (EKC) model does not capture the impacts of population factors, as explained by Dietz & Rosa, (1997) and Fan et al., (2006), are primary factors behind the rapidly increasing levels of air pollution during the next decade. It is an oversight given the need to study population variables when examining environmental impacts and dynamics. One of the more robust frameworks that has addressed this gap and enable such direct disaggregation of socio-economic impacts on environmental quality is the STIRPAT framed model, whereby, in addition to the factors of affluence and technology, the size of the human system are also accounted for. Another is adaptation of an approach introduced by Dietz and Rosa (1994), namely the STIRPAT framework. The model expands on the IPAT (Impact = Population $\times$ Affluence $\times$ Technology) formula put forward by Ehrlich & Holdren, (1971), which suggests that human environmental impacts are a product of three components such as population size, affluence (i.e. income per capita), and technology. Population as a critical component provides insight into the ways in which environmental quality is driven by changes in demographic characteristics.

When research fails to the correlation dependence across sections may produce biased estimates of the effects of population and affluence on the environment,

generating contrastive results across the time series or regions. Therefore, STIRPAT model may be a credible explanation for these differences as they are far from complete dynamic interaction among populations, affluence, and technology within various backgrounds(Wei, 2011). The successful combination in this paper of STIRPAT and second generation Pooled Mean Group (PMG) estimator makes it possible to conduct a more powerful and reliable assessment of the combined effect of four drivers on environmental degradation. This use of the PMG estimator as a method is legitimate as it accounts for cross-sectional dependence and heterogeneity in short run as well as long run relationships, which makes it also statistically and econometrically consistent.

1.14 STATEMENT OF THE PROBLEM

For South Asia and ASEAN countries, its impact on the environment is still a very serious question since FDI to these countries allows them to acquire the large amounts of foreign capital needed for their economic growth. Although FDI is recognized as being positive in terms of economic development, not enough attention has been placed on its environmental impact. On a positive note, FDI can also promote advanced technologies and cleaner practices leading to energy efficiency and the use of clean energy. The two aspects have a dual effect, creating a mechanic that is uncharted in current research.

These areas, although enjoying accelerated economic development, have been confronted with several environmental issues like increasing energy usage, pollution, deforestation, and biodiversity loss. Foreign direct investments usually result in increased industrial activity, construction, and energy demand that put pressure on local ecosystems. FDI could also facilitate the infusion of environmentally sound technologies, renewable energy options, improved environmental management practices. This confirms that the relationship between FDI and the environment is complex and needs more research.

FDI-lead growth in the energy sector, for example, generally increases resource consumption, carbon emissions, and environmental degradation. Likewise, the explosion of the tourism industry, aided by foreign investments, provides considerable economic profit, but also causes a lot of ecological disturbance such as pollution, habitat loss and resources depletion. In this context, consideration should go into the feasibility and scalability of renewable energy projects through FDI, as it can promote environmental sustainability. Often foreign investments lead to technological innovations that help as well as hinder environmental sustainability. Though they may result in improved energy efficiency and lower impact to the environment, they could also lead to waste, resource depletion, and ecological devastation if not well-planned in terms of sustainability.

This study seeks to examine the environmental effects of foreign direct investment (FDI) in strategic sectors (namely, energy, tourism, renewable energy and technological innovation) of South Asia and ASEAN countries. The objective of this research study is to examine the environmental impact of FDI in core sectors (energy, tourism, renewable energy, and tech innovation) of South Asia and ASEAN countries. The research will examine how sectors relate to the ecosystem to enhance FDI promotion into sustainable economic development. The findings contribute to an international debate about sustained development and policy suggestions for creating synergies across FDI strategies and environment to bring both economic advancement and ecological resilience in these varied and rapidly developing regions.

1.15 SIGNIFICANCE OF THE STUDY

This study examines at how tourism, energy use, technological advancement, and foreign direct investment (FDI) affect the environment in South Asian and ASEAN nations. It examines the ways in which these variables affect the use of natural resources and CO₂ emissions, offering insights into how they interact. The study examines how tourism, energy mix, and foreign direct investment affect the

environment in both areas using a comparative methodology. Panel data analysis is used in the study to provide a thorough understanding of the effects of foreign direct investment (FDI) on environmental sustainability, taking into account both the good and negative effects across a range of industries, including technology, tourism, energy, and renewable energy. The study's significance comes from its emphasis on how these areas might strike a balance between environmental quality and economic growth.

As two fast emerging regions with distinct economic, cultural, and regulatory challenges, South Asia and ASEAN are covered in the study. It explicitly examines the impact of foreign direct investment (FDI) on the energy mix, with a focus on renewable energy sources including hydropower, wind, and solar. In light of the growing need for energy and worries about global warming, the study highlights how foreign direct investment (FDI) can either help or impede the shift to low-carbon energy. Understanding whether FDI is promoting sustainable energy or strengthening dependency on fossil fuels, a significant problem in both regions is the foundation of the study's importance.

The study's discussion of tourism and its effects on the environment is another important topic. Even though tourism contributes significantly to economic growth, it frequently causes environmental problems such trash generation, habitat degradation, and over use of natural resources. The study investigates whether foreign direct investment (FDI) in the tourism industry has encouraged environmentally conscious behaviour and eco-tourism. By examining how FDI introduces cleaner technologies that enhance energy efficiency, waste management, and sustainable agriculture, the study also emphasises technical innovation as a significant aspect in mitigating the adverse environmental effects of industrialisation.

Understanding the intricate connection between environmental deterioration and economic growth is another benefit of the study. FDI is essential for economic growth, but if it is not managed properly, it can also have negative effects on the environment. The study sheds light on how these nations have handled this balance,

including case studies and policy suggestions for FDI management that promotes environmental sustainability and economic success. Policymakers, companies, and investors should take note of these findings as they negotiate the difficulties of sustainable development and make sure that environmental preservation does not come at the expense of economic expansion.

1.16 SCOPE OF THE STUDY

The purpose of this study is to examine the impact of tourism, energy mix and foreign direct investment (FDI) on environmental degradation in ASEAN and South Asian countries. It studies the interaction between these factors on CO2 emissions and natural resource consumption. Employing a comparative approach, the study considers the implications of tourism, energy diversification, and foreign direct investment on the environment in both places. In order to offer a complete understanding of the impact of FDI on environmental sustainability, it integrates dynamic panel data analysis focusing both on the positive and negative effect in a number of sectors, such as energy, renewable energy, tourism and technological innovation.

The study focuses on South Asia and ASEAN, two regions that are experiencing major economic changes. The study looks at how these nations have responded to the environmental effects of foreign direct investment in light of their unique legislative, cultural, and economic environments. It focuses on important industries, especially the energy industry, where FDI has had a significant impact. Analysing the growth of low-carbon energy alternatives in response to the rising demand for energy and worries about global warming, the paper examines how foreign direct investment (FDI) has influenced the energy mix, supporting renewable sources including solar, wind, and hydropower.

The tourist industry is yet another crucial area of attention. The study looks into whether foreign direct investment has helped promote eco-friendly travel or made environmental problems like waste generation, habitat destruction, and excessive use

of natural resources worse. Additionally, it looks at how technology innovation might promote sustainability through foreign direct investment (FDI), especially in fields like waste management, energy efficiency, and sustainable agriculture. In order to promote long-term sustainability, the research takes into account how technical developments lessen the negative environmental effects of industrialisation.

Finally, the paper discusses a striking balance between environmental preservation and economic growth. It investigates whether FDI driven economic growth comes at the price of environmental sustainability. The paper uses case studies to illustrate how various nations in these areas have succeeded or failed in maintaining this equilibrium. The study intends to offer policy recommendations for maximising foreign direct investment's environmental effects while preserving economic growth, providing information on how future regulations can encourage green investments and sustainable development.

1.17 OBJECTIVE OF THIS STUDY

The main objective of this study is to examine the environmental implications of foreign direct investment (FDI) among South Asian and ASEAN countries.

The specific objectives are presented in the following:

- i. To investigate the impact of FDI on environmental degradation in South Asia and ASEAN countries.
- ii. To estimate the impact of FDI on economic growth in South Asia and ASEAN countries.
- iii. To investigate the impact of capital formation and labor force on environmental degradation.
- iv. To compare the results between the panel group South Asia and ASEAN countries by considering economic, social, and environmental views.

1.18 HYPOTHESES

- i. There is a significant impact of foreign direct investment on environmental degradation.
- ii. Tourism and foreign direct investment are significantly related.
- iii. There is a short run and long run causality among the variables in South Asian countries as well as ASEAN countries.

1.19 METHODOLOGY

This study aims to investigate how foreign direct investment (FDI) and other macroeconomic indicators impact the environment in South Asia and ASEAN countries over the time duration from 1995-2023. The panel data analysis through country and time variations captures this effect particularly well in South Asia and ASEAN countries, which have seen the highest inflows of FDI in the last couple of decades. Covering the years 1995–2023, the panel data includes countries from both South Asia including Bangladesh, India, Pakistan, Sri Lanka and ASEAN Countries including Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. Cross sectional dependence is tested using the Pesaran CD test employed in the estimation. Since there may be potentially a long run association between FDI and environmental outcomes, the study adopts the Kao Cointegration Test to check to find a long-run equilibrium relationship between FDI and environmental outcomes in panel data. This test tests “the residual of the dynamic panel data model is stationary which shows cointegration”.

The PMG-ARDL model was applied based on CIPS unit root test. Robustness check of FMOLS model also implemented. Furthermore, Causality tests are carried out to determine the direction of causality between FDI and the environment, and to perceive if the relationship is bidirectional or whether increased FDI leads to environmental degradation and vice versa. In light of the potential cross-sectional dependence in the data, particularly with mutually shared economic or environmental

shocks among countries located in the same geographical regions, the study adopts techniques to account for cross-sectional dependence. This approach also allows a thorough discussion of the short run and long run environmental effects of FDI in South Asia and ASEAN countries. Through the application of dynamic panel data models, cointegration tests, and adjustments for cross-sectional dependence, the research seeks to shed light on the complexities of how FDI influences the environment in these regions. The method is briefly summarized here, with additional details presented in Chapter 3.

1.20 CHAPTERISATION

Chapter 1: This chapter introduces the environmental implications and foreign direct investment, as well as various economic variables related to the environment. Here, also include the significance of the study, its scope, statement of the problem, objectives of the study, hypotheses, methodology, and outline of the thesis.

Chapter 2: This chapter focuses on a review of literature from various sources, including books, articles, journals, and websites. The literature is grouped based on a review of Environmental Issues, FDI, Climate change, tourism, economic growth, capital formation, energy consumption, and technological innovation. Empirical and theoretical review and research are also discussed in this chapter.

Chapter 3: This chapter describes the research method, which employs empirical techniques based on Pesaran & Yamagata for slope homogeneity, the Pesaran CD test for cross-sectional dependency, and the CIPS test for panel unit root testing. This consists of KAO cointegration for long-run relationships, PMG-ARDL for parameter estimation, FMOLS for relationship analysis, and Granger causality for investigating causal relationships. The country-specific parameters will then be estimated based on the PMG model.

Chapter 4: This chapter explains the present economic and environmental situation at the global, South Asian, and ASEAN levels. It highlights the rise in CO₂ emissions, growing foreign investment, tourism development, GDP growth, and capital

formation. The discussion also covers energy use, labor force trends, and the shift toward renewable sources. Overall, these factors together show how the regions are shaping their path toward sustainable growth.

Chapter 5: This chapter presents the results step by step, using tests such as Pesaran & Yamagata for slope homogeneity, Pesaran CD for cross-sectional dependency, and CIPS for panel unit root analysis. It further applies KAO cointegration to study long-run relationships, PMG-ARDL for parameter estimation, FMOLS for relationship testing, and Granger causality to check causal links. The findings provide a detailed comparison of South Asia and ASEAN countries. Country-specific results are also explained using the PMG model.

Chapter 6: Chapter 6 shows the main findings of the study. It explains the results in relation to the objectives for South Asia and ASEAN countries. It also compares the results between the two regions.

Chapter 7: This chapter presents the overall conclusions of the study. It gives suggestions based on the findings. It also offers recommendations to improve growth in South Asia and ASEAN countries.

1.21 CONCLUSION

The growing importance attributed to environmental issues with respect to FDI has sparked the interest of academics, economic analysts, as well as policy makers at the international level. There are numerous empirical studies in the literature which seek to understand the theoretical basis, antecedents, and spillover effects of FDI inflows on environmental degradation. This study attempts to quantitatively investigate the impact of FDI inflows on environmental performance in South Asia and ASEAN nations by focusing on the research question, that is, whether FDI inflows, tourism, and economic growth positively or negatively impact environmental performance. Besides examining this main question, this study investigates the spill-over effects of FDI on the environment and reveals other factors that shape the environmental sustainability at the world level.

This study would investigate the impact of FDI, tourism, renewable energy consumption and technological innovation on the environmental implications. The variable FDI presents the FDI net inflows (net inflows % of GDP), environmental degradation (ENVD) presented by CO₂ emissions measured by metric tons per capita (% of the total), and economic growth (EG) presents the GDP growth (annual %). The variable renewable energy consumption (REC) measures the share of total energy use that comes from renewable sources, including solar, wind, biomass, hydropower, and geothermal energy. Variable technological innovation is defined by the number of patent applications, residents. The variable tourism (TRM) presents the International tourism, receipts (% of total exports). The variable non-renewable energy (NECN) has represented the primary energy consumption % of the total. Additionally, numerous studies indicate that higher economic growth is linked to increased energy consumption, greater foreign direct investment (FDI), and the growth of tourism. “Bangladesh, Pakistan, Nepal, India, Bhutan Maldives, Sri Lanka and Afghanistan” are still suffering a lack of energy security, lack of FDI and tourism environment among the developing countries. The ASEAN countries have significant performance that is used to compare with the South Asian and ASEAN countries. This study aimed to investigate the causal relation among tourism, energy, renewable energy, FDI, and environmental degradation in South Asia and ASEAN by using different econometric models.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a targeted review of the relevant literature for the study. The purpose of the study is to review available studies and to determine the major challenges to be overcome. As such, you are making the case for the relevance of the article to a "prior conversation. "Here, we investigate the influence of foreign direct investment (FDI), economic growth, labor force participation rate, capital formation, and tourism on environmental consequences that some literature has highlighted. It is suggested that there are two kinds of impacts of economic growth and FDI on environmental pollution. Despite this opposition to FDI, FDI can have negative environmental impacts. An example is when advanced countries push their (polluting) FDI flows towards the underdeveloped countries with less stringent environmental laws so as to pollute them even more. On the contrary, FDI can raise welfare if production technologies from developed countries (hasaballa, 2013). In previous studies, the literature has been divided into two connections, indicating a possible relationship between foreign direct investment, tourism, technological innovation, economic growth and its environmental impact. The relationship between these variables has been supported by empirical results in several works. The correlation between FDI and the environmental impact of the host country has been well-studied in the literature, often decomposed into eight areas and structured as follows.

2.2 LITERATURE REVIEW ON THE ENVIRONMENTAL IMPACT

Climate change is one of the most important global challenges that is affecting various fields, including environment, FDI, tourism and technological innovation. Recognition of these linkages is critical to inform appropriate policies and strategies for mitigating the adverse impacts of climate change. Climate change has profound effects on natural ecosystems, biodiversity and environmental social systems. Everything in the environment is related and changes because of climate change. The transference of energy and substance between these elements makes them structurally related; hence climatic change is universal and it affects each of these

elements. This paper highlights the major implications of climate change on these significant aspects of the environment (Mume et al., 2024).

Climate change, however, is a multi-dimensional issue that affects not only the environment but also social factors, affecting areas such as health, agriculture, and development. Adaptation and mitigation will be much more effective the more climate change considerations are baked into local and national policies. Climate change should not be perceived merely as an environmental challenge, but rather as one that has profound implications for socio-economic development (Pilato et al., 2018). Similarly, in Muheza District, Tanzania, local groups focus on environmental degradation from climate change, but there is also need to raise awareness about its wider social and economic impacts (Pilato et al., 2018). Climate change affects the water supply, temperature and seasonal patterns, which change the agricultural output and natural resources (Atasoy & Guneysoy Atasoy, 2020; Chen & Raza, 2023). According to (Çelik, 2024), climate policies also shape economic growth and environmental sustainability, showing how closely they are linked. Another area that has received attention is the influence of technological innovations on environmental degradation, revealing that innovations can have an environmental mitigating role or lead to increased environmental pressures, contingent on how they are designed and implemented (Chen & Raza, 2023; Udemba, 2021).

The economic impacts of climate change are particularly important for agriculture. Farmers are worried that future climate regulations may threaten agricultural practices and their economic viability (Niles et al., 2013). So in the world of climate policies, we see a shift towards realizing that adapting is just as important as mitigating climate impact, and recognizing that balancing these two sides is what will lead to true environmental and economic sustainability (Niles et al., 2013). Local policies that favor smallholder farmers are also important to adapt to climate change, because national policies cover only a small part of specific regional needs. It is a complex interrelationship between climate change and FDI. Climate risks can discourage foreign investment through fears of regulatory instability and possible economic disruptions (X. Li & Gallagher, 2022). However, FDI can also support sustainable

practices and technological innovations that tackle climate challenges. Research indicates that countries with robust environmental policies tend to attract more FDI, given that investors prefer stable and sustainable markets (Abdul-Mumuni et al., 2022; B. Muhammad & Khan, 2021). This indicates the necessity for inclusive policies to motivate green investment without compromising on economic growth (Huan & Qamruzzaman, 2022; Md. Qamruzzaman, 2024).

Tourism, especially in popular areas, is easily affected by climate change because changing weather can impact travel, reduce destination attraction, and disrupt local economies. Studies show that urban tourism, in particular, increased heat waves and natural disasters is the big cause of natural risk (Pandy, W. R. 2019;(Michael Hall & Saarinen, 2021). Climate change is seen as a significant threat to the global tourism industry, making it necessary to develop adaptive strategies to ensure the sector's resilience (Scott et al., 2019). Technological innovation is essential in combating climate change. Advancements in renewable energy, sustainable agriculture, and efficient resource management can help reduce carbon footprints and improve environmental resilience (Chen et al., 2023; Xiao & Qamruzzaman, 2022). The relationship between technological innovation and FDI is critical, as investments in green technologies can enhance both environmental outcomes and economic development (Huan & Qamruzzaman, 2022; Md. Qamruzzaman, 2024). Promoting green technologies is increasingly viewed as a path to achieving sustainability goals while attracting foreign investments (Udemba, 2021; Xiao & Qamruzzaman, 2022).

Internationally, it is the uncertainty of the environment caused by climate change. This represents a serious challenge to human society surviving in the future. Human activity is the number one factor in Sea level rise, Climate change and crop yield. Reducing CO₂ emissions is the only way to actually slow down climate change. This can be happened through scientific advancements and an increase in the adoption of clean technologies that make energy use more efficient. However, climate change is the alarming problem behind the global warming (Voumik et al., 2022; (Nahrin et al., 2023). Recent ice melting, an increase in the global average temperature, rising sea levels, and the hottest summer and coldest winter are results of global warming caused by human activities. According to numerous studies, such as Rahman et al., (2023); Voumik et al., (2023); Wu et

al., (2023) and Rahman et al., (2021) state that, burning fossil fuels such as coal, oil, and gas to generate electricity is what has been leading to climate change because these kinds of fuels when burnt contribute the most to larger and expanding CO₂ emissions in the air. But using renewable energy can help reduce global warming.

To conclude, climate change is a significant global issue that affects multiple areas, including the environment, investment, tourism, and technology. Given this filial connection between the two postures, policies must be sustainable to keep social and economic growth. Climate change is impacting agriculture, water resources, and tourism, among other sectors, so governments must also develop plans to foster resilience and adaptation at both local and global levels. The latest technologies and green investments can also cut risks and support sustainability. Climate change will require a comprehensive approach one that incorporates climate considerations into policies, supports sustainable practices, and encourages innovation across all sectors.

2.3 REVIEW OF LITERATURE ON ECONOMIC GROWTH

Economic growth has been at the heart of development policy in both South Asian and ASEAN countries since the mid-20th century, motivated primarily by the need to reduce poverty, improve living standard and modernize economies (Todaro & Smith, 2015; (Stiglitz, 2002). Countries like India, Bangladesh, Indonesia, Vietnam, etc., have opted for rapid industrialization and urbanization as routes to development. But the ecological ramifications of his sector's rise have sent huge warnings up in both regions. Air and water pollution, deforestation and growing greenhouse gas emissions are new challenges. This has led to more interest in economic growth, the environment and the importance of sustainable development in these regions (Dasgupta et al., 2006; Stern, 2004).

Foreign Direct Investment (FDI) serves as an important tool to attract foreign capital inflows especially in emerging and developing countries. Some of the studies such as (Liang et al., 2021), FDI is the key indicator of economic development in developing countries, which is the solution, to the unemployment problem and poverty alleviation. The economic policy of a country, and investments in high quality

infrastructure directly impact on tourism (Škrinjarčić, 2019). (Rashid Khan et al., 2019) analyzed the “Belt and Road Initiative (BRI) group of countries using dynamic GMM model and found that tourism does not significantly impact their economic growth. They presented that economic growth and tourism development have a two-way relationship.

(Kurniawati, 2022) emphasizes that technological innovation especially in telephone and mobile services, boosts economic growth in high and middle income countries. The research highlights the importance of communication technology in promoting economic growth through connectivity, increased business efficiency and broader access to services. According to the "neoclassical growth theory", long-run economic growth is propelled mainly by the accumulation of labor force and human capital (Solow, 1956; Marimuthu, Arokiasamy, & Ismail, 2009). Proponents within this tradition, such as Barro (1999), have in addition highlighted the importance of human capital, with a strong positive relationship established between increases in human capital and real per capita economic growth.

Kraft, M. (2017), references that economic development is often associated with high energy consumption, especially fossil fuels, which have a high effect on the increase of carbon dioxide (CO₂). This nexus between energy consumption and environmental degradation is acute in high energy consumption areas such as South Asia and ASEAN, where energy use has accelerated due to unprecedented rates of industrialization, urbanization and consumer demand.

(Huang et al., 2021) assessed the long run relationship between economic growth and carbon emission. Their study supported a consistently positive relationship between carbon yield, energy use, and income expansion over time, indicating that in a large portion of the world, the expansion of the economy continues to be a close association with rising environmental implications.

2.4 REVIEW OF LITERATURE ON FOREIGN DIRECT INVESTMENT (FDI)

According to the OECD methodology, an FDI enterprise is an incorporated or unincorporated enterprise, which is directly or indirectly owned by a foreign investor, where this direct or indirect ownership is 10% or more of the common shares or voting rights. But in certain situations, nothing significant occurs of holding more than 10% of common shares or having voting control while holding less may come to mean having a significant control on management (Chaudhuri & Mukhopadhyay, 2014). Foreign direct investment (FDI) may be considered most remarkable under the present global economy. From the perspective of some TNCs, FIR is such a vital instrument in achieving economic growth (Azzutti, 2016). There are two types of direct foreign investment (FDI) inflows and outflows. FDI inflows occur when a non-resident sets up a long-term investment in a country, and becomes a stakeholder in its economy. FDI consists of reinvested earning, the intra-firm loan and the net repayment of capital loans (Barauskaite, 2012). On the contrary, FDI outflows refer to the value of transactions where a country initiates in a foreign country. This includes both outward investments, i.e. foreign direct investment and reinvested earnings not just in SEZ, as well as transactions in the form of intra company loans and net receipts from capital repatriation and repayment of foreign liabilities (Barauskaite, 2012).

Global FDI exceeded projections for 2023 and grew by 3 per cent, with reported flows of \$1.37 trillion by the end of the year, compared to projected \$1.3 trillion cited in the UNCTAD' s latest Global Investment Trends Monitor on January 17, 2024. In 2023, major developing economies across Asia witnessed notable decreases in FDI inflows, although they sustained their appeal as destinations for greenfield projects, wherein parent companies establish new operational facilities in foreign territories. Despite a 47% decline in FDI inflows, India maintained its position within the top five global destinations for greenfield projects FDI inflow into ASEAN went down by 16%, but manufacturing FDI maintained its attractiveness, most notably evidenced in a robust 37% increase in greenfield project announcements across

ASEAN-5 (Vietnam, Thailand, Indonesia, Malaysia, the Philippines), with Cambodia also showing a considerable increase. According to (Azemar & Bonaïem, 2023), developed nations have exhibited a resurgence in economic momentum, coupled with a notable increase in FDI directed towards developing countries, which saw a significant 30% surge in 2021, culminating in a historic high of \$837 billion. Nevertheless, the distribution of global FDI remains heavily skewed, with a disproportionate concentration in select regions. Notably, FDI flows to developing Asia, constituting 40% of the global inflows, witnessed a robust 19% growth in 2021, yet a mere six countries accounted for nearly 80% of these flows.

As noted in PHH, and FDI is now giving multinationals incentives to relocate the production of polluting goods from developed countries to emerging economies. This trend is motivated by multiple factors like limited public awareness, weaker environmental laws, cheaper natural resources, and inexpensive manpower. The works of researchers like (Baskurt et al., 2022) across segments of the literature find complex factors explaining the behavior of multinational corporations (MNCs) between bottom-up economic incentives and top-down environmental concerns. In particular, governments and policymakers can encourage environmentally sustainable FDI through the establishment of strict environmental regulations, the provision of incentives for green investments, and the promotion of corporate social responsibility initiatives. Responsible investment, where investors consider the environmental, social and governance investment aspects, is a fast-growing trend. Such changes may result in greater consonance of FDI with goals of environmental sustainability. After all, FDI can play a significant role in GDP growth and expenditure, while providing investment and management resources for environmental investments, especially in developing countries (Dunning, 1993). However, from the development perspective, such foreign investments should be better managed and regulated to achieve the quality of growth and further generate sustainable benefits for nature (Krugman & Obstfeld, 2001).

2.5 LITERATURE REVIEW ON TECHNOLOGICAL INNOVATION

Technological innovation plays an important role in saving energy and reducing environmental pollution. Fossil fuel and renewable energy plays an important role to improve the energy systems. Technological innovation helps fossil fuel base production more efficient and produce less harmful gases. Using efficient energy saves money and keeps the air clean in fossil fuel industries. Technological innovation has made renewable energy consumption (REC) ready to meet future energy demand. Due to the future demands of energy in the world, it is becoming clear that REC will be an important source of energy. REC is known for being energy efficient, reduce greenhouse gas emissions, and increasing energy independence. As a clean energy resource that does not cause the depletion of other resources, its usage is important for the sustainable improvement of activities (Cui et al., 2022). Recent REC growth and technological innovation have lowered renewable energy prices and raised energy demand, boosting economic growth. Yet in East and South Asia, studies point to the environmental consequences of REC. It has been found that an increasing share of REC in these region's energy structures may decrease CO₂ emissions (Li et al., 2022).

The significant impact of technological innovation on lowering CO₂ emissions has drawn the attention of researchers to explore the link between technological development and environmental sustainability. Other research has demonstrated how ongoing or new innovations in fossil fuel and technology base renewable energy helps to reduce carbon emissions (Chen et al., 2020; Cheng et al., 2019; Song et al., 2020). These studies emphasize the necessity for promoting innovation as a strategy for achieving long-term environmental goals.

While the CO₂ emission reductions attributable to technological innovation are well-established in the literature, the potential adverse consequences of technological innovation on the environment is under-studied. More research is needed to better understand if and how innovation may cause harm to the environment. Studies by (Fuinhas et al., 2022) and (Chaudhry et al., 2022) point out that the technological

innovation (TI) contributes to reduction in carbon dioxide emissions. Research conducted in other countries as China (Cheng & Hu, 2023) and Japan (Zhu et al., 2022) has also confirmed a positive link between TI and environmental development. Nonetheless, studies in the literature such as (NGUYEN et al., 2021) have relatively less evidence of the interplay between ecological degradation and technological innovation.

2.6 LITERATURE REVIEW ON TOURISM

From the economic point of view, tourism is not limited to commercial considerations, but also to its qualitative aspects. Tourism could be defined as the planned pursuit of attracting, accommodating and looking after visitors, and meeting their needs and desires in a hospitable way (McIntosh, 1999). As defined by (Danish & Wang, 2018), (Dogru et al., 2019; Paramati et al., 2017) the travel and tourism sector is considered as a driver of economic development between nation and international economy. Tourism plays an important role in supporting the economy of both local and national government as the increasing number of visitors brings significant financial benefits. In countries like Sri Lanka, the tourism industry contributes to generating job opportunities both directly and indirectly, rising real per capita income, increase tax revenue, and improve the balance of trade. Indeed, in 2019 the tourism and travel accounted for 10.3% of the world's GDP, and 330 million jobs (WTTC World Travel and Tourism Council 2020). However, while tourism boosts economy growth, it also contributes to environmental degradation. Powerful empirical evidence from separate scientific works by academia indicates that the greenhouse gas emissions due to present economic behavior and human activities intensify the negative influences of climate change (Dogru et al., 2019; Gössling, 2013). The tourism sector is said to be accountable for approximately 8% of global greenhouse gas emissions (Lenzen et al., 2018).

The tourism industry's non-transportation parts, such as accommodation providers and food service, add further to the high levels of GHGs associated with transportation. Ironically, places they travel may be a victim of climate change and environmental degradation, that is, through the very resources they use and the

climatic conditions that support the tourism industry (Neuvonen et al., 2015). Some destinations are very sensitive to climate change, particularly those which rely heavily on snow (Hernandez & Ryan, 2011). Furthermore, tourist destinations that have no reliable electricity access and poor physical infrastructure as well as destinations located in areas with elevations less than 16 feet height of sea level, are vulnerable to the environmental effects of climate (Berrittella et al., 2006; Dogru et al., 2019).

Several alternative strategies have been recommended to address the problem of environmental pollution and thus climate change and among these include, options to reduce and eventually eliminate dependency on fossil fuel consumption while promoting the use of other alternative sources like renewable energy (Dogru et al., 2019; Nicholls, 2004; Jenkins & Nicholls, 2010). Tourism can provide a significant contribution to the way climate change is tackled if the challenges are confronted and opportunities are grasped. Concerns in the tourism community from eight years were visibly different in the climate change challenges. The first world conference on Climate Change and Tourism CMS, Djerba, Tunisia and organized by the World Tourism Organization (UNWTO) along with partners like the United Nations Environment Programme (UNEP), brought the global attention to impact of climate change on tourism (Carboni et al., 2014). These conferences acknowledged the complex relationships between tourism and climate change, and emphasized the need for future research and policy development focused on both adaptation and mitigation strategies.

2.7 LITERATURE REVIEW ON ENERGY CONSUMPTION AND RENEWABLE ENERGY CONSUMPTION

Energy consumption is essential for sustaining and supporting its development. Mostly, with growing energy consumption comes an improvement in lifestyles (Pachauri, 2006), which becomes a critical element in the pursuit of sustainable development. However, unsustainable energy consumption practices are an important cause of global environmental degradation including the exhaustion of

renewable resources and pollution from fossil fuels (Rennings et al., 2012) which makes the situation highly concerning. (S. Wang et al., 2016) emphasize the close relationship between energy use and economic development. For example, the 2008-2009 global financial crisis, a human made event, lead to a reduced energy demand in many countries and demonstrated the susceptibility of energy systems to economic shocks. The effects from greenhouse-gas emissions and climate change are adding a lot of pressure on the world's economy, making it more crucial to regulate emissions.

In recent times, there has been growing focus on improving how energy is produced, transmitted, distributed, and used (Keleş & Bilgen, 2012). Roughly half of the world's global GHG emissions derive from urban areas. Mayors, as city leaders, have significant leverage to address these issues, through actions such as supporting renewable energy, curtailing pollution, controlling energy consumption and stimulating the behavior of politicians and the public. Cities are key nodes for developing solutions that engage multiple actors, relate public and private sectors and attract investments for transitioning to sustainable energy systems (Musco, 2010).

2.8 LITERATURE REVIEW ON THE RELATIONSHIP BETWEEN ENVIRONMENTAL DEGRADATION AND FOREIGN DIRECT INVESTMENT (FDI)

According to Wang & Luo, (2020), active government involvement, strong economic development, and industrial structure optimizing significantly contribute to improved environmental quality, while at the same time, increased foreign direct investment (FDI) tends to increases environmental degradation. Empirically renewable energy consumption (REC), foreign direct investment (FDI) and economic growth (EG) has been probed into in the pertinent literature there are now being exist since, such as Naz et al., (2019), and Samour et al., (2022). All the more exactly, in the customary structure, FDI is required to clearly influence economic development since FDI is expected to supplement domestic investment, and viewed as a significant enhancement for capital and investment deficiencies. Further analysis showed that

foreign direct investment influences economic growth through knowledge spillovers in countries experiencing significant changes, and that technological and innovative activities play a key role in supporting development performance (Silajdzic & Mehic, 2015). Additionally, the investigation by Nistor, (2014) found the positive effect of FDI on host economies, showing distinctively relying upon the region and the area of the foreign investment; its effect relies generally upon the quality and amount of the inflow. The outcomes show that the FDI inflows along with the human resources improvement contribute emphatically to the host nation's economic development (Ciftci & Durusu-Ciftci, 2022).

The relationship between foreign direct investment (FDI) and environmental issues such as climate change is the subject of ongoing debate in the contemporary trade and environment agenda. The relationships among FDI, and CO₂ emissions are well documented from the "Pollution Haven Hypothesis (PHH)" perspective. This idea suggests that, particularly in open-market industries and resource movements, industries with high pollution tend to move across borders to countries with weaker environmental policies. Foreign investors invest their money in those countries where environmental laws are not much enforced (Khalid et al., 2021) so this attitude of the stakeholders further deteriorate the environment of the South Asian countries. Grimes & Kentor, (2003) came to the conclusion that the level of dependence on FDI of a country is associated with a rise in its level of CO₂ emission after analysing 66 lesser developed countries. In a study of Granger causality between foreign direct investment (FDI) and environmental pollution, Hoffmann et al., (2005) found a bilateral causality between FDI and carbon intensity in middle and high-income countries. Therefore, this combined behaviour is believed to rapidly degrade the environmental quality of the host developing countries.

The Pollution Haven Hypothesis (PHH) was initially proposed by Walter and Ugello (1979), and later expanded upon by Levinson & Taylor (2008a). This hypothesis suggests that emerging countries, often positioned within specific segments of the global value chain, attract high-polluting industries from developed nations. These developing nations use their advantages of cheaper labor and weaker environmental

laws to attract companies looking to save money. For example, Ren et al., (2014) studied foreign trade and FDI effecting environmental pollution in China during 2000-2010. So international economic activities may affect environmental consequences positively. Sapkota & Bastola, (2017) also applied panel fixed effect model and random effect model for time series data collected from 14 Latin American countries from 1980 to 2010. They showed that their result remains valid after controlling for human capital, physical capital and energy, unemployment rate and population and demonstrated that FDI inflows lead to the environmental degradation of the countries in their sample. Another study is based on similar methodology of Solarin & Al-Mulali, (2018) who studied impact of FDI on carbon dioxide emission ecological footprints and carbon footprints in twenty countries. Their study found that outward foreign direct investment contributed to increased pollution in emerging economies.

Wang et al., (2020) analyzed the influence of foreign direct investment (FDI) on carbon emissions of its industry, and adopted the ARDL method for emerging economies. An FDI inflow could be indicated by CO₂ emissions up to 55% of CO₂ injection. In the similar vein, Farooq, (2022) empirically investigated the impact of FDI on CO₂ in the case of Asian economies by using GLS, FMOLS, and GMM estimation techniques. Their results supported the former notion that as a result of FDI, more industrial activities leads to more CO₂ emissions by (Gong et al., 2021). One Belt, One Road Economies: The Nonlinear Dynamic FDI-Emissions Connection. Using BDS (Brock, Dechert, and Scheinkman test) method and Granger causality analysis, they revealed a causal relation between CO₂ emissions and FDI using TVECM and TVAR models. These findings support prior research that FDI construct is involved in CO₂'s long-term impact. They found FDI inflows do not have any long run effect on CO₂ emissions per capita. These diverging perspectives contribute to the discussion on the dual dimension of FDI and the ecosystem. (Rahman et al., 2023) have examined the EKC hypothesis in context of trade, renewable energy and FDI (FDI) in Bangladesh. Thus, this study is distinctive in that the ARDL model with cointegration analysis has not been utilized for the analysis of EKC for this set up. Even if there are a number of studies on the EKC in

Bangladesh, there existed literature lacunæ which the study has tried to fulfil. Particular relevancy has also attached with FDI-induced EKC model particularly when foreign investment is flowing at large from LDCs like Bangladesh.

Li et al., (2019) state that, foreign direct investment (FDI) from one country to another country, could both cause the transfer and displacement of environmentally harmful and ecologically unsustainable economic activities or bring positive environmental impact through technology transfers. They argue that foreign direct investment (FDI) might have both positive and negative implications for the environment. According to this idea, countries with significant inflows of FDI and major positions in the global FDI network are more sensitized to bad environmental effects, and these effects persist especially in the global South. As per (Jorgenson et al., 2022) plays in fostering China's environmental situations; it specifically analyses the cleaner production techniques implemented through bilateral foreign direct investment (FDI) from paired nations and environmental end of life treatment applied. And although FDI that has a significant adverse effect of redistributing environmental end treatment, the study shows that the inflow of FDI has positive impacts on cleaner production and environmental quality. From the other side, external FDI significantly enhances cleaner industrial processes, environmental end-of-life strategies, as well as environmental quality improvement.

Moreover, Cheng et al., (2019) also highlights that FDI implementation along with the adoption of energy sources, reduces environmental degradation in the BRICS cadre. Foreign direct investment (FDI) can help reduce environmental damage and also encouraged investing in renewable energy to fight environmental degradation. However, (Omri et al., 2019) also advanced a contrary view and argued that FDI may actually worsen environmental degradation in Saudi Arabia. On the other hand, (Zhu et al., 2016) have shown that FDI decreased environmental degradation in a number of Asian countries. In particular, (Zhang & Zhou, 2016) investigated the link between FDI and environmental degradation in China. They concluded that FDI does cause a decrease in environmental destruction in China. They also suggested that the percentage of industry structure as well as the level of technology are critical to

declining environmental degradation within the country. The results of the study show that, at the beginning, foreign direct investment (FDI) has an insignificant impact on environmental consequences in the total sample. However, further investigation reveals considerable heterogeneity in the effect of FDI on environmental consequences in both developed and developing South Asian & ASEAN countries. Remarkably, the impact changes according to the quartiles for the environment among developed ASEAN countries.

2.9 LITERATURE REVIEW ON THE RELATIONSHIP BETWEEN ENVIRONMENTAL IMPLICATIONS AND ENERGY CONSUMPTION

Economic growth and the use of renewable energy have been the subject of various studies, which have found that although renewable energy can stimulate economic growth, it may also contribute to environmental damage. Relevant research on how certain natural resources, like natural gas, affect regional environmental degradation is available. This is especially true in the case of countries such as five EU countries and the BRICS, where studies focusing on the environmental effects of these resources remain scarce (Baloch et al., 2019; Balsalobre-Lorente et al., 2018; Dong et al., 2017). Renewable energy and fossil fuel energy impact on environmental degradation among sixteen EU members were examined by Bekun et al., (2019). These results suggest a relatively underdeveloped area of research regarding the effects of different categories of natural resources on environmental performance and policy, and become especially germane given the increased attention paid to environmental phenomena by geographers.

For example, (Baloch et al., 2019) investigated the nexus between natural resource rents, economic growth, renewable energy growth and environmental degradation in BRICS countries. Their investigation utilized cross-section dependency tests, panel models and long run mean group method and revealed that the linkage between environmental degradation and natural resources, and found that this relationship is not straightforward. In Russia many resources seemingly have an effect of mitigating environmental degradation and the other way round for South Africa. In addition,

they found that a dependence on natural resources led to environmental damage in Russia, South Africa, Brazil and China. On the other hand, studies by Dong et al., (2017) and Perkins et al., (2018) argued that greater penetration of renewable energy and natural gas can alleviate environmental deterioration. In contrast, Bekun et al., (2019) observed positive effect of total natural resources on the environmental degradation in sixteen European Union countries. This serves to indicate that any relationship between resource and environmental outcomes is a complex and context-specific one, and is not a matter only of geography, but also human agency and systems. Tugcu et al., (2012) identified this writing in terms of the type of devoured energy. The papers in the next tier of the pyramid have explored the correlation of sustainable power consumption with financial growth. Overall, the current literature in energy economics has devoted attention to the analysis of both renewable and non-renewable energy consumption on economic growth (Tugcu et al., 2012).

Kabir (2007) has demonstrated the FDI inflows have made it easier for a spectrum of sectors of economy such as industry and power to develop. The extension has contributed to an increase in the number of open positions and a decrease in the unemployment rate. Then, GDP and also per capita revenue increases, which enhances the reduction of poverty in a developing world. Kahouli & Omri, (2017) also observed that FDI increase industrialization, transportation, and manufacture but energy is demanding for all this. FDI causes energy consumption to increase, and some argue that the low-income countries energy use is even more erratic than the higher income countries, even though there is a more investment in higher income countries than in low income countries. Mozumder & Marathe, (2007) have tested the cause and effect among economic development and electric consumption using the Johansen vector error correction model (VECM). In the long run, according to the authors, a unidirectional causality is established from economic development to electricity consumption. Thus the plan of conservation could not be inimical to economic progress. Raihan et al., (2022) have also quantified the energy consumption and economic growth nexus and CO₂ emissions.

The demand for conventional energy sources has dramatically increased due to the 3-4% annual growth in global output. The traditional energy consumption in the industry will lead to heavy atmospheric pollution. More specifically, there was a (+2.7%) rise in CO₂ emissions in 2018, compared to 2017. The world has warmed somewhat due to over consumption of conventional sources of commercial energy like coal, oil and gas stated that major sources of environmental pollution in countries are the coal based power plants and burning of garbage (Khan et al., 2018). This has caused serious damage to the environment as well as to human life. The heating can be reduced simply by utilizing methods of carbon neutrality. Elfaki et al., (2022) analyze the relationship between industrialization and carbon emission in a sample of eight ASEAN countries from 1994 to 2018. Panel Dumitrescu and Hurlin causality approach is also applied and a bi-directional causal link is found to run from energy consumption to environmental degradation, and economic growth to environmental degradation. available literature has provided some reasons behind the reasons of environmental degradation as select number of relevant variables in the SAARC countries, the use of CSD and SH tests and also employed a second generation unit root and cointegration tests in addition to the CS-ARDL estimation approach. The second-order interactions between these two variables are not thoroughly tested in the literature and deserve more attention based on the second-generation panel test that has been introduced in this paper. However, the extant literature ignores Slope homogeneity test, CSD test, or standard panel estimators that cause conflicting results. Also, the STIRPAT hypothesis has been seldom evaluated through this statistical procedure. The current study provides a promising start to address gaps in the literature, where empirical research is limited and much of the existing evidence is conflicting.

2.10 LITERATURE REVIEW ON THE ENVIRONMENTAL IMPLICATIONS AND THE ECONOMIC GROWTH RELATION

Environment and economic growth can be traced by the theory of "Environmental Kuznet Curve (EKC)", which is popularly discussed in environmental economics. Now, the world is in the midst of the most unprecedented level of economic growth in history, since the days of the Industrial Revolution. Industrialization creates wealth and energy for the economy, but it also creates large quantities of carbon dioxide as a consequence. "more economic activity must be harmful to the environment and that economic processes were based on fixed technologies, tastes and environmental investments."(WDR, 1992) and it adds, "with increasing income, demand increases as well as the funds necessary for environmental investment to improve quality of environment will increase". Wang et al., (2020) studies the United States and China and concludes that yield growth has stifled the environmental quality of both economies. With another emphasis of Mazur et al., (2015) used data between 1992 and 2010 to study the association between development per capita and environmental quality in the panel of EU states; however, the study did not confirm the EKC hypothesis among 28 of the current EU member states. There was no clear evidence of a U-shaped EKC pattern in the whole EU. Inspection of the graph indicated on a possible threshold for CO₂ emissions around a GDP per capita of 23,000 USD. Remarkably, there was a strong evidence for the EKC hypothesis in the 16 older, wealthier EU members, as the EKC coefficient was always negative and statistically significant. Still, in the entire data set evidence for the EKC phenomenon was not conclusive, probably because the last twelve new EU members have less developed economies. Further, economic development has also influenced the emission of CO₂ tested by Md. Hasanur Rahman & Shapan Chandra Majumder, (2020).

Stern et al., (1996) observed that environmental degradation and economic growth are mutually related. Moreover, Hung and Shaw (2006) that environmental quality and economic development are mutually simultaneous. This is consistent with the Environmental Kuznets Curve (EKC) which holds GDP per capita to affect environmental degradation and environmental quality to affect GDP per capita as

well. Accordingly, there is also a concurrent co-integration between environment degradation and development. Moreover, aside from the two-way causality between environmental degradation and economic development, there exists other variables influencing not only GDP per capita, but also carbon dioxide emissions per capita. Per capita CO₂ emissions, that are of anthropogenic type, are closely related to per capita energy utilization (Omri et al., 2015). FDI plays a significant role in Third World countries, and are the vehicle of economic and social progress. Working under unique status, foreign capital may help in saturating the gap between the capital and public saving requisites and, in turn, improve the fitness of the host economy, and enhance entry to the market as well as contribute in new innovation and good governance (Abbes & Allagui, 2016). The growth hypothesis suggests that economic growth is directly driven by the combined scaling of capital and labor force.

There is now plethora of applied research focusing on the impact of rising level of CO₂ emissions on economic growth (Raihan & Tuspekova, 2023). With the second generation panel structure Ali et al., (2023) has established that 1 percent rise in GDP's CO₂ intensity causes a 1.7728% increase in CO₂ emissions, indicating the importance of this variable in explaining environmental degradation in South European countries. Also, 1% increase in the economic growth led to a 0.2568% increase in CO₂ emissions. The conservation conjecture has been argued that the economic prosperity is the driver of the energy consumption. Ghosh, (2010) analyzed the relationship between GDP growth and CO₂ emissions in India during the years 1971–2006, using an ARDL-bound test and found the long run causal relation between economic growth (EG) and environment degradation

Likewise, Yang & Khan, (2021) also found that natural resources, governance, and finance are significant determinants affecting both economic growth and carbon emission in SAARC countries to the period ranging over 1996–2018. It implies that finance and governance plays an essential role in polluting the environment and driving economic growth in SAARC countries. It also points out that ecological devastation in the SAARC area is also increasing due to reckless looting of natural

resources. Cowan et al., (2014) attempted to investigate the causal relationship among electricity consumption, economic growth, and CO₂ emissions in BRICS countries during the 1990–2010 periods using a panel causality approach. The results, however, were mixed across the BRICS countries. Shahbaz et al., (2014) examined linkage among industrialization, electric power consumption and CO₂ emissions in the context of Bangladesh in the period of 1975-2010. The researcher found a U shape link between industrialization and CO₂ emissions after using the Auto Regressive Distributed Lag Bound Test to analyze the industrialization process and CO₂ emissions. Additionally, their findings show that there is a long-term correlation between electricity use and CO₂ emissions with CCE, whereas in the short term, there is a negative correlation between electricity use and CCE in the instance of Bangladesh.

ASEAN, established in 1967, is a regional grouping of 10 member countries, whose 650 million people represent myriad cultures. For example, Kien et al., (2023) provide evidence that the GDP of ASEAN economies is already increasing at 5.2% and the region is experiencing dynamic growth in the last few years. This unnatural economic expansion however, has not been without costs as, among others (Gormus & Aydin, 2020), reflected in disturbingly high levels of environmental degradation. The world bank data (WDI, 2019), showing a hike of 15% increase from 2011 to 2016 in terms of CO₂ emissions. Begum et al. expand the model from 1970 to 1980 and to develop dynamics between energy consumption, population growth and economic growth in analyzing CO₂ emissions in Malaysia. They found the GDP per capita growth is the negative contributing factor for carbon emission in the Malaysia by using the ARDL-bound test. Ali et al. (2013) analysed the link between economic growths, energy consumption, trade openness, urbanisation and carbon emissions in Nigeria from 1971- 2011 using ARDL bound test approach. The findings reveal that CO₂ emission does not respond to urbanization but positively with economic growth, energy consumption and trade openness. (Hussain et al., 2022) analyze the energy consumption and urbanization on carbon emissions in the 54 African Union countries over the period from 1996 to 2019, applying panel quantile regression (PQR) and fully modified ordinary least squares (FMOLS). If their results are in accordance

with EKC theory, it would provide support for the theoretical hypothesis of the EKC. Meanwhile, Islam et al. (2021) apply simulated dynamic autoregressive distributed lag (D-ARDL) models to examine the influence of foreign direct investment (FDI), energy consumption, and openness on CO₂ emissions for Bangladesh over the period 1972–2016. Their findings reveal the positive impact of economic growth, urbanization, and energy consumption on CO₂ emissions in both the long run and short run, with FDI, globalization, and innovation exerting negative effects on emissions.

2.11 LITERATURE REVIEW ON THE ENVIRONMENTAL IMPLICATION AND THE TOURISM RELATION

In the last decade, tourism and environmental studies have devoted significant attention to understanding the relation between tourism activities and the environmental implications but the reviewed literature shows there is still limited evidence (S. Muhammad et al., 2020). One set of researchers took for granted a positive relationship between CO₂ and tourism sector because the tourism sector is based on accommodation, transport and other tourism related services that directly or indirectly deteriorate the environment due to being associated with increased use of energy and fossil fuels (Tang et al., 2022; Tang et al., 2018). For example, according to (Mayor & Tol, 2010), international tourist flow is an important driver for long-run tourism environmental pollution. What they found over the years is that as tourism increases, it demands vehicles and related transport—this leads to more fuel being used and an increase in carbon dioxide emission. In the second literature (Rafiq et al., 2018), it is hypothesized that tourism ameliorates emissions of carbon through investing in green energy and fostering the efficient infrastructure. Since growth prospects, both in terms of demand and the waning of availability of hydrocarbon resources and the need to reduce humanity's overall environmental impact, have driven the emergence of new challenges to the need of fulfilment of expected energy needs. This implies the need for inventive solutions to join together the energy sector and tourism sector in order to encourage sustainable tourism (Farmaki et al., 2015).

Stayed interactions between renewable energy consumption and tourism are expected to happen and are happening in some cases as a result of the increasing global demands for energy and the increasing demands for energy in the tourism industry.

Balaguer & Cantavella-Jordá, (2002) introduce the tourism-led growth hypothesis (TLGH) and suggests that the extension of global tourism can drive economic development. They explain a theoretical and empirical link between inbound tourism which refers to visitors from others countries traveling to a destination for leisure, business, or other purpose and overall economic growth. Hypothetically, the export-led growth hypothesis (ELGH), which holds that financial development can be produced not only by increasing the amount of labor and capital in the economy, has directly informed the TLGH, yet in addition by extending trades. Savaş et al. (2010) have assessed the TLGH with regards to Turkey. The review has utilized the GDP, actual conversion scale, exchange rate and global tourism appearances to portray the causality among the factors. The outcome uncovers a unidirectional connection among the tourism and exchange rate. The discoveries recommend that tourism industry is the main impetus for financial development, which thus assists turkey with coming full circle its current account deficit. Dhungel (2015) has examined the causality among the travel industry and economic development in Nepal, for the period of (1974-2012), by using Johansen's cointegration. The result has communicated that causality exists for long run, while in short run, no causality exists between two forms. The audit has emphasized that techniques should be considered to accomplish the causality running from the tourism industry to monetary turn of events. In addition, energy consumption and FDI have caused to economic growth investigated by (Nepal et al., 2021; Sheng Yin & Hussain, 2021) and tourism has caused to economic growth which is also investigated by Brida et al., (2020), and Adedoyin et al., (2021).

The review above reveals overall FDI, trade dependence, TI, economic growth and CO₂ emissions are mostly studied individually. There is a lack of research that examines all these variables together from a comprehensive, multivariable perspective. What is more, former findings are typically constrained by conventional

empirical approach, using single-dimensional measures of TD and wrongful measures of FDI, which consequently led to inconsistent results. Energy-infrastructure FDI investment and TD in the BRI node countries is facilitated by China's rapid strengthening of partnerships with neighbouring countries after the establishment of the BRI, in China with partner countries. In addition, the Chinese infrastructure-based FDI has a unique nature that may not be reflected by the overall FDI flows from other source countries. Consequently, an integrated view of BRI node nations is required in order to analyze the environmental stewardship of the BRI by taking into account outward FDI stocks that are peculiar to the Chinese regime.

2.12 LITERATURE REVIEW ON THE ENVIRONMENTAL IMPLICATION AND THE TECHNOLOGICAL INNOVATION RELATION

In recent years, there has been a comprehensive examination of the relationship between technological innovation and CO₂ emissions. Increased spending on research and development (R&D) is seen as a means to enhance economic production efficiency and resource usage efficiency, thus potentially reducing pollution. Technological advancements are expected to help reduce pollution, while environmental programs support the use of technologies to lower CO₂ emission and improve the environment globally. Earlier research focused only on the positive effect of technology innovations on CO₂ emissions using patents as a common measurement of technological innovation. Many researchers prefer patents as they protect company and intellectual property rights that enable the development of technologies to tackle environment-related issues. Chen & Lee, (2020) argue that technological innovation in high-income countries has effectively reduced CO₂ emissions and is thus a form of environmentally friendly green technology innovation. That technological innovation can decline CO₂ emissions has been highlighted in many studies.

Shahbaz et al., (2020) as China's environmental performance is positively impacted by its effective technical innovation. According to Rahman et al., (2019), the foreign company's implementation of clean technology could enhance Pakistan's environmental quality by lowering carbon emissions. Similarly, Ahmed et al. (2016) discovered that in 24 European nations, technological innovation improves environmental quality by lowering CO₂ emissions. (Raihan et al., 2022b) examined the period from 1990 to 2019, which indicated a positive correlation between CO₂ emissions and economic growth, but a negative correlation alongside the use of renewable energy and technological innovation in Malaysia.

Moreover, Raihan & Tuspekova, (2022a) confirmed in their study from 1996 to 2018 that economic growth positively impacts CO₂ emissions while the use of renewable energy and technological innovation impact negatively on CO₂ emissions in Kazakhstan. Technological progress is widely credited with reducing emissions and maintaining economic growth. Hence, gaining more insights on the process of technological innovation is likely to broaden our understanding of mitigation strategy (Raihan et al., 2022a).

As the World Development Indicators (WDI, 2019) show, ASEAN countries, in their efforts for sustainable development, have begun to invest R&D projects. Creating this context provides the urgency to interrogate data regarding ASEAN countries, in order to understand the wide range of factors driving environmental deterioration. This study addresses the prominence of R&D in controlling environmental footprints (EFs) in relation to the influence of additional factors like natural resource exploitation (NRE) and renewable energy (RE) over the last 30 years. The Global Innovation Index (2021) has reported that investments in renewable energy climbed by approximately 17% in 2019 while technological breakthroughs increased by 8.5% (Pao & Fu, 2013). This is a huge development for sustainability and environmental preservation. To significantly attain carbon neutrality by 2060, nations must reduce global emissions by about 20% after 2030 (Cozzi & Gould, 2021).

2.13 LITERATURE REVIEW ON THE ENVIRONMENTAL IMPLICATIONS, CAPITAL FORMATION, AND LABOR FORCE PARTICIPATION RATE

The relation between environmental degradation and capital formation is important for addressing sustainability issues in fast growing regions such as South Asia and the Association of South East Asian Nations (ASEAN). It is arguing that the accumulation of physical assets—investments in infrastructure, machinery and production systems also known as capital formation, is a key driver of economic growth (Solow, 1956). Nevertheless, unchecked or environment damaging capital formation could lead to higher levels of pollution and environmental degradation, especially in countries with poor standards of environmental governance and a high reliance on fossil fuel-led growth (Stern, 2004; Shahbaz et al., 2013). In South Asia, countries have seen significant levels of capital-formation, often in highly mechanised programmes such as infrastructure development, in the development of their manufacturing bases, and in the rise of urban investment. Take the example of India, which has sustained a GCF rate of greater than 30% of GDP for much of the past two decades. However, findings from Chakraborty and Mukherjee (2019) show that GCF and CO₂ emissions in the country are positively correlated with a high magnitude of the country's fossil fuel based electricity generation, steel, cement industry and road transport infrastructure. Similar patterns were noticed in Bangladesh, where public and private capital investments into the garments' industry, electricity and power generation, and urban expansion have resulted in higher greenhouse gas, and industrial pollutants emissions (Hossain et al., 2022). It is not just even in Nepal and Sri Lanka with much lower store of capital, and much less industrialization, that environmental stress has been absent. Hydropower production and urban development investment in Nepal have induced localized ecological disbalances while in Sri Lanka capital expansion for tourism has caused coastal erosion, plastic waste generation, and water pollution (Senaratne & Wickramasinghe, 2016). Like India, Pakistan too has been suffering with higher levels of air and water pollution due to capital-intensive CPEC projects, in particular the coal-based powerhouses and road connectivity (Khan et al., 2021). These are indicative of the

regional conundrum - you need capita to build up but if you do it in a traditional, resource exploitative way that messes with the environment.

The environmental effects of capital formation at the level of ASEAN could differ from nation to nation, depending on income status, regime and economic structure. Singapore has mainstreamed environment safeguards and green technology in its capital investment programme with a relatively high GDP (above 30 per cent). Singapore's sustainable urban planning, green building investments, and robust policy framework have played a critical role in addressing environmental degradation (Zhang & Zhou, 2021). Malaysia, Thailand, Vietnam and Indonesia, on the other hand, are countries that have high manufacturing and export-oriented growth, and in these countries environmental degradation in the form of carbon and deforestation has been positively correlated with stepped-up capital formation. For example, Thanh and Canh (2020) maintain that capital investment on heavy industries, coal power, and land-intensive agriculture in Vietnam have caused high level of emissions and loss of biodiversity. Indonesia's palm oil and extractive industry expansion have been significant sources of capital accumulation and environmental devastation, creating pressing questions of sustainability (Yusuf & Francisco, 2009). The other component of the literature that highlights how foreign direct investment (FDI), significant portion of capital formation, affects environmental outcome is important. In South and Southeast Asia, FDI often focuses on pollution-intensive industries out of relaxed environmental laws and an abundant supply of low-wage manpower and land. This provides evidence in favor of the pollution haven hypothesis, that is, that multinational firms move dirty industries to countries with lax environmental regulations (Eskeland & Harrison, 2003). The abovementioned trend is further supported by empirical evidence from Mani and Wheeler (1998) which suggests that during the 1990s, there was an increase in FDI inflow in Southeast Asian countries into the chemical and metal industries with high pollution contents. Even today, in many of the ASEAN and South Asian countries, mining, coal-based energy and huge industrial parks are the leaders in agenda of capital formation. The EKC hypothesis has also found extensive use in the analysis of pollution-capital formation nexus. The EKC indicates that environmental

destruction first grows with economic and capital growth and begins to fall when countries reach a specific income threshold and begin to invest in cleaner technology, and regulatory structures (Dinda, 2004). Although, countries like Malaysia and Thailand are at the initial steps of reaching the EKC turning point, others, such as Myanmar and Bangladesh, remain on the ascending phase, where further investment is still associated with growing emissions and pollution.

Recent literatures increasingly emphasize the cultivation of green capitals, such as investment in renewable energy, public transport, waste management systems, and nature-based solutions, as a solution to divorcing economic growth with the consequences for the environment. Recent reports by UNESCAP (2021) and Global Green Growth Institute (GGGI), underline the imperative need for capital shifting in South Asian and ASEAN countries towards the climate resilience and low carbon development. Promising signs include Vietnam's solar power boom, India's growing metro networks and electric mobility initiatives, and the Philippines' investment in flood-protecting infrastructure. However, barriers remain. Most countries are dealing with issues of financing, limited technical capability, inadequate policy enforcement, and limited education priorities. The importance of regional co-operation is also highlighted in the literature. Cross-border cooperation in the sharing of green technologies, of environmental governance, and of climate finance can enable South and Southeast Asia to build global capital infrastructure sustainably, without following the environmentally destructive development pathways of the industrialized countries.

However, the association between environmental pollution and LFP is intricate and is becoming more important in emerging economies. Environmental degradation and changing labour market dynamics have emerged as important themes of academic inquiry, as South Asian and ASEAN countries struggle towards industrial development and economic integration. Several other studies have documented a potential impact of pollution levels on labour supply, productivity, and occupational health, especially in particularly sensitive sectors such as agriculture, manufacturing, and informal labour markets that prevail in these areas. A few empirical studies have

demonstrated the negative relationship between environmental pollution and labor productivity. Air pollution and in particular particulate matter has been associated with lower productivity, higher absenteeism, and a greater prevalence of respiratory and cardiovascular diseases in workers (Chang et al., 2016; Hanna, & Oliva, 2015). This is especially pertinent in cities in India, Bangladesh and Indonesia, where poor air quality is an everyday norm. Outdoor pollution alone causes a huge loss of working hours for illness and premature deaths in these regions according to the International Labour Organization (ILO, 2021). The literature also contends that environmental deterioration may impact on labour force participation rate more directly, such as, for the expansion of female labour force, elderly worker labour force, informal worker labour force etc. Alam and Parvin (2020) explain that in Bangladesh, women in slums are more likely to participate in economic activities when pollution levels are low and to withdraw during periods of high pollution to take care of sick family members or to protect themselves from exposure, leading to declines in female participation. Indeed, in Pakistan and Nepal it has been observed that environmental shocks, such as heatwaves and months with high pollution, are associated in lower labour participation in the agriculture and construction sectors – two sectors of voluminous employment but scarce environmental protections (Shammi et al., 2021).

Further, farm workers in South Asia and ASEAN are highly prone to climate-induced physical changes, including temperature increase, water contamination and soil deterioration. These diminish agricultural productivity and shape land management, leading to seasonal or permanent migration to cities, and influencing the demographic profile and stability of the workforce (Dasgupta et al., 2016). Formal labour markets are frequently difficult to access for migrants, which compounds the distortion of participation rates and the increase in socio-economic inequality. A large share of the workforce in both regions is employed in environmentally unsafe sectors - such as tanneries, shipbreaking, mining, and informal recycling - with limited health protection. Research in Vietnam and the Philippines has shown that workers in slipshod factories, and unlicensed open-air markets continue to be exposed to harmful emissions, poisons, and polluted water,

with long-term health effects (Nguyen et al., 2020). Unfavorable working conditions frequently become a deterrent to continued employment, and contribute to job insecurity, especially among low-skilled and women workers. It turns out research shows that the environmental pollution causes an unequal effect on labor markets, everyone knew it's a poor living in a ghetto, no medical treatment and the like, dirty house located near an industrial area, and also no places to work for everything as we once knew. For example, the millions of women workers employed in the garment industry in Cambodia and Bangladesh are often working in polluted and unsafe sites where worker's long-term health and employability is threatened (ILO 2020).

2.14 EMPIRICAL LITERATURE REVIEW

In this study, critically evaluates a wide range of empirical studies that examine what factors and levers have an impact (or form of persuasion) on the stringency of environmental impact, government enforcement, and environmental performance. Our study differs from others in several ways. In the first instance, not only to update the literature with the most recent empirical approaches but also to extend their resulting study by embedding recent advances in the understanding of environmental consequences. Though there are previous studies conducted on environmental degradation for FDI, economic growth, labor force, capital formation, and Technological innovation review some econometric methods.

According to the Pollution Haven Hypothesis (PHH), foreign direct investment (FDI) typically moves from developed to developing nations because of strict environmental regulations and compliance costs that have already increased in developed nations. The preliminary construction of the additional costs of environmental compliance drives up production costs in the superior nations, which ultimately leads to a negative effect on their profit margin (Levinson & Taylor, 2008).

Pollution Halo Hypothesis (PHH) is another theory that helps explain the relationship between clean energy and foreign direct investment. Foreign direct investment would

increase a company's capitalization so it could implement the most efficient energy source in its operations. The aforementioned theories are not supported by any discernible empirical data, according to Paramati et al., (2017). Empirical examination of relationship shows that FDI positively affects the consumption of clean energy using ARDL and the causality test.

Lee, (2013) utilized G20 states on fixed effect regression to observe the association of clean energy with FDI in 1971-2009. No significant influence found on the FDI inflows to clean energy consumption by this study. Similar to the United Arab Emirates, Shia et al. •Using bound test and Granger causality test (2014) to study this phenomena using quarterly data from 1975 to 2011. They found a bidirectional relationship between FDI and clean energy indicating transitivity between these two variables. In a comparative study of the BRICS and the next 11 countries after the BRICS, Shahbaz et al., (2018), who also investigated this association. Their research by using ARDL model found that clean energy consumption is less sensitive to its investment, for which they concluded that FDI does not contribute towards it.

Bukhari et al. (2014) in Pakistan through ARDL-ECM with the data from 1974 to 2010. Their research found a positive correlation between FDI inflows and CO₂ accumulation that negatively impacts environmental quality in Pakistan. In Turkey, Gökmenoğlu & Taspınar, (2016) investigated the environmental Kuznets Curve Hypothesis by using Granger causality and error correction model. Their study validated the existence of PHH, which means that FDI and CO₂ are driven by each other. Mukhtarov et al., (2021), using a study from another country explored this relationship in Azerbaijan between 1996–2013. The structural time series model was used in this study and also found that the FDI inflows have positive impact on environmental degradation. A very recent study by (Jafri et al., 2022) in China, the same results were found by both ARDL and non-ARDL models.

Using 29 Provinces in China, it was found by Hao & Liu, (2015) that FDI tends to reduce CO₂ emissions in the country. Likewise, utilizing the same data source at the provincial level, Yu & Xu, (2019) adopted the PCSE estimator for China and indicated that FDI reduce emission of carbon dioxide and hence, environmental

quality improves in China. They also found out that FDI is beneficial to environmental quality as well, proving Pollution Halo Hypothesis correct. Moreover, some studies found a null effect of FDI on CO₂ emission. Haug & Ucal, (2019) found that FDI does not affect CO₂ in Turkey in the long run. Similarly, Mahmood et al. (2020) found similar results with fixed effect and random effect estimators. These studies have also included African countries. Using the ARDL technique from 1953 to 2006 Jalil & Feridun, (2011) examined the relationship between financial development and CO₂ in China. Zhang & Xu, (2017) with maximum likelihood approach for ARDL and VECM approach from 1975–2011 discovered an outcome of an irregular association between financial development, and CO₂. Other Studies, methods and their result are given below:

Table 2.1: Summary of Empirical Literature Review

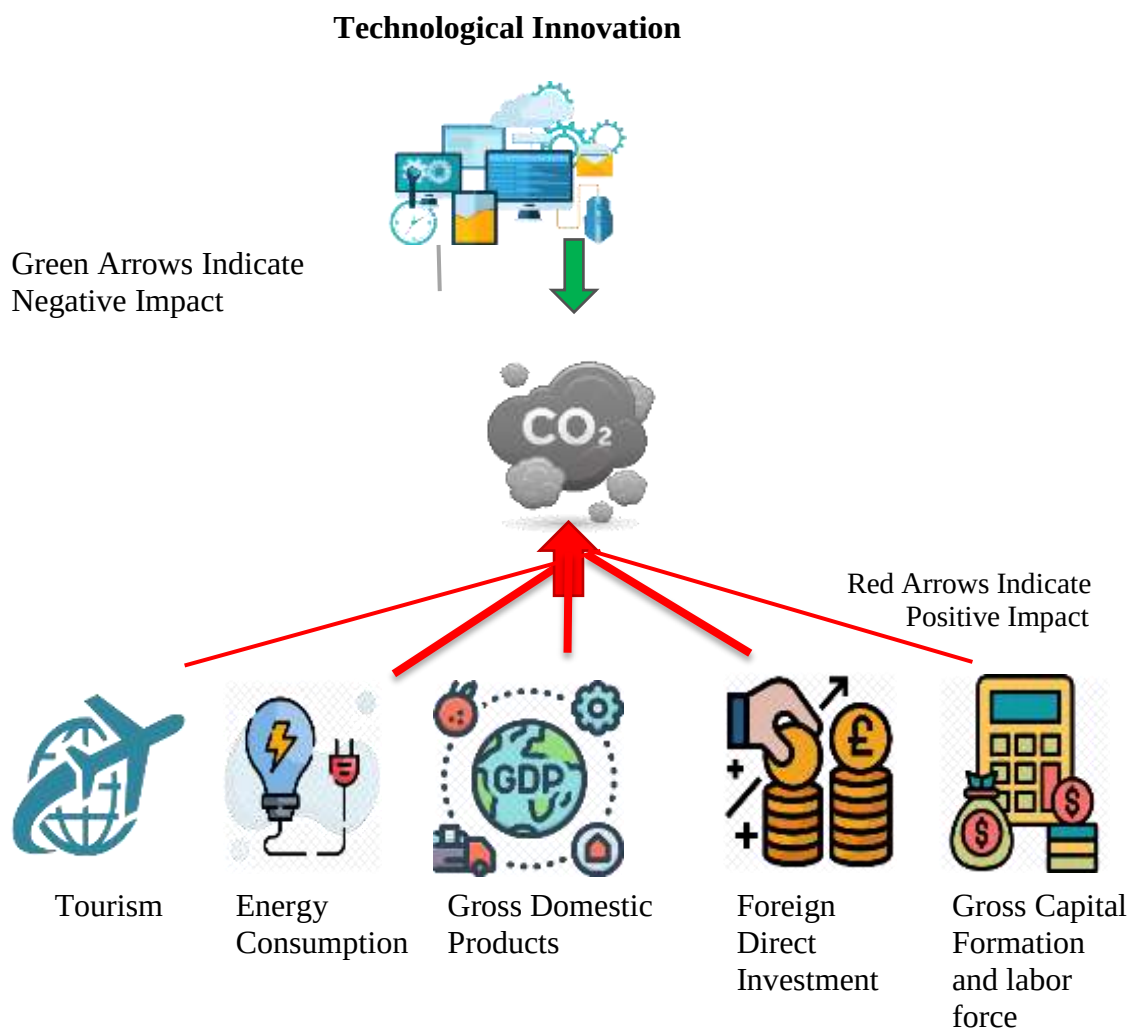
Author (Citation)	Methodology	Timeframe/Country	Variables/Proxies	Key Findings
Bello et al. (2024)	Driscoll-Kraay panel estimation and CS-ARDL	1981–2022, ASEAN	Energy consumption, FDI, CO2 emission, and GDP.	FDI contributes to increased CO2, confirming the Pollution Haven Hypothesis and EKC
Zafarullah, H., & Mehnaz, M. (2025)	Qualitative Analysis	1998-2024, ASEAN	CO2, GDP, Renewable Energy consumption, TI	Strong relationship between GDP, EC, and CO2
Khan, M. K., & Kazak, J. (2025).	ARDL	1999 to 2023 , Developing Countries	FDI, TI, Trade Openness, and Co2 emission	FDI negative impact on Environment
Bhowmik el al., (2025)	CCEMG	2004 to 2022, South Asia	Hydropower energy (HPE), FDI, GCF, REC, and CO ₂ emissions	REC reduce CO2 emission
Muhammad et al. (2020)	Panel Quantile Regression and 2SLS	2000–2016, 65 BRI countries including China	FDI, GDP, CO2 emission, Urbanization	Higher GDP and FDI contribute to increased CO2 emissions
Qimin, Sha, and Xinyuan (2020)	BRI Integrated Assessment Model	2005, Global sample of 191 countries including BRI	GDP, Population, Energy consumption projections	BRI could reduce CO2 emissions by 3.2 billion tons
Hou et al. (2020)	Input/Output Model	2011, Global sample of 140 countries including BRI	Consumption-based carbon emissions	BRI regions contribute to a 20% reduction in global emissions
Rauf et al. (2020)	FMOLS and DOLS	1981–2016, BRI countries and China	EC, GDP, FDI, TO	Strong relationship between GDP, EC, and CO2, while FDI decreases CO2 emissions

Sarkodie and Strezov (2019)	DOLS and Panel Quantile	1982–2016, South Africa, India, Iran, Indonesia, China	EC, GDP, FDI	Increases in FDI and EC lead to higher GHG emissions
Shao (2018)	GMM	1990–2013, 188 countries	FDI, Trade, Carbon Intensity, Fossil fuel, Industrial Intensity,	FDI reduces carbon intensity, while fuel consumption and industrial intensity increase it
Liu and Hao (2018)	FMOLS, DOLS	1970–2013, BRI home/host countries	EC, IVA, GDP, CO2	Increased IVA and EC contribute to higher CO2; FDI has mixed effects on CO2 emissions
Solarin et al. (2017)	ARDL	1980–2012, Ghana	FDI, Population, FD, Trade	FDI and Population both contribute to increased CO2 emissions
Mert and Bölük (2016)	Pool means group and Mean group	2002–2010, Kyoto countries	REC, Fuel EC, FDI, GDP	Mixed results: FDI and REC reduce CO2, but EC increases CO2 emissions
Khan, et al. (2020)	CS-ARDL	1990–2017, G7 Economies	Energy-related Patents, Imports, Exports	Eco-innovation reduces CO2, while imports and exports have inverse effects on CO2
Töbelmann and Wendler (2020)	GMM	1992–2014, EU Countries	Number of Patents	Increased innovation (patents) leads to a decrease in CO2 emissions
Churchill et al. (2019)	CCEMG	1970–2014, G7 Countries	R&D expenditure	Innovation, through R&D spending, helps reduce CO2 emissions

Source: Own creation

2.15. THEORETICAL FRAMEWORK REVIEW

This literature review features a theoretical framework investigating the connections between different economic variables and environmental debasement, principally zeroing in on CO₂ emanations. Energy utilization by and large increments fossil fuel by-products, especially in creating economies, in spite of the fact that its effect fluctuates with pay levels. Likewise, financial development, frequently estimated by GDP, shows a perplexing connection with ecological quality. This relationship oftentimes lines up with the EKC speculation, wherein outflows at first ascent with economic development however possibly decline subsequent to arriving at a specific financial edge. As to, its consequences for discharges are blended, either expanding or diminishing them relying upon the host nation's phase of financial turn of events and the venture's source. Besides, the effect of mechanical advancement on emanations is exceptionally setting subordinate. While certain examinations exhibit that it lessens emanations, particularly in created nations, others find that it might increment outflows in specific situations. In like manner, global the travel industry's effect on ecological debasement fluctuates impressively across nations. Some examination shows that travel industry exercises lead to expanded discharges, while different investigations propose that under unambiguous circumstances, the travel industry can add to worked on natural quality. In conclusion, gross capital development is by and large connected with expanded CO₂ emanations. Nonetheless, its effect can change in view of the idea of the speculation and the particular economic construction of the nation being referred to. These different discoveries highlight the intricate, interconnected nature of economic elements and their ecological effects, featuring the requirement for nuanced, setting explicit ways to deal with reasonable turn of events and ecological administration. This complex structure highlights the multifaceted interaction between economic turn of events, innovative progression, and ecological effects, featuring the requirement for nuanced, setting explicit ways to deal with feasible turn of events and natural administration.



Source: Own Creation

Figure: 2.1 Theoretical Framework of the Study

The framework of this review, as shown in Figure 2, places a mind boggling connection between different financial variables and CO₂. At the model's centre are CO₂, impacted by different factors. Five key elements are theorized to increment outflows, as demonstrated by red bolts: the travel industry, energy utilization, EG, FDI, and gross capital development. These components are hypothesized to contribute emphatically to CO₂ discharges, possible because of expanded economic movement, energy use, and modern cycles related with financial development and improvement. Interestingly, mechanical development is addressed with a green bolt

pointing towards CO₂, recommending a potential moderating impact on discharges. This system suggests that mechanical headways might prompt diminished CO₂, potentially through better proficiency, cleaner advancements, or inventive answers for carbon decrease. The model catches the complicated connection between financial development, specialized advancement, and ecological impacts. It underscores the troubles in controlling emanations and investigates potential methodologies to diminish them by means of mechanical advancement.

2.16 LITERATURE GAP

Based on Methodology and Econometric Approach

Several empirical studies using econometric techniques to understand the link between environmental damage and the macroeconomic indicators (FDI, energy consumption, technology innovation and tourism) have appeared in the literature; however, several research gaps may exist, especially in the case of South Asia and ASEAN countries, for instance, in terms of modelling technique. This overly narrow framework constrains the explanatory power of such models and does not convey the multi-faceted nature of environmental decline in emerging market economies. There have been few studies investigating the long run and short run dynamics of FDI, energy consumption, innovation, tourism, and the environmental Kuznets curve-The role of FDI; CO₂ emissions. Although panel PMG-ARDL, and FMOLS models have not been used in works, using them for South Asia and ASEAN as a combined regional framework is not happen, even when both regions have common development challenges. However, current research often fails to consider country differences in regulatory quality, environmental policy stringency, and industrial structure, and assumes the uniformity of coefficients of fixed effects or pooled OLS for countries. Second, relatively few studies employ second-generation panel methodologies--panel quantile regression, panel threshold regression or PMG-ARDL (better equipped to capture the heterogeneity across panels like South Asia and ASEAN within which economic and environmental performance is highly diverse. Notwithstanding the recent development of environmental econometrics, there

remains an obvious methodological void in developing a complete and robust econometric modelling that analyses the joint effects and interactive influence of FDI, energy consumption, technological innovation and tourism on the environmental degradation in the CASEAN. This gap can be reconciled through advanced panel methodologies, longer time spans and interactional modelling that would provide a more nuanced understanding and a better empirical basis for policy development.

Based on Variables

Despite the abundance of this literature, there still exists a substantive gap in the amalgamation of various economic and structural variables in the settings of South Asia and ASEAN. Although the impact of FDI on environmental quality is well documented within the scope of pollution haven hypothesis and pollution halo hypothesis, very few studies however, investigate how FDI combined with other economic determinants such as domestic capital stock, labour productivity, and energy intensity, interacts in influencing emissions at a regional level. Because there are no multi-variable panel models accounting for this interaction, the camouflaged environmental effect of FDI in economies with contemporary industrialization that explains urbanization is not fully understood. Second, the labour variable has been inadequately investigated in the environmental econometric literature. Participation in the labour market and the structure of the labour market (industrial vs. service sector employment) may be important in determining emission patterns as a result of their connections to production intensity, energy usage and technology adoption. Such regions do sometimes, but seldom take labour as a direct explanatory variable or as a moderator in environmental models. Third, even though capital formation is widely used as a proxy of growth in the study of pollution, only few papers considered its quality composition and its impact on technology and energy variables. The upshot is that the models disregard whether capital accumulation is financing green infrastructure or pollution-intensive industries, a key consideration for environmental policy. Energy consumption is still the most studied variable, although many models do not discriminate renewable from non-renewable energy

flows or are incapable of capturing nonlinear or threshold effects. With varying nature of energy transitions across South Asia and ASEAN, there is an absence on the use of modern-day econometric techniques to capture country-specific variations in the energy-emission relationships. Technological progress is a second important but commonly not very well measured variable (it is often proxied by patents or R&D spending, but its transfer and absorptive capacities were not considered in the analysis). Furthermore, there is little empirical examination of the role of innovation in relation with FDI or capital intensity plays in conditioning the impact of innovation on the environment across income level within these two regions. Lastly, despite tourism being a growing sector in both South Asia and ASEAN, the environmental implications of this development are often investigated based on fragmented or by country. There is lack of studies based on region-wide panel data that incorporates tourism with industrial and energy-related factors in accounting for long-term emission dynamics or footprints.

Based on Region

Although there are quite a lot of studies in such areas, the influence of macro-economic factors on the environment from a regional perspective of South Asia and ASEAN in single econometric framework is not very well developed, if at all developed. Internationally, in South Asia and among the big economies such as India, Pakistan, and Bangladesh, research has been conducted and large confined to the nexus of energy consumption and carbon dioxide (CO₂) emissions. Such studies then rely frequently on time-series data investigating the classical causality, But there is a dearth of integrating labour and capital formation explicitly in the models to account the direct as well as interaction effects for environmental degradation. Energy consumption and emissions are mainly attributed to labour-dependent sectors, particularly in agriculture and manufacturing, which are often overlooked in the region's econometric-based environmental-based models. Further, to the extent that capex and investment is a proxy for growth, little is done in these studies to examine whether capital is directed towards green or brown sectors, particularly in economies such as Nepal or Sri Lanka where public sector investment is expanding.

The tourism branch is an other relevant, but less studied covariate. Although countries including Thailand, Cambodia, and Maldives (South Asia) rely heavily on foreign tourism, the environmental externalities of the activity have typically been analyzed using case-specific or descriptive frameworks, but not ecological panel econometric models. Few studies have examined the influence of tourism on emissions through its relation to infrastructure investment and energy consumption under different development stages at the intra- and inter-regional levels in the two regions. While FDI's impact on environment in ASEAN countries is not outright denied, many of the papers also point to pollution haven hypothesis of development in countries such as in Indonesia, Vietnam, and Thailand. Yet in most studies FDI is studied in isolation, ignoring how it interacts with technological change, labour market structure or with the art operations in the place of destination. Developing both the digital transformation and the clean energy sector has become part of side of ASEAN's digital, green, and smart growth, however, few empirical studies have focused on the moderating and mediating mechanism that innovation has on pollution from FDI and energy consumption.

Based on Policies and Emerging Economics

Most econometric models developed in the existing literature have been designed to estimate statistical associations or long-run elasticities but are not suitable to move from estimates to actionable policy insights. For example, several researches suggest that the relationship between FDI and emissions is a positive one or a negative one, but only a couple distinguish between green FDI and pollution-intensive investment and are thus of limited utility for informing FDI policy reform in developing countries. For instance, although energy consumption is well known as a major source of pollution, there is little policy-relevant research that compares renewable and nonrenewable energy use or evaluates the impact of existing energy transition policies implemented in the ASEAN or South Asia. The contribution of technological innovation is also frequently oversimplified, as proxies ranging from R&D to patent applications are presented as key drivers, while there is little reflection on how government-driven innovation policies, subsidies, or institutional

frameworks affect environmental outcomes. Sapping innovation So policymakers have scant assistance in making the best use of innovation in decarbonization. Labour-environment linkage is the third neglected aspect from the perspective of policy. Yet empirical work seldom investigates how employment regime (e.g., informal, industrial or tourist related employment) interacts with environmental performance, a relationship that has clear implications for green job creation and sustainable policy, and for just transition planning. Lastly, there are very few studies that are framed in the context of the South Asia and ASEAN that consider region-specific policy heterogeneity. Disregarding different governance capacity, institutional enforcement, or stage of economic development, prevailing models are not sophisticated enough to facilitate differentiated policy responses in the realm of environmental policymaking across disparate economies. There is no policy-driven econometric approach in the literature that directly tells how integrated development strategies with FDI regulation, energy reform, innovation investment, labor market formation, and tourism policy, can be gauged in connection with environmental objectives in South Asia and ASEAN. It is crucial to close this gap and support evidence-based, regionally appropriate, long-term orientated policymaking in some of the world's most rapidly expanding yet environmentally fragile regions.

Based on Secure Sustainability

Comparing these links with the Sustainable Development Goals (SDGs) 7, 8, 9, 12, and 13 reveals a substantial gap in the research. Synopsis of each of these objectives Sustainable Development Goals (SDGs) 7 and 8 are about affordable and clean energy, SDG 9 is about industry, innovation, and infrastructure, SDG 12 is about responsible consumption and production, and SDG 13 is about climate action. In South Asian and ASEAN nations, which are experiencing rapid industrialization and urbanization, the existing econometric assessments typically focus mainly on economic performance or CO₂ emissions without converging the results with global sustainability standards. For example, though the literature often looks at FDI and its relationship to emissions (SDG 13), rarely does the research separate sustainable from unsustainable FDI flows or consider how foreign capital is related to a

country's or region's green investment targets (SDG 9). This narrows the scope of such findings in terms of informing policy for promoting green growth and low-carbon infrastructure. Likewise, while labour market development is a cornerstone to realizing SDG 8, little in the current literature examines how labour-intensive sectors, such as un- and informal employment in tourism and manufacturing, drive environmental destruction, or contribute to sustainable livelihoods under the threat of altering ecologies. The interconnected nature of employment, energy consumption and environmental quality is largely neglected, which is highly important in the trade-off between economic inclusiveness and ecological protection. Energy consumption, a crucial determinant for SDG 7 and SDG 13, is often studied as an undifferentiated aggregate, but on renewable energy uptake, on energy efficiency, and on transition paths—even in countries with high energy intensity such as India, Indonesia, or Vietnam—scrutiny is relatively inadequate. Therefore, literature does not provide clear answers on how the transformation of energy structure contributes to long-term sustainability objectives. Similarly, technology – essential for SDGs 9 and 13 – is under-studied as an enabling frame for the reduction of emissions or cleaner production. Most of the studies rely on crude indicators, such as patent counts or R&D spending, and they do not analyze how the innovations have been received, diffused or mitigated by public policy in South Asia and ASEAN. The tourism environment linkage of falters for econometric studies in SDG 12 as well. While the economic aspects of tourism are well documented and disseminated to the public, relatively little is known with respect to the environmental externalities (e.g., pollution, waste, carbon emissions, coastal degradation) of tourism or how the proliferation of sustainable tourism policies or programs (e.g., eco-tourism, carbon offset programs) affect environmental indicators at the regional level. Furthermore, most of the papers in these areas fail to do justice to the synergies and trade-offs in the SDGs and other related issues. For example, policies fostering FDI and employment can lead to higher emissions in the absence of innovation and green regulation (but these interactions are seldom captured in econometric models). Developing multi-variable econometric models which are SDG-compliant and measures the joint influence of FDI, labor, capital, energy use, technological progress and tourism on environment sustainability in South Asia and ASEAN is an important

literature void. Efforts in the future should be made to use theoretical models to operationalize SDG targets and indicators, such that the integrated and sustainability-based policy landscape particularly in emerging economies.

CHAPTER 3: THEORETICAL FRAMEWORK, DATA COLLECTION, AND METHODOLOGY

3.1 THEORETICAL FRAMEWORK

This study uses to the production function model and STIRPAT model approach to modeling the nexus among foreign direct investment (FDI) and environmental implications where environmental degradation (ENV) depends on foreign direct investment (FDI), tourism (TRM), economic growth (EG), technological innovation (TAI), labor force (LF), capital formation (CF), and energy consumption. Reducing CO₂ emissions is generally considered necessary to achieve environmental sustainability, and an increase in CO₂ emissions is called environmental degradation. Increasing the environmental degradation, which in turn affects the natural environment, human health, and the global climate system. The analysis of environmental outcomes, therefore, hinges on the drivers of CO₂ emissions. The theoretical underpinning is constructed around the recognition that economic endeavor, especially associated with FDI, has a major bearing on economic growth and environmental outcomes. As FDI plays the role of a catalyst that can promote economic development, it can cause more energy consumption and more pollution, particularly in industries that are energy-intensive or less environmental regulation.

To account for this dynamic interaction between these two variables, the production function model is used to associate FDI and other determinants, for example, labor and capital, with economic performance. This model shows very nicely what influence the foreign investments can have on growth as the growth of production ability and technological development. The link between FDI and environmental degradation is ambiguous and region-specific. More specifically, this study focuses on FDI in South Asia and ASEAN countries, which have contrasting economic and environmental settings. FDI is pivotal in these areas for promoting economic development, but also creates environmental sustainability challenges.

Hence, the equation has been denoted by using the typical Marshallian Demand function according to (Friedman, 1949). Based on the Marshallian demand function, we can articulate the subsequent environmental degradation function:

$$Y = EG = ENV = f(K, L) \quad (1)$$

The output level, denoted as Y , represents the GDP growth rate and environmental degradation (such as CO₂ emissions per capita), while K refers to capital, measured by FDI inflows, and L represents labor, which can be captured through labor force participation or technological innovation in these countries. To achieve this, we need a model that can measure the effect of FDI, tourism, technological innovation, energy use, and renewable energy on the degradation of the environment. To do this, the study uses the popular STIRPAT model.

STIRPAT (Stochastic impacts by regression on population, affluence, and technology) (Dietz and Rosa 1997) is a more refined version of the original IPAT model. In our study, the key variables are impact, population, affluence, and technology which are aligned with the central components of the STIRPAT framework. While the IPAT model has been frequently used to examine the relationship between environmental impact and the drivers of population, affluence, and technology, it does not incorporate the random, unpredictable nature of these relationships. The STIRPAT model addresses this limitation by introducing a stochastic element that accounts for uncertainty and variability in the associations between these drivers and environmental outcomes.

The IPAT model, originally proposed by Ehrlich and Holdren (1971) and further refined by Holdren et al. (2012), has been used extensively to study how both population size and growth contribute to environmental degradation. The model identifies three key factors that drive environmental change such as population, affluence, and technology. Researchers like Huang et al. (2021) have applied the IPAT model to understand human activities' impact on the environment and identify methods to mitigate these effects. However, the IPAT model fails to address the varying impacts of these environmental effects. To overcome this limitation, the

STIRPAT model, introduced by York et al. (2003), incorporates ecological elasticity, enhancing the model's ability to reflect diverse environmental effects. STIRPAT is a flexible, and empirical model that enable the estimation of environmental impacts resulting from changes in population, affluence, technology, and other factors, while it is also accounting for unmeasured variables and data measurement errors through the inclusion of a stochastic error term. The STIRPAT model is represented as:

$$I_i = aP_i^b A_i^c T_i^d e_i \quad (2)$$

In the model, I is an indicator for environmental impact, P stands for population, A is an affluence, measured as GDP per capita, and T denotes technological use as defined by the IPAT model. The parameter a is an intercept or fixed parameter. The populations, affluences and technology, the factors affecting environmental impact, are expressed by exponents of $b, c, \text{ and } d$ with their respective coefficients. The e is the random error term. i stands for the index for the observation unit of these quantities (i.e., $I, P, A, T, \text{ and } e$).

The relationship between human activity and ecological effect is investigated using the STIRPAT model. In this study, there are mainly four models: Model 1 considers environmental degradation and economic growth as dependent variable (which is commonly measured by CO_2 emissions and economic development). Model 2 represents IPA, model 3 as ITE and Model 4 indicates STIRPAT.

FDI inflows simplify reduce the cost of acquiring foreign funds, allowing for the allocation to the research and development of advanced sustainable technologies. The study has adjusted the aforementioned equation (1) to reflect the various ways that tourism, GDP expansion and FDI might impact a nation's energy consumption and environmental degradation.

This relationship between the quality of the economy and the environment is delicate because the nature of growth can either stimulate or hinder the efforts to reduce ecological footprints. Industrial practices, management of resources, and implementation of sustainable technologies (Abid, 2015; Sahoo et al., 2024). Sabir et

al., (2020) identified a positive and statistically significant impact of FDI on the environmental degradation of South Asian countries using the EKC Model. Destinations were highly popular around the globe and high-energy consumption disturbs the environment. In the case of developed countries according to England, (2000) capital formation is used to explore the impact on carbon emission. Sustainable tourism practices which reconcile environmental protection with economic development are essential (Hunter, 2002). In highly industrialized and touristic countries, energy consumption is one of the most important parameters affecting their ecological footprint. Gillingham et al., (2009); Khaddour, (2024), and Moser & Kleinhüchelkotten, (2018) explain the opportunity to eliminate adverse impacts associated with energy use from the ecosystem by transitioning to a variety of other alternative energy sources, including hydroelectric, solar, and wind. The relationship between LNENV, LNFDI, LNEG, LNTRM, LNENRC, LNGF, LNRENRC, LNLF, and LNTAI is addressed in the present study. It transforms all of the variables into their natural logarithms, which facilitates the estimation of the conditional bivariate elasticities (Murshed et al., 2021).

Environmental degradation is intricately linked to the use of renewable energy, tourism, and technological innovation. Blömstrom et al. (2000) argue that FDI alone is insufficient to drive economic growth or ensure prosperity in a host country. Mankiw (2013) explains that international trade plays a crucial role in economic growth by promoting technological innovation. Economic growth itself is influenced by tourism, energy consumption, and capital formation. In both the short and long term, these explanatory variables are expected to significantly affect environmental degradation in South Asia and ASEAN countries.

3.2 DATA, SOURCE AND MODEL SPECIFICATION

3.2.1 Data Source

The study used an extensive panel database for the years 1995-2023 to analyse the association between environmental implications and various major economic and development outcomes in South Asian and ASIAN countries. Specifically, the study focused on an examination of the impact of environmental implications on FDI, economic growth, energy consumption, tourism, capital formation, labor force participation rate, and technological innovation.

Data for this study was collected from the World Development Indicators (WDI) and Our World in Data. This analysis aims to contribute evidence on the impact of environmental shifts and policies on these critical economic parameters, and their correlations across different ASIAN countries, notably in South Asia. The period between 1995 and 2023 provides a wealth of historical context, enabling scholars to discern long term trends and changes in the character of these relationships.

Table 3.1: Variables Identification and Details

Variable		Log Form/Notation	Variable Details	Sources
Dependent Variable	Environmental Degradation	LNENV	CO2(POWID)Annual CO2, emissions (Total per capita)	Our World in Data (OWID)
Independent Variable	FDI	LNFDINIF	Foreign direct investment, net inflows (BoP, current US\$)	World Bank (WB)
	Economic Growth	LNNEG	GDP (constant 2015 US\$)(EGT)	WB
	Tourism	LNTRM	International tourism, number of arrivals	WB
	Non-renewable Energy	LNENRC	Primary energy consumption (TWh)	OWID
	Renewable Energy	LNRENRC	Renewable energy consumption (% of total final energy consumption)	OWID
	Capital	LNCF	Gross capital formation (current US\$)	WB
	Labor	LNLF	Labor force participation rate, total (modeled ILO estimate)	WB
	Technology	LNTAI	Patent applications per million people	WB

Source: Own creation

3.2.2 Estimation Methodology

This study is to investigate the short run and long-run relationships between foreign direct investment (FDI), renewable energy consumption, non-renewable energy consumption, CO2 emissions, and economic growth by employing Pesaran et al., (1999) PMG-ARDL framework. The ARDL model is an error correction model that is well suited for the identification of long and short-term relationships. This is especially useful when you're out doing, as they have long-run relationships, as long as the variables are some order of co-integration, whether I(1), or some combination of I(0). I(1), between the dependent and independent variable is I(1). This approach should be avoided if the variables are I(2). Moreover, the ARDL methodology offers the unique advantage of dealing with endogeneity by selecting the most appropriate lags for endogenous and exogenous variables, resulting in consistent and efficient estimators (Hadi &Ghafoor, 2023). Following Pesaran et al. in accordance with the Autoregressive Distributed Lag (ARDL) model of causality (1999), the PMG-ARDL model serves as the core approach to finding long run relationships between the variables.

The Econometric Model such as the production function or baseline model for economic growth or environmental degradation model with specification defines the functional form like this:

$$EG = ENV = f(FDINIF, LF, CF, TAI) \quad (3)$$

Where, ENV refers to environmental degradation, which can be measured by CO2 emissions, and EG represents economic growth. The model specifies that environmental degradation is influenced by four key factors such as foreign direct investment (FDINIF), labor force (LF), capital formation (CF), and technological innovation (TAI). These variables are linked through their positive or negative associations with environmental degradation.

To test the causality relationship between economic growth and environmental degradation, the study uses a simple linear equation model derived from the production function.

Simple linear equation model:

$$EG = ENV_{it} = \beta_0 + \beta_1 FDINIF_{it} + \beta_2 LF_{it} + \beta_3 CF_{it} + \beta_4 TAI_{it} + \varepsilon_{it} \quad (4)$$

Here, EG expresses economic growth, ENV is called environmental implications or CO2 emission in the environment, β_0 is the intercept term, and $\beta_1, \beta_2, \beta_3$, and β_4 are the coefficients of explanatory variables. Where ε represents as error term, $i = 1, 2, 3, \dots, N$ depicts the cross-country, and $t = 1, 2, 3, \dots, T$ be the time of the panel data. After applying the logarithmic transformation, the model is formulated in the equation (5)

logarithmic transformation model:

$$LnEG_{it} = LnENV_{it} = \beta_0 + \beta_1 LnFDINIF_{it} + \beta_2 LnLF_{it} + \beta_3 LnCF_{it} + \beta_4 LnTAI_{it} + \varepsilon_{it} \quad (5)$$

Where, β_0 is intercept term, $\beta_1, \beta_2, \beta_3$, and β_4 represent the coefficients of independent variables. t represents the time, i represents cross-section unit and ε_{it} represents error term.

However, the empirical method for ARDL model is introduced by Pesaran et al., (1999) and extended by Pesaran (2004). The tentative equation of panel ARDL model is given in the following equation no 6:

Panel ARDL model as:

$$\begin{aligned}
\Delta \text{LNEG}_{it} &= \Delta \text{LNENV}_{it} \\
&= \beta_0 + \beta_1 \text{LNFDINIF}_{i,t-1} + \beta_2 \text{LNL F}_{i,t-1} + \beta_3 \text{LNCF}_{i,t-1} \\
&+ \beta_4 \text{LNTAI}_{i,t-1} + \sum_{j=1}^k \gamma_{1j} \Delta \text{LNFDINIF}_{i,t-j} + \sum_{j=0}^k \gamma_{2j} \Delta \text{LNL F}_{i,t-j} \\
&+ \sum_{j=0}^k \gamma_{3j} \Delta \text{LNCF}_{i,t-j} + \sum_{j=0}^k \gamma_{4j} \Delta \text{LnTAI}_{it,t-j} + \varepsilon_{it} \quad (6)
\end{aligned}$$

Here, Δ “first difference term, ε_{it} is the error term and β_1 , β_2 , β_3 , and β_4 converse to the long run and short run estimation coefficient shown by γ_{1j} , γ_{2j} , γ_{3j} , and γ_{4j} .” Long run estimation is shown by equation 7. Long run estimation ARDL model as:

$$\begin{aligned}
\Delta \text{LNEG}_{it} &= \Delta \text{LNENV}_{it} \\
&= \beta_0 + \beta_1 \text{LNFDINIF}_{i,t-1} + \beta_2 \text{LNL F}_{i,t-1} + \beta_3 \text{LNCF}_{i,t-1} \\
&+ \beta_4 \text{LNTAI}_{i,t-1} + \varepsilon_{it} \quad (7)
\end{aligned}$$

The error correction term (ECT) panel cointegration is one of the most popular tests of cointegration in panel data that allows for the investigation of the long run relationship and short run adjustments among variables. Cointegration refers to a long-run relation between non-stationary variables. In other words, two or more-time series have a finite and stable long-run equilibrium relationship. When there exists long-run cointegration in the model, the ECT equation is given as:

$$\begin{aligned}
\Delta \text{LNEG}_{it} &= \Delta \text{LNENV}_{it} \\
&= \beta_0 + \sum_{j=1}^k \gamma_{1j} \Delta \text{LNFDINIF}_{i,t-j} + \sum_{j=0}^k \gamma_{2j} \Delta \text{LNL F}_{i,t-j} \\
&+ \sum_{j=0}^k \gamma_{3j} \Delta \text{LNCF}_{i,t-j} + \sum_{j=0}^k \gamma_{4j} \Delta \text{LnTAI}_{it,t-j} + \alpha \text{ECT}_{it-1} \\
&+ \varepsilon_{it} \quad (8)
\end{aligned}$$

However, α is the ECT estimation in panel data models that measures the short-term disequilibrium relationship between the variables. In the presence of cointegrated variables, the ECT is the speed of adjustment of the system towards the equilibrium position after a shock. In other words, ECT indicates the movement of an economy from a disequilibrium situation to an equilibrium situation.

The Econometric Impact on population and Affluences (IPA) Model specification has defined the functional form like the equation 9:

$$IPA = ENV = f(FDINIF, EG, LF, CF,) \quad (9)$$

Here this IPA model is a small difference from the IPAT model. IPAT specifies that environmental impacts are three points such as population, affluence and technology. Without technological innovation the studies are identifying the IPA model in this research.

To visually represent the causal effect of IPA model for this simple linear model the study wants to use the IPA model function derived as;

$$IPA = ENV_{it} = \beta_0 + \beta_1 FDINIF_{it} + \beta_2 EG_{it} + \beta_3 LF_{it} + \beta_4 CF_{it} + \varepsilon_{it} \quad (10)$$

The study employs a log-transformed version of the model, which are shown in the equation 11 below:

$$\begin{aligned} LnIPA &= LnENV_{it} \\ &= \beta_0 + \beta_1 LnFDINIF_{it} + \beta_2 LnEG_{it} + \beta_3 LnLF_{it} + \beta_4 LnCF_{it} \\ &+ \varepsilon_{it} \quad (11) \end{aligned}$$

Where, β_0 is intercept term, and $\beta_1, \beta_2, \beta_3$, and β_4 represent the coefficients of independent variables. t represents the time, i represents cross-section unit for South Asian and ASEAN countries.

However, the empirical method for ARDL model is introduced by Pesaran et al. (1999) and extended by Pesaran (2004). The tentative equation of panel ARDL model is given in the following equation no 12:

$$\begin{aligned}
 LnIPA &= \Delta L NENV_{it} \\
 &= \beta_0 + \beta_1 L NFDINIF_{i,t-1} + \beta_2 L NEG_{i,t-1} + \beta_3 L NLF_{i,t-1} \\
 &+ \beta_4 L NCF_{i,t-1} + \sum_{j=1}^k \gamma_{1j} \Delta L NFDINIF_{i,t-j} + \sum_{j=0}^k \gamma_{2j} \Delta L NEG_{i,t-j} \\
 &+ \sum_{j=0}^k \gamma_{3j} \Delta L NLF_{i,t-j} + \sum_{j=0}^k \gamma_{4j} \Delta L NCF_{it,t-j} + \varepsilon_{it} \quad (12)
 \end{aligned}$$

Where, Δ is “first difference term, ε_{it} is the error tem and $\beta_1, \beta_2, \beta_3$, and β_4 converse to the long-run and short run estimation coefficient shown by $\gamma_{1j}, \gamma_{2j}, \gamma_{3j}$, and γ_{4j} .” Long run estimation has been shown by equation 13.

$$\begin{aligned}
 LnIPA &= \Delta L NENV_{it} \\
 &= \beta_0 + \beta_1 L NFDINIF_{i,t-1} + \beta_2 L NEG_{i,t-1} + \beta_3 L NLF_{i,t-1} \\
 &+ \beta_4 L NCF_{i,t-1} + \varepsilon_{it} \quad (13)
 \end{aligned}$$

When, there is existence of long run cointegration, the ECT model from IPA equation is given in 14:

$$\begin{aligned}
 \Delta L NENV_{it} &= \beta_0 + \sum_{j=1}^k \gamma_{1j} \Delta L NFDINIF_{i,t-j} + \sum_{j=0}^k \gamma_{2j} \Delta L NEG_{i,t-j} + \sum_{j=0}^k \gamma_{3j} \Delta L NLF_{i,t-j} \\
 &+ \sum_{j=0}^k \gamma_{4j} \Delta L nCF_{it,t-j} + \alpha ECT_{it-1} + \varepsilon_{it} \quad (14)
 \end{aligned}$$

Where α is the ECT estimation, which indicates the movement of an economy from a disequilibrium situation to an equilibrium situation.

However, the next model specification is for the selected panel group as impact on technology and energy (ITE) shown in equation 15:

Functional form as: $ITE = ENV = f(FDINIF, ENRC, RENRC, TRM, TAI)$ (15)

This model is intended to check the association between environmental impact (ENV) and a host of activities such as foreign direct investment (FDINIF), energy consumption (ENRC), renewable energy consumption (RENR), tourism (TRM), and technological innovation (TAI). To design policies for sustainable development, it is important to know how these factors affect the environment. Now the simple linear equation form of ITE is in equation 16.

Simple linear equation model form of ITE as:

$$ITE = ENV_{it} = \beta_0 + \beta_1 FDINIF_{it} + \beta_2 ENRC_{it} + \beta_3 RENRC_{it} + \beta_4 TRM_{it} + \beta_5 TAI_{it} + \varepsilon_{it} \quad (16)$$

This relationship is a linear regression measuring the effect of the independent variable on the environmental outcome. By identifying the coefficients β_1 , β_2 , β_3 , β_4 and β_5 , the study is able to determine the magnitude and sign of the impact that each factor has on the environment. Now the study would take the log transformation form of ITE as shown in equation 17.

logarithmic transformation model form of ITE as:

$$\begin{aligned}
lnITE &= LnENV_{it} \\
&= \beta_0 + \beta_1 LnFDINIF_{it} + \beta_2 LnENRC_{it} + \beta_3 LnRENRC_{it} \\
&+ \beta_4 LnTRM_{it} + \beta_5 LnTAI_{it} + \varepsilon_{it} \quad (17)
\end{aligned}$$

This model uses a log-transformation on the variables in order to be able to interpret the relationships in elasticity terms. Log transformation helps to understand percentage changes and elasticity in a better way by giving a better view on proportional relationships among variables. Now the study would take the tentative equation of panel ARDL model given in the following equation no 18:

Panel ARDL model form of ITE as:

$$\begin{aligned}
\Delta LNITE &= \Delta LNENV_{it} \\
&= \beta_0 + \beta_1 LNFDINIF_{i,t-1} + \beta_2 LNENRC_{i,t-1} + \beta_3 LNRENRC_{i,t-1} \\
&+ \beta_4 LNTRM_{i,t-1} + \beta_5 LNTAI_{i,t-1} + \sum_{j=1}^k \gamma_{1j} \Delta LNFDINIF_{i,t-j} \\
&+ \sum_{j=0}^k \gamma_{2j} \Delta LNENRC_{i,t-j} + \sum_{j=0}^k \gamma_{3j} \Delta LNRENRC_{i,t-j} \\
&+ \sum_{j=0}^k \gamma_{4j} \Delta LNTRM_{i,t-j} + \sum_{j=0}^k \gamma_{5j} \Delta LNTAI_{i,t-j} \\
&+ \varepsilon_{it} \quad (18)
\end{aligned}$$

Where, Δ is “first difference term, ε_{it} is the error tem and $\beta_1, \beta_2, \beta_3$, and β_4 converse to the long-run and short run estimation coefficient shown by $\gamma_{1j}, \gamma_{2j}, \gamma_{3j}$, and γ_{4j} .”.This equation characterizes the short-run relationship of environmental impact through lag and differenced variables.

The inclusion of lagged terms can accommodate the delay effects and short-term fluctuations. Now Long run estimation has been shown by the equation 19. Hence, the temporal relations are more nicely represented as.

Long run estimation model form of ITE as:

$$\begin{aligned}
\Delta \text{LNITE} &= \Delta \text{LNENV}_{it} \\
&= \beta_0 + \beta_1 \text{LNFDINIF}_{i,t-1} + \beta_2 \text{LNENRC}_{i,t-1} + \beta_3 \text{LNRENRC}_{i,t-1} \\
&\quad + \beta_4 \text{LNTRM}_{i,t-1} + \beta_5 \text{LNTAI}_{i,t-1} + \varepsilon_{it} \quad (19)
\end{aligned}$$

The following reduced form concentrates on the short-run relationships, and dismisses the lag effects of the variables. This simple model is beneficial in examining direct immediate associations between variables and environmental impacts. When, there is existence of long run cointegration, the equation of ECT is as in equation 20:

ECT equation model form of ITE as:

$$\begin{aligned}
\Delta \text{LNITE} = \Delta \text{LNENV}_{it} &= \beta_0 + \sum_{j=1}^k \gamma_{1j} \Delta \text{LNFDINIF}_{i,t-j} + \sum_{j=0}^k \gamma_{2j} \Delta \text{LNENRC}_{i,t-j} + \\
&\sum_{j=0}^k \gamma_{3j} \Delta \text{LNRENRC}_{i,t-j} + \sum_{j=0}^k \gamma_{4j} \Delta \text{LNTRM}_{it,t-j} + \sum_{j=0}^k \gamma_{5j} \Delta \text{LNTAI}_{it,t-j} + \\
&\alpha \text{ECT}_{it-1} + \varepsilon_{it} \quad (20)
\end{aligned}$$

Where, Δ is “first difference term, ε_{it} is the error tem and α is the ECT estimation which indicates the movement of an economy from a disequilibrium situation to equilibrium situation.

The model adjusts the long-run equilibrium that exists between variables by including an Error Correction Term (ECT). The ECT allows the model to correct for short-run deviations from long-run balance so that short-run sensitivities reflect the long-run fundamentals.

This model is employed to distinguish and measure the direct relations between these driving forces and environmental effects. It’s a useful organizer to help the study to think about the ways that economic, technological, and social factors can lead to both environmental harm and an environmentally healthier world. However, the model specification is for the selected panel group as STIRPAT shown in equation 21:

STIRPAT Model specification (Functional form) as:

$$STIRPAT = ENV = f(FDINIF, EG, LF, CF, TAI, TRM, ENRC, RENRC) \quad (21)$$

This equation is the basic STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model, derived from the IPAT identity. Now the simple linear equation form of STIRPAT is in equation 22. This relationship is a linear regression measuring the effect of the independent variable on the environmental outcome.

Simple linear equation model form of STIRPAT as:

$$\begin{aligned} STIRPAT &= ENV_{it} \\ &= \beta_0 + \beta_1 FDINIF_{it} + \beta_2 EG_{it} + \beta_3 LF_{it} + \beta_4 CF_{it} + \beta_5 TAI_{it} \\ &\quad + \beta_6 TRM_{it} + \beta_7 ENRC_{it} + \beta_8 RENRC_{it} + \varepsilon_{it} \end{aligned} \quad (22)$$

By identifying the coefficients $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ and β_8 , the study is able to determine the magnitude and sign of the impact that each factor has on the environment. β_1 is the intercept, term t represents the time, i represents cross-section unit for South Asian and ASEAN countries. Now the study would take the log transformation form of STIRPAT as shown in equation 23.

$$\begin{aligned} STIRPAT &= LnENV_{it} \\ &= \beta_0 + \beta_1 LnFDINIF_{it} + \beta_2 LnEG_{it} + \beta_3 LnLF_{it} + \beta_4 LnCF_{it} \\ &\quad + \beta_5 LnTAI_{it} + \beta_6 LnTRM_{it} + \beta_7 LnENRC_{it} + \beta_8 LnRENRC_{it} \\ &\quad + \varepsilon_{it} \end{aligned} \quad (23)$$

By taking the natural logarithm of the dependent and independent variables, this equation converts the original STIRPAT model to a linear regression type. This

transformation is linearizing the multiplicative ones and is appropriate to the linear regression. The log transform can help the elasticities (percentage changes) which are more straightforward to interpret. Skewness is reduced and variables are scaled to a common level.

However, the empirical method for ARDL model is introduced by Pesaran et al. (1999) and extended by Pesaran (2004). The tentative equation of panel ARDL model is given in the following equation no 24:

Panel ARDL model form of STIRPAT as:

$$\begin{aligned}
 \text{STIRPAT} &= \Delta \text{LNENV}_{it} \\
 &= \beta_0 + \beta_1 \text{LNFDINIF}_{i,t-1} + \beta_2 \text{LNEG}_{i,t-1} + \beta_3 \text{LNLF}_{i,t-1} \\
 &+ \beta_4 \text{LNCF}_{i,t-1} + \beta_5 \text{LNTAI}_{i,t-1} + \beta_6 \text{LNTRM}_{i,t-1} + \beta_7 \text{LNENRC}_{i,t-1} \\
 &+ \beta_8 \text{LNRENRC}_{i,t-1} + \sum_{j=1}^k \gamma_{1j} \Delta \text{LNFDINIF}_{i,t-j} + \sum_{j=0}^k \gamma_{2j} \Delta \text{LNEG}_{i,t-j} \\
 &+ \sum_{j=0}^k \gamma_{3j} \Delta \text{LNLF}_{i,t-j} + \sum_{j=0}^k \gamma_{4j} \Delta \text{LNCF}_{i,t-j} + \sum_{j=0}^k \gamma_{5j} \Delta \text{LNTAI}_{i,t-j} \\
 &+ \sum_{j=0}^k \gamma_{6j} \Delta \text{LNTRM}_{i,t-j} + \sum_{j=0}^k \gamma_{7j} \Delta \text{LNENRC}_{i,t-j} \\
 &+ \sum_{j=0}^k \gamma_{8j} \Delta \text{LNRENRC}_{i,t-j} + \varepsilon_{it} \quad (24)
 \end{aligned}$$

Where, Δ is “first difference term, ε_{it} is the error tem, and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ and β_8 converse to the long-run, and short run estimation coefficient shown by $\gamma_{1j}, \gamma_{2j}, \gamma_{3j}, \gamma_{4j}, \gamma_{5j}, \gamma_{6j}, \gamma_{7j}$ and γ_{8j} .” Long run estimation has been shown by the equation 25.

Long run estimation model form of STIRPAT as:

$$\begin{aligned}
\text{STIRPAT} &= \Delta \text{LNENV}_{it} \\
&= \beta_0 + \beta_1 \text{LNFDINIF}_{i,t-1} + \beta_2 \text{LNEG}_{i,t-1} + \beta_3 \text{LNLF}_{i,t-1} \\
&+ \beta_4 \text{LNCF}_{i,t-1} + \beta_5 \text{LNTAI}_{i,t-1} + \beta_6 \text{LNTRM}_{i,t-1} + \beta_7 \text{LNENRC}_{i,t-1} \\
&+ \beta_8 \text{LNRENRC}_{i,t-1} + \varepsilon_{it} \quad (25)
\end{aligned}$$

In this step, the study obtains the short-term dynamic relationship by estimating an error correction term that has been introduced in equation number 26.

ECT equation model form of STIRPAT as:

$$\begin{aligned}
\text{STIRPAT} &= \Delta \text{LNENV}_{it} \\
&= \beta_0 + \sum_{j=1}^k \gamma_{1j} \Delta \text{LNFDINIF}_{i,t-j} + \sum_{j=0}^k \gamma_{2j} \Delta \text{LNEG}_{i,t-j} \\
&+ \sum_{j=0}^k \gamma_{3j} \Delta \text{LNLF}_{i,t-j} + \sum_{j=0}^k \gamma_{4j} \Delta \text{LNTCF}_{it,t-j} + \sum_{j=0}^k \gamma_{5j} \Delta \text{LNTAI}_{it,t-j} \\
&+ \sum_{j=0}^k \gamma_{6j} \Delta \text{LNTRM}_{it,t-j} + \sum_{j=0}^k \gamma_{7j} \Delta \text{LNENRC}_{it,t-j} \\
&+ \sum_{j=0}^k \gamma_{8j} \Delta \text{LNRENRC}_{it,t-j} + \alpha \text{ECT}_{it-1} + \varepsilon_{it} \quad (26)
\end{aligned}$$

Where, Δ is first difference term, ε_{it} is the error tem which are independent and normally distributed with zero mean and constant variance, the short run estimation coefficient are shown by γ_{1j} , γ_{2j} , γ_{3j} , γ_{4j} , γ_{5j} , γ_{6j} , γ_{7j} , γ_{8j} . The quantity α is the rate of adjustment how the system recovers equilibrium or, it indicates the movement of an economy from a disequilibrium situation to equilibrium situation.

In this equation, an Error Correction Term (ECT) is added which represents the difference from the long-run equilibrium. The ECT in the model finds out the short run deviations work out with time expectancy and evaluate the long-run connections among the crucials and also the impact on the environment.

3.3 Empirical Methodology

The empirical steps on this thesis are organized and serially written in the below table.

Table 3.2: The framework of the PMG-ARDL process

Empirical Methods	Empirical Contents
Slope Homogeneity	Pesaran & Yamagata
Cross Sectional Dependency	Pasaran CD Test
Panel Unit Root test	CIPS
Panel Cointegration	KAO Cointegration Test
Parameter Estimation	PMG-ARDL
Relationship	FMOLS
Causal Relation	Granger Causality test
Each Country Parameter Estimation	PMG

3.3.1 Slope Homogeneity Test:

In panel data modeling, the unknown common slope assumption across countries may not be realistic, particularly when in terms of their features the countries are dissimilar. To take this heterogeneity into account, the slope heterogeneity is tested using the test suggested by Pesaran and Yamagata (2008). This test assesses the spread of the slopes between countries as a function of their weights. The intuition guiding this is that the assumption of equal slopes may not hold when the countries have different weighted slopes. The test statistic for this heterogeneity test is given by the following formula:

$$S_p = \frac{1}{N} \sum_{i=1}^N (\hat{\beta}_i - \hat{\beta}_p)^2$$

Where, $\hat{\beta}_i$ is the estimated slope for country I, $\hat{\beta}_p$ is the weighted average of the slope and N is the number of countries. This compares the degree of divergence of the individual slopes from the pooled slope for determining whether one can assume slope homogeneity for all the countries in the panel. If the test statistic yields an evidence for non-zero variability in slopes then this admits the existence of heterogeneity and that model allows for slope differences which has to be used.

3.3.2 Cross-sectional Dependence (CSD)

The CSD (Cross-sectional Dependence) test for panel data is a statistical method used to identify the presence of cross-sectional dependence in panel datasets, where cross-sectional units are related in some way. Cross-sectional dependence of a panel data set implies correlation among various cross-section units in that panel. It can occur because of common shocks or spillover effects among other sources of interdependence. The CSD test is important since many panel data approaches, including fixed effects or random effects models, assume independence of cross-sectional units. If this assumption does not hold, the estimates may be biased and inconsistent. Hence, testing cross-sectional dependence is an important step to follow prior to undertaking panel data analysis. There are many tests available for detecting cross-sectional dependence in panel data, among which the Breusch and Pagan (1980) LM test is one, and the Pesaran CD test is one of the most popular.

The LM statistic is valid for fixed N as T approaches infinity, was first introduced by Breusch and Pagan (1980). However, it may exhibit size distortions when N is large and T is finite, as the statistic is not properly centered for finite T, with the bias increasing as N grows. To address this, Pesaran (2004) proposed an alternative statistic to correct for this issue, given by:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho} \right) \quad (1)$$

It is assuming that the null hypothesis of no cross-sectional dependency (CD), the distribution of N (0, 1) is sufficiently big for $N \rightarrow \infty$ and T.

Under the null hypothesis of no cross-sectional dependence (CD), this statistic follows a normal distribution $N(0,1)$ as both N and T tend to infinity.

The CD statistic has a mean of zero under the joint null hypothesis in a broad range of panel-data models, including homogeneous/heterogeneous dynamic models and non-stationary models. However, due to small sample bias in parameter estimates, the CD test is asymptotically valid as T becomes large, since the fixed effects (FE) and random effects (RE) residuals have a mean of zero, even for fixed T , assuming symmetric disturbances (Pesaran, 2004).

There are many advantages of the CSD test. Some of which including hidden correlations between cross-sectional units can be revealed, leading to a more reliable analysis of panel data. It can be applied to different kinds of panel data models. The CSD test is popular but has some limitations such as the tests assume cross-sectional dependence because of common shocks or spillover effects, which may not hold in all cases, for large panels, this can be computationally demanding, the tests are conditioned on correct specification of the panel data model. The CSD test is an important step in the context of panel data analysis because it helps identifying cross-sectional dependence across the cross-sectional units. Failing to address this dependency before engaging in additional analysis can result in biased findings.

3.3.3 CIPS Unit Root Test

The CIPS (Cross-Sectionally Augmented Im-Pesaran-Shin) test is an extension of the Im-Pesaran-Shin (IPS) test, which allows for cross-section dependence in panel data. This is especially relevant when there is correlation between cross-sectional units in the panel data, which is frequent in macroeconomics or finance-related data sets. Specifically, the CIPS test adds the cross-sectional average of the lagged dependent variable to the model to account for cross-sectional dependence. It is employed in the detection of unit roots in panel data, allowing for heterogeneity in the series and cross-sectional dependence. The specification used in the CIPS unit root test is similar to the IPS test but adds a cross-sectional element. The test equation is:

$$Y_{it} = \alpha_i + \beta Y_{i,t-1} + \tau \left(\frac{1}{N} \sum_{j=1}^N Y_{j,t-1} \right) + \varepsilon_{it}$$

Where:

Y_{it} : is the time series for the i-th cross-sectional unit at time t

α_i : is the individual-specific intercept

β : is the autoregressive parameter (if $\beta=1$, the series has a unit root)

$(1/N) \sum Y_{j,t-1}$: is the cross-sectional average of the lagged dependent variable

ε_{it} : is the error term (white noise).

The CIPS test follows the hypotheses given below: Null Hypothesis (H_0): There is an unit root in the panel data (the time series is non-stationary), or H_0 : The panel data contains an Unit Root against H_1 : The panel data is stationary. The CIPS test has some advantages over Lags in levels test. It considers CSD, and it is considered better for panel data containing interdependence amongst cross sectional units. The autoregressive parameters can also be heterogeneous, which allows for potentially different behavior of cross-sectional units. It is useful when dealing with macroeconomics or financial datasets, where cross-sectional dependence is an issue. For panel data when cross sectional dependence is available, the CIPS unit root test is a significant statistics tools. This is a meaningful generalization of the standard IPS test as it allows for more flexible and accurate inferences using realistic panel data.

3.3.4 Kao Cointegration Test

The Kao cointegration test is a commonly used method for panel testing of cointegration. This is a panel analogue of the Engle-Granger cointegration test that can be used to check the presence of cointegration across multiple cross-sectional units within a panel dataset. The Kao test basically imposes a restriction on the equation above and assumes that there is a common cointegrating vector across all

cross-sectional units, then tests the long-run equilibrium relationship. Kao Cointegration test is based on the estimation of a panel error correction model. Set that the series are not cointegrated under the null hypothesis and alternatively they are cointegrated for the alternative hypothesis. The Kao cointegration test is founded on the panel equation:

$$\Delta Y_{it} = \alpha_i + \beta Y_{i,t-1} + \tau \Delta Y_{i,t-1} + \varepsilon_{it}$$

Where:

Y_{it} : is the time series for the i-th cross-sectional unit at time t

α_i : is the individual-specific intercept

β : is the cointegrating parameter (if $\beta = 1$, the series are cointegrated)

$\tau \Delta Y_{i,t-1}$: represents the short-run dynamics in the error correction model

ε_{it} : is the error term (white noise).

The Kao cointegration test is based on the following hypotheses: Null Hypothesis (H_0): No cointegration (the series are not cointegrated) and alternate Hypothesis (H_1): cointegration exists (the series are cointegrated). In Panel Error Correction Model, the residuals are given, and then it is the test statistic which is based on the ADF (Augmented Dickey-Fuller) test of the model residuals in the panel data. For each cross sectional entity, the ADF test is performed to check the stationarity of the residuals. So, if the residuals are stationary then it indicates that there exists a cointegrating relationship among the time series in the panel.

It is well known that a variety of cointegration tests have been proposed for cointegration tests for panel data such as the Kao cointegration test. It enables the identification of common cointegrating relations across many units of cross sections. This performs well for panel data in which it is assumed that the cross-section units share common cointegration relationships. It is noted that this test was developed for Panel Data. The Davidson and Mackinnon test is most commonly used in

econometrics and finance to assess if there is a long-run equilibrium relationship between multiple time series in a panel dataset.

3.3.5 Parameter Estimation: PMG-ARDL Approaches

The dynamic panel data approach known as the PMG-ARDL model (Pooled Mean Group - Autoregressive Distributed Lag) combines the benefits of the Pooled Mean Group (PMG) estimator with the Autoregressive Distributed Lag (ARDL) model. By capturing the relationship between a dependent variable and its own lags as well as the lags of explanatory factors, the ARDL model makes it possible to analyze both short- and long-term impacts. The PMG estimator, on the other hand, allows for differences in the short-term dynamics of all cross-sectional units (such as nations or businesses) while assuming a constant long-term link across all of them. When studying heterogeneous data, the short-term impacts vary from cross-sectional unit to cross-sectional unit while the long-term equilibrium may be consistent across units, this method works very well.

This study used the PMG-ARDL model developed by Pesaran, Shin, and others (2001) to investigate the short-run and long-run impacts of financial inclusion on environmental degradation. The pooled mean group technique in this model permits variable's short-term dynamics while imposing homogeneity on the long-term coefficients across nations. The Mean Group (MG) estimator, on the other hand, allows the coefficients to fluctuate over the short and long terms without placing any constraints on them. Pesaran (2007) asserts that when long-term homogeneity is assumed, the PMG estimator is more efficient than the Mean Group (MG) estimator in calculating coefficients. The following describes the empirical model used in this investigation:

$$\Delta y_{it} = \beta_0 + \sum_{j=1}^p \gamma_{ij} \Delta x_{it-j} + \alpha_i ECT_{i,t-1} + \epsilon_{it}$$

Here, Δy_{it} denotes the change in the dependent variable, Δx_{it-j} denotes the lagged values of the independent variables, and $ECT_{i,t-1}$ is the lagged error correction term. The coefficient α_i shows that how fast the system corrects itself to return to long-

term equilibrium, following brief perturbations. Statistically significant and negative α_i indicates that the system self-corrects over time.

The long-term linkages between the variables as well as the short-term dynamics are clearly revealed by this error correcting model. Because the PMG estimator can account for both heterogeneous short-run dynamics and homogenous long-run coefficients. It is very effective in this situation. Incorporating the ECT into the model allows it to account for the duration of shocks and the rate at which the system regains equilibrium, both of which are critical for comprehending the long-term effects of variables while short-term disturbances are taken into account. For the analysis of dynamic interactions in panel data, particularly in macroeconomics and environmental studies, the PMG-ARDL model is therefore, a perfect instrument.

To make it clear, the ECT coefficient in PMG-ARDL is the core that determines the speed of system recovery after deviating from the long-term trajectory. Thus, a valid ECT which is significant and properly signed establishes the presence of ECT's long run stable cointegrating relation which would allow for good long-term and short-term modeling of economic behavior.

3.3.6 FMOLS Test:

In econometrics, fully modified ordinary least squares (FMOLS) is an estimation technique for parameter estimates in the non-linear models. FMOLS is used to avoid both serial correlation and endogeneity, which occur due to the correlation of the explanatory variables with the error term in cointegrated systems, in an approach by Phillips and Hansen (1990). In contrast to OLS, FMOLS is based on a non-parametric correction applied to the regression equation so as not to obtain biased and consistent long-run estimators when the regressors and errors are correlated. When it comes to panel data, Panel FMOLS can either impose a homogeneous (pooled) long-run coefficient across all cross sections or allow for distinct (group-mean) coefficients, depending on the cross-section degree of heterogeneity.

Panel FMOLS is especially well-suited for cases studying economic or financial data over time with cross-sectional dimension involving countries or firms like investigating long-run relationship GDP and energy consumption. It works best in situations where the variables are integrated of order 1, or $I(1)$, and where cointegration has already been demonstrated using methods such as Pedroni or Kao tests.

3.3.7 Granger Causality Test:

The Panel Pooled Mean Group (PMG) Autoregressive Distributed Lag (ARDL) model is an econometric method that enables estimation of short run and long run series relationships in panel data that are heterogeneous across cross-section units, such as countries or regions. The PMG estimator delivers a common long-run relationships across units but differing short-term dynamics, which turns out to be a very convenient feature for analysing heterogeneous panels with different short-term activities. In these circumstances, the model is frequently combined with Granger causality testing to investigate the temporal causality of economic variables. Panel Granger causality tests make it possible to test whether one variable can forecast the future value of the other, in a dynamic panel data context. The test is important for pin pointers of the direction of causality which is very important in investigating complex system such as the relationship between financial inclusion, economic growth and environmental pollution (Pesaran, 1999).

In this regard, the parametric method, especially PMG-ARDL in panel data, combines long-run equilibrium relationships with short-run dynamics in a Granger causality framework. It is implemented by estimating a vector of variables and their lags with model allowing for both short run variability and long run correlation. In the standard PMG-ARDL model, the error correction term (ECT) is included to pick up the response to disequilibrium adjustment of the variables following a shock. The main benefit from incorporating Granger causality under PMG-ARDL framework is that it accounts for the direction of the causality by taking into account for short-run deviations as well as the long run equilibrium. For example, in environmental economics, the method can be used to determine if the financial inclusion leads to

environmental degradation or the long-run environmental policies drive the financial inclusion efforts considering heterogeneous nature of the cross-sections (Pesaran et al., 2001).

For example, the relationship between two variables, Y and X, can be expressed as follows:

$$Y_{it} = \alpha_i + \sum_{k=1}^p \beta_k Y_{it-k} + \sum_{k=1}^p \gamma_k X_{it-k} + \epsilon_{it}$$

Here Y_{it} is the dependent variable (e.g., environmental degradation), X_{it} is the independent variable (e.g., financial inclusion) and α_i represents entity-specific fixed effects. The null hypothesis for Granger-causality from X to Y, here H_0 , is tested by seeing if the coefficients on the lagged values of X are 0, and the null hypothesis for causality from Y to X is that the coefficients on the lagged values of Y are zero. This provides a way for researchers to examine the direction and magnitude of causal relationships, while controlling for both short-run dynamics and long-run effects. This approach is more efficient in estimating causality relative to other panel data models like the Mean Group estimator, as it provides for short-run heterogeneity but maintains long-run homogeneity across units (Pesaran, 2007; Holtz-Eakin et al., 1988).

CHAPTER 4: CURRENT SITUATION ANALYSIS: GLOBAL, SOUTH ASIA AND ASEAN COUNTRIES CO2 EMISSION

4.1 INTRODUCTION

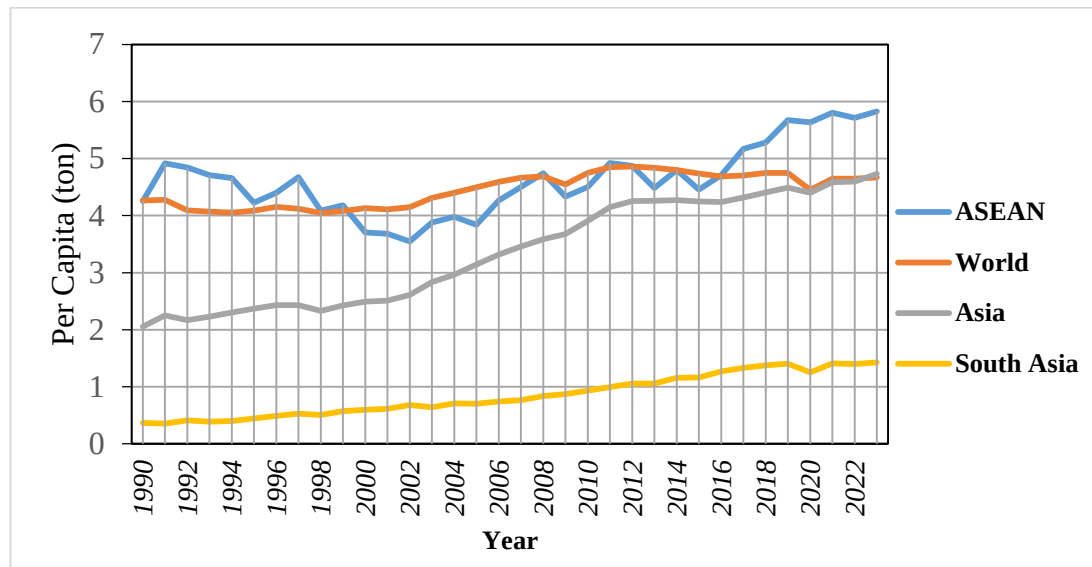
Global climate change is a dire threat to the world. As an initial step toward limiting the global temperature increase to 2 degrees Celsius or less compared to pre-industrial temperature, 195 nations have committed to national greenhouse gas (GHG) emission reductions in the Paris Agreement. Achieving that goal will necessitate the transformation of the global energy system over multiple decades. Energy-related CO₂ emissions and industrial processes increased moderately, by 0.9% (+321 Mt), reaching a record-high 36.8 Gt in 2022. This evaluation is based on the IEA's (2022) detailed analysis which carefully examines all the regions and types of fuel, utilising the latest official statistics, as well as publicly available data on energy consumption, economic indicators and weather patterns at a national level. The year 2021 rise in emissions follows two years of extreme fluctuations in energy-related emissions. Emissions decreased by more than 5% in 2020, as energy demand dropped due to the Covid-19 pandemic. Then, in 2021, emissions blasted above pre-pandemic levels by more than 6 percent as economic stimulus measures and a broad vaccine rollout lifted economies. In 2024 IEA estimates we will still be increasing the warming of 2.4% by 2100, with no improvement since last year, and it is little pessimistic that warming will head towards 2.7% under current policies. For the latest data (2023–2024), the current CO₂ emission status in the South Asian and ASEAN countries indicates that the development, energy consumption, and environmental pressures are diverse in the two regions. In South Asia, per capita CO₂ emissions remain low, with total CO₂ emissions increasing with population and industrial development. India, the biggest emitter in the region, was a top contributor to CO₂ emissions globally in absolute terms, largely because of coal-burning electricity and rapid urbanisation. Yet India's per capita emissions are low, 1.9 metric tons a person, far below the world average. Bangladesh, Pakistan, Nepal, and Sri Lanka also have the lowest per capita emissions consuming between 0.5 to 1.1

tons, and they also face rising emissions as they urbanise and industrialise and seek to meet their growing energy needs. Access to renewable energy is restricted, the use of fossil fuels is being depended on, and environmental standards are weak to promote sustainable development. This contrasts with what we see, for instance, from the CO₂ emissions per capita of the ASEAN countries, which are higher and growing more rapidly, reflecting the more advanced industrial structure and the high rate of economic development there. Indonesia, Thailand, Vietnam and Malaysia are among the top contributors, with emissions from coal-fired power, transportation, deforestation and export-oriented manufacturing. Singapore, with its small population, has one of the highest per capita emissions in the region as a result of its energy-intensive economy. Cambodia, Laos and Myanmar have lower emissions rates but are starting to rise as their economies grow. First, ASEAN approaches or exceeds average world value of per capita emissions, while South Asia lags behind although steadily increasing. This divergence stresses the importance of differentiated climate approaches. As ASEAN adopts a final push toward renewable and energy efficiency, South Asia has to navigate development aspirations with the imperatives of cleaner energy access and reforming infrastructure so that it is not locked into a high-carbon growth pattern.

4.2 CO₂ EMISSIONS IN THE WORLD, ASEAN, AND SOUTH ASIA

Figure 4.1 displays the CO₂ emissions per capita (in metric ton) trend from 1990 to 2022 and compares them in four major regional groups (South Asia, ASEAN, Asia and World according to the World Bank (2025)). This is a long-term linear graph line that gives an important overview of the carbon emissions development in comparison to regional economic development, industrialization and energy consumption patterns over a period of 33 years. The chart opens in the early 1990s, when ASEAN had generally higher per capita emissions as compared to South Asia and indeed a lot more than global average. Until now, this initial posture reflects the region's higher level of economic development at that time with Malaysia, Thailand and Singapore which are already undergoing the pace of industrial growth driven by exports.

Yet, the ASEAN trend line is not a straight line; it exhibits volatility in the early years, reflecting cases of economic transition, policy shifts, and external shocks, such as the 1997 Asia Financial Crisis, which potentially prompted temporary emission decrement.



Source: World Bank (2025)

Figure 4.1: Global, South Asia and ASEAN Countries CO2 Emissions

There is a clear and steady rise in ASEAN’s per capita emissions from around 2009. This is indicative of the region’s rapid growth in infrastructure, urbanization, and manufacturing, and its increasing dependence on fossil fuels to support the industrial expansion and increasing population. ASEAN’s per capita emissions, meanwhile, overtake the global average by the 2020s and track the growth path of the wider Asian region. The world average line is relatively consistent over the period. There's a small dampened wiggle in the early 1990s and then a slow and modest rise.

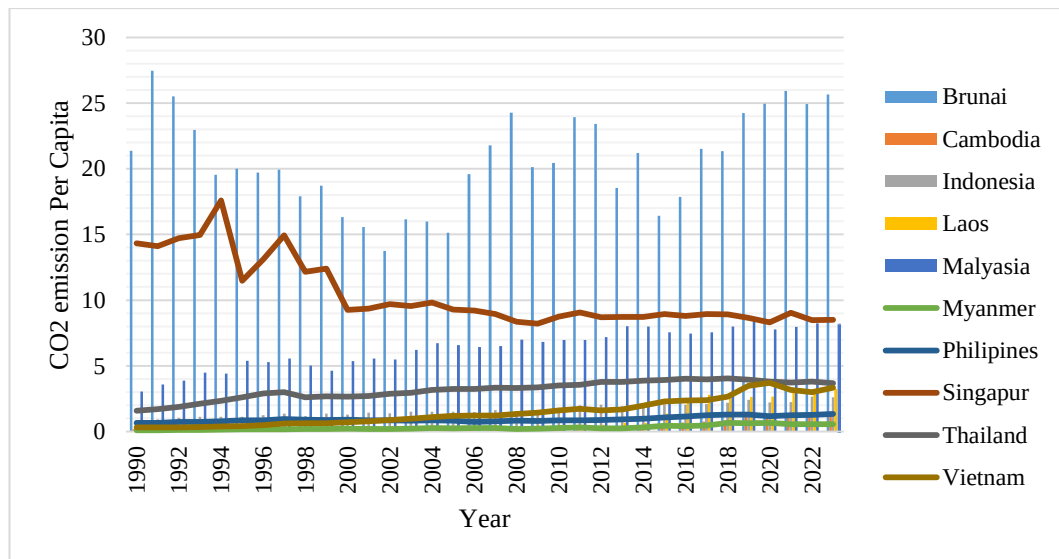
The gentle slope of the ascent reflects the fact that even as emissions have risen globally, they have been buffered by improvements in energy efficiency, the rolldown of renewable energy in developed countries, and lower rates of growth in emissions in areas like Africa or Latin America. Notwithstanding, the average figure is misleading. There are considerable differences between areas and countries as Asia’s more varied patterns-show. Asia in general enjoys the steepest and continuous

increase in CO₂ emissions per capita over the course of the period. This trend has coincided with the ascendance of industrial powerhouses like China, India, South Korea and others, whose surging manufacturing sectors, coal-dependent energy systems and growing urban populations have caused emissions to skyrocket. The link between growth and emissions is especially evident because of Asia's share of global GDP and energy use has raced up with its emissions profile.

The developmental trajectory of the region has been at a high carbon cost, highlighting the trade-off between economic progress and sustainability. The South Asian region always displays the lowest per capita emissions. Even though population has soared, and the economy has expanded moderately, countries such as Bangladesh, Nepal, Pakistan and indeed India have kept a relatively modest footprint of CO₂ exhaust per head. This held true, in great part, because the region's industrial base is small, people own few personal vehicles and access to energy-intensive infrastructure is low, especially in rural communities. But since early 2000s, one can see the figure of per capita emissions in South Asia are significantly rising, which proves that the tendency of industrialization, urbanization, high energy-using are inevitable. This visualization then changes the quantitative differences in emissions into qualitative issues of equity, climate justice and responsibility. ASEAN has graduated in per capita emissions to the high emissions bracket of the world, whereas South Asia (SA) with its low contribution to per capita emissions has become a global production supply chain for the world. That discrepancy makes climate negotiations difficult, particularly regarding to who should carry the heavier burden of cutting emissions. It clearly highlights the importance of common but differentiated responsibility in climate policies that take into account the history of emissions, the need for development and the present capacity in order to have an equitable and effective climate mitigation.

Figure 4.2 shows the CO₂ Emission in ASEAN countries. The data is obtained from World Bank (2025). This Figure 4.2 shows the detailed comparisons of the eight ASEAN countries in terms of the per capita CO₂ emissions from the year 1990 until the year 2023. It's clear from the chart that Brunei (the blue bars) by far the highest

per capita CO₂ emissions throughout the period and although there have been some ups and downs, it has remained at the top of the list.

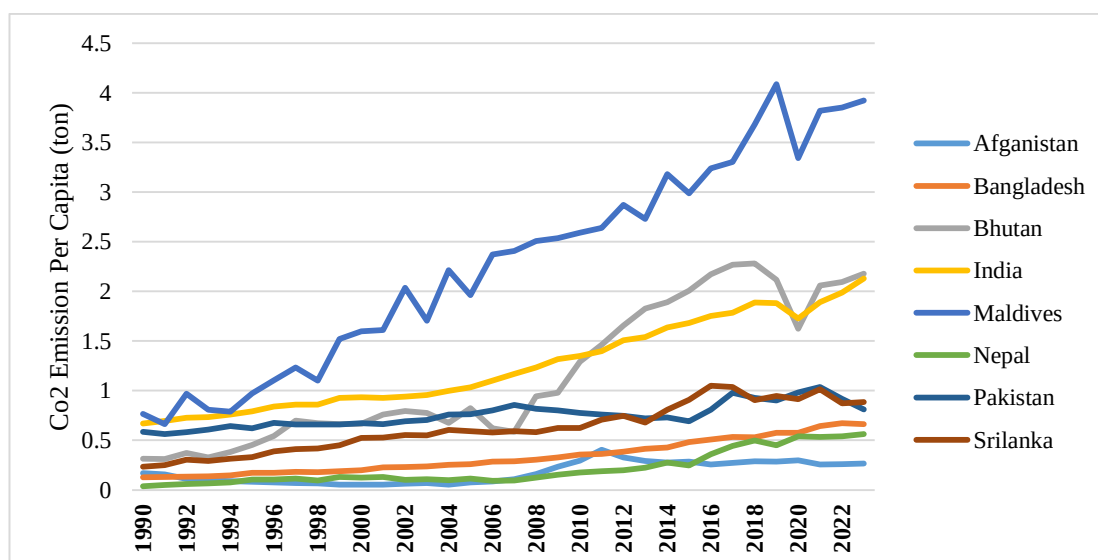


Source: World Bank, 2025

Figure 4.2: CO2 Emission in ASEAN Countries

Its emissions stayed higher than other ASEAN countries due to its low population and high levels of reliance on fossil fuels for energy and industrial purposes. Singapore (red line) also shows high per capita emissions and now it is declining slowly over the years, which may indicate improvements in energy efficiency or changes in industrial trends. Leading from behind would be Malaysia (green line) and Indonesia (orange line) the middle tier growers who showed their consistency with incremental inclines over the years which have been slowly industrializing and growing their populations. Independent of the damage that occurs, there are nations like Cambodia, Laos, Myanmar. The Philippines Lead with the Lowest Per Capita Emissions. The Philippines with relatively small per capita emissions showed slight growth over the last three decades. These lower rates might be because of less industrial activity, more dependence on agriculture and fewer facilities for energy in the form of fossil fuel. Overall, the figure demonstrates the wide range in per capita emissions across ASEAN, where small, rich, and natural-resource-endowed countries emit much more than their less developed neighbors. These differences have

significant consequences for regional climate policy and equity in emission reduction targets and can be critical to identify pathways to sustainable development according to the economic and energy profile of each country.



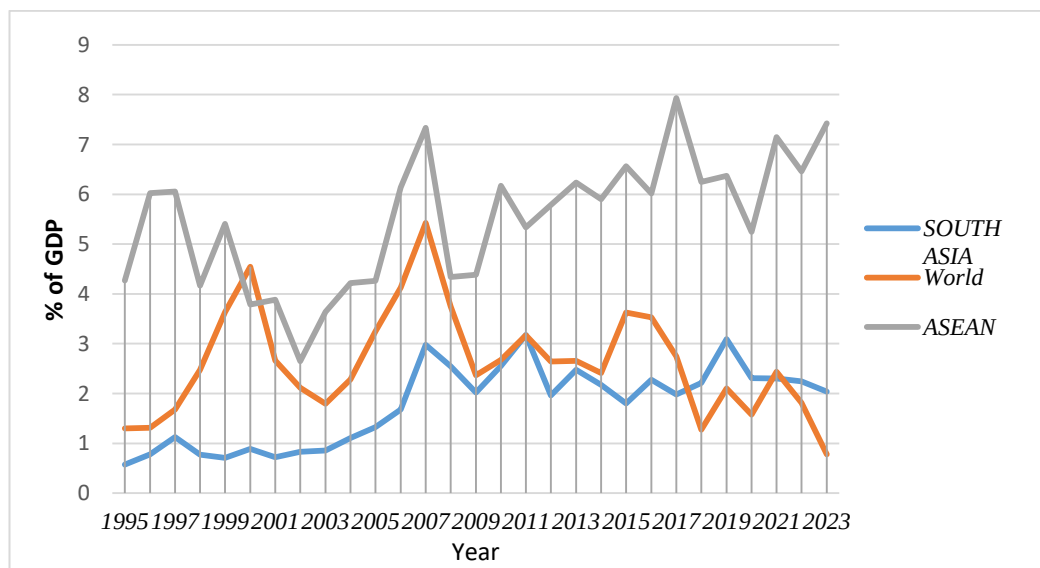
Source: World Bank, 2025

Figure 4.3: South Asia Countries CO₂ Emissions

Figure 4.3 shows the South Asia Countries CO₂ emissions showing per capita carbon dioxide emissions (in tons) for eight South Asia countries for the years 1990-2022. The chart indicates great difference in the emissions from these countries. Maldives (light blue line) has by far the highest per capita emissions across the whole period, which increase dramatically and at a constant rate after mid-1990s, reaching some 4 tons in recent years. This contrast is due to its considerable reliance on fossil fuel imports, on tourism and transport. Bhutan (green line), a country that is carbon negative and had an obvious rise in per capita emissions from around 2009 onward due to increased infrastructure and industrial activity. India (purple line), on the other hand, has a heavier per capita emission than the Maldives and Bhutan but has experienced a continual rise, approaching almost 2 tons per capita in 2022 due to

industrialization, urban expansion, and higher energy consumption. For Pakistan and Sri Lanka, there is a more moderate evolution over the years with emissions passing the threshold of 1 ton for the year 2010. In contrast, Afghanistan, Bangladesh and Nepal having the lowest per capita CO₂ emissions and small growth rates suggests little industrialization and low energy use per person. This graph in general brings out the inter-country varieties and the steep upward trajectory of emissions in South Asia and draws attention to environmental unsustainability as well as the pressing need for clean energy transitions specific to the economic situation of individual country.

4.3 FDI TREND IN ASEAN AND SOUTH ASIAN COUNTRIES



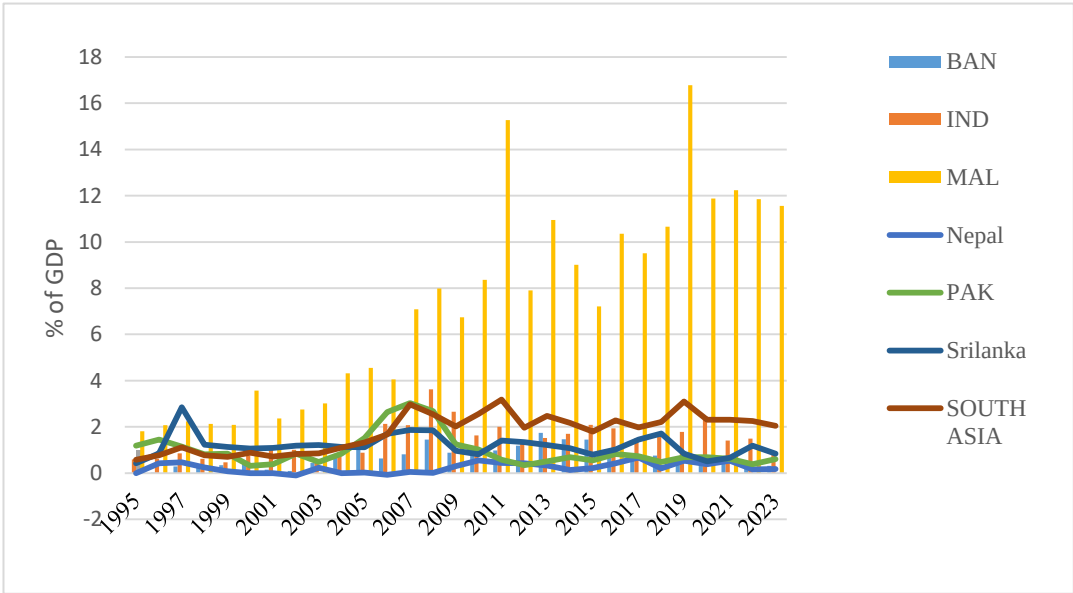
Source: World Bank, 2025

Figure 4.4: Foreign direct investment in ASEAN, South Asia and World, net inflows (% of GDP)

Figure 4.4 shows the results of Foreign Direct Investment in ASEAN, South Asia, and the World net inflows as % of GDP that compares the trends in foreign direct investment (FDI) inflows between the year 1995 and 2023. As the graph makes evident, the ASEAN countries (green line) always accounted for a higher percentage of FDI to GDP than the South Asia (blue line) and the world (red line). Under-

reported and under-emphasized in much of the national policy discourse, regional FDI inflow to ASEAN has surged massively since 2000, and peaked at nearly 8% of GDP around 2007, driven by increased investor confidence, liberalized trade policies and efforts in regional integration such as the AEC. Disregarding the ups and downs, ASEAN overall has in fact demonstrated a strong and stable performance of FDI in the said period. FDI inflows in South Asia, by comparison, have stayed modest for the most part, at around 1% to 3% of GDP, with a small bump around the mid-2000s and the late 2010s (the latter likely reflecting India’s liberalization reforms and a surge in digital and service sector activity).

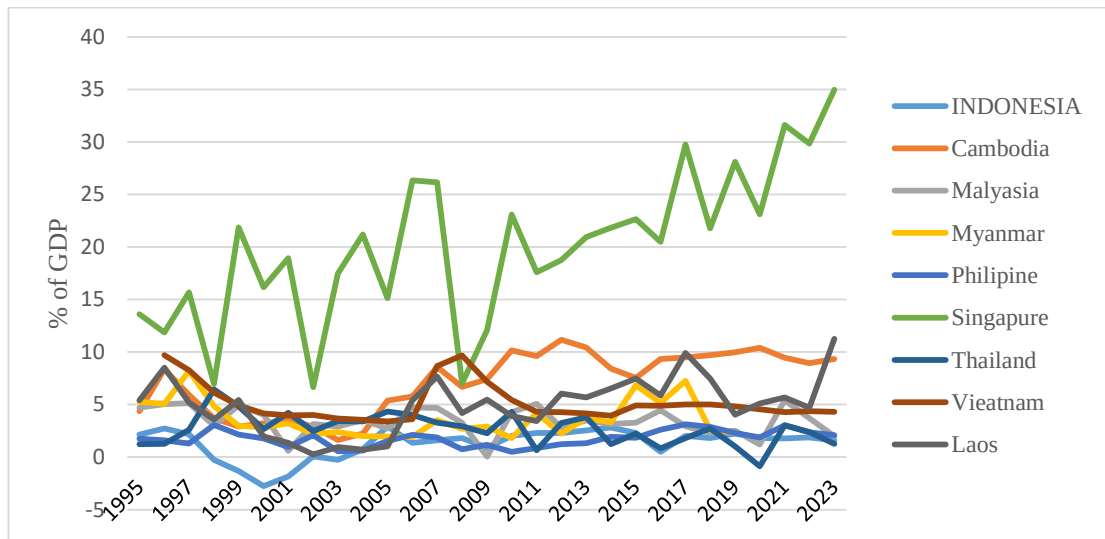
Average world FDI inflows increased until the 2008’s global financial crisis, then decreased and leveled off at a stable rate with a few local dips, including a significant one around the year 2020 (most likely reflecting the pandemic global effect of COVID-19). In general, the chart underlines the relative dynamism of ASEAN in receiving FDI in comparison to global and South Asian benchmarks, putting the region in a league of its own as far as seamless and efficient international inflow of capital is concerned.



Source: World Bank, 2025

Figure 4.5: Foreign direct investment in South Asia, net inflows (% of GDP)

Figure 4.5 shows foreign direct investment inflows in South Asia in form of its net inflows as % of GDP, showing the 'FDI inflows to GDP' trends for major South Asian countries as well as for the region of South Asia for the years from 1995 to 2023. The differences in FDI performance in the region are also evident in the chart. Notably, inflow of FDI in Maldives (MAL) is quite high in proportion to GDP, where investment inflow as a share of GDP is found in excess of 10% and has reached over 16% in multiple years (16.03% in 2014 and 17.57% in 2017). And that's largely because tourism is the tiny island's economic engine and foreign investment is heavy in hospitality, real estate, and infrastructure. India (IND) has appeared rather steady and modest over time as the largest economy in the region with FDI levels generally between 1.5% to 3% of GDP, indicating a sustained, albeit cautious, investor's interest in its huge market and some reform-led sectors such as telecom, IT and manufacturing. PAK and Sri Lanka however, demonstrate similar trend of low FDI inflow as the amount invested is never more than 1% to 2%, and is influenced by political stability, security risk and economic changes. Bangladesh (BAN) and Nepal, on their part, remain typical of low FDI inflows and they never rise above 1% of GDP. This shows that foreign investors are not very active perhaps with given regulatory barriers, infrastructure constraints and governance weakness. As for the regional average, the indicators for South Asia show a rather unremarkable trend over the years, hovering around 2% of GDP with occasional peaks that were essentially happening in case of India and Maldives. The figure depicts a greatly uneven FDI terrain in South Asia, with the Maldives being the one that skewed the average disproportionately, while the rest found it challenging to bring sustained foreign investments. To achieve the potential of a competitive investment location, and region, South Asia needs to further invest in an improved investment climate and embrace political stability and necessary infrastructure to succeed.

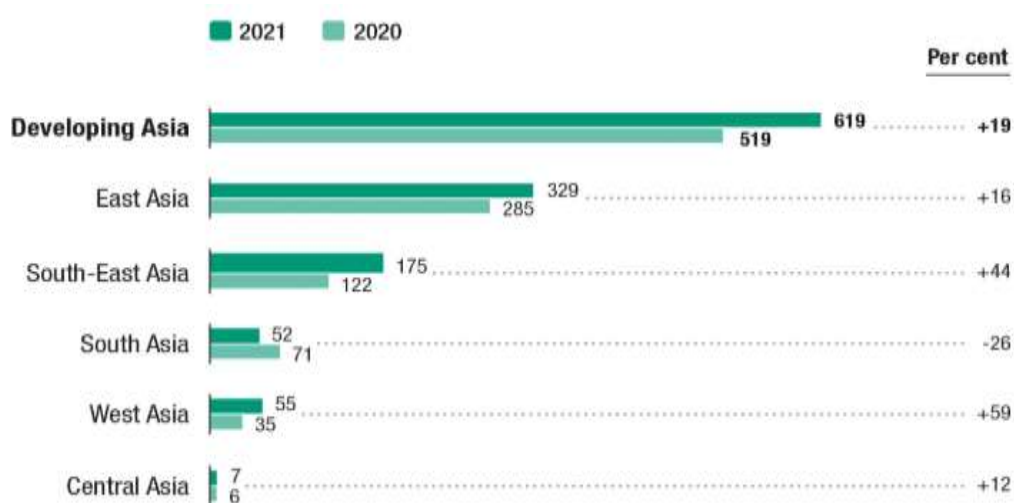


Source: World Bank, 2025

Figure 4.6: Foreign Direct Investment in ASEAN Countries, net inflows (% of GDP)

The changing pattern of foreign direct investment (FDI) in ten ASEAN countries in 1995-2023 is illustrated in Figure 4.6. The data show that there are large differences in all countries/regions' ability to attract FDI both in quantity and in stability. Singapore has a regular and relatively high FDI influx from 10 to 20 percent of GDP in all years. Given that Singapore is a leading financial centre in the world with favorable regulatory environment and strategic location and there is sustained foreign inflow. By contrast, the most dramatic and volatile pattern is found in Cambodia, where FDI inflows had already jumped before 2010 and were projected to exceed 35% of GDP by 2023. This may reflect the influence of Cambodia's openness to foreign capital, as well as investment in garments and construction, and its small base GDP which increased the multiplier effect on the ratio of FDI to GDP. Vietnam is also witnessing an upward trend, with growth rates that have been sustained since the early 2000s. Thanks to the expansion of manufacturing, trade liberalization and integration into global value chains. Malaysian, Thailand and Indonesia continue to register moderate FDI inflows, averaging 2%-6% of GDP, which suggest that they are still relatively more developed and are also subject to swings in investor confidence from time to time. Laos, Myanmar, and the Philippines have lower and more volatile FDI inflows. Laos and Myanmar have been held back by political and

economic uncertainties and the Philippines, which has a relatively large labor force and considerable potential in the service sector, has not seen continuous high-level inflow of FDI, possibly due to infrastructure and regulatory difficulties. This number demonstrates the diversity of the ASEAN investment environment. Countries such as Singapore, Cambodia and Vietnam emerge as leading countries that attract FDI in the region and the rest of the countries confront continuous restraints. The political stability, infrastructure, regulatory quality and the degree of sector openness are found to be the significant factors which affect these divergent trends.



Source: UNCTAD World Investment Report 2022 11.24 am (23.12.2024)

Figure 4.7: FDI Flows to Developing Countries in Asia and Sub regions, 2020-2021 (Billions of Dollars)

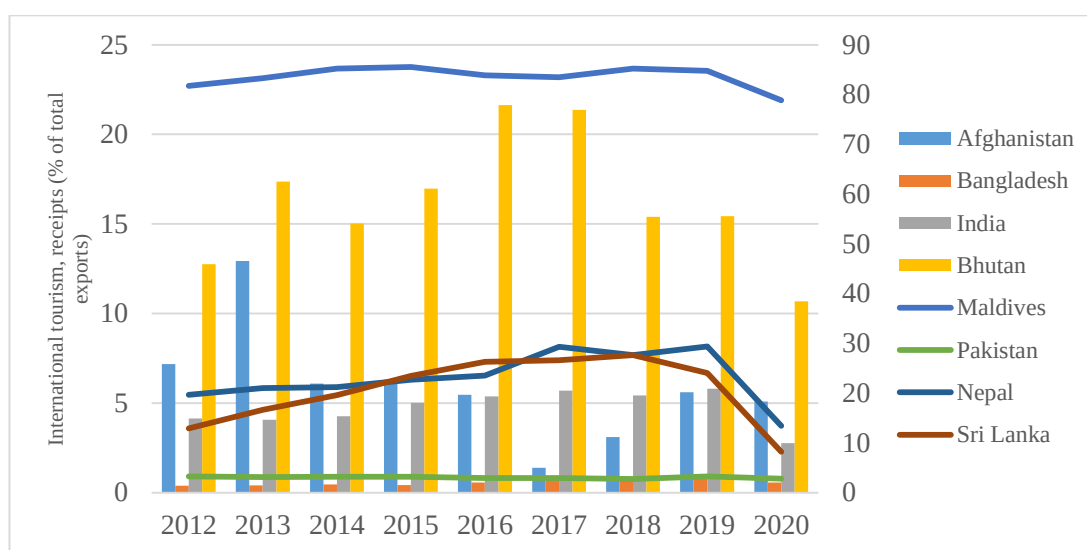
Figure 4.7 shows Foreign direct investment (FDI) inflows in billions of US dollars by subregion of Asia for the year 2020 and 2021. FDI returned with a vengeance, as the graph shows, after its slump during the COVID-19-triggered downturn. Cross-border investment nosedived in 2020 amid worldwide uncertainty, restrictions on mobility and supply-chain disruptions. But by 2021, many Asian economies started to recover. They were followed by South, East, Southeast, Central and Western Asia collectively with \$619billion up from \$519billion. This is an overall increase of 19% indicating increasing investor's confidence and resistance in the region. Among subregions, South-East Asia was the top performer, with FDI flows increasing by an

impressive 44 per cent from \$122 billion to \$175 billion. The spike can be attributed to the revival of investor enthusiasm in export-oriented manufacturing, booming digital services like e-commerce and fintech, and the increasing trend of greenfield investments - strategic investments that build all-new facilities as has been seen in Vietnam, Indonesia and the Philippines. These countries have profited from much-needed supply chain diversification, ideal demographics and a more favourable ease of doing business. Governments throughout the region unveiled stimulus packages, digital economy blueprints and infrastructure projects. All aimed at enticing more foreign investment. East Asia too did well with FDI inflows rising 16 per cent that is increase \$285 billion to \$329 billion. The main engine of the subregion, China, also continued to attract FDI both by volume and had continued investment in high-technology, electronics manufacturing, and consumer-oriented industries. That East Asia's well performing is a testament to the regional industrial prowess, innovation capability and sound macroeconomic policies. Global instability aside, the region remained a safe and lucrative steady state for investors. On the other hand, there has been a substantial 26 per cent fall in FDI to South Asia, estimated at \$52 billion in 2021 down from \$71 billion in 2020. This decline was mainly a result of a significant decline in FDI to India, which had an exceptional year in 2020 on the back of large investments in the technology sector. In 2021 capital flows to India cooled off to the world due to uncertainties over regulatory changes and the waves of the pandemic. Other South Asian states including Bangladesh, Pakistan, and Sri Lanka also experienced limited FDI inflow, frustrated by infrastructure bottlenecks, political instability, and small market size \$386 billion. Meanwhile, FDI inflows to Western Asia jumped an impressive 59%, helped by rising oil prices, as well as regional economic reforms and growing interest in logistics, tourism and diversifying energy. Central Asia, which received less overall, experienced a similar increase or 12% as another sign of gradual recovery and investment in natural resources and infrastructure. Data indicate that the recovery in FDI flows between Asian subregions is quite uneven. Most regions rebounded decisively, supported by reopened economies, policy reform and structural advantages, though recovery in South Asia took longer and mega-deals were down as investment patterns had

shifted. These trends highlight the importance of reform targeting to enhance investment climates and competitiveness in the lagging regions.

4.4 TREND OF TOURISM DEVELOPMENT

Figure 4.8 displays the per cent of international tourism receipts to total export for eight South Asian countries for the years 2012–2020. This is a measure of the importance of tourism in the export economies of the different countries. And of course, the most well-known of all presented countries is the Maldives, the most tourism-dependent economy of all, receiving over 70% of its total exports from international tourism.



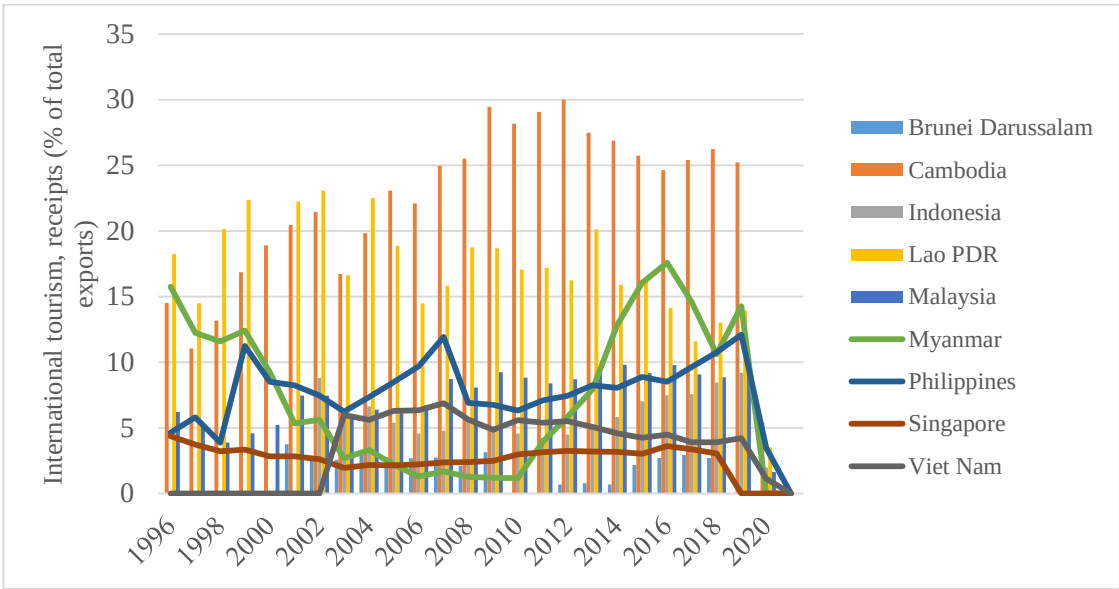
Source: World Bank 2025

Figure 4.8: South Asian International Tourism

It reached above 80 percent in 2016 and 2017, underscoring the country's heavy dependence on the tourism industry including luxury travel and island resorts. One thing worth noting is that there is a big decrease in 2020 because of COVID-19 and travel bans. Nepal also exhibits a high and consistently increasing percentage of tourism receipts to the total export until 2019, and a marked decrease was seen in 2020, indicating the susceptibility of its tourism sector to global disasters. Sri Lanka

has also seen tourism’s growing role in exports up through 2018 and then a drop off in 2019 and 2020 due to the 2019’s Easter bombings as well as the global pandemic. With steadier diversification-based growth, India has minimal reliance on tourism, accounting tourism receipts at 5% to 7% of total exports. Bhutan, Bangladesh and Pakistan have consistently low levels (generally below 5 percent), though their source value remains a modest contribution to their export economies. Afghanistan is still erratic and data poor. The figure further shows that countries such as the Maldives, Nepal, and Sri Lanka are heavily reliant on international tourism and are hence more vulnerable to variations in global tourism. The 2020 fall gave the lesson that how hard the tourism has been hit by the pandemic, highlighting the crucial need of diversification and resilience projects in tourism dependent economies.

Figure 4.9 presents the share of international tourism receipts as per cent of all exports over the period of 1996-2020 for ten ASEAN countries.



Source: World Bank, 2025

Figure 4.9: International Tourism, Receipts in ASEAN Countries

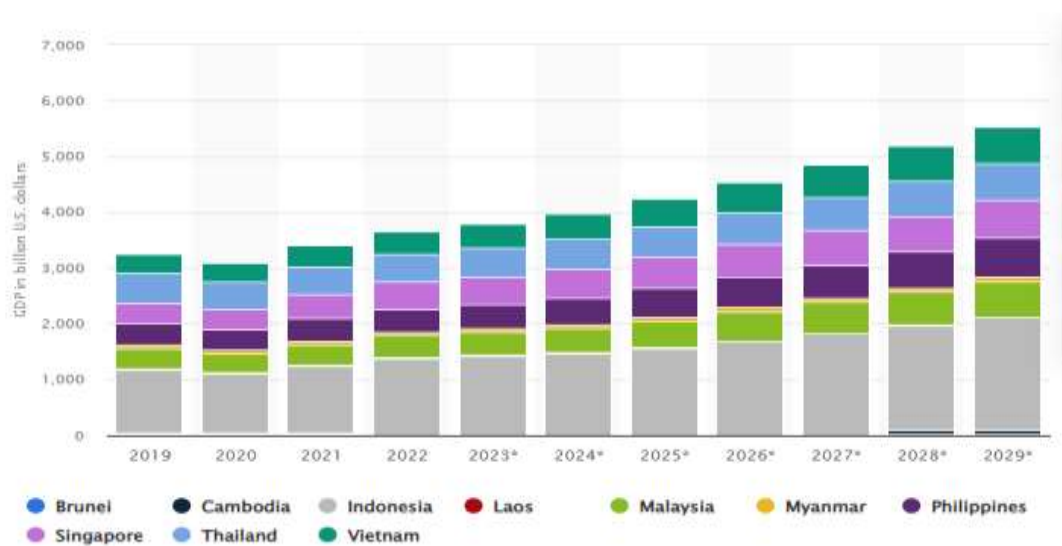
This figure indicates the extent to which the countries of the ASIAN countries rely upon tourism and the disruption to tourism-based export earnings caused by global

shocks including the COVID-19 pandemic in 2020. Cambodia remains the top country of the ASEAN region in terms of tourism dependency, with receipts of about 20% to 30% of total export within the period of 2000 and 2019. This serves to emphasize the importance of tourism for the economy in Cambodia in regard to cultural treasures. But in 2020, the trendline plunges as the world's air traffic gets grounded. Myanmar also exhibits major changes, particularly during post-2010, with substantial peaks in 2014 and 2018 where the tourism receipts contributed up to approximately 20%, implying its increasing role as a destination in the times of political steadiness. But it collapses once again in 2020 with the pandemic and the added political turmoil. Thailand and Laos PDR both demonstrate mid-level dependence averaging between 10% to 20%, reaffirming their rapid diversified export sectors. The coronavirus hit hardest in 2020 in Thailand, a global tourism hub, where the sector plummeted after years of growth. Vietnam, Malaysia, Philippines, and Brunei are at around 5% to 10% with moderate tourism reliance. The numbers in Indonesia and Singapore are even lower, typically under 5%, because these are broad-based export economies that are mainly manufacturing, services and finance, not tourism dominated. The general pattern is that although some ASEAN members such as Cambodia and Myanmar rely heavily on international tourism, others have a more diversified export structure. The dramatic decrease of all countries in the year 2020 points to the susceptibility of the tourism sector of global crises and underscores the importance of developing resilience strategy and economic diversification in the region.

4.5 TREND OF GROSS DOMESTIC PRODUCT (GDP)

A visual summary of the GDP growth paths of the ten member countries of ASEAN from the year 2019 to 2029 is displayed in Figure 4.10 (the 2023–2029 values are projected). The stacked bar shows how they add up to a larger regional GDP (each contributing member's percentage). In both the 2019 and the 2023 periods the chart illustrates that the GDP growth in the U.S. dollar is modest, albeit somewhat dampened in 2020 by the economic fallout of the COVID-19 pandemic. But from year 2023, the chart depicts steady and even accelerating expansion, culminating in

regional GDP more than doubling by 2029. It is from around \$3.6 trillion in 2022 to more than \$6.5 trillion will be 2029. It is dominated by Indonesia which is followed by Thailand, Malaysia, Vietnam and Philippines that essentially form a second tier of major economies. Singapore, a small nation nevertheless makes a substantial contribution with its high GDP per capita due to its dominance in high end services. The economy of Cambodia, Laos, Myanmar and Brunei are still relatively small, but also included in the upward trend. Vietnam’s contribution is notably rising year-by-year due to the rapid expansion of the manufacturing base and growing foreign investment. This chart illustrates ASEAN region’s attractive economic potential, with a solid growth in the next 10 years to come. The upward trend reflects the position of ASEAN as a vibrant economic community in the world economy. It also indicates the path to greater regional integration and industrial diversification, with Vietnam, Indonesia, and the Philippines are emerging as stand-out future growth performers.



Source: Our World in Data, 2025

Figure 4.10: Gross Domestic Product (GDP) of the ASEAN (in billion U.S. dollars)

Between 2019 and 2022, despite the potential disruptions to the economy including the COVID-19 pandemic, GDP across ASEAN countries displayed consistent

growth. There was a slight downturn in the overall economic output in 2020 but it recovered in subsequent years, highlighting robustness. The highest share was maintained by Indonesia, followed by the other top contributors such as Thailand, Vietnam and the Philippines to their GDP of the region. Significant economies include Singapore, Malaysia, and the Philippines, whereas smaller economies include Brunei, Cambodia, Laos, and Myanmar, contributing less in terms of their percentages as reflected in the total GDP. Others allow for the gradual increase of GDP figures per year until 2023 to 2029, showing a continued growth across ASEAN countries in any way. Industrialization, technological development, trade agreements, foreign investments, and increasing domestic consumption are some of the factors responsible for this projected growth. Significantly, Vietnam posted the fastest GDP growth by far, likely due to its booming manufacturing, exports and foreign utilisation from direct investment. Likewise, Indonesia is likely to remain the number one economy in the region, driven by its vast domestic market as well as its diversified economic activities. The GDP of Thailand and the Philippines has been steadily rising, demonstrating recovery and development of tourism, exports and industry. Finally, both Malaysia and Singapore, famed for their developed economies and financial distincts, have seen solid but consistent growth. Cambodia, Laos, and Myanmar, not as fast-growing, are also progressing economically, but on a smaller scale to their larger ASEAN neighbors. Thus, the chart indicates an optimistic economic perspective for the ASEAN region with growth anticipated each successive year. The uptick in GDP numbers highlights the economic resilience, policy-led growth, and strategic importance of the region in contributing to global trade and investment. These trends will solidify ASEAN as one of the most consequential economic blocs and a greater force on the world stage.



Source: Our World in Data, 2025

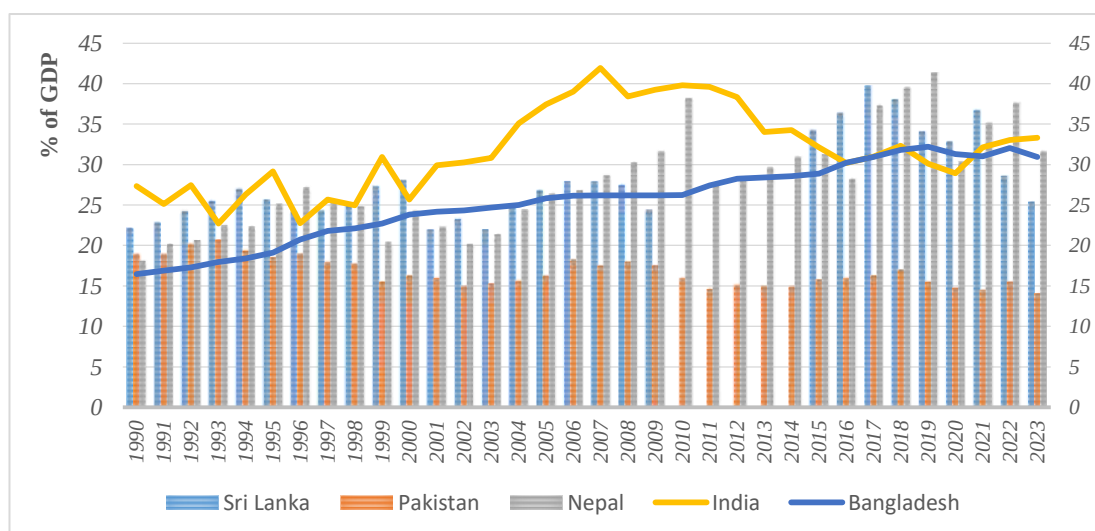
Figure 4.11: South Asia GDP Growth Rate 1961-2025

The Figure 4.11 displays the GDP growth trends of South Asia over the decades showcasing both the annual GDP growth rates and multiple years of percent change. The top graph, blue line shows GDP growth percentage during year 1960s to year 2022. In the beginning stage, the region was plagued by severe economic volatility and spontaneous negative growth, especially in the 1960s, 1970s, and 1980s. Starting from the 1990s, the South Asian region also experienced more consistent economic growth between 4% and 8%, signaling economic development that was likely boosted by industrialization, globalization, and policy reforms.

This data get complemented by the bottom bar chart, which shows year-on-year changes in GDP, where green bars indicate expansion while a red bar indicates contraction. The chart shows several downturns, especially during economic crises in the 1970s and early 1990s. But the biggest decline in GDP came in 2020, mirroring the fallout from the COVID-19 pandemic on South Asia's economy. A robust recovery followed in the following year, marked by a tall green bar, showing how quickly the region recovered.

4.6 TREND OF CAPITAL FORMATION

Figure 4.12 demonstrates investment levels in five South Asian countries such as India, Bangladesh, Nepal, Pakistan and Sri Lanka from 1990 to 2029 and onward. GCF is investment in fixed assets including infrastructure, machinery and building. This is an important measurement of economic growth and future productive capacity. The chart indicates that India's gross capital formation rate was always the highest among these countries, with a peak of over 40% of GDP in the mid-2000s, driven primarily by fast industrial growth and infrastructure building. But past 2010, the investment rate of India fell slowly to settle around 30% to 32% of GDP. The level of capital formation in Bangladesh shows an upward trend from approximately 17% in the 1990s to more than 33% in 2023, implying an increase of infrastructure investment and private sector. The same was also true for Nepal (green bars), where it became even stronger, crossing 35% in some years which indicates a more favorable investment climate. By contrast, Pakistan's GCF is the lowest and stagnant at 13% to 18% of GDP, reflecting deep structural and investment challenges.

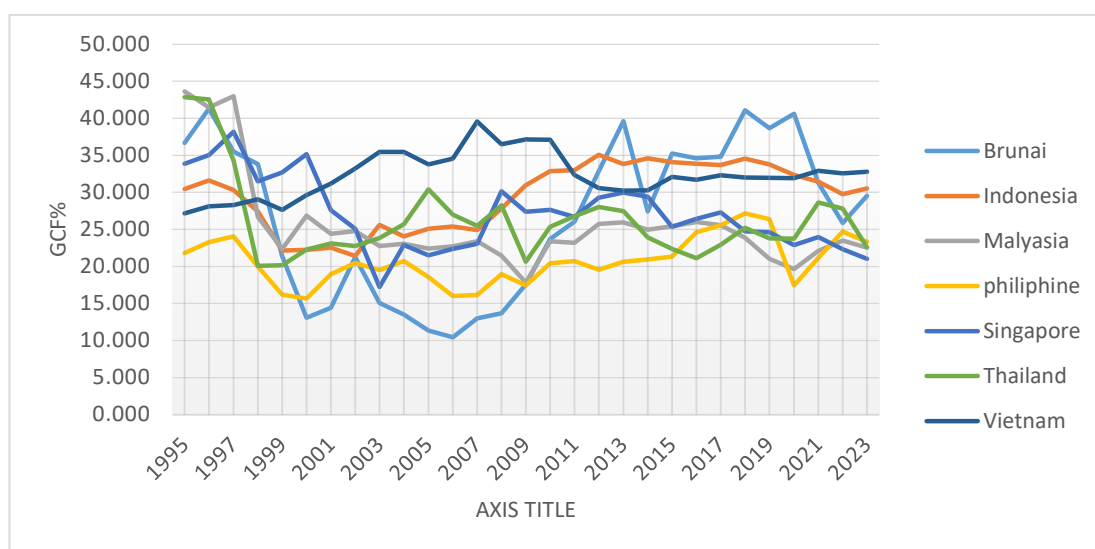


Source: World Bank, 2025

Figure 4.12: Gross capital formation % of GDP (South Asia)

Sri Lanka achieved between 22% to 30% of GDP with a less noticeable rebound post-2010. The figure highlights a favorable investment momentum in Bangladesh

and Nepal. There is a stabilizing trend in India and there is a relatively low level of investment intensity in Pakistan and Sri Lanka. The diverging trends indicate contrasting economic fortunes and priorities for development, with implications for sustained growth, job creation and infrastructure preparedness in the South Asian region.



Source: World Bank, 2025

Figure 4.13: Gross capital formation % of GDP (ASEAN)

The figure depicts the gross capital formation, % of GDP, for the ASEAN countries for the period 1995–2023. Gross capital formation (GCF) is simply, investment in things like infrastructure, machinery, and buildings that help enhance future production. From the graph, two countries such as Vietnam and Brunei had higher ratio in particular reaching more than 35–40% in some years, reflecting strong investment. Indonesia and Singapore trended slightly more steadily, ranging overall from 25% and 35%, whereas similar trends were observable but not at such pronounced extremes. By contrast, the Philippines and Thailand have had lower and more variable rates, generally between 20 and 25% indicating less regular investment patterns.

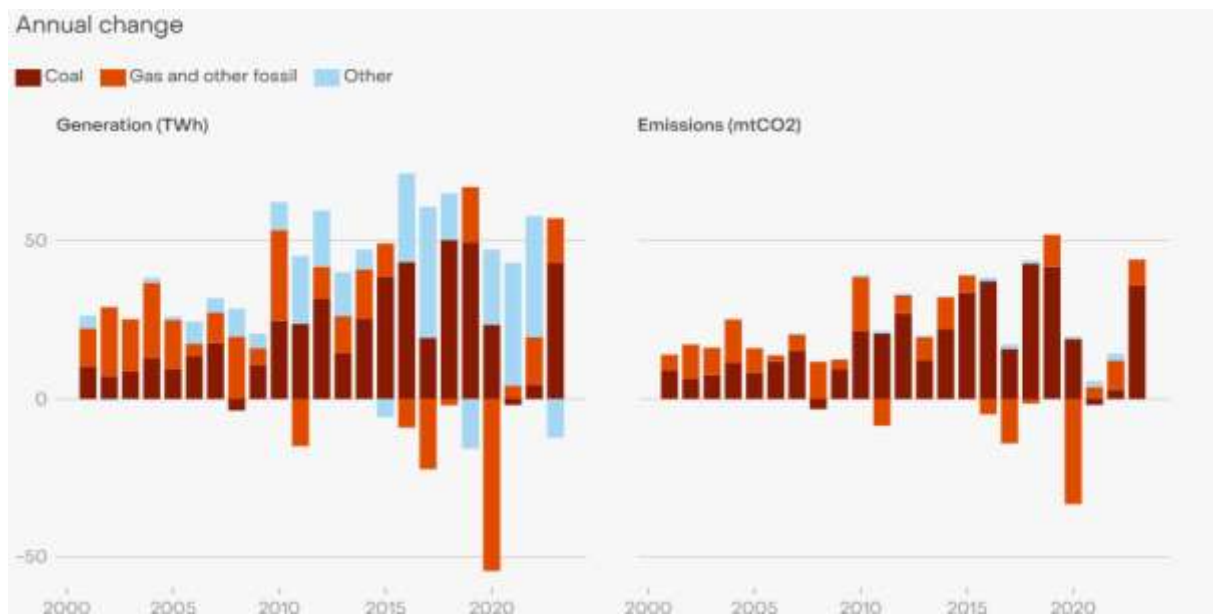
As the above graph demonstrates, many of the ASEAN economies have been through an initial period of volatility in the late 1990s and early 2000s, when, broadly speaking, the figures for investment to GDP were much closer to trend

growth. In recent years (2015–2020) Vietnam has an outstanding high investment rate of nearly 40%, which portrays its fast-paced economic growth and industrialization. Brunei, on the other hand, had high fluctuations and sometimes sudden declines followed by recovery, which raised the possibility of oil-price dependence. Overall, the chart suggests that ASEAN countries differ in their rates of investment, but most lie in the range of 20–35% of GDP, indicating that capital formation continues to be an important source of growth in the region.

4.7 FOSSIL FUEL AND RENEWABLE ENERGY CONSUMPTION

The Figure 4.14 depicts yearly variations in electricity production (TWh) and carbon dioxide (CO₂) emissions (mtCO₂), respectively, originating from fossil fuel use throughout the ASEAN area. On the right side of the chart, there is corresponding annual evolution of CO₂ emissions, with a similar color palette showing results for each type of fossil fuel. Fossil fuel electricity generation has steadily grown since the early 2000s, with coal and gas being the two dominant forms. After the mid-2000s, coal's contribution has been historically highest among sources of generation. Regular spikes in electricity generation are also apparent, usually when higher energy is demanded, both from industrial and economic sector. But there are also significant drops, which reflect economic slowdowns, orienting shifts in energy policy or global crises. And the light blue bars show us the benefit from non-fossil sources, with periodic growth, which possibly indicates a more significant involvement from renewable energy or some alternative energy sources in the inventory.

This is similar to the pattern shown in the right-side chart, which depicts annual changes to CO₂ emissions. Higher CO₂ emissions levels directly correlate with elevated fossil fuel-based electricity production, especially in years marked by peak coal and gas use. The highest emissions increases are in years of rapid coal-fired power expansion, reflecting coal's carbon intensity being several times greater than that of other fuels.

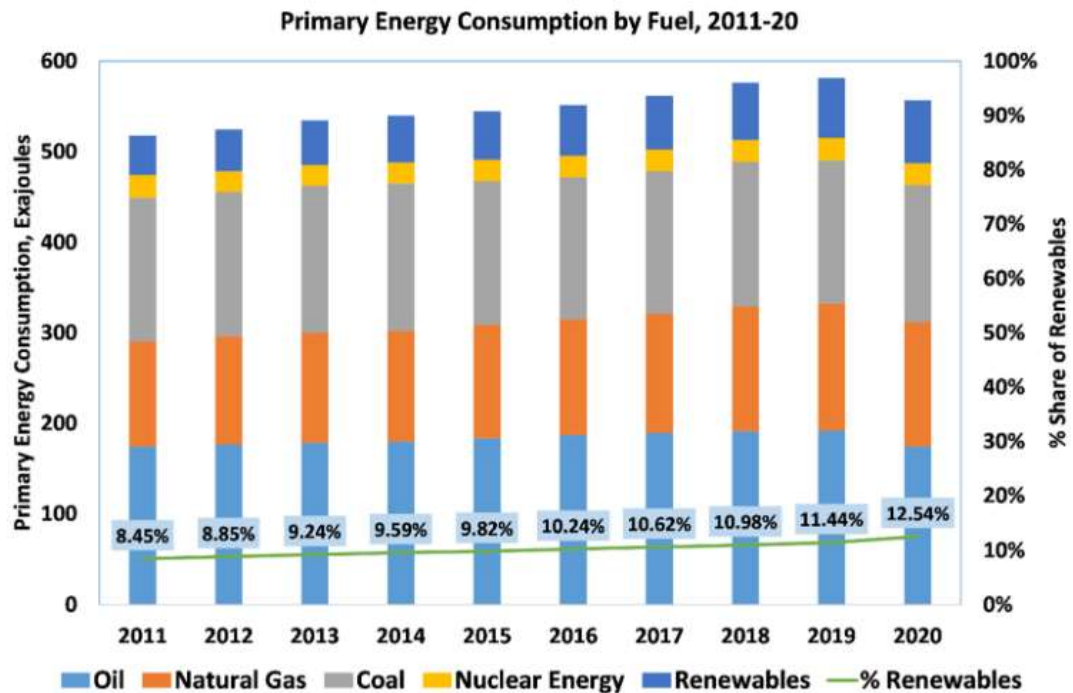


Source: Yearly electricity data, Ember

Figure 4.14: Emission Growth in the ASEAN's Electricity Generation and Power Sector Emissions has been Driven by Fossil Fuels

By contrast, years of declining coal or gas consumption do not correlate with declines in emissions, although they are less common. There is a notable decrease in power generation and emissions around 2020, caused primarily by the temporary loss of energy demand due to lockdowns, reduced industrial activity, and decreased transportation demands. However, the downturn is met with a surge in the following years pointing to a resurgence in energy use and the respective emissions.

The increase in light blue bars in power generation, particularly after 2015, indicates that ASEAN countries are slowly adding more alternative and renewables to their grids. Despite some progress, the continued dominance of coal and gas suggests fossil fuels are still a dominant part of the region's energy mix. Going forward, an energy transition that is sustainable will need further investments in renewables and policies that reduce reliance on carbon-intensive power-generation sources to rein in growth in emissions and align with global climate goals.



Source: Mittal, A. (2023)

Figure 4.15: South Asian Energy Consumption

The Figure 4.15 displays the fuel type of primary energy consumption from 2011 to 2020. The color-codes of energy sources are oil (blue), natural gas (orange), coal (gray), nuclear (yellow) and renewables (green). The green trend line shows the percentage share of renewables in the total energy mix and exact figures are labelled for each year. “Throughout the 2010s, oil, coal, and natural gas all contributed together to overwhelmingly comprise most primary energy consumption.” Oil continued to account for the largest share, followed by coal and natural gas, reflecting the continued reliance on fossil fuels in the region. Nuclear energy continued to provide a small, consistent share of energy, and renewables, starting from a very small base, showed a slow but steady growth in their share of the total energy mix.

The proportion of renewables steadily grew from 8.45 percent in 2011 to 12.54 percent in 2020, indicative of an emancipation from the fossil fuels to less harmful alternatives. Favorable policies, technological progress, and investment in renewable resources (e.g., solar and wind) have contributed to this growth. The growth rate is

small while the trend is positive, indicating a shift toward sustainability. The actual breakthrough seems slow with fossil fuels are still in dominance across the region's energy market.)

Although South Asia is blessed with significant renewable energy potential, it is still highly dependent on oil, gas and coal, a factor that highlights the challenge of making a significant transition to clean forms of energy. Whether this last decade belongs to energy transition will be decided by policies and investments for future energy systems that helps to accelerate the transition towards renewables and cut dependence on carbon-intensive fuels. The ongoing rise in share of renewables is encouraging, but much more is needed to achieve climate goals and deliver energy sustainability for the region for the long term.

4.8 LABOR FORCE PARTICIPATION RATE

Table 4.1 reports the fraction of the population of working age (usually 15 years and older) that is employed or searching for employment. The dataset (World Bank, 2025) captures the relative economic activities of the peoples of ten ASEAN countries. Looking at the table, labour force participation rate (LFPR) in Cambodia is the highest at 75.8%, followed by Vietnam (73.0%) and then Singapore (69.3%). At the bottom, Myanmar is lowest with 55.5% LTFP, and Laos, Philippines and Brunei are between 59% to 64%. Cross-country differences in LFPR is driven by various socio-economic and demographic factors. In countries such as Cambodia and Vietnam where the informal and agricultural sector is high with 90% of workers (able bodies) that are engaged in labour because they must even work without any contracts. Cultural attitudes and a dearth of social security may also force people especially women and young people into jobs. On the other hand, for Singapore, which has similar institutions to the Australian economy, but higher income levels, a high labour force participation comparison, there are policies to encourage older workers and women to return to the labour force such as through training incentives, tax rebates, and flexible work arrangements. Lower LFPRs in Myanmar, Laos and Philippines can be associated with structural issues like political instability, weak labour market, lack of decent work opportunities, or people furthering their education

at young ages, thus joining the workforce later. In the case of Myanmar, persistent political instability and economic disruptions have also contributed to depressing such patterns of formal employment participation. At the same time, gender roles, care responsibilities and inability to access employment services obstruct the engagement of women in many ASEAN member states.

Table 4.1: Labour Force Participation Rates in ASEAN Countries

Country	LFPR (2023)
Cambodia	75.8 %
Vietnam	73.0 %
Singapore	69.3 %
Indonesia	67.6 %
Thailand	67.1 %
Malaysia	65.0 %
Brunei	64.3 %
Philippines	60.2 %
Laos	59.6 %
Myanmar	55.5 %

Source: World Bank, 2025

Table 4.2 South Asia Labour Force Participation Rates in 2023

Country	LFPR (Total)	Male LFPR	Female LFPR
India	57%	77%	33%
Pakistan	49%	83%	24%
Bangladesh	58%	-	36%
Nepal	80%	-	59%
Sri Lanka	72%	76%	35%
Afghanistan	-	-	23% (2019)
Bhutan	-	-	62% (2019)
Maldives	-	-	43% (2019)

Source: World Bank, 2025

The South Asian averages for the total men and women LFPR are shown in Table 4.2. The LFPR records the proportion of those aged 15 and over in work or searching for work. The data reveal huge disparities among countries and considerable divergences of results between the sexes. Nepal stuns with the highest aggregate LFPR at 80%, strikingly high in the female LFPR component at 59%. Many women participate in even the informal sector particularly agriculture. Sri Lanka exhibits a similarly high aggregate LFPR of 72% with male and female rates at 76% and 35%, respectively, reflecting high education levels and relatively more employment opportunities. India has an aggregate LFPR of 57 percent, but it is highly skewed between men (77 percent) and women (33 percent) due to gendered barriers such as social norms, unpaid care work, and safety and security in public spaces or workplace. Bangladesh has a relatively small gender gap compared to India and Pakistan with total LFPR at 58% and women at 36% due to its large share of female garment workers and growing urban opportunities. The country with the greatest gender gap is Pakistan where 83% of men and 24% of women are in the LFPR, despite a total LFPR of about 49% to 50%, indicating strong cultural norms and job market availability among women. Even in the handful of countries in which these are outdated in case of Afghanistan with 23 per cent of women worked, Bhutan with 62percent and Maldives with 43 per cent of women were in employment. It is clear

that there are gaps in gender equality in South Asia. Such differences require comprehensive labour policies, the scaling up of education and skilling for women and social reform that enhances female participation in economic life.

4.9 TECHNOLOGICAL INNOVATION

Table 4.3 compares the performance of the South Asian countries on the Global Innovation Index (GII), which measures innovation capacity in terms of inputs (institutions, human capital, infrastructure) and outputs (knowledge and technology outputs and creative goods and services). The table covers five Countries-India, Pakistan, Bangladesh, Nepal, and Sri Lanka-along with their GII scores and global rankings. India is the top-ranked economy in South Asia with a GII score of 38.3, ranked 39 in the world and ranked 2 among other lower middle-income economies. This high position is indicative of India's capabilities in providing ICT services, scientific publications, start-up ecosystem and digital public infrastructure such as Aadhaar and UPI. India has a flourishing tech ecosystem in cities like Bengaluru, Hyderabad and Pune, as well as government-led innovation campaigns in the form of programs such as Startup India and Digital India. Sri Lanka ranked 89th with a score of 22.6 outscoring its regional counterparts Pakistan, Bangladesh and Nepal. This humble rating shows its average performance in terms of its education, services, and technology capacity. However, low investment in R&D and political unrest are still its main inhibitors. Pakistan is at 91st place with GII score of 22.0, which exposes its obstacles in infrastructure, R&D output and education. Although there are pockets of innovation in software development and e-commerce, structural problems are slowing the march forward. Bangladesh and Nepal score 19.1 and 18.1 respectively, placing them at 106th and 109th respectively. The low scores imply the underinvestment in innovation ecosystems, weak patenting and publication output, and inadequate investment in science and technology infrastructure. Even if ICT access and industrial development have made some progress (particularly in garments for Bangladesh), both Pakistan and Bangladesh face underfunded research systems, and low levels of public-private collaboration. It shows a stark innovation divide in South Asia, although India stands out as an anomaly in the region. The

majority of nations are still lagging far behind that of global innovation leaders due to under-investment, policy limitations, and lack of skilled manpower. To bridge this divide, the report calls for targeted changes to education, R&D support, digital connectivity and governance.

Table 4.3: Global Innovation Score in South Asia

Country	GII Score (2024)	Global Rank
India	38.3	39th (2nd among lower-middle-income)
Pakistan	22.0	91st (lower-middle-income)
Bangladesh	19.1	106th (lower-middle-income)
Nepal	18.1	109th lower-middle-income
Sri Lanka	22.6	89th lower-middle-income

Source: theglobaleconomy.com, 2024

Table 4.4: Global Innovation Score in ASEAN Countries

Country	GII Score (2024)	Global Rank
Singapore	61.2	4th globally
Malaysia	40.5	33rd globally
Thailand	36.9	41st globally
Vietnam	36.2	44th globally
Philippines	31.1	53rd globally
Indonesia	30.6	54th globally
Brunei	22.8	88th globally

Source: theglobaleconomy.com, 2024

A comparison of the respective ASEAN countries in terms of their ranking according to the Global Innovation Index (GII) developed by the World Intellectual Property Organization (WIPO) to assess the innovation capacity and the innovation output of countries can be found in Table 4.4. The GII is one of those indices that are based on several indicators including human capital, research, infrastructure, market sophistication, and creative outputs. Table 4.4 shows the GII scores and global rankings of seven ASEAN countries in 2024 and reveals the region's diverse innovation profile. Singapore leads the index with an impressive score of 61.2 making it fourth in the world. This performance further enhances Singapore's position as a global innovation leader, supported by strong institutions, world-class infrastructure, a highly skilled workforce and investment in R&D. Singapore is really good at this, incubating and commercializing new technology, supporting start-ups, and encouraging private and public sector collaboration. Its additional smart nation developments and strong fintech, biotech and logistics industries contributed to its innovation success. Malaysia has a GII score of 40.5 and ranks 33rd in the GII 2019, pointing to a strong innovation system at the level of upper-middle-income economies. Malaysia has heavily invested in tertiary education, including higher education institutions. It has funded the development of integrated circuits and established infrastructure for the design of semiconductors, IT and software engineering. In addition, performance is driven by government initiatives such as the Malaysia Digital Economy Blueprint and national innovation policies.

Thailand's rank of 41st and Vietnam's rank of 44th trail not so far behind at 36.9 and 36.2 respectively on the GII. Both countries have developed into vibrant innovation ecosystems in ASEAN. On the Thai side, it has emphasized on its digital economy initiative, Advanced Manufacturing (Thailand 4.0) and start-up initiatives. Investment in education and government backed science and technology have led to such progress. Scoring 31.1 and 30.6, the Philippines and Indonesia are 53rd and 54th on the planet respectively. Both countries have made successes in recent years but still suffer from a lack of research and development investment, bureaucratic shortcomings and uneven access to digital tools. The Philippines has BPO and creative industries as its strong points, and Indonesia is currently leading in the

development of fintech, agritech, and innovative e-commerce. Brunei has the lowest of the listed ASEAN countries, but is 88th globally, and has a GII of 22.8. This is due to its narrower base of innovators, lack of diversification outside of oil and gas, and inadequately developed research system. Nevertheless, Brunei has made over the past few years a renewed investment in the ICT infrastructure and is putting in place the education reforms aiming to enhance the innovation landscape. This has resulted in a diverse innovation performance across the ASEAN countries. Singapore is obviously out ahead in the region, and is competitive globally, while in Thailand, Indonesia, Philippines there is a steady move led by policy and investment. Meanwhile, Brunei, Philippines and Indonesia are further behind but with promising evolution if a combination of research, education and digital ecosystems can be developed. The findings are indicative of both the diversity and the opportunity that exist within the ASEAN innovation system. It is imperative for a regional-level risk- and success-sharing innovation-based growth strategy.

CHAPTER 5: RESULTS ANALYSIS

5.1 INTRODUCTION

The following chapter covers descriptive statistics and econometric tests for South Asia and ASEAN countries in context of environmental implication for the foreign direct investment (FDI). This analysis has a goal of investigating the interactions among primary environmental variables, labor force participation rate, technological innovation, energy consumption, and economic growth.. Taking advantage of the wide-ranging application of several advanced statistical methods, we explore how these variables interrelate and contribute to the environmental and economic development of South Asia and ASEAN countries.

It conducted a series of econometric tests from the Homogeneity Test, Cross-Sectional Dependence (CSD) Test, Unit Root Test, CIPS Test, PMG ARDL (Pooled Mean Group Auto-Regressive Distributed Lag), FMOLS (Fully Modified Ordinary Least Squares) and Causality Tests to determine the robustness of the findings. The tests enable not only to learn about the long-run relationships among the variables but also to clarify the causal linkages underlining the economic performance in both regions. It provides in-depth results and interpretations across both regions in the subsequent sections for South Asia and ASEAN countries. Section A covers a South Asian analysis, regional studies, and the relationships between FDI, labor forces, technology, and economic growth. Section B applies this analysis to ASEAN countries, allowing a comparative review that underscores both similarities and differences between these variable. Section C covers the environmental implications for foreign direct investment in South Asia and ASEAN country wise.

Performing these tests on South Asia as well as the ASEAN is likely to provide insights not just into the region-specific trends and dynamics in the economic variables relevant for sustained economic and environmental development but help in the comparison across the two regions and country wise in designing appropriate economic policies for sustainable economic and environment development.

5.2 SECTION A: SOUTH ASIAN COUNTRIES RESULT ANALYSIS

The subsequent tables provide a detailed calculation and analysis of the environmental impact of different economic factors for South Asian countries. Its data is used to analyze and uncover the complex relationships that shape environmental outcomes, with a particular focus on explaining both positive and negative causation between foreign direct investment and environment in South Asia. This is important because environmental implications are often a byproduct of economic growth in developing countries.

5.2.1 Descriptive Statistics

The descriptive statistics in Table 5.1 presents an overview of the attributes of the dataset, an important step for carry on econometric analysis. The mean, the average value for each variable, and the median, the middle value has been calculated. The proximity of mean and median for many variables indicates a relatively symmetric distribution, which is a requirement of linear regression assumptions. These statistics reflect the extent of spread between the maximum and minimum observations in the data. Also, a high range can highlight the presence of potential outliers or high variability in the data, which can influence underlying econometric models. It gives the spread or dispersion of the data points around the average. Variables such as LNENV and LNENRC have considerably higher standard deviation which shows that the variability is high. This can lead to the reduction in accuracy of estimates in regression models. Given the skewness of the distribution of this data, values around zero indicates a normal distribution, which is preferable for many econometric methods. However, LNRENRC and LNTAI are slightly skewed and may require some transformation or use of robust methods instead.

Table 5.1: Descriptive Statistics

	LNENV	LNENRC	LNFDINIF	LNNEG	LNCF	LNLF	LNRENRC	LNTAI	LNTRM
Mean	-0.377835	6.226866	21.12928	26.15331	24.50192	4.032173	1.852245	7.212505	19.94974
Median	-0.285476	6.142971	21.04457	25.96528	24.22977	4.040513	2.265304	6.481658	20.42412
Maximum	0.727549	9.290800	24.88779	28.79388	27.81131	4.142134	3.489381	11.04409	24.17835
Minimum	-1.722425	3.707167	14.45545	24.10931	21.93303	3.897599	-0.674139	5.030438	11.81441
Std. Dev.	0.574408	1.666010	1.830785	1.251407	1.563237	0.053551	1.131431	1.826535	2.662559
Skewness	-0.423365	0.343311	-0.050412	0.483052	0.496887	-0.501737	-0.867979	1.029336	-0.954124
Kurtosis	2.942130	1.953208	3.955225	2.308579	2.419621	2.337186	2.375383	2.583424	3.940391
Sum	-43.8289	722.3165	2450.997	3033.784	2842.222	467.7320	214.8604	836.6506	2314.170
Sum Sq. Dev.	37.94363	319.1926	385.4542	180.0922	281.0266	0.329789	147.2155	383.6665	815.2606

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13.

Normal distributions have a kurtosis value near three. In contrast, high values (LNFDINIF, LNTRM) correspond to heavy tails, indicating the presence of outliers or extreme values affecting the analysis. They provide the sum of the observations and the squared sum of the observations, respectively. These are useful in the computation of variance and other statistics, being the basis for more advanced econometric models. Familiarity with these statistics also assists in diagnosing possible problems such as multicollinearity, heteroscedasticity or non-normality, important features for econometric analysis and model. This type of analysis is necessary to determine which econometric methods to use, including (but not limited to), transformation of dependent or independent variables, heteroskedasticity or cluster-robust standard errors, or completely different estimation techniques.

Table 5.1 helps to describe the descriptive statistics about the variables. Mean value of the variable LNENV is -0.377835 and with moderate dispersion, slight left skew is observed with -0.423365 , with only a few values above the mean value. LNENRC varies greatly Std. Dev. 1.666010 with a slight positive skew. LNFDINIF is with high mean 21.12928 and near symmetric but fatter tails with Kurtosis as 3.955225. LNEG and LNCF do present high means and moderate variability, with slight right skewness.

As can be seen from this, LNLF has a low mean 4.032173 and with moderate variability, and slight left skew. LNRENRC and LNTAI are very high variate, and LNRENRC is left skewed while LNTAI for right hand side of histogram loses distribution and has many extreme tails. LNTRM's mean value is 19.94974 that is very high, having left skewed and has large variance and heavy tails. This shows signs of problems like skewness and kurtosis, which may require variable transformation before going to econometric analysis.

5.2.2 Correlation Analysis

The analysis of correlation in panel data is important since it takes into account the relationships between variables over time and across different countries in South Asia. It allows for the understanding of trends, correlations and potential causation. Using correlations, can control for multicollinearity and obtain better model estimations. It also helps to understand the role of unobserved heterogeneity in longitudinal data.

Table 5.2 shows the relationships between the various variables by analysing their positive and negative correlations. The coefficients take on values between -1 and 1, with values closer to 1 indicating a strong positive relationship, values closer to -1 indicating a strong negative relationship, and values near 0 suggesting little, or no, relationship at all. Specifically, LNENRC has a very high positive relationship with LNFDINIF (0.85) and LNTAI (0.92) which imply a tendency for these variables to go together. This suggests that whenever one variable increases, the other also increases, and it might be worth considering to investigate the reasons behind this. Likewise, LNCF is similarly and positively correlated with variables like LNENRC (0.91) and LNTAI (0.86), suggesting that variables may reflect substantive relationships between the features. Conversely, there are some variables that have negative correlation. LNEG, for instance, shows a low negative correlation with LNF (-0.29), indicating that when LNEG rises, LNF usually falls. This inverse relationship may suggest conflicting forces acting upon these variables or opposing trends. LNRENRC also displays a significant negative association with LNLF (-0.49), indicating an inverse relationship that could warrant further investigation. The correlation matrix provides an efficient way to highlight meaningful relationships between the dataset variables, laying the groundwork for hypothesis-driven exploration of their interactions in subsequent research. Correlations between entities are an ongoing knowledge which could allow prudent decision making or a prognosis based on the data.

Table 5.2: Results of Correlation Analysis

	LNENV	LNENRC	LNFDINIF	LNEG	LNLF	LNRENRC	LNTAI	LNTRM	LNCF
LNENV	1.00	0.69	0.81	0.72	-0.47	0.50	0.80	0.43	0.71
LNENRC	0.69	1.00	0.85	0.99	-0.34	-0.06	0.92	0.34	0.91
LNFDINIF	0.81	0.85	1.00	0.88	-0.29	0.05	0.85	0.40	0.90
LNEG	0.72	0.99	0.88	1.00	-0.29	-0.08	0.92	0.31	0.96
LNLF	-0.47	-0.34	-0.29	-0.29	1.00	-0.49	-0.30	-0.24	-0.12
LNRENRC	0.50	-0.06	0.05	-0.08	-0.49	1.00	0.19	0.32	-0.17
LNTAI	0.80	0.92	0.85	0.92	-0.30	0.19	1.00	0.48	0.86
LNTRM	0.43	0.34	0.40	0.31	-0.24	0.32	0.48	1.00	0.28
LNCF	0.71	0.91	0.90	0.96	-0.12	-0.17	0.86	0.28	1.00

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

5.2.3 Slope Heterogeneity Test:

In this study, first test is for slope heterogeneity. Whether the relationships (or coefficients) between the dependent variable (in our case, environmental and economic variables) and the independent variable are homogeneously aligned across the sample, or heterogeneously so. In essence, the test checks whether the effect of any independent variable differs across the case data significantly.

Table 5.3: Slope Homogeneity Test Δ Statistic P-value

Pesaran, Yamagata. 2008	Delta	P Value
Δ test	4.457	0.000
Δ_{adj} test	5.507	0.000

Source: World Development Indicator (WDI) 2025 and calculation using STATA-16

H0: Slope coefficients are equal or, homogeneous (equal homogeneity), here, the relationship of each independent variable (whether environmental or economic) with the dependent variable of same country or observation in sample is identical

Again, the p-value for this test is miniscule (0.000), which implies that we reject the null hypothesis for any conventional significance level (1%, 5%, 10%, etc.). What this indicates is that there is enough evidence to indicate that slope coefficients are not homogenous which means that the relationships between each of the independent variables and the dependent variables (like environmental implications and economic growth) indeed have differences across the observations in the dataset.

Table 5.4: Blomquist & Westerlund (2013) also for Testing for Slope Heterogeneity

Blomquist, Westerlund. 2013	Delta	P Value
Δ test	4.457	0.073
Δ_{adj} test	5.507	0.027

Source: World Development Indicator (WDI) 2025 and calculation using STATA 16

H0: There is homogeneity of the slope coefficients across observations. H1: There is heterogeneity of the slope coefficient across observations.

Here, the p-value for the test turns out to be 0.073, which is higher than the usual 5% significance level, but lower than 10%. The implication is that if we fail to reject the null hypothesis at the 5% level we may reject it at the 10% level. There could be heterogeneity in the relationships between the variables in the sample since the adjusted p-value (0.027) is significant at the 5% level. This indicates some heterogeneity in the data, albeit less conclusively than the Pesaran and Yamagata test.

The initial, Pesaran and Yamagata (2008), test indicates that there is strong heterogeneity in the slope coefficients, implying that the linkages between economic and environmental variables is heterogeneous across the South Asian countries. That shows that one single model could not explain the complexities of these relationship across all the countries.

5.2.4 Cross Sectional Dependency (CD) Test:

The Breusch-Pagan LM test and Pesaran CD test are the primary methods used to identify any cross-sectional dependency in panel data, which is very relevant to our analysis of South Asian countries. These tests assess the cross-country correlation of the empirical residuals from a panel data model. The Breusch-Pagan LM test assesses for independence in the error terms, and the Pesaran CD test is stronger, allowing for spatial and temporal correlations. If the tests result in p-values that fall below the conventional threshold of 0.05, it signifies that cross-sectional dependence is present, implying that the error terms of the countries are correlated. This indicates that the countries have similar influences and therefore need to be included in the model to avoid biased estimates and also obtain accurate and reliable results for policy recommendations

Table 5.5: Result of Breusch-Pagan LM Test

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	17.71932	6	0.0070
Pesaran scaled LM	2.228376		0.0259

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Table 5.5 The Breusch-Pagan LM test and the Pesaran scaled LM test can perform the cross-sectional dependence. Breusch-Pagan LM test: statistic = 17.71932, df = 6, p-value = 0.0070. As the p-value is less than the usual significance level of 0.05, we reject the null hypothesis of no cross-sectional dependence. What this means is that there is a lot of correlation between the error terms across the cross-sectional units in the panel data. That is, the data in the countries are no longer independent of each other, and their error terms are likely mutually influenced by common trends.

The Pesaran scaled LM test statistic (2.228376) with the corresponding p value (0.0259) supports cross-sectional dependence. Similarly, the p-value, like that of the Breusch-Pagan, is less than 0.05, indicating that we reject the null hypothesis of no cross-sectional dependence. These results corroborate the Breusch-Pagan LM test confirming the correlation of error terms of the panel data among the cross-sectional units, thus and also confirming the cross-sectional dependence. Importantly, there is a need to address cross-sectional dependence in the analysis of these results, as nuisance estimates and invalid statistical inferences will necessarily be made if they are ignored. This correction leads to more accurate, reliable, and true relationships in the examined data. Next step is to use Pesaran CD test for confirmation.

In Table 5.6, the Pesaran CD test statistics indicate a strong cross-sectional dependence among most of the variables of South Asian countries. LNEG (Log of Economic growth) has had a test statistic of 13.03671, LNENV (Environmental degradation) at 11.87369, and so on. Likewise, LNCF (capital formation) and LNENRC (Energy Consumption) of that the value is high about 12.28044 and 12.53994 respectively.

Table 5.6: Pesaran CD Test Result (t-stat)

Pesaran CD	Statistics
LN _{EG}	13.03671***
LN _{ENV}	11.87369***
LN _{CF}	12.28044***
LN _{ENRC}	12.53994***
LN _{RENRC}	1.645516***
LN _{FDINIF}	9.860977***
LN _{LF}	-1.64992*
LN _{TRM}	12.64778***
LN _{TAI}	4.865894***

***, **, and * indicates 1%, 5% and 10% level of significance.

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

These very high values, all significant at the 1 % significance level, pointing toward a strong inter relatedness among the variables such as energy use, pollution, capital formation and economic growth dependency across countries in this region. When one country, for example India, spills over some energy demand or emissions spike, the neighboring countries such as Bangladesh or Pakistan are virtually affected through both economic and environmental spillovers.

From the other key variables such as LN_{FDINIF} (FDI in flow) having 9.860977 and LN_{TRM} (Tourism) = 12.64778 also shows significant cross-country linkages. Such results are not surprising in a region in which economic activities such as trade and investment often transcend national borders and are governed by common institutions and global market trends. In contrast, the LN_{TAI} with a test statistic of 4.865894 depicts significant dependence, which suggests that any technological changes in one of the South Asian countries are likely to affect the other region due to either regional integration, transference of technological innovation or multinational presence. All these variables reveal significant dependence at 1% level

pointing to how regional dynamics can be significant not just in economic modeling but environmental modeling as well.

But not all variables are equally interdependent. LNRENRC (Renewable Energy Consumption) has a lower t-statistic of 1.645516 but significance, LNLFF (Labor Force) also is negative (-1.649920) but significant at only the 10% level. Although South Asia is well interconnected in the fields of fossil fuels and tourism, their renewable energy strategies as well as labor market dynamics may still remain domestic and independent. It could be that, for example, Pakistan increases its hydropower capacity regardless of what India, or Sri Lanka, are doing. These more localized trends mean that such cross-country dependence is weaker over these areas, revealing the diversity in national policy and priorities across the region. Results at the overall level lend strong support for the existence of cross-sectional dependence in most key regions, mandating its consideration in any econometric model that seeks to analyze South Asian countries for coherent inference.

So, discovering the strong dependence cross-section among variables (like Pesaran CD test), it can't rely on first-generation unit root tests (like Levin-Lin-Chu or Im-Pesaran-Shin), since they assume cross-sectional independence (like Pesaran CD test). This is where the CIPS test comes in, which is designed for this purpose; it is a second-generation unit root test based on Pesaran (2007) that accommodates the cross-sectional dependence in panel data.

5.2.5 CIPS Unit Root Test

Table 5.7 shows the stationarity of the panel data variables using the Unit Root test CIPS. Econometric analysis significantly relies on the properties of stationarity since non-stationary data can provide misleading regression results. Results are shown "At Level" and "1st First Difference" with * ** significance at 1%, ** significance at 5%, and * significance at 10%.

Table 5.7: CIPS Result

<i>Variable</i>	<i>At Level</i>	<i>First Difference</i>
LNEG	-1.547	-3.599***,
LNENV	-2.72	-4.622***,
LNCF	-1.742	-5.147***,
LNENRC	-2.381	-5.379***,
LNRENRC	-4.373***	-6.255***,
LNFDINIF	-4.371***	-5.074***,
LNLF	-2.684	-3.981***,
LNTRM	-1.473	-2.292*
LNTAI	-3.619**	-5.845**

***, **, and * indicates 1%, 5% and 10% level of significance

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

At level, LNEG, the test stat is -1.547, which is not significant at conventional levels. There is evidence that LNEG is non-stationary at level or contains a unit root and the mean and variance are changing over time. LNENV is also non-stationary in level, with a statistic of -2.72. The nonstationarity indicates that a shock to LNENV has a permanent impact and that the process does not revert to a long-term average. The value of test statistics of LNCF is -1.742, indicating non-stationarity at level. This indicates that LNCF's time series characteristics are unstable and can be affected by trends or otherwise non-stationarity. Test statistic for LNENRC is -2.381, that is failed to reject at level. LNRENRC is stationary at level, 1% level. This suggests that LNRENRC is return closer to its normal long-term level.

The statistic of -4.371 for LNFDINIF also indicate stationarity at level, significant at 1% level. This indicates that LNFDINIF is stable and does not contain a unit root. The test statistic of LNLF is -2.684; therefore it's not stationary at level. This suggests non-constant time series properties for LNLF, which could be persistent shocks. LNTRM statistics is -1.473, non-stationary at level this indicates which is not mean-reverted signals or external factors are influencing LNTRM. LNTAI has the value, that is -3.619, the above statistic suggests stationarity at level of

significance at 5% .It suggests LNTAI is a mean-reverting process with time-invariant statistical properties.

At First Difference output states that, statistic of LNEG is -3.599 (1% significance) suggests stationarity after first differencing. This shows that LNEG is differenced in the identification unit root. Therefore, they are stable to analyse. LNENV with statistic of -4.622 indicates that LNENV is only stationary after first differencing at 1% level of significance. The purpose of this transformation is to make its mean and variance stable. The table shows that LNCF is stationary after first differencing and the statistic of -5.147 indicates that significance at the 1% level of significance. This shows that differencing does the job in removing this non-stationarity. LNENRC has a test statistic of -5.379 shows stationarity after first-differencing at 1% significance level of significance. This indicates that differencing stabilizes the time series properties of LNENRC. The first differenced series LNRENRC is stationary at the 1% level with test statistic of (- 6.255). It proves its time-invariant nature. Stationary after first differencing with test statistic of - 5.074 suggests that LNFDINIF should eliminate any unit root.

LNLF has test statistics of – 3.981 with p value of 0.000 that is significant at 0.01 and rejects H0: LNLF is stationary after first-differencing This process makes LNLF stable. For LNTRM, it is stationary at first difference with the statistic being -2.292 which carries significance at the 10%. This indicates that differencing is effective at making the time series stationary, but at a lesser confidence level. LNTAI, -5.845 implies that it is stationary after first difference with 5% level of significance. In other words, differencing makes LNTAI stationary. The results of the unit root test show that most of the variables need differencing to achieve stationarity. At level, only LNRENRC and LNFDINIF appear stationary, while differencing is needed for others.

All the variables become stationary after the first differencing indicates that all the variables are econometrically suitable. This transformation is critical to avoid false regression results and enable sound inference. Except LNTRM, all series are

stationary across the board, indicating strong evidence against trends after the first differences. LNTRM is significant at the 10% level, therefore further analysis that includes this series should be approached with caution. These overall results help inform the proper treatment of data in econometric modeling for robust and valid conclusions.

5.2.6 Kao Cointegration Test

The Kao cointegration test has significant importance to check the long-run equilibrium relationship among non-stationary variables. Panel data, which has both cross-sectional and time series dimensions, is appropriate for datasets where multiple entities (countries or firms) are observed at multiple time periods (Baltagi, 2005). The Kao test is appropriate in this scenario, since it allows for the assumption of a common cointegration vector across sections of the panel while testing for cointegration using the unique form of panel data. The cointegration between time-series is a very important precondition of estimation in models like a cointegrated vector autoregressive (CVAR) or vector error correction model (VECM). Given their ability to capture the short and long-run relationship between series, these models are favoured over typical regressions which may fail to generate non-spurious statistical inferences (Pedroni, 1999; Kao, 1999).

Table 5.8: Kao Cointegration Test

	t-Statistic	Prob.
ADF	-3.720552	0.0001
Residual variance	0.003127	
HAC variance	0.002506	

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The results of the Kao cointegration test conducted in relation to the selected panel variables of interest are presented in Table 5.8, which provide confirmation of the long-run relationship amongst them. The test is performed under the null hypothesis of no cointegration among the panel variables (H_0), versus the alternative hypothesis of cointegration among all panels (H_1). The test results provide significant evidence

against the null hypothesis. The Augmented Dickey-Fuller (ADF) t-statistic is -3.720552 with the ADF p-value of 0.0001 , which indicates good evidence to reject the null hypothesis of no cointegration. Residual variance (closely 0) evaluated at 0.003127 , which measures the residual variation of the estimated cointegrating regression. These results also indicate a HAC (Heteroskedasticity and Autocorrelation Consistent) value of variance equal to 0.002506 , allowing to make the test more robust against heteroskedasticity and comparing it with autocorrelation (Newey & West, 1987).

These results justify modeling both short-run and long-run dynamics in error correction models. The result of the cointegration suggests that some economic variables (like FDI, GDP, and environmental implications) are closely bounded by long-term structural links, and this type of models are more useful for policy evaluation and economic forecasting (Engle & Granger, 1987). Furthermore, new cointegration tests, specifically the ones augmenting the effects of cross-sectional dependence and individual heterogeneity, lead to more consistent empirical results in panel econometrics (Fukuda, 2017). Therefore, the Kao cointegration test not only confirms a key feature of long-run economic behavior but allows for the estimation of stable-structured econometric models.

5.2.7 Lag Selection Criteria

It shows that the results of a lag selection procedure is based on a range of criteria to estimate the optimal number of lags for the panel model in Table 5.9. Note that the LogL (log-likelihood) values grow with more lags, means better fit having the value of LR test as 168.0207 with p value of 0.0000 (at 5%).

Table 5.9: Lag Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-478.4339	NA	$6.73e-08$	9.026553	9.250064	9.117179
1	766.1378	2258.667	$2.96e-17$	-12.52107	-10.28596^*	-11.61482^*
2	868.0830	168.0207^*	$2.07e-17^*$	-12.90894^*	-8.662236	-11.18706

*indicates lag order selected by the criterion

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The FPE drops too with respect to lags, which would mean higher accuracy overall; however, the optimal value occurs at lag 2 ($2.07\text{e-}17$). Using AIC (Akaike Information Criterion), SC (Schwarz Information Criterion), and HQ (Hannan-Quinn Information Criterion) to find a trade-off between parsimony and fit. Here, Lag 0 is not suitable as it shows high values for AIC, SC, and HQ. Lag 1 is supported by SC (-10.28596^*) and HQ (-11.61482^*), marking it as their best choice. However, Lag 2 is preferred overall since AIC (-12.90894^*), FPE ($2.07\text{e-}17^*$), and LR (168.0207^*) indicate the strongest fit for the model.

Table 5.9: Overview of lag selection at various lags using AIC, SC & HQ criteria. The LogL (log-likelihood) values provide insights into the model fit to the data, with higher values denoting a stronger fit. The LogL increases substantially as the number of lags increases from 0 to 2 (from -478.4339 at lag 0 to 868.0830 at lag 2), which suggests that the explanatory power of the model improves with more lags. LR (Likelihood Ratio) test for whether the addition of lags significantly improves the model. The test indicates significant null at 5% level at lag 1 (2258.667) and lag 2 (168.0207^*) level, where the asterisk denotes lag 2 is statistically preferred. This means that each previously unconsidered lag represents valuable information for the model. FPE is an indicator of the predictive correctness of the model, hence lower values are better. The FPE is reduced from $6.73\text{e-}08$ for lag 0 to $2.07\text{e-}17$ for lag 2 but as number of lags increase, the model can better predict future values. These criteria look at the trade-off between the fit of the model and the complexity of the model: the AIC (Akaike Information Criterion), SC (Schwarz Information Criterion), and HQ (Hannan-Quinn Information Criterion). These penalize models with large amounts of parameters to reduce overfitting. The AIC value (-12.90894) at lag 2 indicates that this lag is the one that maintains the best ratio of fit and complexity. Taken together, the common selection of lag 2 across all criteria suggests this is the best model configuration in the sense of representing the data, being robust and parsimonious. By selecting a relatively simple model, we can account for the underlying dynamics while avoiding excessive complexity, allowing for reliable

forecasting and analysis. Thus, by determining the appropriate lag structure, this model can better take these time effects into account for econometric analysis.

5.2.8 Regression Output of Economic Growth Model

Table 5.10 shows the findings of an ARDL model with economic growth (LNEG) as the dependent variable. Those explanatory variables used for this model are labor force (LNLF), capital formation (LNCF), technological advancement (LNTAI) and LNFDINIF, in addition to the cointegration term (COINTEQ01) and short-run dynamics of all variables. The coefficient of LNFDINIF in the long-run equation is 0.278 with a p-value of 0.119, indicating a positive but statistically insignificant relationship between FDI and economic growth more than 0.10 in long-term. Coefficient of LNCF is 0.276 with p value of 0.023, showing a positive relationship between LNCF and economic growth, which is statistically significant at the 5% significance level. This implies that capital formation has a significant positive effect on economic growth in the long run. Thus, the coefficient of LNTAI is 0.173 with p-value of 0.441, meaning that technological progress has no effect on economic growth in the long run. But in the long run, the coefficient of LNLF is 6.592 with a p-value of 0.145 indicating a positive but insignificant effect on economic growth. In the short-run equation, the variable COINTEQ01 has a coefficient of -0.040 with p-value of 0.052, showing an adjustment process towards long-run equilibrium and being statistically significant at the 10% level.

Table 5.10: Result of ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Dependent variable: LNEG (Economic Growth)				
Long Run Equation				
LNFDINIF	0.278	0.177	1.573	0.119
LNCF	0.276	0.12	2.31	0.023
LNTAI	0.173	0.224	0.774	0.441
LNLF	6.592	4.48	1.471	0.145
Short Run Equation				

COINTEQ01	-0.04	0.02	-1.971	0.052
D(LNFDINIF)	0.003	0.01	0.253	0.801
D(LNCF)	0.066	0.01	6.688	0.000
D(LNTAI)	-0.012	0.02	-0.594	0.554
D(LNLF)	0.179	0.282	0.633	0.528
C	-0.539	0.305	-1.77	0.08

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Differenced terms represent the short-run effects of changes in the explanatory variables. The coefficient on D(LNFDINIF) is 0.003 and is not significant at conventional levels with p value of 0.801, indicating that foreign direct investment does not have a statistically significant short-run impact on growth. The coefficient that relates to capital formation (D(LNCF)) in the specific output of the model measures 0.066 with p-value of 0.000, which supports the claim on mentioned theory that capital formation highlights a positive short-run effect on growth of the economy. The coefficient estimate for D(LNTAI) is -0.012, with a p-value of 0.554 shows that technological innovation does not positively impact on economic growth in the short run. The coefficient for D(LNLF) is 0.179 with a p-value of 0.528, indicating that changes in the labor force do not produce a significant short-run effect on economic growth. The constant term C has a coefficient of -0.539 and a p-value of 0.080, which is marginally significant at the 0.10 level of significance. Now, conducting tests on long term versus short term, one can infer from the long-run results that capital formation plays statistically significant role for growth on long run with no effect of technological progress and domestic investment on long-run growth. In the short run and the long run, only capital formation significantly impacts economic growth.

Table 5.11: Results of FMOLS Method

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent variable: LNEG (Economic Growth)				
LNFDINIF	0.018	0.03	0.603	0.548
LNCF	0.485	0.038	12.622	0.000
LNTAI	0.069	0.068	1.016	0.312
LNLF	0.424	0.866	0.49	0.626

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The Table 5.11 presents Fully Modified Ordinary Least Squares (FMOLS) results which estimate the long-run relationship between economic growth (LNEG) and the other explanatory variables LNFDINIF, capital formation (LNCF), technological advancement (LNTAI), and labor force (LNLF). The estimated coefficient value of LNFDINIF is 0.018 with a p-value of 0.548, indicating that domestic investment needs a positive but statistically insignificant relationship with growth. According to this model, the high p-value indicates that FDI does not have a significant impact on economic growth in the long run. The coefficient of LNCF is 0.485 with p-value of 0.000, which shows a statistically significant positive relationship with economic growth as expected. We conclude that capital formation is the main and positive association of the economic growth in the long run. The relationship is significant at 1%, which demonstrates that capital formation is an important factor in economic development. For LNTAI, the coefficient is 0.069 underpinned by a p-value of 0.312, revealing that technological advancement has an economic growth that is positively correlated but statistically insignificant effect. This result suggests that technological progress, in this framework, has little effect on long run economic growth. LNLF has a positive sign, the coefficient is 0.424 with a statistically insignificance with p-value of 0.626, thus the size of the labor force has a positive influence on the economic growth. This carries a high p-value, indicating that fluctuations of the labor force do not contribute enough to economic growth, in the long run. The outcome of the FMOLS model indicates that in long run capital formation has a significant positive effect on economic growth, while domestic capital investment, technological progress and labor force size do not have any

statistically significant effects. This means that, in the long term, capital formation is the only variable contributing to economic growth, and the other variables do not significantly impact the output in this regression analysis.

5.2.9 Results of Basic Environmental Implications Model 1

Table 5.12 shows the output of South Asian countries, long-run and short-run relationship results of the basic environmental implications model (ARDL), the dependent variable environmental implications (LNENV), and the independent variables. Both outputs show the long run Equation and short run equation, respectively, based on the output. From the above long run result, foreign direct investment net inflow (LNFDINIF) has a coefficient of 0.019206 with t-statistic of 0.445664 and its p value 0.6569. Assume that the p-value for generic purpose is above the regular alpha (0.05), which indicates that LNFDINIF does not have a significant effect on environmental degradation in the long run. The coefficient for labor force participation rate (LNLFP) is -1.69948 and its t-statistic is -1.78726, and its p-value is 0.0773. Though it is close to 0.05 threshold, p-value is not significant at more conservative level, implying that in long run, labor force may have minor negatively correlated to environmental degradation. Capital formation (LNCF) has a positive and significant effect with coefficient of 0.251069 having t-statistic of 5.289177. Its p-value of 0.001 shows a significant long run contribution of capital formation on environmental degradation, meaning that 1% increase in the capital formation leads to 0.25% increase the carbon emission or environmental degradation. LNTAI has a positive coefficient equal to 0.041066, but it has a t-statistic value equal to 0.564756 with a p-value equal to 0.5737, which means that LNTAI has, in fact, no statistically significant influence on environmental degradation in the long run.

Table 5.12: ARDL Output of Basic Environmental Implications Model 1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
Long Run Equation				
LNFDINIF	0.019206	0.043096	0.445664	0.6569
LNLF	-1.69948	0.950883	-1.78726	0.0773
LNCF	0.251069	0.047464	5.289717	0.001
LNTAI	0.041066	0.072715	0.564756	0.5737
Short Run Equation				
COINTEQ01	-0.24901	0.065316	-3.81238	0.0003
D(LNFDINIF)	-0.00312	0.017803	-0.1751	0.8614
D(LNLF)	0.933494	0.339862	2.746687	0.0073
D(LNCF)	-0.01126	0.03317	-0.33935	0.7352
D(LNTAI)	-0.0166	0.014446	-1.14916	0.2536
C	-0.02801	0.033339	-0.84021	0.4031

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

In the short-run study, the error correction term or speed of adjustment term COINTEQ01 shows that the -0.24901 as its coefficient meaning that 24.901 percent of the past period's shock disequilibrium corrects to equilibrium in the current period. The results imply that there exist a strong and statistically significant long-run relationship between the variables, and deviations from the long-run equilibrium are being adjusted for in the short run. However, D(LNFDINIF) has a coefficient of -0.00312 with a t-statistic of -0.1751, and with a p-value of 0.8614. This finding implies that an increase in FDI does not significantly affect environmental degradation in the short term. D(LNLF) has a coefficient of 0.933494 with t-statistic value of 2.746687 and p-value of 0.0073, meaning that an increase in the labor supply plays an important role of promoting environmental degradation in the short run.

The coefficient of LNCF is -0.01126 and its t-statistic is -0.33935 with p-value of 0.7352, which means that changes in the capital formation do not have a significant

effect on the environmental degradation in the short run. For D(LNTAI), its t-statistic value is -1.14916, and its p-value is 0.253561, and it has a negative coefficient of -0.0166. In other words, the studies suggest that changes in technology have a minor role in the progress of environmental degradation in the short term. The constant term (C) has a coefficient of -0.02801 with a t-statistic of -0.84021, and a p-value of 0.403, indicating the constant term is not statistically significant.

Table 5.13: FMOLS Output of Model 1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
LNFDINIF	0.051995	0.027265	1.907003	0.0593
LNLF	-1.20554	0.781261	-1.54307	0.1259
LNCF	0.286954	0.034665	8.277937	0
LNTAI	-0.01997	0.061088	-0.3269	0.7444

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The input of FMOLS (Fully Modified Ordinary Least Squares) for the environmental implications Model-1 in South Asian countries considers the factors affecting LNENV (environmental degradation) in Table 5.13. A positive coefficient of 0.051995 shows that natural resource based foreign direct investment (LNFDINIF) contribute positively to environmental degradation. The result is slightly significant with p-value of 0.0593, suggesting that there is an increase in environmental degradation when FDI increases. Further, the impact of LNLF on LNENV is negative and not significant, as it has a coefficient of -1.20554 with p value of 0.1259), and capital formation (LNCF) has a positive relationship with environmental degradation at p-value of 0.0000, having a coefficient of 0.286954. Technological innovation (LNTAI) has a coefficient value of -0.01997, and p value of 0.7444. In general, LNFDINIF and LNCF are important environmental contributing factors, where LNLF and LNTAI have no conspicuous influences. FMOLS output of Model 1 gives the derived effects of the factors of interest on LNENV (environmental degradation) in percentage. LNFDINIF shows a coefficient

of 0.051995, meaning for 1% rise in LNFDINIF, it leads to 0.051% rise in environmental degradation. However, this effect is statistically significant with p-value of 0.06, indicating that there is a significant relationship.

The coefficient of LNLF is -1.20554 which means that the environmental degradation decreases by 1.2% with a 1% increase in LNLF, and it is not significant with p-value of 0.1259. LNCF has 0.286954 as a coefficient value, which indicates a 1% increase in LNCF increases the environmental degradation by 0.29%, and with p-value of high significance (0.0000), the relationship is quite strong. LNTAI has an estimate of -0.01997, signifying a decrease of 0.02% environmental pollution over a 1% increase in LNTAI. However, it is not statistically significant with p-value of 0.5885). The same is for LNFDINIF and LNCF because their effects are growing by percentages, while growth of LNLF and LNTAI has no statistically significant results.

5.2.10 Results of Environmental Implications of Population and Affluence (IPA)

Model 2:

First, in Model 2, the ARDL (Autoregressive Distributed Lag) model results are presented which helps determine the short-run and long-run relationships of environmental degradation (LNENV) with respect to several factors. The coefficient for LNFDINIF in the long-run equation is -0.003198, suggesting a slight negative effect on environmental degradation, but the effect is statistically insignificant ($p=0.8682$). Right after that comes economic growth (LNEG) with a coefficient of 0.343174; its long-term effect is significant and positive (p -value 0.0000), meaning that a 1% increase in economic growth (LNEG) leads to 0.34% increase in environmental degradation. The capital formation (LNCF) has a coefficient of 0.164393, which is also significant (p -value 0.0057), implying that a 1% increase in LNCF leads to an increase of 0.16% in environmental degradation. The presence of LNLF is negative in the long term (-0.167715) but insignificant (p -value 0.7786). The error correction term (COINTEQ01) in the short-run equation indicates that 31% (-0.310878) of the disequilibrium (long-run equilibrium) is corrected each period

and is significant at the 1% level (p-value 0.0018), indicating a moderate speed of adjustment to long-run equilibrium.

Table 5.14: ARDL Output of IPA Model 2

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Dependent Variable: LNENV (environmental degradation)				
Long Run Equation				
LNFDINIF	-0.003198	0.019192	-0.166618	0.8682
LNEG	0.343174	0.078798	4.355095	0.0000
LNCF	0.164393	0.057562	2.855944	0.0057
LNLF	-0.167715	0.594158	-0.282273	0.7786
Short Run Equation				
COINTEQ01	-0.310878	0.095764	-3.246286	0.0018
D(LNENV(-1))	-0.189439	0.201115	-0.941943	0.3496
D(LNFDINIF)	-0.009145	0.029130	-0.313934	0.7545
D(LNFDINIF(-1))	0.008002	0.012291	0.651010	0.5172
D(LNEG)	1.184150	0.380878	3.109003	0.0027
D(LNEG(-1))	-0.567948	0.523046	-1.085848	0.2814
D(LNCF)	-0.101312	0.044487	-2.277348	0.0259
D(LNCF(-1))	0.081554	0.132143	0.617162	0.5392
D(LNLF)	-0.376593	1.069340	-0.352173	0.7258
D(LNLF(-1))	-0.479020	0.339979	-1.408968	0.1634
C	-3.937316	1.224492	-3.215468	0.0020

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

On the other hand, D(LNENV(-1)) is insignificant in the short run (0.3496), which indicates that there is no short-run effect on environmental degradation. The variables LNFDINIF and its lagged term D(LNFDINIF(-1)) are not statistically significant, which means that a variation in financial indicators (LNFDINIF) does not have short-term impact on environmental degradation. In addition, for LNEG (economic growth), we can say that the relationship is positive and significant (the coefficient equals 1.184150 and p-value equal to 0.0027), which means that in the short run if there is a 1% increase in economic growth, then environmental

degradation also increases significantly 1.18%. That means economic growth increases big amount of carbon emission which increase environmental degradation.

But in the short run capital formation $D(LNCF)$ shows a negative and significant relationship with environmental degradation (coefficient=-0.101312 and p-value=0.0259), indicating that capital formation might have a short-run negative impact on environmental degradation. $LNCF$ (capital formation) and its lagged term $D(LNCF(-1))$ in the short run displays contrasting results as while $D(LNCF)$ is found to be significant the lagged term $D(LNCF(-1))$ is insignificant. Any other short-run effects of $LNLF$ (labor force) on environmental degradation are also insignificant, indicating that labor force does not impact the environment directly in any short-run (Praveen et al., 2022). Results indicate that the constant term C is significant at 1%, so it shows that there are more factors effecting environmental degradation other than the variables mentioned in the model.

Table 5.15: FMOLS Output of Model 2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: $LNENV$ (environmental degradation)				
$LNFDINIF$	0.040600	0.024118	1.683384	0.0953
$LNNEG$	0.346184	0.129844	2.666157	0.0089
$LNCF$	0.108331	0.070098	1.545429	0.1253
$LNLF$	-1.044217	0.582861	-1.791536	0.0761

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Table 5.15 reports the FMOLS (Fully Modified Ordinary Least Squares) output for IPA (environmental impact of population and affluences) model 2 on the effects of various variable on environmental degradation ($LNENV$). The coefficient $LNFDINIF$ of 0.040600 indicates a positive correlation between $LNFDINIF$ and environmental degradation, meaning that a 1% growth in $LNFDINIF$ leads to 0.04% increase in environmental degradation. But this effect is not statistically significant, p is 0.0953. As for $LNNEG$, which has a coefficient of 0.346184, we observe a significant positive effect (p-value 0.0089), thus an increase of 1% of the $LNNEG$

produces an increase of 0.35% of the degradation of the environment. Although the relationship is positive for LNCF with 0.108331 as the coefficient, it is the statistically insignificant with p-value of 0.1253. LNLF has a coefficient of -1.044217, indicating a negative impact whereby a 1% increase in LNLF will cause a 1.04% decrease in environmental degradation, but this is borderline significant (p-value 0.0761). Overall, these results suggest that the impact of LNEG is both substantial and significant in terms of environmental degradation, whereas the impact of LNFDINIF, LNCF and LNLF is less clear and may potentially indicate the need for specific interventions at the policy level with respect to reducing these impacts.

5.2.11 Results of Environmental Implications of Affluences and Technological Innovation (ITE) Model 3

Table 5.16 presents the short run and long run dynamic relationships of environmental degradation (LNENV) are analyzed through the ARDL model results for the ITE model 3. For the long run model, LNFDINIF has a well-defined coefficient of -0.0186, implying it has negatively significant influence on environmental degradation p-value is 0.0088, which means if LNFDINIF increases by 1% then environmental pollution decreases by 0.02%. The variable LNNRC has coefficient of 0.0181 and its p value is 0.9191 hence, it is positive and not significant) LNRENR, which has a coefficient of -0.0276, p-value 0.3127, is not significant, but it shows that 1% increase in renewable energy leads to a reduction of 0.03% in environmental degradation. LNTRM has a positive coefficient of 0.0117 and a robust parameter of significance at 1% (p value: 0.000), indicating a small rise in environmental degradation with every 1% increase in LNTRM but technological innovation (LNTAI) has a negative coefficient of -0.0057, meaning that innovation has tried to reduce environmental pollution insignificantly. To conclude, the study indicates that FDI in natural resource sector has higher propensity to prevent environmental degradation but not renewable energy and technology advancements. However, tourism can contribute to long-term environmental damage and thus there is need for balanced policies.

Table 5.16: ARDL Output of Model 3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
Long Run Equation				
LNFDINIF	-0.0186	0.0069	-2.6874	0.0088
LNENRC	0.0181	0.1776	0.1020	0.9191
LNRENRC	-0.0276	0.0271	-1.0161	0.3127
LNTRM	0.0117	0.0034	3.4076	0.0010
LNTAI	-0.0057	0.0291	-0.1971	0.8443
Short Run Equation				
COINTEQ01	-0.5164	0.2832	-1.8235	0.0720
D(LNFDINIF)	0.0174	0.0171	1.0171	0.3122
D(LNENRC)	0.4438	0.2259	1.9646	0.0530
D(LNRENRC)	-0.0694	0.0470	-1.4766	0.1438
D(LNTRM)	-0.0055	0.0038	-1.4386	0.1542
D(LNTAI)	-0.0261	0.0204	-1.2793	0.2046
C	-0.6731	0.5493	-1.2253	0.2241

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

In the short run COINTEQ01 is negative and significant at 10% (p-value =0.0720), implying that any deviation from long run equilibrium will be adjusted, but it would be a slow process. Of the short-run dynamics, only energy consumption (D(LNENRC)) is a significant positive contributor to environmental degradation (p-value = 0.0530), suggesting that temporary spikes in energy use could cause increased environmental harm. The remaining short-run variables that is; FDI (D(LNFDINIF)), RENRC(D(LNRENRC)), TAI(D(LNTAI)) and TRM (D(LNTRM)) showed high p-values, indicating non-significant impacts. In general, results of the study suggest that foreign direct investment has a long-run positive effect on environmental quality; nevertheless, renewable energy consumption, tourism and technological innovation show less significant impact on the protection of environment for both short-run and long- run effects.

Table 5.17: FMOLS Output of Model 3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNFDINIF	-0.0079	0.0149	-0.5267	0.5996
LNENRC	0.4083	0.1129	3.6169	0.0005
LNRENRC	-0.0650	0.0407	-1.5972	0.1134
LNTRM	0.0072	0.0041	1.7729	0.0793
LNTAI	-0.0099	0.0403	-0.2457	0.8064

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

FMOLS output for IAT Model 3 is presented in Table 5.17, the long run relationships with LNENV. The LNFDINIF coefficient is further negative -0.0079, indicating that a one percent increase in FDINIF will cause 0.008% decrease in environmental degradation. This effect is nevertheless not statistically significant, given a p-value of 0.5996. This implies that the long run effect of LNFDINIF on environmental progress is not significant or identifiable. Policymakers, too, can look elsewhere than economic growth, which has not proved a major driver of ecological harm, to overcome environmental challenges. The coefficient of 0.4083 estimated for LNENRC indicates that LNENRC has a significantly positive relationship with environmental degradation p-value 0.0005. That is, an increase in the energy consumption LNENRC of 1% is related to an increase of 0.41% in environmental degradation. This long-lasting consequence emphasises the significant position of energy consumption that leads to changes in the environment. This effect should be paid attention by energy efficient policy and alternative energy sources for quieting down the development. This is in line with the fact that the LNRENRC coefficient is -0.0650, indicating a negative impact of natural resources and energy consumption on the environment. With the p-value of 0.1134 it indicates borderline significance, hinting towards ambivalence of its effect. This suggests that LNRENRC might help reducing environmental degradation but insignificantly. Promoting the use of renewable energy may have some positive environmental effects, but more data and research may be required to establish this connection. The variable technology has a

negative impact on pollution that is highly expected. 1% increase in technology helps to reduce emission by 0.001% insignificantly. The variable LNTRM's coefficient is 0.0072, with p-value of 0.0793, indicates a positive effect on environmental degradation, but that is at 10% level of significant. This suggests little impact of tourism LNTRM on environmental outcomes. Although tourism impacts environmental policies and practices, tourism seems less responsible in this model for degradation. There may be additional channels through which tourism can affect the environment that policy makers must consider. In summary, the FMOLS results highlight that energy consumption (LNENRC) plays an important role in the environmental degradation process, whereas the results for LNFDINIF, renewable energy (LNRENRC), and tourism (LNTRM) are ambiguous. These imply that policies directed towards these aspects of purchasing behavior can contribute to alleviating environmental pressures.

5.2.12 Results of STIRPAT or Environmental Impact for Population, Affluences, and Technological Innovation Model 4:

Model 4 shows in Table 5.18, the results for the ARDL model, detailing the long-run and short-run effects on environmental degradation (LNENV). For the long-run equation, the coefficient of LNFDINIF is found to be 0.021507, which implies a positive but statistically insignificant effect of increasing FDI on the environmental degradation, as the p-value (0.4979) is also greater than 0.05. LNEG exhibits a p-value 0.0107 with 0.675884 as coefficient, suggesting a significant positive effect whereby an increase of 1% in LNEG results in a 0.68% increase in an environmental degradation factor, which is a critical finding as this becomes an important change variable. The coefficient of capital formation (LNCF) is 0.167034 and p value is 0.2189 and labor force LNLF (-1.484628) suggests some negative impact, but it is not significant (p-value 0.1335). LNRENRC has an significant positive effect (p value 0.0035; Coefficient=0.335340). The coefficient for LNTAI is 0.040390 which suggests a weak but positive effect (p-value 0.4927). LNTRM has a coefficient of 0.08647 and is marginally significant (p-value 0.0528), meaning it seems to have a slight positive effect. LNENRC has a coefficient of -0.615051 which implies that it

has a significant negative effect (and the p-value of 0.0184 confirms this) and as much as an increase of LNENRC by 1% would result in a decrease in environmental degradation by 0.62%.

Table 5.18: ARDL Output of Model 4

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Dependent Variable: LNENV (environmental degradation)				
Long Run Equation				
LNFDINIF	0.021507	0.031561	0.681450	0.4979
LNEG	0.676884	0.257842	2.625189	0.0107
LNCF	0.167304	0.134835	1.240806	0.2189
LNLF	-1.484628	0.977736	-1.518434	0.1335
LNRENRC	0.335340	0.110998	3.021128	0.0035
LNTAI	0.040390	0.058551	0.689820	0.4927
LNTRM	0.018647	0.009462	1.970701	0.0528
LNENRC	-0.615051	0.254523	-2.416488	0.0184
Short Run Equation				
COINTEQ01	-0.165140	0.078700	-2.098333	0.0396
D(LNFDINIF)	0.002952	0.011043	0.267346	0.7900
D(LNEG)	0.518905	0.429041	1.209453	0.2307
D(LNCF)	-0.034400	0.047566	-0.723198	0.4720
D(LNLF)	0.340581	0.152625	2.231488	0.0289
D(LNRENRC)	-0.115527	0.058392	-1.978477	0.0519
D(LNTAI)	-0.031633	0.015005	-2.108181	0.0387
D(LNTRM)	-0.004904	0.005217	-0.939942	0.3506
D(LNENRC)	0.430930	0.106986	4.027922	0.0001
C	-2.347457	1.103248	-2.127770	0.0370

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

However, in the short-run of the equation, the error correction term (COINTEQ01) is equal to -0.165140, statistically significant at the 5% level with a p-value of 0.0396, implying that around 16.5% of the disequilibrium from the long-run path is corrected each period, thus showing a moderate speed of adjustment towards long-run equilibrium. This indicates a very small immediate effect, as these coefficients

are not statistically significant. Nevertheless, D(LNRENRC) exerts an important negative effect with p-value of 0.0519, showing a transitory improvement in environmental degradation. On immediate benefits, D(LNTAI) also shows a significant negative impact with p-value of 0.0387. D(LNTRM) has a substantially favorable effect with p-value of 0.3506, signifying a heterogeneous adjustment for negative growth. The model shows the great long-lasting impact of economic growth (LNEG)(coefficient=0.676884 and p value is 0.0107) and renewable energy consumption ((LNRENRC = 0.335340, p = 0.0035) on the degradation of the environment, with LNEG enlarging and LNENRC reducing the degradation where coefficient of LNENRC is -0.615051 and p value is 0.0184. LNRENRC and LNTAI further contribute to reductions in the short run, whilst LNTRM acts a contributor of degradation. What they don't realize is they are playing a more fundamental error correction mechanism at work that seeks to affect the short and long run of any policy you might forward.

Table 5.19: FMOLS Output of Model 4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
LNFDINIF	0.004044	0.014925	0.270977	0.7870
LNEG	0.451338	0.211686	2.132117	0.0355
LNCF	-0.072315	0.045625	-1.584978	0.1163
LNLF	0.635295	0.557719	1.139097	0.2575
LNRENRC	-0.069211	0.039655	-1.745325	0.0841
LNTAI	-0.001010	0.039866	-0.025325	0.9798
LNTRM	0.006294	0.004363	1.442667	0.1524
LNENRC	0.327509	0.117486	2.787633	0.0064

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

From Table 5.19, the LNFDINIF has a coefficient of 0.004044, which leads us to conclude that FDI has a positive and statistically insignificant long term effect on environmental degradation with a p-value of 0.7870. LNEG has positive correlation having level of significance of 0.0355 with a coefficient value of 0.451338, which suggests that one percent increase in LNEG causes environment degradation by 0.45

percent, which is considerable impact. LNCF has a negative but very strong coefficient of -0.072315 as we can see, but is not statistically significant with p-value of 0.1163, which means that we cannot tell if it has any influence. LNLF has a coefficient of 0.635295, indicating a positive insignificant effect with p-value of 0.2575. The coefficient of the variable LNRENRC is -0.06921 , LNTAI is -0.001010 with p value of 0.9798. LNTAI has a very low negative insignificant effect. LNTRM's coefficient of 0.006294 indicates a positive but insignificant effect with p-value of 0.1524. LNENRC, with a coefficient of 0.327509, has a significant positive effect (p-value 0.0064), indicating that the consumption of energy plays a significant role in environmental degradation. These results have significant implications for policies and practices as they demonstrate the relative contributions of energy consumption (LNENRC, LNEG) to environmental degradation, whereas the effects of other variables are more ambiguous, highlighting areas for potential targeted interventions. As observed from the FMOLS results in Model 4, important insights can be drawn from the technological, economic, and environmental dynamics. The high positive impact of LNEG and LNENRC implies that the high impact of energy consumption is a generator of environmental problems. It suggests that implementing effective energy efficiency and renewable policies could be key to minimizing environmental degradation. At the 10% significance level, the negative impact of LNRENRC was marginally significant, suggesting that increased renewable energy consumption may contribute to reducing welfare losses, though further studies are warranted to investigate the nature of this potential relationship. The lack of significant effects from LNFDINIF, LNCF, LNLF, LNTAI, and LNTRM suggests that not all predictors contribute significantly to long-term environmental change when considering multiple predictors simultaneously. Well-structured energy policies with a focus on renewable energy are thus a way to a greener future where human well is a priority as well.

5.2.13 Results of Pairwise Panel Causality Tests

The results of the panel causality tests are reported as pairwise relationships between variables. The null hypothesis for each test is that one variable does not Granger-cause the other. P-values that are lower than a significance level of typically less than 0.05 give evidence against the null hypothesis, suggesting a causal relationship. Bidirectional causality is shown in the test. LNENRC leads to LNENV with p-value of 0.0244, and conversely the p-value of 0.0006, indicating a feedback loop between energy consumption and environmental degradation. The results reveal that LNEG has a causal effect on LNENV with p-value of 0.0307, showing that environment is affected by economic growth. However, LNEG doesn't Granger cause LNENV with p-value of 0.3892, which indicates a unidirectional relationship, meaning that economic growth is not affecting environmental degradation.

However, the hypothesis shows that LNCF causes LNENV with p-value of 0.0292, meaning that the capital formation influences the environmental degradation. The inverse is not significant with p-value of 0.1177. LNENV causes LNLF with p-value of 0.00, revealing that labor utilization dynamics are influenced by environmental implications or carbon emission but not vice versa. No causal relationship between LNFDINIF and LNENV in any directions, and their p-values are 0.6560 (LNFDINIF $\rightarrow$ LNENV) and 0.1404 (LNENV $\rightarrow$ LNFDINIF). There is also bidirectional causality running from LNTRM to LNENV with p-value of 0.0460 and then from LNENV to LNTRM, indicating that mutual influence exists between tourism measures and environmental degradation.

Moreover, there is no considerable causality from LNFDINIF to LNENRC with p-value of 0.4400, whereas, LNENRC causes LNFDINIF with p-value of 0.0217, which implies that energy consumption impacts on foreign direct investment. LNLF does not granger cause LNENRC (p-value 0.4111), but LNENRC does granger cause LNLF, suggesting that labor market dynamics are affected by energy use. LNTAI has no significance from LNENRC with p-value of 0.9802, but LNENRC has

significance to cause LNTAI with p-value of 0.0038, meaning that about energy consumption affects technological innovation. For LNTRM and LNENRC, LNTRM has no causality on LNENRC with p-value of 0.4710 but LNENRC has a significant causality on LNTRM with p-value of 0.0000), suggesting that energy consumption drives tourism performance. No causal relation between LNEG and LNCF, which suggests that none of these variables causes LNCF having p-values of 0.2726 and of 0.2083 respectively.

Furthermore, LNFDINIF does not Granger cause LNEG with p-value of 0.7280 while LNEG does Granger cause LNFDINIF, suggesting that the development of the economy impacts on the foreign direct investment. No strong causality from LNLF to LNEG with p-value of 0.8614, however LNEG has strong causal impact LNLF, indicating that economic growth affects labor force dynamics. The test also indicates that LNEG cause to LNENRC since its p value (0.0010) is very significant. Nevertheless, LNENRC does not cause to LNEG with an insignificant p-value (0.2764).

Table 5.20: Pairwise Panel Causality Test Results

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
LNENRC $\neq$ LNENV	4.93751	2.25107	0.0244
LNENV $\neq$ LNENRC	6.35401	3.41586	0.0006
LNEG $\neq$ LNENV	4.82855	2.16147	0.0307
LNENV $\neq$ LNEG	3.24703	0.86098	0.3892
LNCF $\neq$ LNENV	4.85183	2.18061	0.0292
LNENV $\neq$ LNCF	4.10280	1.56468	0.1177
LNFDINIF $\neq$ LNENV	2.74170	0.44544	0.6560
LNENV $\neq$ LNFDINIF	3.99270	1.47414	0.1404
LNLF $\neq$ LNENV	1.37643	-0.67722	0.4983
LNENV $\neq$ LNLF	8.61054	5.27141	1.E-07
LNRENRC $\neq$ LNENV	4.58017	1.95722	0.0503
LNENV $\neq$ LNRENRC	3.25486	0.86742	0.3857
LNTAI $\neq$ LNENV	4.04037	1.51334	0.1302
LNENV $\neq$ LNTAI	2.49563	0.24310	0.8079

LNTRM ≠LNENV	4.62702	1.99575	0.0460
LNENV ≠LNTRM	11.6495	7.77034	8.E-15
LNCF ≠LNENRC	6.20403	3.29253	0.0010
LNENRC ≠LNCF	3.52363	1.08843	0.2764
LNCF ≠LNENRC	4.69252	2.04961	0.0404
LNENRC ≠LNCF	2.57010	0.30433	0.7609
LNFDINIF ≠LNENRC	3.13906	0.77220	0.4400
LNENRC ≠LNFDINIF	4.99204	2.29591	0.0217
LNLF ≠LNENRC	3.19948	0.82187	0.4111
LNENRC ≠LNLF	9.88380	6.31842	3.-10
LNRENRC ≠LNENRC	0.54458	-1.36126	0.1734
LNENRC ≠LNRENRC	2.25506	0.04528	0.9639
LNTAI ≠LNENRC	2.23024	0.02487	0.9802
LNENRC ≠LNTAI	5.71658	2.89170	0.0038
LNTRM ≠LNENRC	3.07653	0.72078	0.4710
LNENRC ≠LNTRM	13.6996	9.45616	0.0000
LNCF ≠LNCF	0.86578	-1.09714	0.2726
LNCF ≠LNCF	3.73019	1.25828	0.2083
LNFDINIF ≠LNCF	1.77704	-0.34780	0.7280
LNCF ≠LNFDINIF	9.44742	5.95958	3.E-09
LNLF ≠LNCF	1.98770	-0.17457	0.8614
LNCF ≠LNLF	8.79481	5.42294	6.E-08
LNRENRC ≠LNCF	0.64802	-1.27620	0.2019
LNCF ≠LNRENRC	2.24662	0.03833	0.9694
LNTAI ≠LNCF	0.85194	-1.10852	0.2676
LNCF ≠LNTAI	5.51853	2.72884	0.0064
LNTRM ≠LNCF	4.19627	1.64154	0.1007
LNCF ≠LNTRM	33.0948	25.4049	0.0000
LNFDINIF ≠LNCF	3.44076	1.02028	0.3076
LNCF ≠LNFDINIF	6.26402	3.34186	0.0008
LNLF ≠LNCF	4.70409	2.05913	0.0395
LNCF ≠LNLF	6.10495	3.21105	0.0013

LNRENRC $\nrightarrow$ LNCF	3.68731	1.22302	0.2213
LNCF $\nrightarrow$ LNRENRC	1.54675	-0.53717	0.5911
LNTAI $\nrightarrow$ LNCF	2.63313	0.35617	0.7217
LNCF $\nrightarrow$ LNTAI	11.4219	7.58322	3.114
LNTRM $\nrightarrow$ LNCF	4.31769	1.74139	0.0816
LNCF $\nrightarrow$ LNTRM	3.17338	0.80042	0.4235
LNLF $\nrightarrow$ LNFDINIF	2.32333	0.10142	0.9192
LNFDINIF $\nrightarrow$ LNLF	3.78102	1.30008	0.1936
LNRENRC $\nrightarrow$ LNFDINIF	4.25914	1.69324	0.0904
LNFDINIF $\nrightarrow$ LNRENRC	3.37962	0.97001	0.3320
LNTAI $\nrightarrow$ LNFDINIF	5.62781	2.81870	0.0048
LNFDINIF $\nrightarrow$ LNTAI	3.64798	1.19068	0.2338
LNTRM $\nrightarrow$ LNFDINIF	1.51912	-0.55989	0.5756
LNFDINIF $\nrightarrow$ LNTRM	1.10189	-0.90298	0.3665
LNRENRC $\nrightarrow$ LNLF	2.20277	0.00227	0.9982
LNLF $\nrightarrow$ LNRENRC	5.05817	2.35029	0.0188
LNTAI $\nrightarrow$ LNLF	5.00805	2.30907	0.0209
LNLF $\nrightarrow$ LNTAI	3.50376	1.07208	0.2837
LNTRM $\nrightarrow$ LNLF	1.80574	-0.32420	0.7458
LNLF $\nrightarrow$ LNTRM	5.40006	2.63142	0.0085
LNTAI $\nrightarrow$ LNRENRC	2.37625	0.14494	0.8848
LNRENRC $\nrightarrow$ LNTAI	1.76101	-0.36099	0.7181
LNTRM $\nrightarrow$ LNRENRC	2.66678	0.38384	0.7011
LNRENRC $\nrightarrow$ LNTRM	2.20019	0.00016	0.9999
LNTRM $\nrightarrow$ LNTAI	0.26994	-1.58710	0.1125
LNTAI $\nrightarrow$ LNTRM	0.78078	-1.16703	0.2432

Note: the sign $\nrightarrow$ indicates the statement “does not homogeneously cause.”

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

LNEN are highly correlated with LNTAI with p-value of 0.0064, suggesting that economic growth drives technological innovation and converse is not true. LNTRM has a p-value of 0.0001, meaning that economic growth measures impacts on

tourism development. Indeed, it tells us that LNCF significantly causes LNFDINIF with p-value of 0.0008, which means that the capital formation impacts on foreign direct investment. There exists a bidirectional causality between LNLF and LNCF which provides a possible source of the relationship with LNLF causing LNCF with p-value of 0.0395 and vice versa with p-value of 0.0013. This is clearly a reciprocal relationship between the labor force and financial capital formation. Capital formation does not cause the tourism development ($p = 0.4235$, not significant) and tourism also not cause Capital formation ($p = 0.0816$, not significant). Evident from LNCF being proved as a significant cause of LNTAI (p-value 0.0031) but LNTAI does not Granger-cause LNCF ($p = 0.7217$).

In this section, there is the results of the causality tests. To prove this, within the results, LNTAI effectively impacts LNLF with p-value of 0.0209, meaning that technological innovation activities are evidently contributing labor force dynamics. Our results reveal a one-way relationship, since LNLF does not strongly cause LNTAI with a p-value of 0.2837. LNLF is a significant cause to LNTRM with p-value of 0.0085, indicating that tourism development have been impacted by the labor force. Nonetheless, LNLF has no significant effect on LNTRM with p-value of 0.7458, indicating that there is one-way causation. LNTAI and LNRENRC are not significant causally related. There is no direct causality between technological innovation with energy consumption. LNTRM and LNRENRC show no significance of causality as well, indicating that tourism development activities and energy consumption do not cause each other.

5.3 SECTION B: RESULT OF ASEAN COUNTRIES

The following tables show data calculations and analysis for the environmental impacts that are driven by economic abstracts across ASEAN countries. Using this dataset, we examine the complex relationships that shape environmental outcomes, focusing on the positive and negative causal relationships between foreign direct investment (FDI) and environmental quality in the region. This analysis may be especially relevant for the ASEAN countries, since rapid economic growth in

emerging economies, as the ASEAN countries have seen, is often paired with detrimental environmental effects. To check robustness, the study uses a series of advanced econometric techniques, such as the Cross-Sectional Dependence (CSD) test to uncover dependences across countries, the CIPS unit root test to check whether variables are stationary, kao panel cointegration tests to verify long-run relationships. Additionally, they use general method of moments based multivariate PMG-ARDL and CS-ARDL models to estimate short-and long-run dynamics for FDI and environmental indicators, and perform panel Granger causality tests. Together, these approaches provide insights into how economic activities contribute to environmental sustainability in ASEAN countries.

5.3.1 Descriptive Statistics

The summary statistics indicate that the majority of the variables have reasonably symmetric distributions, with mean and median values around each other. LNEG, for example, exhibits moderate variability with values ranging from 23.086 to 27.796, while the mean is 25.861 and the median is 26.149. Higher spread is shown by LNFDINIF's standard deviation of 1.622, whereas LNLF's standard deviation of 0.085 indicates significantly less fluctuation. Different skewness results are obtained: LNENV (0.099) exhibits a minor positive skewness, while LNEG (-1.179) and LNCF (-0.582) show left-tailed distributions.

Both LNTAI (4.567) and LNRENRC (4.422) exhibit leptokurtic, or heavy-tailed, distributions for kurtosis. Significant variances exist in the overall numbers as well; for instance, LNEG (5172.193) is substantially higher than LNRENRC (95.841), indicating scale disparities. In support of this, the sum of squared deviations reveals that LNEG (292.387) exhibits significantly more variability than LNTRM (331.674). All things considered, the statistical basis for additional econometric analysis is formed by these numerical measures, which offer distinct insight into central tendency, dispersion, skewness, and kurtosis.

Table 5.21: Descriptive Statistics

	LNEG	LNFDINIF	LNLF	LNCF	LNTAI	LNENRC	LNENV	LNTRM	LNRENRC
Mean	25.861	22.229	4.256	3.260	7.833	6.159	1.306	15.101	0.479
Median	26.149	22.481	4.243	3.257	8.431	6.517	1.271	15.244	1.278
Maximum	27.796	25.889	4.405	3.776	9.588	7.940	3.234	17.502	3.025
Minimum	23.086	17.921	4.042	2.345	3.045	2.794	-0.897	8.173	-6.908
Std. Dev.	1.212	1.622	0.085	0.264	1.723	1.235	1.072	1.291	3.170
Skewness	-1.179	-0.406	-0.003	-0.582	-1.699	-1.231	0.099	-1.259	-1.707
Kurtosis	3.552	2.914	1.958	3.597	4.567	3.641	1.884	6.891	4.422
Sum	5172.193	4445.777	851.247	651.974	1566.605	1231.705	261.175	3020.202	95.841
Sum Sq. Dev.	292.387	523.651	1.451	13.856	591.056	303.472	228.758	331.674	1999.678

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

5.3.2 Correlation Between the Variables in ASEAN Countries

A correlation study of the ASEAN panel data reveals several connections between environmental and economic variables. Since there is a very weak positive correlation (0.024) between LNFDINIF and LNENV, FDI inflows hardly affect environmental quality, perhaps depending on whether the investments are made in polluting or clean businesses. LNEG (economic growth), on the other hand, has a substantial positive association with both LNFDINIF (0.625) and LNENRC (0.920), indicating that growth is driven by foreign investment and the use of energy consumption. Additionally, LNTAI and growth have a good correlation (0.616), economic growth and the environment have a weak negative correlation (-0.331).

Additionally, the findings indicate that LNFDINIF has a fairly significant correlation with LNENRC (0.651) and a large correlation with LNTAI (0.813), indicating that foreign investments frequently promote the use of renewable energy sources and are driven by technology. FDI promotes tourism, as evidenced by its positive association with LNTRM (0.462). LNCF itself continues to have weak correlations across variables, indicating few linear relationships, and labour force (LNLF) only has a moderate effect on capital formation creation (0.309) and weak relationships with other indicators like as economic growth and technological innovation. The economic-environmental system's unequal labour and capital inputs are reflected in these results.

The last finding is that LNTAI has a substantial positive correlation with LNENRC (0.712), indicating that technology drives the use of energy consumption, while its correlation with tourism (0.444) indicates that technological innovation also fosters tourism. Both LNENRC (-0.158) and LNRENRC (-0.819), however, exhibit negative associations with LNENV, suggesting that environmental quality may still be harmed by renewable energy and fossil fuel energy consumption. Although it only marginally benefits the environment, LNENRC is substantially correlated with FDI investment (0.651) and economic growth (0.920).

Table 5.22: Correlation Test

	LNEG	LNFDINIF	LNLF	LNCF	LNTAI	LNENRC	LNENV	LNTRM	LNRENRC
LNEG	1.000	0.625	0.052	0.000	0.616	0.920	-0.331	0.191	0.349
LNFDINIF	0.625	1.000	0.300	0.212	0.813	0.651	0.024	0.462	0.159
LNLF	0.052	0.300	1.000	0.309	0.215	0.184	0.086	0.045	0.122
LNCF	0.000	0.212	0.309	1.000	0.058	0.098	0.076	-0.077	0.043
LNTAI	0.616	0.813	0.215	0.058	1.000	0.712	0.123	0.444	0.040
LNENRC	0.920	0.651	0.184	0.098	0.712	1.000	-0.158	0.129	0.239
LNENV	-0.331	0.024	0.086	0.076	0.123	-0.158	1.000	-0.043	-0.819
LNTRM	0.191	0.462	0.045	-0.077	0.444	0.129	-0.043	1.000	0.244
LNRENRC	0.349	0.159	0.122	0.043	0.040	0.239	-0.819	0.244	1.000

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Overall, the findings point to beneficial economic growth and energy consumption but unfavourable environmental trade-offs, highlighting the necessity of cointegration and causality testing to validate outcomes related to long run sustainability.

5.3.3 Slope Heterogeneity Test:

The slope homogeneity test allows to find out if the relationship between independent variables and dependent variable is the same for all cross-sectional units of panel data. In other words, the test checks whether the effect of any independent variable differs across the case data significantly.

5.23 Slope Homogeneity Test Δ Statistic P-value

Pesaran, Yamagata. 2008	Delta	P Value
Δ test	5.208	0.00
Δ_{adj} test	6.434	0.00

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Pesaran and Yamagata (2008) use the slope homogeneity test to determine if slope coefficients are the same for each panel unit. Given the data, the null hypothesis of homogeneity is rejected since Delta = 5.208 with $p = 0.000$ is significantly below the 0.05 significance level indicating Slope heterogeneity, which states that the impact of independent variables on the dependent variable varies throughout nations or businesses, is confirmed by this. Even when the intercept is taken into consideration, the adjusted Delta statistic, which reads as Adj. Delta = 6.434 with $p = 0.000$, confirms this finding. It would therefore be improper to use consistent slope coefficients for all cross-sectional units in this dataset.

5.24 Blomquist, Westerlund. 2013 Slope Homogeneity Test Δ Statistic P-value

Blomquist, Westerlund. 2013	Delta	p value
Δ test	8.587	0
Δ_{adj} test	10.609	0

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Additionally, these results are supported by the Blomquist and Westerlund (2013) test. With the p value of 0.000, the Delta statistic yields 8.587 and once more it is rejecting the null hypothesis of homogenous slopes. According to this, slope coefficients change greatly amongst panel units, suggesting that the explanatory variables have varying effects on each entity. With Adj. Delta value of 10.609 having p value of 0.000, the corrected Delta supports this finding and shows considerable variability throughout the model. Both tests taken together demonstrate that heterogeneity must be taken into account for proper modelling and that independent factors do not all have the same impact on the dependent variable.

5.3.4 Cross Sectional Dependency Test:

The Cross-Sectional Dependence (CD) test plays a key role there (Assaf et al., 2023), when data are not homogeneous, since it helps identify correlations among the errors across units, enhancing estimation performance, providing a framework for appropriate model specifications, as well as enabling valid statistical inference. Cross-sectional dependence, if it exists, will not be accounted for and this will lead to biased, inefficient and unreliable results, especially in complex contexts where heterogeneity needs to be dealt with. There are different tests for this to be found in the literature, such as the Breusch-Pagan LM Test, and the most commonly used is Pesaran CD test.

Table 5.25: Breusch-Pagan LM

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	64.17522	15	0.0000
Pesaran scaled LM	7.882680		0.0000

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The Cross-Sectional Dependence (CD) test finds correlations between residuals across units, it is crucial when working with heterogeneous panel data. Unreliable, ineffective, and biased findings may arise from ignoring this reliance. In Table 5.25, the Breusch-Pagan LM Test reports a statistic of 64.17522 with 15 degrees of freedom and a p-value of 0.000. This rejects the null hypothesis of no cross-sectional dependency and it confirms that residuals are not independent across units because the p-value is significantly below the conventional significance levels (0.01, 0.05, 0.10).

The Pesaran Scaled LM Test also confirms this conclusion by rejecting the null hypothesis of independence which is evidenced by the test statistic of 7.882680 and the p-value of 0.001. Like the Breusch-Pagan LM test, this test is especially reliable in large panels and offers compelling proof of cross-sectional dependence. It is concluded that the dataset has substantial cross-sectional dependence which is increased by the results' consistency across the two tests.

These findings imply that conventional models that requires independent residuals, such as fixed effects or random effects, are inappropriate without modifications. Standard errors and parameter estimates can be distorted by ignoring cross-sectional dependence, which lowers the validity of hypothesis testing and policy conclusions. Advanced econometric methods that specifically take cross-sectional dependence into account for reliable and effective estimations should be used.

The Pesaran (2004) CD test is critical to the model because it reveals cross-sectional dependence in panel data, stating that there are correlations across cross-sectional units. It contributes to efficient and less biased estimates, correct model specification, and valid statistical inference.

Table 5.26: Pesaran CD

Pesaran CD	Statistics
LNKG	23.20138***
LNENV	9.097725***
LNCF	3.404201***
LNENRC	22.37058***
LNRENRC	-1.81563*
LNFDINIF	10.76314***
LNLF	-1.4759*
LNTRM	16.39381***
LNIAI	13.40605***

***, **, and * indicates 1%, 5% and 10% level of significance

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The Pesaran (2004) CD test findings in Table 5.26 further reveal that there is a strong cross-sectional dependence across many of the ASEAN panel variables. For instance, LNKG (23.20138) is characterized by a large dependence indicating that the economic growth of countries is highly related to each other, which likely reflects common global trends but also thanks to the policies that the countries share. In the same way, the LNENV (9.097725) is indicative of high dependence in the environmental degradation, which may be attributed to similar policies pursued or global spillovers of pollution. LNCF (3.404201) shows the moderate dependence in capital formation due to local investment preferences.

There is also considerable correlation in energy-related terms. LNENRC (22.37058) exhibits a strong evidence of cross-sectional dependencies, suggesting common dependence on fossil-based technologies and joint energy consumption. On the contrary, LNRENRC (-1.81563) means weak or non-significant relationship in renewable energy consumption emphasizing that there are differences in adoption

and development among ASEAN countries. The foreign investment also exhibits high dependence as evidenced by LNFDINIF (10.76314) representing the correlated nature of the multinational investment policies among the ASEAN countries.

Other variables reveal mixed outcomes. LNLF (-1.4759) is all about the lack of any variation in labor force. But, LNTRM (16.39381) has most dependency and strong tourism spillover effects among countries is established. So does LNTAI (13.40605) as cross-border R&D and diffusion indicate strong technological dependence. In general, these findings emphasize that most of the variables, particularly growth, environment, energy, tourism, and technology, are strongly related to each other, and less related to renewable energy and labor force participation rate.

5.3.5 CIPS Unit Root test:

The Cross-sectionally Augmented IPS (CIPS) test (Pesaran, 2007) is devised to take care of panel data that suffers from cross-sectional dependence. In contrast to the conventional IPS test that presupposes independence across the units, the CIPS test includes cross-sectional averages (plus their lags) to control for interdependence. This renders it more robust when countries are interconnected by trade, FDI, tourism or financial links. The null hypothesis specifies a unit root (non-stationarity) and the alternative hypothesis implies stationarity in at least one of the panel unit.

CIPS unit root tests are used to test whether our time series variable is stationary or nonstationary. A stationary variable has constant mean, variance, and autocorrelation over time, while a nonstationary variable has a time-dependent mean, variance, and autocorrelation. The variable names are listed in the first column, the test statistic at the level of the original series in the second column, and the test statistic at the first differenced level of the series in the third column.

Table 5.27: CIPS Unit Root Test

	At Level	1 st Difference
LNNEG	-2.127	-4.428***
LNENV	-3.091**	-5.32***
LNCF	-2.853	-5.304***
LNENRC	-2.484	-4.611***
LNRENRC	-1.299	-3.458***
LNFDINIF	-4.593***	-5.912***
LNLF	-2.504*	-4.599***
LNTRM	-2.878*	-4.508***
LNTAI	-3.688***	-5.722***

***, **, and * indicates 1%, 5% and 10% level of significance

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

All the variables except LNFDINIF, LNTAI and LNENV are non-stationary at levels as indicated in Table 5.27. For instance, CIPS value of LNEG is -2.127, which is also not significant at the level of 1%, 5% or 10%. Likewise, we find that LNENV and LNCF fail to be significant at level, which again provide strong evidence that the unit roots exist. This implies that the economic and environmental data for ASEAN countries exhibit long-run properties or shocks and are not I(0) in their levels.

But if you difference the variables for the first time, they are stationary. For example, LNEG has a CIPS statistic of -4.428 which is significant at the 1% level, indicating that after differencing it is stationary. Similar thing happens to rest of the variables in the table and they all are still significant at 1% level after reconstitution. It shows us that the variables are integrated of order one, also known as I(1), which means that they have to be differenced in order to become stable.

In general, the CIPS test indicates that ASEAN panel variables are significantly non-stationary at levels except few of the variables and all are stationary in the first difference. This result is significant since the use of non-stationary data without transformation could generate spurious regression. Having I(1) processes for the

series, it can then go ahead with other econometric procedures like testing for cointegration and examine the long run relationships between the economic growth, environment, energy and investment series.

5.3.6 Kao Cointegration Test and Lag Order

The Kao Residual cointegration test in Table 5.28 reveals cointegration in the long-run among the variables. The ADF test statistic of -3.429 is significant at 1% level and the null hypothesis of no cointegration is thus rejected. The inspection showed that the variables have long run linear co-integration, that is they move together in the long run although not necessarily in the short run.

Table 5.28: Kao Cointegration Test

Kao Cointegration Test	t-Statistic	Prob.
ADF	-3.429	0
Residual variance	0.002	
HAC variance	0.003	

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

5.3.8 Lag Order

Table 5.29: Lag Order Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1178.94	NA	0	12.774	12.93	12.837
1	1235.301	4568.894	3.63e-17*	-12.31506*	-10.75422*	-11.68255*
2	1297.4	111.5118*	0	-12.112	-9.146	-10.91

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Table 5.29 provides the lag order selection results in order to identify the appropriate number of lags in the model. The LR test indicates a substantial gain from lag 0 to lag 1 (4568.894), and little additional information from lag 2 (111.5118). At lag 1, FPE with the value of 3.63e-17; AIC with the value of -12.31506; SC with the value of -10.75422 and HQ with the value of -11.68255 are minimum, suggesting that the

optimal lag is at lag 1 for the best forecasting ability and the tradeoff between model fit and model complexity. In conclusion, lag 1 works best for the model.

5.3.7 Regression Results for ASEAN Countries Growth Model

Table 5.30 presents the results of the Autoregressive Distributed Lag (ARDL) model with The ARDL model (Table 5.30) indicates that FDI (LNFDINIF) causes growth positively in the long run with a coefficient of 0.262 with the p value of 0.000, indicating that a 1% increase in FDI increases economic growth by 0.26% significantly. Capital formation (LNCF) reports a negative and insignificant coefficient of -0.309 with p value of 0.113. The technology (LNTAI) which is negative value of coefficient as -0.298 and insignificant value in form of p value as 0.211. The labor force (LNLF), however, has a significant positive effect with the coefficient value of 3.517 with its p value of 0.030 at 5% level of significance, meaning that the labor participation is a key element of long-run growth.

Table:5.30 Result of ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Dependent variable: LNEG (Economic Growth)				
Long Run Equation				
LNFDINIF	0.262	0.068	3.886	0
LNCF	-0.309	0.194	-1.595	0.113
LNTAI	-0.298	0.237	-1.257	0.211
LNLF	3.517	1.608	2.188	0.03
Short Run Equation				
COINTEQ01	-0.033	0.018	-1.835	0.068
D(LNFDINIF)	0.004	0.004	1.082	0.281
D(LNCF)	0.13	0.034	3.803	0
D(LNTAI)	0.031	0.017	1.83	0.069
D(LNLF)	0.056	0.139	0.406	0.685
C	0.306	0.161	1.893	0.06

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The short run adjustment term is -0.033 with the p value less than 0.068 shows significance at 10% and implies slow convergence to equilibrium. From the short-run dynamics, we find that coefficient of capital formation as 0.130 with the p value of 0.000 contributes significantly to growth in the short run and the coefficient of technology as 0.031 with the p value of 0.069 has a positive marginal significance at the 10% level of significance. On the contrary, from the table 5.30 it is observed that both FDI and the labor force are not statistically significant in the short run, indicating that their impact passes on over to the long run.

Table:5.31 Results of FMOLS Method

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent variable: LNEG (Economic Growth)				
LNFDINIF	0.26	0.029	9.095	0.000
LNCF	-0.452	0.111	-4.055	0.000
LNTAI	0.392	0.059	6.673	0.000
LNLF	1.072	0.908	1.181	0.239

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The FMOLS estimation results shown in Table 5.31 again support the decisive impact of FDI on economic growth estimated at 0.260 with its t value as 9.095 and the p value of 0.000, indicating that with a 1% surge in FDI, the economic growth raises by 0.26% significantly. However, the capital formation (LNCF) variable has a large negative coefficient value of -0.452 with t value of -4.055 and p value as 0.000, indicating that the investment and resource allocation are inefficient. Technology (LNTAI) is very significant on a positive coefficient side at a 1% or this factor nevertheless indicates technological innovation as a main element of long-term growth.

Finally, the labor force (LNLF) possesses a positive coefficient of 1.072 with t value of 1.181 and p value of 0.239, indicating that variations in labor participation do not significantly affect long-run economic growth. Combined results support the notion

that, in the context of Nepal, sustainable economic growth is determined by FDI and technology promotion and is deterred by capital formation and labor force only provides it a backup. These findings highlight the importance of efficient capital utilization and the role of technology and foreign investment in unlocking sustained growth.

5.3.8 Output of ASEAN Basic Environmental Implications Model 1

Table 5.32 shows the results of the analysis of the dependent variable and the independent variables. The analysis is conducted in two stages by first considering the long-run equation and then the short-run equation. This approach also captures the long-run and short-run dynamic interactions among the variables, making it possible to comprehend the complex interactions among the variables.

Table 5.32: ARDL Output of Basic Environmental Implications Model 1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent variable: LNENV (Environmental Degradation)				
Long Run Equation				
LNFDINIF	0.086552	0.042069	2.057387	0.0413
LNCF	0.828225	0.235998	3.509462	0.0006
LNTAI	0.109942	0.121408	0.905554	0.3666
LNLF	-1.50601	1.148556	-1.31122	0.1917
Short Run Equation				
COINTEQ01	-0.12681	0.058607	-2.16376	0.032
D(LNFDINIF)	-0.02106	0.01466	-1.43658	0.1528
D(LNCF)	0.043169	0.072949	0.59177	0.5549
D(LNTAI)	0.060234	0.027018	2.229385	0.0272
D(LNLF)	1.392662	0.953645	1.460357	0.1462
C	0.269964	0.152682	1.768146	0.079

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

In the table 5.32 shows the long-term relationship and it reveals that FDI (LNFDINIF) is also statistically significant and positively affecting environmental

degradation with a coefficient of 0.086552 with t value of 2.057 and p value as 0.0413. Moreover, capital formation (LNCF) also positively and strongly putting impact having its coefficient value of 0.828252 with t-statistic value of 3.509 and p-value of 0.0006, indicating that more capital causes more environmental deterioration. Technological innovation (LNTAI), however, has a very weak and non-significant impact having its coefficient value of 0.109942 with p value of 0.3666. And labor force (LNLF) is negatively but not significantly influences having the coefficient of -1.50601 with p value of 0.1917. This means that in the long run, only FDI and capital formation contribute to the environmental degradation significantly.

For the short-run results shown in Table 5.32, the coefficient on the error correction term (COINTEQ01) is -0.12681 with t value of -2.163 and p value of 0.032 suggest significant convergence to the long-run equilibrium. The short round estimates are as follows: the coefficient on FDI as -0.02106 and the coefficient on capital formation as 0.043169 are lacked of significance. More interestingly, the coefficient of technology (LNTAI) becomes positively and statistically significant with the value of 0.060234 with t value of 2.229 and p value as 0.0272, and can be detected at 5% level, indicating that technological innovation increases environmental degradation in early stage. The short-run coefficient of the labor force is 1.392626 with the p value of 0.1462 shows insignificant.

Table 5.33: FMOLS Output of Basic Environmental Implications Model 1

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent variable: LNENV				
LNFDINIF	0.106985	0.032141	3.328567	0.0011
LNLF	-2.58038	1.021016	-2.52727	0.0123
LNCF	-0.17052	0.12525	-1.36143	0.175
LNTAI	0.446444	0.066091	6.754967	0.001

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The FMOLS model for model 1 shown in Table 5.33 shows that the coefficient of FDI is 0.106985 with the p value of 0.0011 has a positive and significant effect, confirming again that foreign direct investment is a source of environmental degradation. The coefficient of Labour force (LNLF), has a negative correlation with value of -2.58038 and p value as 0.0123, showing the possibility of reduced environmental degradation when there is a high labour force participation. The coefficient of Capital formation as -0.17052 with its p value as 0.175 is negative and insignificant, implying that it does not significantly affect environmental outcomes in this model.

Moreover, the coefficient of technology (LNTAI) as 0.446444 with p value of 0.001 has the highest and positive significant relationship with environmental degradation, indicating the use of technology leads to more environmental costs. Taken together, the results indicate that FDI and technology cause environmental destruction strongly, but the labor force plays a mitigating role for the production of eco-smart capital. The result is mixed and insignificant. These results indicate that prudent foreign direct investment and technology policies are required in order to reconcile growth with sustainability.

5.3.9 Results of ASEAN Environmental Implications of Population and Affluence (IPA) Model 2

Table 5.34 indicates that in the long-run foreign direct investment (LNFDINIF) has a negative and significant impact on environmental degradation with a coefficient of -0.041205 having p value of 0.0032 which implies that a 1% increase in FDI reduces environmental degradation by 0.04%. In contrast, the economic growth (LNEG) has a positive and a highly significant impact on environmental degradation with a coefficient of 0.850495 with p value of 0.0000, indicating that 1% rise in economic growth increases the environmental degradation by 0.85%.

Table 5.34: ARDL Output of Model 2

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Dependent Variable: LNENV (environmental degradation)				
	Long Run Equation			
LNFDINIF	-0.041205	0.013754	-2.995958	0.0032
LNEG	0.850495	0.126480	6.724361	0.0000
LNLF	0.276214	0.455159	0.606852	0.5449
LNCF	0.075447	0.056681	1.331083	0.1852
	Short Run Equation			
COINTEQ01	-0.446283	0.084344	-5.291232	0.0000
D(LNFDINIF)	0.008198	0.007699	1.064883	0.2886
D(LNEG)	0.426859	0.374400	1.140115	0.2561
D(LNLF)	1.211161	1.296975	0.933835	0.3519
D(LNCF)	-0.030147	0.059671	-0.505222	0.6141
C	-9.438998	1.915036	-4.928888	0.0000

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Labor force (LNLF) has a positive but insignificant impact on environmental degradation with a coefficient of 0.276214 having the p value of 0.5449, and so is capital formation (LNCF) which also exhibits a positive but insignificant relationship on environmental degradation with a coefficient of 0.075447 having the p value of 0.1852. Therefore, over time only the FDI decreases environmental degradation significantly whereas growth worsens environmental degradation significantly.

In the short-term the coefficient of error correction term (COINTEQ01) is - 0.446283 with the p value as 0.0000, indicating a significant and rapid adjustment to equilibrium. Yet, none of the explanatory variables exhibit any significant short-run dynamics. The coefficient of FDI as 0.008198 with p value of 0.2886, the coefficient of economic growth as 0.426859 with p value as 0.8814, the coefficient of labor force as 1.211161 with p value as 0.3519, and the coefficient of capital formation as - 0.030147 with p value as 0.6141 are all insignificant. This implies that although the

long run equilibrium exists, short run deviation in these factors do not have any significant observable impact on environment degradation.

Table 5.35: FMOLS Output of Model 2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
LNFDINIF	0.022422	0.016282	1.377060	0.1702
LNEG	0.035382	0.222660	0.158906	0.8739
LNLF	-0.676582	0.625748	-1.081236	0.2811
LNCF	0.101604	0.054123	1.877266	0.0621

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The FMOLS estimates as shown in Table 5.35 reveal somewhat different scenario. The Economic growth (LNEG) has a slightly positive but not significant effect on environmental degradation with the coefficient of 0.035382 having p value as 0.8739, suggesting that there is a weak growth–environment effect. Labour force (LNLF) to population has a negative insignificant impact on environmental degradation with the coefficient of -0.676582, having p value as 0.2811. So, it is not strongly associated. Furthermore, the capital formation (LNCF) has a positive impact on environmental degradation with the coefficient of 0.101604 having p value as 0.0621, which slightly exceeds the 5% level, but it is more significant than others. This suggests that capital formation might be a more appropriate proxy for environmental damage than economic growth and labor force.

The PMG-ARDL findings indicate that FDI helps reduce environmental degradation, whereas economic growth aggravates it in the long run. For FMOLS, it is noted that none of the variables are significant at 5%, but capital formation with p value of 0.0621 is close to the 5% level of significance. These results suggest that the economic factors-environmental degradation nexus is elaborate, dependent on the model specifications, and perhaps other variables with certainly different approaches may be needed for robust policy implications.

5.3.10 Results of Environmental Implications of Technological Innovation and Energy (ITE) Model 3

In the Table 5.36 shows the long-run dynamic relation between economic variables and environmental degradation. Based on the ARDL results, long-run relations are found between economic variables and environmental degradation. The largest direct impact is made by energy resource consumption (LNENRC) with a coefficient of 1.330923, which indicates that high levels of use of energy resource contributes greatly to undermining the environment. The renewable energy (LNRENRC) with a coefficient of 0.171927 having p value of 0.0144 suggests that there is a positive and significant impact on environmental degradation. The influence of FDI (LNFDINIF), however, exhibits a significantly negative relation with a coefficient of - 0.041718 having p value of 0.0010, indicating that higher amount of foreign direct investment results in less environmental damage. Technology (LNTAI) has shown a positive-significant coefficient of 0.042023 with p value of 0.0287 and tourism (LNTRM) yields a positive-significant effect of 0.038220 with p value of 0.0111. Therefore, energy consumption, technological innovation and tourism development make the environmental degradation worse in the long run, while FDI mitigates the process.

Table 5.36: ARDL Output of Model 3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
	Long Run Equation			
LNENRC	1.330923	0.069991	19.01556	0.0000
LNFDINIF	-0.041718	0.012326	-3.384459	0.0010
LNRENRC	0.171927	0.069160	2.485915	0.0144
LNTAI	0.042023	0.018960	2.216428	0.0287
LNTRM	0.038220	0.014789	2.584323	0.0111
	Short Run Equation			
COINTEQ01	-0.405391	0.123334	-3.286941	0.0014
D(LNENRC)	0.326575	0.239297	1.364724	0.1752
D(LNFDINIF)	-0.011925	0.018370	-0.649176	0.5176
D(LNRENRC)	-0.184611	0.082136	-2.247625	0.0266
D(LNTAI)	0.043009	0.046617	0.922607	0.3582

D(LNTRM)	-0.065538	0.029150	-2.248253	0.0266
C	-2.925306	0.910210	-3.213882	0.0017

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

In the short run, the coefficient of ECT term (COINTEQ01) with - 0.405391 having p value of 0.0014 suggests that it is negative and statistically significant, indicating that 40.5% of disequilibrium is corrected each period. The short-run impact is mixed. The coefficient of the FDI as - 0.011925 with the p value of 0.5176 and the coefficient of the technology as 0.043009 with the p value of 0.3582 are statistically insignificant. The negative coefficient value of energy use (D(LNRENRC) as - 0.184611 with p value of 0.0266 and the negative coefficient value of tourism (D(LNTRM) as - 0.065538 with p value of 0.0291 in the short run suggest negative significant impact on environmental degradation. The findings suggest that although energy consumption and tourism development escalate long-term degradation but changes in their short-run dynamics can cause some temporary alleviation in environmental degradation.

Table 5.37: FMOLS Output of Model 3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
LNENRC	0.598206	0.143060	4.181506	0.0001
LNFDINIF	0.013957	0.012534	1.113507	0.2674
LNRENRC	0.054777	0.057321	0.955615	0.3409
LNTAI	0.039535	0.041358	0.955912	0.3408
LNTRM	-0.037820	0.013488	-2.804003	0.0058

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Table 5.37 presents the results of a FMOLS regression, an econometric regression technique for estimating the long run relationships between cointegrated variable. The energy consumption (LNENRC) is still very significant at 0.598206 with p value

of 0.0001, indicating that it as one of the primary drivers of long-run environmental degradation. The coefficient of FDI as 0.013957 with p value of 0.2674 has a positive insignificant correlation, hardly changing in significant measure in the long run. The coefficient of Renewable energy use (LNRENRC) as 0.054777 with p value of 0.3409 has a positive insignificant correlation, implying that there is no strong evidence that renewable energy directly worsens environmental quality either.

And, lastly, technological innovation (LNTAI) has a positive insignificant impact on environmental degradation, 0.039535, implying that technological advancement could alleviate environmental pressure. Taken together, the findings of PMG-ARDL and FMOLS suggest that the environmentally unfriendly effect of energy consumption is prevailing in the long run, FDI could mitigate degradation in the long run, while tourism and technology could provide counter-effects depending on the horizon. These results highlight the necessity of policy coordination between energy and investment fields in short-run and long-run environment, respectively.

5.3.11 Results of ASEAN Environmental Impact for Population, Affluences, and Technological Innovation (STIRPAT) Model 4

In the Table 5.38 shows the results of the ARDL model where environmental degradation (LNENV) is regressed on energy consumption (LNENRC), economic growth (LNEG), capital formation (LNCF), FDI (LNFDINIF), labor force (LNLF), renewable energy (LNRENRC), technology (LNTAI) and tourism (LNTRM). In the end, nearly all of the variables are significant at 5% level except FDI which is significant at 10% level. The estimation results indicate that LNENRC, LNRENRC, LNTAI, LNTRM, LNCF, and LNLF have positive effects on the environmental degradation, whilst LNEG and LNFDI are negatively associated. This suggests that even if growth and renewable energy can diminish, or neutralise in the long run, the damage done to the environment, material energy use and capital accumulation will not.

Table 5.38: ARDL Output of Model 4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
Long Run Equation				
LNENRC	1.597	0.042	38.416	0.000
LNEG	-0.749	0.196	-3.826	0.000
LNCF	0.120	0.030	4.029	0.000
LNFDINIF	-0.014	0.007	-1.884	0.063
LNLF	0.514	0.247	2.078	0.041
LNRENRC	0.424	0.050	8.516	0.000
LNTAI	0.025	0.012	1.998	0.049
LNTRM	0.062	0.017	3.618	0.001
Short Run Equation				
COINTEQ01	-0.473	0.229	-2.066	0.042
D(LNENRC)	0.080	0.356	0.225	0.823
D(LNEG)	0.536	0.341	1.572	0.120
D(LNCF)	0.082	0.075	1.100	0.274
D(LNFDINIF)	-0.028	0.031	-0.929	0.356
D(LNLF)	2.153	1.730	1.245	0.216
D(LNRENRC)	-0.203	0.069	-2.928	0.004
D(LNTAI)	0.032	0.048	0.670	0.505
D(LNTRM)	-0.083	0.030	-2.783	0.007
C	2.941	1.351	2.177	0.032

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

In the long term, the findings indicate that there is a small negative relationship between FDI and environmental degradation, reflected by a coefficient of - 0.014. This implies that for every 1 per cent increase in FDI, environmental degradation decreases slightly with 0.014 per cent. But since the p-value is 0.063, the effect is weakly significant at best (and only at the 10% significance level rather than 5%). To put it simply, FDI can contribute to less environmental pressure in the future but evidence for it is not very robust.

In the short period, the cointegration term (COINTEQ01), has a coefficient of – 0.473 with p value of 0.042 which indicates that deviations from the long-run equilibrium are corrected by 47% in each period. Among the short-run variables, the labor force change (D(LNLF)) had a large coefficient of 2.153, but statistically lacked significance with p value of 0.216, suggesting that it did not have a powerful short-run impact. Notably, renewable energy consumption (D (LNRENRC)) was found to have a significant negative effect with a coefficient of - 0.203 with p value of 0.004, indicating that more use of renewable energy may alleviate degradation in the short term. Tourism (D(LNTRM)) has demonstrated a significant negative impact as -0.083 with p value of 0.007, corroborating the purifying nature of tourism.

Table 5.39: FMOLS Output of Model 4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: LNENV (environmental degradation)				
LNENRC	0.546	0.144	3.807	0.000
LNEG	-0.086	0.283	-0.304	0.762
LNCF	0.224	0.074	3.046	0.003
LNFDINIF	0.000	0.013	-0.001	0.999
LNLF	-0.235	0.562	-0.418	0.677
LNRENRC	0.026	0.056	0.461	0.646
LNTAI	0.041	0.039	1.040	0.300
LNTRM	-0.038	0.015	-2.575	0.011

Source: World Development Indicator (2025) and Own calculation

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

The FMOLS output in Table 5.39, LNENRC turns up once more to be very firmly positive and significant, with an elasticity estimate of 0.546 with p-value of 0.000, affirming the detrimental effect of dependence on non-renewable sources to the environment. Financial development (LNCF) shows positive and significant, with an elasticity estimate of 0.224 with p value of 0.003 indicating that relatively greater

investments and infrastructure expansion have the price of the deterioration of environmental quality. The long term degradation is shown to be essentially driven by the two factors.

Variably, foreign direct investment (LNFDINIF) had an irrelevant impact with coefficient nearly zero with p-value of 0.999. Also, economic growth (LNEG) was negatively signed with the coefficient as -0.086 having a large associated p-value of 0.762 showed that there were no significant effects on the environmental quality. The labor force (LNLF) was also an insignificant variable with the coefficient of - 0.235 having p-value of 0.677, showing that the labor force does not significantly affect the environmental reality in this economy. The association between environment and renewable energy (LNRENRC) was also weak and insignificant with coefficient of 0.026 having p value of 0.646.

Finally, the tourism (LNTRM) significantly affects environmental quality negatively at a significant level of 1% with coefficient of - 0.038 having p-value of 0.011, indicating that higher tourism activity reduces the level of environmental degradation. This could represent eco-tourism or an environmental effect found among certain countries. Technology (LNTAI) also had a positive but insignificant relationship with coefficient of 0.041 having p value of 0.300. Hence, its influence is ambiguous to environmental transformation. In general, the results highlight that nonrenewable energy and capital accumulation have the highest degree of responsibility for pollution, whereas tourism plays a counter role, and FDI is mostly irrelevant in both short- and long-run contexts.

5.3.12 Causality Test

There is a mixed test of the predictive relationships between economic variables and environmental degradation (LNENV) shown in Table 5.40, which is given by the Granger causality test. For LNFDINIF and LNENV (i.e., both for FDI inflows and LNENV) neither lag was significant as both directions gave very high p-values of 0.6600 and 0.8235 respectively, implying that there is no causality. Similarly, LNEG and LNENV did not have a significant causal relationship (although the p-value of

0.0827 for $\text{LNENV} \rightarrow \text{LNEG}$) is marginally insignificant), indicating that environmental damage could affect growth under certain circumstances. On the other hand, capital formation (LNCF) Granger-caused the environmental degradation with a p value of 0.0275 while the opposite was not significant as p value shows 0.4364. There was a significant predictive effect of LNENRC on LNENV with p value of 0.0175, while the inverse was not significant with p value of 0.0888. On the contrary, other variables such as labor force (LNLF), renewable energy (LNRENRC), and technology (LNTAI) had no significant direct effect on LNENV as p value for all of them is more than 5% level of significance.

Table 5.40: Results of Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
$\text{LNFDINIF} \neq \text{LNENV}$	189	0.41640	0.6600
$\text{LNENV} \neq \text{LNFDINIF}$		0.19438	0.8235
$\text{LNEG} \neq \text{LNENV}$	189	1.11850	0.3290
$\text{LNENV} \neq \text{LNEG}$		2.52621	0.0827
$\text{LNCF} \neq \text{LNENV}$	189	3.66301	0.0275
$\text{LNENV} \neq \text{LNCF}$		0.83288	0.4364
$\text{LNENRC} \neq \text{LNENV}$	189	2.45364	0.0888
$\text{LNENV} \neq \text{LNENRC}$		4.13382	0.0175
$\text{LNLF} \neq \text{LNENV}$	189	1.63486	0.1978
$\text{LNENV} \neq \text{LNLF}$		0.53002	0.5895
$\text{LNRENRC} \neq \text{LNENV}$	189	0.40171	0.6699
$\text{LNENV} \neq \text{LNRENRC}$		0.12227	0.8850
$\text{LNTAI} \neq \text{LNENV}$	189	1.22255	0.2969
$\text{LNENV} \neq \text{LNTAI}$		1.03964	0.3557
$\text{LNTRM} \neq \text{LNENV}$	189	0.15436	0.8571
$\text{LNENV} \neq \text{LNTRM}$		0.47844	0.6205
$\text{LNEG} \neq \text{LNFDINIF}$	189	5.81717	0.0036
$\text{LNFDINIF} \neq \text{LNEG}$		0.25332	0.7765
$\text{LNCF} \neq \text{LNFDINIF}$	189	0.18291	0.8330
$\text{LNFDINIF} \neq \text{LNCF}$		0.90710	0.4055

LNENRC $\neq$ LNFDINIF	189	6.46324	0.0019
LNFDINIF $\neq$ LNENRC		0.10005	0.9048
LNLF $\neq$ LNFDINIF	189	0.31785	0.7281
LNFDINIF $\neq$ LNLF		2.59901	0.0771
LNRENRC $\neq$ LNFDINIF	189	3.28157	0.0404
LNFDINIF $\neq$ LNRENRC		0.77473	0.4627
LNTAI $\neq$ LNFDINIF	189	8.29588	0.0004
LNFDINIF $\neq$ LNTAI		1.11036	0.3316
LNTRM $\neq$ LNFDINIF	189	2.28898	0.1042
LNFDINIF $\neq$ LNTRM		3.81254	0.0239
LNCF $\neq$ LNEG	189	2.82222	0.0621
LNEG $\neq$ LNCF		0.59813	0.5509
LNENRC $\neq$ LNEG	189	0.17390	0.8405
LNEG $\neq$ LNENRC		2.67267	0.0717
LNLF $\neq$ LNEG	189	0.05288	0.9485
LNEG $\neq$ LNLF		0.30390	0.7383
LNRENRC $\neq$ LNEG	189	0.16740	0.8460
LNEG $\neq$ LNRENRC		0.48549	0.6164
LNTAI $\neq$ LNEG	189	0.90991	0.4044
LNEG $\neq$ LNTAI		2.55151	0.0807
LNTRM $\neq$ LNEG	189	0.27870	0.7571
LNEG $\neq$ LNTRM		7.33350	0.0009
LNENRC $\neq$ LNCF	189	1.37962	0.2543
LNCF $\neq$ LNENRC		0.24124	0.7859
LNLF $\neq$ LNCF	189	1.58413	0.2079
LNCF $\neq$ LNLF		0.25117	0.7782
LNRENRC $\neq$ LNCF	189	0.27480	0.7601
LNCF $\neq$ LNRENRC		0.39491	0.6745
LNTAI $\neq$ LNCF	189	0.79163	0.4546
LNCF $\neq$ LNTAI		2.37513	0.0958
LNTRM $\neq$ LNCF	189	1.04360	0.3543
LNCF $\neq$ LNTRM		2.01348	0.1365

LNLF $\neq$ LNENRC	189	1.29611	0.2761
LNENRC $\neq$ LNLF		0.50779	0.6027
LNRENRC $\neq$ LNENRC	189	1.91950	0.1504
LNENRC $\neq$ LNRENRC		0.21153	0.8096
LNTAI $\neq$ LNENRC	189	0.90197	0.4076
LNENRC $\neq$ LNTAI		4.11448	0.0179
LNTRM $\neq$ LNENRC	189	5.95048	0.0031
LNENRC $\neq$ LNTRM		1.89164	0.1537
LNRENRC $\neq$ LNLF	189	4.03951	0.0196
LNLF $\neq$ LNRENRC		0.14766	0.8629
LNTAI $\neq$ LNLF	189	0.96212	0.3840
LNLF $\neq$ LNTAI		0.23318	0.7922
LNTRM $\neq$ LNLF	189	4.01068	0.0197
LNLF $\neq$ LNTRM		7.09685	0.0011
LNTAI $\neq$ LNRENRC	189	1.33050	0.2676
LNRENRC $\neq$ LNTAI		1.03626	0.3574
LNTRM $\neq$ LNRENRC	189	0.74591	0.4761
LNRENRC $\neq$ LNTRM		0.68988	0.5033
LNTRM $\neq$ LNTAI	189	6.10176	0.0027
LNTAI $\neq$ LNTRM		2.97126	0.0537

Note: The sign “ $\neq$ ” indicates the statement “does not Granger Cause.”

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

Beyond the environment, interesting causal relations were found among economic variables in the test. LNENRC was highly predictive of FDI inflows with p value of 0.0019, but not FDI outflows with p value of 0.9048. Likewise, technological transfer (LNTAI) was significantly predicting FDI inflows with p value of 0.0004 but not vice versa with p value of 0.3316. FDI also significantly predicted tourism (LNTRM) with a p value of 0.0239 and tourism did not predict FDI. Meanwhile, economic growth (LNEG) significantly impacted tourism with p value of 0.0009, which confirmed the finding that a growing economy will develop tourism. With other variable pairs like LNCF on LNEG or LNLF on LNEG, there was no direction

of causality, even though some of the values like p value of 0.0717 for LNEG → LNENRC faced borderline significant.

Finally, the findings suggest some significant results. Tourism emerged as a strong significant predictor of technological development (LNTRM → LNTAI) with p value of 0.0027, indicating that the expansion of tourism will provoke the adoption or innovation of technology. Nevertheless, for the category of renewable energy (LNRENRC), no causality was found for the majority of the variables, e.g., LNCF with p value of 0.7601, LNENRC with p value of 0.8096, and LNTRM with p value of 0.5033. Furthermore, in the opposite direction, the relationship of technology to capital formation with p value of 0.4546) and technology to tourism did not reveal any clear cause and effect with p value of 0.0537, just near the level of significance). In other words, the strongest predictive links are from non-renewable energy and technology to FDI inflows, from FDI to tourism, and from economic growth to tourism, all other links being weak or non-existent.

5.4 SECTION C: COUNTRY WISE ENVIRONMENTAL IMPLICATIONS

This subsection C, gilding the foreign direct investment (FDI) in environmental implications of South Asia and ASEAN countries. The impact of FDI inflows on these regions and their environment is important as these regions are increasingly being coveted by mechanics of global capital. However, the effect of FDI on environmental quality is different among countries due to energy consumption, economic development, tourism development, technological progress, human resources, capital formation, and renewable energy. These variables are common to barriers to environmental degradation or embodied within sustainability depending on the investments made.

In this section, the detailed Penrose output across both the individual countries namely the effect of different variables on environmental quality in each country is discussed. Through the assessment of both beneficial and adverse impacts, the research attempts to offer a detailed insight into the role of FDI on the environmental outlook of South Asia and ASEAN countries.

5.4.1 South Asian Countries

Table 5.41 displays the estimated association of environmental degradation (LNENV) with various independent variables in the context of Bangladesh, India, Pakistan and Sri Lanka. Where dependent variable that is called LNENV is environmental degradation or environmental implications.

For Bangladesh the cointegration coefficient (COINTEQ01) is positive (0.0003***) and on the contrary significant, which is not common as ECM model norm the value should be negative. This implies that when the environment deviates from the long-run equilibrium it does not adjust quickly back. Other studies on South Asian economies have also found similar weak or unstable adjustment patterns (Rahman & Kashem, 2017; Destek & Sarkodie, 2019). Hence, despite a long-run relationship, the adjustment mechanism in Bangladesh is highly sluggish and erratic and reveals that the status quo policies are insufficient to achieve environmental equilibrium.

The past degradation ($D(LNENV(-1)) = -0.67^{***}$) helps reduce current degradation, showing some self-correction over time. The negative effect of FDI ($D(LNFDINIF) = -0.01$) suggests that foreign direct investments contribute to the diminishing of environmental deterioration. Economic development or economic growth occurs ($D(LNEG) = 2.95^{**}$) it induces environmental degradation, implying that as the Bangladeshi economy grows, it becomes increasingly harmful to the environment. Capital formation has negative contribution to enhance the environmental quality ($D(LNCF) = -0.13^{***}$) that investment in environmental improving activities significantly effect to improve the environment while renewable energy consumption ($D(LNRENRC) = -0.06^{***}$) reduce the degradation, indicating the position of clean energy for environmentally repairing.

In India, the coefficient of cointegration (COINTEQ01= -0.02*) is negative and significant suggests that environmental degradation is being adjusted inversely over time. Lagged effect of environmental degradation ($D(LNENV(-1))$) (= -0.60***) also

contributes to decrease the current degradation and its autoregressive effect, promoting a self-correcting mechanism. FDI ($D(LNFDINIF) = 0.06^{***}$), capital formation ($D(LNCF) = 0.01^{***}$), and energy consumption ($D(LNENRC) = 1.56^{***}$) are causes environmental degradation i.e., foreign investment, capital formation and energy consumption are pollution-biased. Notably, economic growth ($D(LNEG) = -0.04$) does not play a significant role in environmental degradation suggesting that India's growth style is not significantly with the environment. For renewable energy ($D(LNRENRC) = -0.48$), labor force ($D(LNLNF) = -3.76^{***}$), and technology ($D(LNTAI) = -0.11$), they are important means to mitigate environmental degradation, indicating that clean energy and technology advancement could help in improving the environmental business condition of India.

Table 5.41: Country Based Results in South Asian Countries

Variable	Bangladesh	India	Pakistan	Sri Lanka
Dependent Variable: LNENV (environmental degradation)				
COINTEQ01	0.0003***	-0.02*	0.004***	-0.04
$D(LNENV(-1))$	-0.67***	-0.60***	0.16***	-0.70***
$D(LNFDINIF)$	-0.01***	0.06***	0.02***	0.12***
$D(LNFDINIF(-1))$	-0.03***	0.02***	0.01***	0.06***
$D(LNEG)$	2.95**	-0.04	1.19***	-0.13
$D(LNEG(-1))$	-0.95	0.41***	0.17	0.10
$D(LNCF)$	-0.13***	0.01***	0.01***	0.08***
$D(LNCF(-1))$	0.75***	0.01***	-0.05***	-0.06***
$D(LNLNF)$	-4.85**	-3.76***	-0.64	-0.45*
$D(LNLNF(-1))$	-0.77**	-0.28	-1.15	-0.56***
$D(LNTAI)$	-0.07***	-0.11***	-0.07***	-0.35***
$D(LNTAI(-1))$	0.12***	-0.05***	0.06***	-0.35***
$D(LNTRM)$	0.001***	-0.02***	-0.02***	-0.01***
$D(LNTRM(-1))$	0.01***	-0.02***	0.02***	0.001***
$D(LNRENRC)$	-0.06***	-0.48***	-0.03***	-0.75***
$D(LNRENRC(-1))$	-0.07***	-0.43***	0.01***	-0.29***
$D(LNENRC)$	0.17***	1.56***	-0.19***	0.39***
$D(LNENRC(-1))$	0.01	0.56***	-0.20***	0.01
C	-0.33**	-2.26	-0.42**	-4.18

Note: ***, **, * shows 1%, 5% and 10% level of significance.

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

For, Pakistan, the cointegration coefficient ($COINTEQ01 = 0.004^{***}$) is positively signed and is statistically significant, which is unlike ECM models where $COINTEQ$

is mostly assumed to be negative. The environmental infrastructure of Pakistan does not have a strong adapting body. The lagged effect ($D(LNENV(-1)) = 0.16^{***}$) also increases present degradation, which means that environmental damage in the past is permanent. FDI ($D(LNFDINIF) = 0.02^{***}$) significantly affects environmental deterioration, suggesting that foreign investments in Pakistan are pollution-biased. There is a significant positive effect of economic growth ($D(LNEG) = 1.19^{***}$) and capital formation ($D(LNCF) = 0.01^{***}$) on environmental degradation, therefore growth deteriorate more in the country. $D(LNRENRC) = -0.03^{***}$ renewable energy is found to have a negative influence, which implies that it contributes to reduction in environmental degradation though with lower effect in comparison with other countries. Technology ($D(LNTAI) = -0.07^{***}$) likewise has a negative impact, attenuating the environmental damage.

For Sri Lanka the cointegration coefficient ($COINTEQ01 = -0.04$) is negative and not significant, implying that the environmental degradation is not gradually changed with time. There is also a significant negative response to lagged environmental degradation ($D(LNENV(-1)) = -0.70^{***}$) which exerts controlling influence on current degradation, suggesting that past damage is mitigated. FDI ($D(LNFDINIF) = 0.12^{***}$) add to the pollution and increasing the level of environmental degradation, it suggests that foreign investment in Sri Lanka is pollution-biased. GDP growth ($D(LNEG) = -0.13$) does not affect environment significantly in Sri Lanka. Among the positive effects, there is the renewable energy ($D(LNRENRC) = -0.75^{***}$); it has a negative effect, reducing the environmental degradation. Also, technology ($D(LNTAI) = -0.35^{***}$) assists in decreasing environmental damage, this means technology advancements enhance environmental quality in Sri Lanka (Salim et al., 2025).

5.4.2 ASEAN Countries

In Indonesia, the coefficient of cointegration ($COINTEQ01 = 0.06^{***}$) shows a positive and significant relationship, which implies that environmental degradation does not move back to equilibrium soon, when it diverges. Previous environmental

degradation ($D(LNENV(-1)) = -0.67^{***}$) decreases current degradation, indicating that problems correct themselves over time. The FDI ($D(LNFDINIF=0) = 0.001^{***}$) exacerbates environmental deterioration slightly, and the economic growth ($D(LNEGNIF)=1.10^{**}$) makes the environment worse. Capital formation ($D(LNCF) = -0.09^{***}$) contributes to making the environment better. Renewable energy ($D(LNRENRC) = -0.05^{**}$) also very slightly negatively affects degradation, being clean energy that has a slight role to improve degradation. Indonesia's environmental quality is negatively affected by economic growth and FDI, increasing the risk of degradation. However, renewable energy and capital formation help improve the situation.

In Malaysia, the cointegration value ($COINTEQ01 = -0.14^{***}$) reveals that the environmental degradation gradually turns out for the better over time. Patency degradation ($D(LNENV(-1)) = -0.13^{**}$) Previous degradation decreases current degradation. FDI ($D(LNFDINIF) = 0.03^{***}$) positively impacts the environmental degradation, while economic growth ($D(LNEG) = 2.60^{**}$) deteriorates the environment. The effect of technology ($D(LNTAI) = 0.01^{***}$) is positive and small. We observe that an increase in renewable energy ($D(LNRENRC) = 0.07^{**}$) reduces degradation and that capital formation ($D(LNCF) = -0.46^{***}$) has a negative impact, thereby benefiting the environment. Malaysia looks up to economic growth and FDI at the expense of environmental protection, although renewable energy and capital formation are a targeted relief.

In the Philippines, the positive cointegration coefficient ($COINTEQ01 = 0.02^{***}$) is not fit for ECT result, suggesting that environmental degradation does not quickly return to equilibrium when it deviates. Previous degradation ($D(LNENV(-1)) = -0.66^{***}$) leads to a decrease in current degradation, evidenced as a self-repairing effect. $D(LNFDINIF)= 0.001^{***}$) and foreign direct investment (FDI) provides signal for environmental degradation. The effect of economic growth ($D(LNEG)= -0.70$) is not significant. Capital formation ($D(LNCF) = 0.27^{***}$), labor force ($D(LNLF)=0.43^{*}$) are positively related i.e., labor force and investments contribute toward decreasing environmental deterioration. The use of renewable energy

(D(LNRENRC) = 0.44***) has a positive and significant effect, decreasing harm from the environment.

Table 5.42: Country Based Results in ASEAN Countries

<i>Variable</i>	<i>Indonesia</i>	<i>Malaysia</i>	<i>Philippine</i>	<i>Singapore</i>	<i>Thailand</i>	<i>Vietnam</i>
Dependent Variable: LNENV (environmental degradation)						
COINTEQ01	0.06***	-0.14***	0.02***	-0.46***	0.08***	-1.62***
D(LNENV(-1))	-0.67***	-0.13**	-0.66***	-0.60***	0.63***	0.66***
D(LNFDINIF)	0.001***	0.03***	0.001***	-0.41***	-0.02***	0.32***
D(LNFDINIF(-1))	-0.01***	-0.02***	-0.01***	-0.25***	0.01***	0.19***
D(LNEG)	1.10**	2.60**	-0.70	7.02***	0.07**	12.44
D(LNEG(-1))	-1.79**	2.21**	-0.70***	-2.02**	0.39***	-4.03
D(LNLF)	-0.44	3.98	0.43*	0.69	2.03***	4.22
D(LNLF(-1))	0.59	-2.51	0.57***	7.29	0.58***	1.35
D(LNCF)	-0.09***	-0.46***	0.27***	-0.11**	-0.05***	-1.08***
D(LNCF(-1))	0.71***	-0.01	-0.03***	0.58***	-0.12***	-0.70***
D(LNTAI)	-0.18***	0.01***	0.02***	-0.86***	0.001***	-0.63***
D(LNTAI(-1))	0.21***	-0.08***	0.02***	-0.25***	0.06***	-0.24***
D(LNTRM)	0.001**	-0.23***	-0.03***	-0.15***	-0.01***	-0.57***
D(LNTRM(-1))	-0.02***	-0.19***	0.11***	0.07***	0.07***	-0.53***
D(LNRENRC)	-0.05**	0.07**	0.44***	1.05***	-0.29***	1.15***
D(LNRENRC(-1))	-0.64***	0.15***	0.21***	0.16***	-0.05***	0.24***
D(LNENRC)	1.28***	0.24*	1.49***	0.23	1.28***	0.31
D(LNENRC(-1))	0.09	-0.06	0.95***	-5.59***	-0.93***	-0.44***
C	-0.18	0.09	-0.03	0.25	-0.24	3.54

Note: ***, **, * shows 1%, 5% and 10% level of significance.

Source: World Development Indicator (WDI) 2025 and calculation using Eviews-13

In Singapore, the cointegration coefficient (COINTEQ01 = -0.46***) is negative and significant, implying that its environmental degradation is adjusting back to its prior level. The negative D(LNENV(-1)) = -0.60***) is benefit for environment or correct themselves over time. However, FDI (D(LNFDINIF) = -0.41***) contributes significantly to degradation, and economic growth (D(LNEG) = 7.02***) has a significantly negative effect, exacerbating the environmental quality. Technology

($D(LNTAI) = -0.86^{***}$) and capital formation ($D(LNCF) = -0.11^{**}$) also decreases environmental degradation.

On the other hand, the cointegration coefficient in Thailand ($COINTEQ01 = 0.08^{***}$) is positive and significant, which is not common as ECT value should be negative. This implies that when the environment deviates from the long-run equilibrium it does not adjust quickly back. Previous degradation ($D(LNENV(-1)) = 0.63^{***}$) aggravates current degradation, a proof of ecological damage. FDI ($D(LNFDINIF) = -0.02^{***}$) marginally decreases degradation while economic growth ($D(LNEG) = 0.07^{**}$) creates a small increase but labor force ($D(LNLF) = 2.03^{***}$) significantly decrease environmental quality. Capital formation ($D(LNCF) = -0.05^{***}$) contributes positively to the favorable environment. Renewable energy ($D(LNRENRC) = -0.29^{***}$) played a negative and significant role to diminish the environmental degradation.

The cointegration coefficient ($COINTEQ01 = -1.62^{***}$) has a negative and significant negative in Vietnam, indicating that environmental degradation is adjusting itself over time. Previous deterioration ($D(LNENV(-1)) = 0.66^{***}$) also increases current deterioration and demonstrates that the environmental impact is persistent. Foreign direct investment ($D(LNFDINIF) = 0.32^{***}$) is highly responsible for degradation meaning pollution-intensive over $D(LNFDINIF)$. The economic growth ($D(LNEG) = 12.44$) is positive but insignificant on environmental deterioration. Technological innovation ($D(LNTAI) = -0.63^{***}$) mitigates environmental degradation. However, renewable energy ($D(LNRENRC) = 1.15^{***}$) has a clear positive impact, contributing significantly to positive environmental degradation.

If the cointegration coefficients are positive you might also see Ahamad & Tanin (2021), or an article such as Shahbaz et al. (2013) who reported similar results for a sample of developing countries characterised by slow adjustment towards equilibrium and by implications about the difficulty of policy intervention in these countries.

CHAPTER 6: FINDINGS AND DISCUSSION

6.1 INTRODUCTION

The carbon emissions (CO₂) or environmental degradation due to urbanization, industrialization, energy consumption and unsustainable practices have assumed global challenges especially in developing regions such as South Asia and ASEAN. In South Asia and ASEAN countries, where economic growth and population density are fast paced, the considerations are different. South Asia has witnessed considerable industrialization and much of which has resulted in environmental degradation. ASEAN nations including Indonesia, Thailand, Singapore and Vietnam have similar strong economic growth with respect to foreign direct investment (FDI) and environmental threats like deforestation, air pollution, and resource depletion which are equally fierce. Comparing the multilayered regional makeup of the environment, economy and labor potentiality yields insights that may inform regional sustainable development approaches.

The study has four interconnected questions relating to economic growth, labor force growth, capital formation and environmental sustainability. This study, therefore, addresses four specific objectives such as (1) To investigate the impact of FDI on environmental degradation in South Asia and ASEAN countries. (II) To estimate the impact of FDI on economic growth in South Asia and ASEAN countries. (III) To investigate the impact of capital formation and labor force on environmental degradation. (IV) To compare the results between the panel group of South Asia and ASEAN countries by considering economic, social, and environmental views. This discussion is to analyze the findings of the results on the basis on previous literature, and to compare and contrast the findings across South Asia and ASEAN countries.

6.2 TO INVESTIGATE THE IMPACT OF FDI ON ENVIRONMENTAL DEGRADATION IN SOUTH ASIA AND ASEAN COUNTRIES

This objective envisages the relationship between Foreign Direct Investment (FDI) and environmental implications in South Asia and the ASEAN regions. Technological innovation, energy consumption, labor force, and tourism are some major factors contributing to environmental degradation, either directly or indirectly. The study has set up four econometric models to examine whether FDI adds to carbon emissions or helps to reduce them. These models are used to study the relationship between FDI and the environment. Model 1 investigates the fundamental influences of FDI on the environment. Model 2 explores the effects of population and capital inflow on the economy and environment. Model 3 discusses the environmental implications of technological innovation and energy consumption. Finally, Model 4 presents the STIRPAT model which accommodates valid social, economic, and environmental variables.

6.2.1 Theoretical Explanation (Environmental implications of Foreign direct investment for South Asia)

In the short term, FDI and environmental implications or carbon emissions are likely to be positively correlated with each other because FDI involves many industries and infrastructure projects in host countries which accelerate environmental degradation. Such resource-consuming and pollution-generating industries over-indexing manufacturing, energy production, and construction. Such sectors are dependent on fossil fuels, generating extra energy demand and CO₂ levels. The rapid growth of industrialisation driven by FDI intensifies environmental damage, owing in part to the increases in pollution, depletion of resources and increased carbon emissions (Zafarullah, H., & Mehnaz, M. 2025). Further, nations with lax or loose environmental standards or ineffectively enforced laws may experience an even greater negative effect, as multinational corporations (MNCs) often take the opportunity to lower costs by engaging in environmentally unfriendly practices, such as clear cutting, pollution and depletion of natural resources. Moreover, the fast pace

of the development of these industries will exceed the level of environmental management, and there is no effective method for separating and recycling the waste material to protect the resources, leading to more terrible impact on the environment as well.

In the long run, the relationship of Foreign Direct Investment (FDI) with environmental quality can be determined by the Environmental Kuznets Curve (EKC) hypothesis for South Asian countries where this hypothesis states that although initially economic growth deteriorates environment quality but later after the maturity process the reverse happens. In its early development stages, FDI leads to industrialization, urbanization and resource extraction, which all contribute substantially to environmental damage in South Asia. In addition, the lack of stringent environmental regulation has made this problem worse because FDI normally seeks natural resource-based industries that are by nature unsustainable. Moreover, the above-mentioned industries focus more on how to reduce expenses and in order to fulfill those necessities they start polluting the environment in different forms like smoke, deforestation etc. Consequently, the long run effect of FDI on these countries has shown high economic growth accompanying environmental degradation (Rauf et al., 2020). Due to attempting to enhancement of industrial expansion at a high pace, environmental aspects have not been taken into consideration.

6.2.2 Empirical Explanation ((Environmental implications of Foreign direct investment for South Asia)

In the short run, increased flows of FDI are often associated with more rapid industrialization and infrastructure development, both of them can accelerate environmental degradation. ITE model 3 shows that 1% change in foreign direct investment results in 0.02% change in carbon emission significantly. The STIRPAT model shows positive relation with environmental degradation, but not significant. In the short run, an increase in FDI into a country increases the carbon emissions. This reflects the fact that, in the short term, FDI attracts industries that are resource-based

and polluting such as manufacturing, energy production, and infrastructure building. These sectors are typically dependent on fossil fuels, resulting in greater energy use, more carbon emissions, and other forms of environmental damage. In the short term, the Error Correction Term (ECT) is known as COINTEQ01 reports a coefficient value of -0.165 for South Asia with p-value of 0.040. It demonstrates a significant tendency to adjust to the equilibrium level.

According to the long run STIRPAT model, FDI has a positive but insignificant effect on environmental degradation. Its coefficient Value is 0.002 (based on PMG-ARDL model) and 0.004 (based on FMOLS model). This means that though FDI increases carbon emissions to some extent, its influence is marginal and statistically insignificant, implying that it is unlikely for FDI inflows to significantly affect carbon in the setting examined settings. In the long run, the finding of energy and technology based model 3, indicate a significantly negative relationship between FDI inflows and pollution with coefficient of - 0.046 having probability value of 0.000, which means that FDI will gradually minimize the environmental damage. This might be a result of cleaner technologies and better production technologies, although there may be difficulties in the actual implementation of environmental regulations. The empirical results of FDI agree with the dominant trend literature (Mert&Bölük, 2016; Rafindadi et al., 2018; Shao, 2018) that FDI fosters the development of green energy infrastructure and induces technology spillovers that subsequently reduce the level of carbon emissions. FDI at the outset can be a detrimental influence on the environment, but in the long run, it can bring with it the transfer of better technologies and clean practices. Economies shift, as they mature and they often make transition toward cleaner industries and services. In this context, FDI is a key element of such transition through access to advanced technologies and management practices with a focus on efficiency and sustainability. The findings on FDI suggested that the effect of FDI on environmental degradation will decrease due to the penetration of technology. This results were consistent with those of (Pao& Tsai, 2011) from the observation of BRICS, of (Pazienza, 2015) separately covering OECD countries, of (Zhang & Zhou, 2016) throughout Chinese regions, of (Liu et

al., 2017) and Jiang et al. (2017) based on Chinese cities that FDI has enhancing impact on carbon emission.

The findings show that FDI plays an important role in the environment. In the short term, FDI can result in more environmental pollution as a result of industrialization and energy use. However, in the long-term, FDI could result in an environmental improvement if it is accompanied with the transfer of clean technologies and the adoption of sustainable approaches. Findings focus on the necessity of a sound policy , regulatory system and the effective environmental rule enforcement for FDI to be positively correlated with environmental performance. As FDI can be conducive to the transition to greener industries for countries with different levels of development, such transition is contingent upon the nature of those industries that receive FDI along with the environmental policy implemented.

6.2.3 Theoretical Discussion (Environmental Implications of Foreign Direct Investment for ASEAN)

In the short term, the association of FDI and environmental degradation in ASEAN countries is not very strong. Insofar as foreign direct investment (FDI) is expected to bring superior technologies and environmentally friendly methods, foreign companies have prioritized leveraging business and market share and generating profits. This is due to the Pollution Haven Hypothesis, which theorizes that developing nations such as those in ASEAN often receive industries that is prone to pollute and relies heavily on non-renewable energy, such as oil, gas, and mining. These sectors result in higher emissions and deplete natural resources, exacerbating problems in the short term. Moreover, the host countries often have lax environmental legislature, so that the environmental spillovers from FDI are not immediately apparent.

FDI may potentially have positive effects on environment in the long run. When foreign firms establish business in such countries, they utilize cleaner goods and resources in a more efficient manner resulting in greener activities. Technology

spillover theory suggest that FDI induces the inflow of advanced technologies and skills that can in turn enhance the environment. Eventually, foreign firms adapt to local environmental laws and the country becomes more sustainable. The theory of the Environmental Kuznets Curve (EKC) is very good at describing this, it is the idea that initially growing the economy may lead to more pollution, but as a nation becomes richer, it can devote resources into cleaner technologies and better regulations (Bello et al. 2024). For ASEAN to take full advantage of FDI, it has to enhance environmental regulations, promote the flow of eco-friendly investments and enforce the law properly. This would help to mitigate harm to the environment, and also put us on a path towards more sustainable growth over the long-term.

6.2.4 Empirical Discussion (Environmental implications of Foreign direct investment for ASEAN)

In the STIRPAT model's short run, the results for ASEAN economies reveal that FDI inflows will decrease environmental degradation, but the result is not statistically significant. For example, the estimate of $D(LNFDINIF)$ is - 0.028 and the p-value is 0.356, which implies that the direction of short run relationship between FDI and environmental degradation is negative, but it is not strong enough to be statistically significant, meaning that the impact is minimal. In the short run, the contribution of FDI to environmental practice in ASEAN countries is quite limited. Initially, when investors from other countries invest in these markets, they would rather concentrate on the rapid growth of their economy, increase industrial output and quick returns on investment. This focus, however, is often at the cost of nature, where companies chase production scale, infrastructure setup, and effort savings. Due to this initial investment, environmental sustainability often takes a backseat at this stage. Even for FDI that comes with new technology, it cannot be assumed that it will be used in an environmentally sound manner. The lack of statistical insignificance of the short run impact could also result from weak environmental regulations, limited public attention on the environment, or the slow pace at which green technologies are adopted in the face of the rising FDI.

Meanwhile, the ECT coefficient is -0.473 for the ASEAN, indicating that the area of adjustment towards long run equilibrium is high, and this means the faster the movement to the equilibrium following the short-run deviation. The negative signs of ECM confirm the existence of long run relations between variables for all BRI regional samples (Banerjee et al., 1998).

In terms of short run, such FDI inflow leads to accelerated industrialization and infrastructure development which may contribute to the rise of CO₂ emissions. Multinational companies establish factories and industrial facilities that stimulate high fossil fuel consumption and add to emissions. Debt to support these investments can cause a lot of carbon output. Moreover, the need for FDI could have some economic growth rather than on environmental protection for ASEAN countries, reflected in the diluted enforcement of environmental laws and standards.

In the long run STIRPAT model it is found that FDI and environmental degradation have a negative relationship. The long-run PMG-ARDL coefficient of FDI (LNFDINIF) is - 0.01, which is significant with p value of 0.06, confirming a 1 percentage change in FDI decreases carbon emissions or environmental degradation by 0.01%. This result is in line with the halo hypothesis, which suggests that FDI inflows may bring cleaner, more environmentally sound production technologies from the developed countries to the developing ones, with a positive effect on pollution. But the issue is more complicated with other factors. For instance, energy consumption (LNENRC) positively affects environmental degradation, which means that the sectors that use more dirty or inefficient energy resources will aggravate the pollution level. Likewise, LNCF (capital formation) and labor force (LNLF) show a positive relationship with pollution and environmental degradation. This implies that FDI flows could be biased to energy-intensive industries or those with looser environmental regulation and where industrial activities aggravate, rather than alleviate the environmental damage.

Besides, some other factors such as economic growth (LNEG) and negative influence of the environment (LNENV) complicate the relationship between FDI and

environmental degradation. Workforce, for example, may either generate or prevent pollution, depending on the type of industry and area the FDI is in. The converse is also true in that adverse environmental effects, such as pollution and resource depletion, become more pressing as FDI enters sectors with less environmental protection. The complex interplay of these various factors indicates the significance of the characteristics and regulatory contingencies of sectors in terms of whether the impact of FDI is environmentally beneficial or negative. Although the ARDL findings imply that FDI may decrease environmental pollution under some circumstances, FDI's actual effect is very much shaped by the larger economic and institutional environment in which it functions, as is shown by the other variables in the equations.

On the other hand, the insight from the fully modified ordinary least squares (FMOLS) model is consistent with what is obtained from the ARDL model. The long run and short run estimates of foreign direct investment (FDI) and environmental degradation in the case of ASEAN countries show a different picture. The LNFDINIF's coefficient in the FMOLS model is 0.000, and its p-value is 0.999, suggesting that FDI does not have a statistically significant effect on environmental degradation when endogeneity issues are controlled. This finding is in sharp contrast to the ARDL model which had shown a marginal but statistically significant negative association between FDI and pollution level with coefficient of - 0.01 having p value of 0.06, meaning that over time, the FDI might have a positive contribution in reducing pollution. This FMOLS result questions the robustness of this finding and indicates that the positive long run impact from FDI in the ARDL model may be somewhat exaggerated for possible biases or omitted variables.

The difference between the ARDL and FMOLS models, thus suggests that, the significance of including endogenous terms in empirical models. The FMOLS model controls for possible endogeneity of FDI into FDI and the environment. Endogeneity means that variables affect each other in both directions and could result in biased estimates, so that the different conclusions could explain the opposite in full sample results of the two models. Additionally, the FMOLS results reveal that factors other

than FDI including capital flow (LNCF) and renewable resources (LNRENRC) have a direct and positive linkage on environmental degradation. Capital flows have a positive association with environmental degradation with coefficient of 0.224 having p value of 0.003, indicating that FDI might induce economic development but also pollution if it goes to the energy-consuming or environmentally damaging sectors. Conversely, renewable energy has an indirect impact relationship to environmental degradation, suggesting that investing in clean energy or sustainable industry might press better option for environmental sustainability situation.

Energy and technology-based model 3 shows the same negative relation with environmental degradation. This finding indicates that FDI inflow significantly improves environmental quality. It is possible that the inflow of foreign investment to ASEAN would be in energy-inefficient or weak environmental law industries or sectors with less rigid environmental regulation, thus resulting in pollution and exhaustion. The results are inconsistent with the study of (He, 2006) and (Ren et al., 2014) who conducted studies in China, where they found that FDI contributes environment. Similarly Hitam&Borhan, (2012)and Lau et al., (2014)reached comparable results in the context of Malaysia, while Tang & Tan, (2015) reached similar results in Vietnam. Paramati et al., (2016) also observed this pattern in twenty developing countries. Furthermore, Sbia et al., (2014) documented the adverse environmental effects on FDI in the Middle Eastern nations, and Abdouli and Hammami (2017b) confirm this in MENA region. Shahbaz et al., (2015) found that in high, middle and low-income countries, and Solarin et al., (2017) also observed in the case of Ghana, according to which the FDI results in environmental degradation. Several other studies, among them Pazienza (2015), have found that foreign direct investment (FDI) decreases pollution, which is supportive of the halo hypothesis. According to the halo effect theory, FDI can facilitate the reduction of pollution by introducing cleaner production technologies to developing countries from developed countries (Shahbaz et al., 2016).

The discrepancy of results between the ARDL and FMOLS highlights the importance of accounting for both models when assessing FDI's influence on the

environment. The ARDL model indicates that FDI, under certain circumstances, can contribute to mitigating pollution and the diffusion of cleaner technologies, but its effect largely depends on the sector attracting FDI and the enabling environment. The FMOLS (accounting for indigeneity) model on the other hand, suggests that the relationship between FDI and environmental degradation may not be straightforward, and the actual environmental cost of FDI might depend more on the sectoral attributes and the level of environmental regulations in receiving countries. Thus, although FDI may in principle be conducive to environmental progress over time, it is context-bound and contingent on a range of broader economic, industrial, and regulatory considerations.

6.2.5 Environmental implications of Foreign direct investment for South Asia and ASEAN Countries Comparison:

The short run and long run estimates obtained from the ARDL and FMOLS models of both ASEAN and South Asia are useful in understanding the nexus between Foreign Direct Investment (FDI) and environmental degradation. In the short term, the PMG-ARDL outcomes for the ASEAN indicate that FDI (LNFDINIF) coefficient of - 0.028 is not statistically significant for environmental degradation as the p-value is 0.356, signifying the relationship between FDI and the environment is multi-faceted. While FDI could bring better technologies, the subsequent industrialization entails more energy consumption and expansion of pollution intensive sectors like manufacturing and infrastructure which are higher compared to the positive effects in terms of the environment. In the same vein in South Asia, FDI's short run contribution to environmental degradation through D(LNFDINIF) is insignificant, highlighting that environmental benefits from FDI inflows are not immediate but LNLF, LNTRM, LNTAI and LNRENRC have a significant effect on environmental quality. Other factors like energy consumption (LNRENRC) and labor force (LNLF) also have a significant influence on the environmental outcomes particularly in the ASEAN and South Asian countries where industrial expansion and energy consumption are experiencing an unprecedented rise.

The ARDL and FMOLS models confirm the negative persistence effect of FDI on environmental degradation in ASEAN in the long run. In the long run, South Asia and ASEAN exhibit different patterns in the relationship between environmental degradation (LNENV) and foreign direct investment (LNFDINIF). The little positive coefficient of 0.022 for LNFDINIF in South Asia is statistically negligible with p value of 0.498, indicating that non-infrastructure FDI has no discernible long run impact on environmental deterioration in the area. Higher green infrastructure FDI is linked to a minor long run decrease in environmental degradation in ASEAN, on the other hand, where the coefficient is negative (-0.01) and marginally significant ($p = 0.06$). Given the disparity in the two nations' legislative frameworks, adoption of technology, and sustainable investment practices, it is possible that such FDI, although seemingly environmentally neutral in South Asia, could make a modest contribution to environmental improvements in ASEAN.

Enhancing the ease of doing business, making infrastructure investments, and providing tax breaks for important industries are some ways that South Asia might boost FDI inflows. Investor's confidence will be raised by boosting green investments, bolstering trade agreements, and guaranteeing political stability. Long run prosperity depends on building a competent labor force and facilitating access to funding. South Asia may increase foreign investment and stimulate economic growth these sectors.

Long run environmental improvement in South Asia can also be achieved by carefully focusing foreign direct investment (FDI) inflows towards sustainable sectors and green technologies. Environmental degradation can be lessened in the area by concentrating on areas like waste management, renewable energy, and environmentally friendly infrastructure. Furthermore, increasing foreign direct investment (FDI) in sectors that place a high priority on clean production and environmental sustainability would enhance the quality of the air, water, and soil over time, ultimately leading to a more sustainable model of economic growth. Maximising FDI's environmental benefits will require strong legislative frameworks and incentives for green investments.

Therefore, while FDI-related environmental damage challenges both regions, relatively higher attentiveness on the part of ASEAN to combine FDI with green technologies, renewable energy sources, and better regulations has made it more prepared to use FDI for environmental benefits in the long run.

6.3 TO ESTIMATE THE IMPACT OF FDI ON ECONOMIC GROWTH IN SOUTH ASIA AND ASEAN COUNTRIES

The estimates of the PMG-ARDL Model and FMOLS Method have important implications for the extent to which Foreign Direct Investment (FDI), Capital Formation (LNCF), Technological Innovation (LNTAI), and Labor Force (LNLF) are affecting economic growth (LNEG) in South Asia and ASEAN countries.

6.3.1 Theoretical Discussion: FDI and Its Implications for Economic Growth in South Asia

There is a common perception that FDI contributes significantly to the economic development of developing countries. Some theoretical channels of FDI on economic growth are found in the literature such as flows of capital, technological externalities, human capital accumulation and market expansion.

First, FDI is a source of capital, which is otherwise difficult to mobilize in regions where the domestic savings are inadequate for the development of infrastructure, business, and industries. Capital inflow from FDI can be used as production factors. It can raise the productivity level of existing industries and bring new industries, and make them productive, which are all part of economic growth (Liang et al., 2021). Second, FDI helps to generate the transfer of technology and management skills from foreign enterprises to local firms. Such transfers generally result in increased productivity, efficiency, and innovation in regional industries, yielding substantial benefits to the economy.

FDI also contributes to the development of human capital by adding new abilities, learning, and skills to the manpower. This promotes an increased general education

and skill level of the labor force, which in turn supports more efficient and successful industries. Furthermore, FDI introduces the host country to world markets, providing domestic companies with access to international supply chains, a global sales network, and customers around the world. This makes them more competitive exporters and drives economic growth.

The contribution of FDI to economic growth, however, depends on various factors, including the quality of the institutions of the host country, the regulatory system, good governance, and the ability of the local firms to internalize and utilize foreign technology and capital. Foreign investment is less productive in countries that lack institutional capacity, have high levels of corruption, or inefficient use of foreign capital. Hence, if FDI and capital stock in South Asian countries impact growth totally, then South Asian countries have to resolve institutional issues, and they have to promote the environment where the potential positive role of FDI transactions on growth could be exploited to its maximum.

6.3.2 Empirical Analysis: FDI and Its Implications for Economic Growth in South Asia

The long run results for the PMG-ARDL model reveal that FDI (LNFDIINIF) has a positive but insignificant influence on economic growth (LNEG) in the South Asian region with coefficient of 0.278 having p-value of 0.119. This implies that FDI might indeed have a positive association with growth, but this effect is weak and not robust enough to be statistically significant. Several factors can be used to explain this low contribution, including weakened institutional quality, poor regulatory conditions, lack of technology absorption capacity. South Asian nations tend to attract FDI into resource-intensive or low-tech industries, with relatively low impacts on productivity growth or sustained long run development.

According to the PMG-ARDL model estimates, FDI has no significant short-run effect on economic growth with coefficient of 0.003 having p-value of 0.801. This is consistent with the logic that short run FDI fluctuations may get more absorbed by

other economic factors like global market conditions, local economic conditions, or short run policy shifts, rather than matter for growth immediately. The absence of short-run effect in South Asia may reflect structural obstacles such as bad infrastructure, regulatory inefficiency, and low-quality human capital, which prevent FDI from having any immediate and observable effect.

The FMOLS results for South Asia also reveal that FDI positively affects economic growth. However, this is not a significant effect on economic growth with coefficient of 0.018 having p-value of 0.548. This corroborates the argument that although in the long run FDI could have a positive influence, its contribution is deeply confronted with the structural and institutional limitations in the region. The coefficient is positive, so FDI does have the potential to stimulate growth, although the lack of statistical significance suggests that the mere presence of FDI is not enough to catalyze economic dynamism.

The contrary is evident in other country's studies, where some writers do not note any spillover effect or it is marginal in an economic sense. e.g., while (Blomstrom, 1986) shows that sectors in Mexico with a higher level of foreign ownership grow faster in levels of productivity. His study along with that of similar papers faced with a key identification problem such as if FDI is accepted towards more productive industries (industry effect would be across the sample but missing in each observation), the observed positive correlation would overestimate the positive effect of FDI on growth. Aitken & Harrison, (1999), based on plant level data for Venezuela, show this to be true in their data and then go on to fail to find any evidence. There are some encouraging results on the scale and competitiveness of FDI effects following the old approach to measuring returns. This has been consistent with (Haddad & Harrison, 1993)'s study based on panel data for Morocco, showing the aggregate effect of FDI on productivity is low. In the case of (Aitken & Harrison, 1999)'s study, FDI increases productivity in plants both in foreign and domestic which are recipients of the investment, but reduces the productivity of plants that are domestically owned. This result contradicts spillover theory.

A further reason why the impact of FDI may be weak in South Asia. It is foreign investors in the region who have little interest in the long run, with the utmost focus being on short run returns. Such behavior may lead to dampening the possible FDI returns due to the transfer of technology and innovation. The limited interaction between foreign and local firms in most South Asian countries implies that the positive externalities associated with FDI productivity increases, technological upgrading, and increased competition are not fully exploited.

On the other hand, Capital Formation (LNCF) is highly and positively linked with economic growth with coefficient of 0.276 having p-value of 0.023 and bears witness to its role in stimulating economic growth. This is additionally reinforced by the FMOLS regression with a strong positive impact with coefficient of 0.485 having probability of 0.000.

Technology innovation (LNTAI) has a positive but non-significant impact on economic growth in South Asia, which may imply that although technological advancement might lead to growth, its effectiveness has not yet been realized. This is also supported from the value of the FMOLS model coefficient value at 0.069 with probability of 0.312, which suggests that (manufacturing) technology growth in the South Asian countries is not yet a powerful engine of growth. LNLF is also positively related to economic growth in the long term with coefficient of 6.592 having probability value of 0.145, but the estimated value is not statistically significant. This is to say that although an enlarged labor force could contribute to economic expansion, there might still be some more significant determinants in a region, such as capital accumulation and technological innovation.

The productivity and competence of the potential labor force is among the most important variables affecting economic growth (Duval et al., 2010). Yet, Clark et al., (1999) indicate that labor participation rates are negatively correlated with per capita income. Li et al., (2019) investigated the relationship between renewable and economic growth in SAARC nations. They find that renewable energy has a beneficial effect on economic growth.

The efficiency and capacity of the skilled labor force are one of the main factors that affect economic growth (Duval et al., 2010). However, Clark et al., (1999) show that per capita income is inversely related to labor participation rates. Li et al., (2019) examined the nexus between renewables and economic growth in SAARC economies. Their results indicate that renewable energy positively impacts economic growth.

The empirical findings of South Asian economies confirm that FDI has a positive but insignificant effect on growth in the short and long run. FDI may have positive contributions to growth via capital inflow and, possibly, technology diffusion, but it still cannot have a significant impact, as there are several structural and institutional obstacles in the area. The absence of technological absorption capability, poor regulatory institutions, and poor human capital quality have reduced the capacity of FDI to generate substantial and sustainable growth. For South Asia to maximize the benefits of FDI, it must improve institutional frameworks, governance and the absorptive capacity of domestic industries.

On the other hand, the significance of capital formation and expansion of the labor force in contributing to economic growth points toward the importance of investment in physical & human capital for long-run growth prospects of South Asia. Accumulation and investments of capital significantly affect the economic development of individual economies and the economy as a whole. It is a normal expectation that inflation will go up with a growing economy (Fabayo & Ajilore, 2006). KUMAR & PARAMANIK, (2020); Rahman & Vu, (2020), and Shahbaz et al., (2015) also showed data in line with financial development having a positive impact on economic growth. Anton & AfloareiNucu, (2020) also discovered that financial development supported the adoption of green technologies-led to the support for economic growth. Nonetheless, factors like technology, infrastructure, and governance should be consolidated with an enabling business environment to foster FDI's contributions to growth more efficiently in the long run.

FDI is important for economic development in South Asia, but it is evident that structural reforms need to be implemented to ensure that foreign investment leads to long-term development in the region.

6.3.3 Theoretical Discussion: FDI and Its Implications for Economic Growth in ASEAN Countries

Foreign Direct Investment (FDI) is generally considered a major driver of economic development in ASEAN. In principle, FDI can promote growth in various modes. First, Foreign Direct Investment (FDI) offers flows of capital into the host country, and it is crucial to countries that have a low domestic rate of savings and investment (Wang & Wang, 2015). This capital can be invested in infrastructure, industry, and business and this raises the total economic potential. Second, FDI usually brings technology and managerial know-how that can contribute to the productivity of domestic enterprises. These transfer payments raise the effectiveness of labor, product quality and new production methods as drivers of development.

FDI also enables the host country to become part of the world economy by accessing new export and trading opportunities. MNCs import readymade supply network, distribution channels, and market access that enhance the competitiveness of local firms in the international arena. FDI can also bring competition to the national market and stimulate local firms to innovate and to rationalize. These things, in turn, make productivity higher and help in the long run economic growth.

With respect to the Association of Southeast Asian Nations (ASEAN) region, there are particularly high theoretical expectations for FDI. The Southeast Asian nations traditionally attract investment and trade and gain from the flow of capital and technology. However, FDI's contribution to economic growth depends on a region's institutional quality such as governance structures, regulation environments, or ease of doing business. Institutions matter and a pro-business climate if maintained it is

likely that FDI will have an enhancing impact on local industries and the local economy.

6.3.4 Empirical Discussion: FDI and Its Implications for Economic Growth in ASEAN Countries

There is empirical evidence in ASEAN that FDI has been a major driving force of economic growth. In terms of FDI, based on the finding from ARDL model, FDI (LNFDINIF) has a large positive and significant effect on growth (LNEG) in ASEAN with coefficient of 0.262 having p-value of 0.000. This predicts that in case of ASEAN, FDI plays a significant role in growth, promoting economic growth in the region by way of capital inflows and technology spillovers.

When positive relation between FDI and economic growth prevails in ASEAN, it confirms the theoretical suppositions that FDI helps in capital formation, technology transfer, and industrialization. The immediate effect for ASEAN are also in line with the latter with weaker coefficient value of 0.004 having p-value of 0.281). The short-term effect of FDI may be dampened slightly because of external factors like the global economic situation. However, the long-term effect stands out, indicating the important role that FDI has played in the economic course of the region.

The evidence from FMOLS also highlights that FDI is important in ASEAN. The FMOLS estimate indicates that FDI is positively related to economic growth in ASEAN with coefficient value of 0.260 having p-value of 0.000. This serves to remind that FDI is important not only in its pure forms of capital and technology but also in supporting the longer term industrial and technological development of the area.

FDI has been found by several investigators to be significant and positive in affecting the economy of host countries through supporting domestic investment and employment, technology transfer, and creating additional inter sectoral linkage

(Agosin& Machado, 2005). Har, Teo& Yee, (2008) further concurs that Malaysia views FDI as a non-negligible engine to their economy but in the context of the Malaysian economy, FDI and economic performance have directly upward association. There are only a few studies in the reference that find that FDI inflow has a negative impact on economic growth (Seldon and Song,1994; Herman et al., 2004).

Capital Formation (LNCF) is negative with economic growth with coefficient of - 0.309 having probability value of 0.113 but not significant. FMOLS, however, indicates a very significant negative influence with coefficient of - 0.452 having p value of 0.000, indicating that in spite of some irregularities, investment still proves to be a key growth driver in ASEAN. (LNTAI) in ASEAN has a strong significant positive impact on economic growth with coefficient of 0.424 having probability value of 0.000. Thus, technological innovation is key to stimulating growth in the region. This result is also reinforced by the 0.392 with probability value of 0.000. The LNLF indicator appears to exert substantial short run influence on growth with coefficient of 3.517 having probability value of 0.030. Its long- run impact is not statistically significant with coefficient value of 1.072 having probability of 0.239. This suggests that in the short run, a larger labor force foments growth, but its long-run impact may not be as important as the likes of capital accumulation and technological progress.

One of the reasons to cause the huge positive effect of FDI in ASEAN is the good business environment in this area. On average, ASEAN member states have better institutions, infrastructure, and openness compared to other developing regions. The conditions are favorable for international investors to invest for the long term, which is a win-win situation. The role of FDI in development is enhanced by the interconnection of ASEAN in global value chains, which allows multinational corporations (MNCs) to not only invest capital, but also supply or offer technologies, and managerial skills.

Moreover, ASEAN's focus on economic liberalization and trade openness has made the region attractive to Foreign Direct Investors. Regionalism in terms of regional market integration, including the efforts made to establish the ASEAN Economic Community (AEC), has promoted more efficient cross-border investment flows, greater market access and greater standardized regulations. All of these help to enhance the growth potential of FDI.

The ASEAN's empirical evidence shows that FDI is a major force in promoting economic growth. The PMG-ARDL as well FMOLS models indicate that the FDI has a strong, positive, and significant impact on economic performance in the region. This is consistent with the theoretical premise that FDI will lead to capital accumulation, technology diffusion, and thereby industrialization. ASEAN's friendly business environment, strong institutional quality, and international connectedness are important determinants that enable the region to fully utilize the potential advantages of FDI.

On the whole, both theoretical and empirical discourses show that FDI is an indispensable ingredient for the long-run economic development in ASEAN. For ASEAN to continue to receive the benefits of FDI, the region has no choice but to keep its investment regime open, to build institutions, and to become more competitive in markets. These efforts will make FDI remain a source of economic growth and prosperity in the region.

6.3.5 Combined Discussion on Economic Growth in South Asia and ASEAN Countries:

A number of research papers have been conducted showing that FDI has a positive impact on GDP per capita and is a stimulating impetus in the sense that foreign investment is the cause of the country's economic development. Likewise in (Basu & Guariglia, 2007), they found a positive and significant association between FDI and growth in 119 countries. But the impact of FDI on economic growth primarily relies on the host country's environment.

Alfaro et al., (2004); De Mello, (1997), and Liu et al., (2017) support that the role of FDI depends on the institutions and economic environment of the country. FDI can be influential in the development of a country in a positive sense, particularly when it leads to innovation and knowledge transfer in cooperation with local firms that have the potential to impact on the economy (Alfaro, 2003).

But not all research findings support the positive effects of FDI. For instance, (Borensztein et al., 1998) claim that FDI can have an adverse impact on the development of LDCs and Fry (1993) agree, and asserts that FDI can harm growth in some countries. De Mello, (1999) finds that the effect of FDI on OECD is positive, however, the effects of FDI on non-OECD countries are negative. Such conflicting results imply that the relative contribution of FDI in promoting growth is contingent upon a combination of factors such as the type of economy and the quality of institution in the host country.

Moreover, the estimations for FMOLS indicate that financial development has a positive effect on GDP per capita, in line with Bist, (2018). The research revealed that for some African countries a greater credit to private sector had a positive influences on GDP, while for some African countries it had an adverse effect on economic growth. This gap could result from weaker growth models and higher quality of non-performing assets of these countries. Rajan & Zingales, (1996) also state that better developed financial markets matter for growth, which is in line with such measures coming out of other works as well. This explains the non-linear relationship between financial development and economic growth.

The COINTEQ01 term is the Error Correction Term (ECT) that reflects the velocity at which the system returns to equilibrium following a short run impact. It quantifies the short run, long run adjustment mechanism. In the case of South Asia, the value of the coefficient for COINTEQ01 is -0.040 and the p-value is associated with it is 0.052 , indicating that the system slowly reverts to equilibrium, since the p-value slightly exceeds 5%. This indicates that the process of movement to the long run equilibrium of economic growth for South Asia is not so fast. For ASEAN, the

coefficient of COINTEQ01 is -0.033, with its probability value being statistically insignificant at the 0.068. This reflects a relatively slower reversion process to the long run and the process of mean-reversion appears to be less compared to what occurs in ASEAN.

The gross fixed capital formation of the SAARC countries has a positive impact on economic development. When an economy grows, it can be expected that there would be an upward swing in the level of inflation, Fabayo & Ajilore, (2006). For ASEAN, the long-run effect of real capital formation is negative with coefficient of -0.309 having probability value of 0.113 and it is not statistically significant. This may suggest that while the capital stock is critical, inefficiencies or resource misallocation can erode its beneficial effect. The FMOLS result supports an inversely negative relationship with coefficient of -0.452 having probability value of 0.000, which demonstrates that capital formation might not be effectively contributing to economic growth in ASEAN where non-productive investments or a structural problem are probably taking place. It is attune to the findings of Kanu, S. I., & Ozurumba, B. A. (2014), who establish a negative relationship between economic growth and capital formation in Nigeria.

In South Asia, LNCF has a positive and significant short run impact on the long run economic growth. The FMOLS estimates provide the same evidence as well, with a significantly positive correlation coefficient of 0.485 with probability value of 0.000, which reflects the crucial role of capital investment in long-term growth. For ASEAN, however, the long-run impact of capital formation is negative with coefficient value of -0.309 having probability value of 0.113 and it is insignificant statistically. This may imply that capital investment matters, but inefficiencies or the misuse of resources could lower its positive effect. From FMOLS, indeed there is a negative relationship with coefficient of -0.452 having probability value of 0.000, implying that the capital formation in ASEAN might not be efficiently contributing to the growth of the economy in ASEAN as well, perhaps due to non-productive investments and structural factors.

South Asia has a positive long run relationship between the Labor Force (LNLF) and Economic Growth. This suggests that a greater working population can contribute to promoting economic growth. However, this effect may not be strong enough to be statistically significant in ASEAN. The Labor Force is a positive like South Asia. The effect is not significant in the long run. This implies that the scale of labor force by itself does not exert any direct significant impact on long Run economic growth in both regions. Some other variables such as capital formation and technological innovation are more relevant.

In South Asia, Long-term technological innovation (LNTAI) has a positive impact on income but insignificant. In the same vein, the ASEAN displays statistically significant positive relationship, with positive effect of technological innovation with coefficient value of 0.392 having probability value of 0.000, thus reflecting that technological progress plays a crucial part in fostering the economic growth in member countries. This is a clear testimony that ASEAN has possibly succeeded more than South Asia in the way of adopting new technologies, increasing productivity and accelerating industrial efficiency.

In South Asia, capital formation is the dominant determinant of economic growth, and the labor force and Technology contribution are negligible. From the results, it is clear that in ASEAN, capital formation influences negatively in the long term.

6.4 TO INVESTIGATE THE IMPACT OF CAPITAL FORMATION AND LABOR FORCE ON ENVIRONMENTAL DEGRADATION.

6.4.1 To Investigate the Impact of Capital Formation on Environmental Degradation in South Asia

In South Asia, the relationship among capital formation, labor force participation, and environmental degradation is intricate and interwoven, which affects its development and environmental sustainability. Capital formation based on infrastructure investment and investment in human capital leads to subsequent

growth through better production and services necessary for life, for example roads, housing, energy, and access to clean water. This expenditure can have a substantial benefit on quality of life and economic growth. But the impact on the environment of such progress is tremendous. Mega infrastructure projects have, as it is generally seen, resulted in the destruction of the environment, deforestation and pollution due to the growth of industrial and urban infrastructure. The theoretical perspective posits that capital accumulation is a fundamental factor leading to growth and yet it intensifies environmental degradation through the utilization of resources and pollution, especially in resource-based sectors (González-Blanco et al., 2019).

This theory is supported by empirical evidence. The evidence from ARDL & FMOLS estimators suggests that capital formation is positively and significantly associated with environmental degradation in South Asia. In particular, a 1% increase in capital formation is shown to result in a 15% –30% increase in CO₂ emissions in the long run. This is consistent with the premise that capital accumulation leads to economic growth, but at the same time speeds up ecological destruction, particularly in sectors where the extraction of fossil fuels and other natural resources is high. But in the short run, the effect of capital formation on environmental degradation is very little with coefficient value of - 0.034% from PMG-ARDL model 4, indicating that its immediate environmental consequences are either small or being counteracted by procedures like economic instabilities or inefficient government regulation. Despite neutral short-run impact, the long-run implications of capital formation highlight the importance of environmentally sound policies to trade-off between growth and the preservation of the environment.

6.4.2 To Investigate the Impact of Labor Force on Environmental Degradation in South Asia

At the same time, the increased labor force in South Asia driven by the growing economy also imposes stress on the environment. An expanding labor force fosters rising demand for industrial production, energy, and transport with the result of higher pollution, greenhouse emissions and deforestation. From a theoretical

perspective, labor force participation is believed to increase industrial activity and resource use, and thus environmental degradation (Brown, 2005). The STATA model provide empirical evidence in favor since, the short run labor force participation raises environmental degradation significantly positively with coefficient value of 0.341 having p value less than 0.05. This result substantiates that industrialization rapidly becomes stiff and the use of resources and pollution are exacerbated as the dimension of the labor force expands.

The long-run impact of labor force participation on pollution, however, may damp harsh as it influence environment degradation. The empiric results from the models highlight the negative impact of labor force participation in the long-run with coefficient value of - 1.699 for Model 1 and -1.485 for Model 4. This means that as countries develop, they switch to more efficient resources technologies, and also to greener behavior. This unexpected result suggests that the expansion of the labor force might lead to creation of green jobs and production processes are more environmentally friendly and it is less damaging to the environment. These results are consistent with the theoretical expectation that explosive demographic increase and investments in green technologies can conspire in reducing environmental degradation.

Capital accumulation and labor supply drive environment degradation in the short-run through promotion of industrialisation and urbanisation that would in-turn present increased pollution, resource depletion and biodiversity loss. In the overall scheme of things, it can actually be more advantageous if sustainable practice, energy-efficient and low eco-impact infrastructures, and green tech are injected instead. Available empirical evidence also suggests that, on the one hand, capital accumulation and labor force growth are related to more pollution and environmental degradation, but, on the other hand, a structural change facilitated by a change of the scale and composition of investment towards a growing presence of sustainable industries, and green jobs can mitigate the harmful effects on the environment. The short-term effects will manifest themselves in an immediate crunch on resources, but the long-term cures for these strains in green technologies

appears encouraging. For this to happen, South Asia will need policies through which economic growth can be combined with the need to protect the environment, so as to produce growth without adversely affecting the environment and the natural resources in the region. To sum up, the near-term environment costs of capital building and labor force expansion can be offset by timely interventions, investment in green technologies and better governance for a sustainable future of South Asia.

6.4.3 Capital formation and labor force Impact on environmental degradation in the ASEAN

Capital formation and labor force participation are both important factors in determining the direction of the ASEAN countries' environment. In the short term, both depressed and distant variables promote industrialisation, urbanisation and resource consumption. All of these are responsible for the degradation of the environment. But the lasting implications of these factors is more nuanced. Capital creation, investing in sustainable industry and the green tech can be a game changer for the environment. Likewise, labor force participation, in the right segments and green sectors of the economy can reduce degradation of the environment with stress of the economy toward low-carbon industries and practices that are sustainable.

The evidence shows that, while ASEAN is confronted with the environmental costs associated with capital formation and the expansion of its working population, it also has positive prospects. The region's green tech investing, renewable energy initiatives, and eco-friendly industries could also counteract some of the negative carbon compounding of industrialization and urbanization. Strong policy frameworks, sustainable development incentives and regional cooperation will be essential in enabling economic growth in ASEAN without sacrificing environmental well-being in the years ahead. Through training the workforce and raising awareness of the environment, it can move the region toward greener and more sustainable futures.

The interconnections between capital accumulation and participation of labor force can be complex and multi-dimensional for ASEAN. The accumulation of physical and human capital represented by investments in infrastructure, development of manufacturing bases and energy is at the heart of the industrialization, urbanization and economic growth process across the ASEAN. This expansion often comes at a high environmental price. In theory, these sectors are more intensive in the use of natural resources as capital is allocated to capital-intensive sectors such as manufacturing, construction and power and thus resources are exhausted, waste is generated and pollutants are released more rapidly. These consumption-driven sectors are highly dependent on burning fossil fuels and exploiting non-renewable resources, resulting in higher carbon emissions, deforestation, air pollution and water pollution. The so-called “iron triangle” model that the trade-off between economy and environment is an ineluctable one have indicated that the bio-capital accumulation has its own importance in the regional economic growth. And meanwhile, capital formation (as for training bio-capital) aggravates environmental pollution except for sustainable political measures.

Empirical evidence also supports the relationship. The findings of the PMG-ARDL and FMOLS also show that a 1% change in capital formation in ASEAN brings on 0.12% increase in CO₂ emissions in the long run and 0.060234 in the short run. These results support the well-developed idea that the accumulation of capital in energy-intensive sectors and mega infrastructure projects is the major contributor to environmental damage. The coefficient of 0.224 in the FMOLS estimates confirms that the accumulation of capital leads to industrialization and urbanization, which further stresses the environmental resources. However, the empirical findings suggest that capital formation is not environmentally sustainable in the sense that infrastructure investments based on established technologies impose a high carbon emission and environmental cost. Our empirical findings are consistent with Lynch (2016) as well as Onalan&Basegmez (2018) that infrastructure investments lead to better economic outcomes but they are the major contributors to carbon emissions and environmental damages if their sustainability is not upheld.

Likewise, ASEAN's labor force participation is intimately associated with both economic expansion and environmental deterioration. In theory, as they contribute to further resource depletion and pollution the number of people in the work force increases, so do the numbers of cars and trucks on the road, the amount of energy used, and the pounds of goods produced. All of which lead to greater consumption of resources and greater pollution. Industrialization and urbanization as scale effects are brought about by an expanding labour force, which can lead to increased air and water adverse environmental effects (e.g., pollution, greenhouse gases, deforestation). On the other hand, the influence of labor force participation on environmental deterioration is not totally negative. If the new entrants are accompanied by investments in cleaner industries and green technologies, labor force growth can contribute to reducing the environmental degradation that results from economic growth. In principle, the rising labor force in ASEAN could also trigger a structural transformation toward sustainable industries and technologies that are green, and hence create a green economy.

Empirically link this to ASEAN, where both short run and long run capital formation and labor force are able to impact environment. In the short term, there is a positive and significant relation between labor force and environmental degradation, The coefficient on the lag of labor force participation, LNLF, is 0.341 with $p < 0.05$. This means that an expansion of the labor force, which leads to a vigorous use of industrial activity, can result in more efficiency demand and pollution. Nevertheless, in the long-term, the impact decays and bears a pooled negative coefficient of - 0.014 with P-value of 0.063 in the PMG-ARDL model, illustrating that as the labor force expands further, the degradation of environment may fall. This unexpected result indicates that in the meantime as ASEAN countries experience moving up the ladder of income, the expanding labor force will give momentum someday to leap into more resource-efficient technologies and greener activities. These observations are consistent with a theoretical perspective on the role that population growth plays in interacting with strategic investments in green technology and education to mitigate environmental damage.

Capital formation and labor force participation both lead to environmental degradation in the short run by accelerating industrialization and urbanization, which raise the level of pollution, resource use, and destruction of forests. Nevertheless, if the ASEAN countries predominantly favour sustainable development, green technologies, the long-term implications of these drivers may well be beneficial for its surrounding environment. Empirical findings underscore the importance of taking a balanced approach with capital formation, a key contributor to growth, directed to environmentally friendly sectors, and growth of the labor force balanced against education and employment creation in sustainable activities. Robust policy and institutional frameworks along with adequate investment in green technologies and regional cooperation will be critical to ensure that economic development in ASEAN doesn't take a toll on the environment. In conclusion, capital formation and labor force participation add to pollution in the short-run but its long run effect can be reduced by making sustainable investments and adopting eco-friendly policies so that ASEAN countries can move towards a greener and sustainable future.

In summary, although increased capital formation and labor force participation contribute to the pollution in the short run, their long run effects are beneficial when ASEAN countries adopt eco-friendly methods and environmental regulations that will encourage the region to be on the path of a sustainable and equitable future.

6.5 To compare the results between the panel group South Asia and ASEAN countries by considering economic, social, and environmental views.

6.5.1 Economic Views

In the region of South Asia, economic development is closely related to other macroeconomic variables such as FDI, economic growth, capital formation, and energy consumption. FDI is essential for economic growth because it brings needed capital, technology, and energy consumption that can also increase industrial productivity, create jobs, and increase production, tourism, and trade. Capital formation in South Asia is not only significantly related to growth with coefficient

value of 0.276** having p-value of 0.023, but it also has a direct positive association, establishing the argument that investments in infrastructure and industries contribute to growth. Meanwhile, FDI does appear to have positive influence on the growth of economy in South Asia but the effect is less strong compared to ASEAN region. In ASEAN, it is seen that the coefficient of FDI is 0.019206 with P-value of 0.6569, this indicates that there is a contribution of FDI to economic activity of a country that seems to be weak. With further economic development, more energy is consumed and industries are further developed, so the demand for resources and energy resources expands accordingly. These activities lead to more pollution, depletion of resources, and environmental stress, as can be observed in the positive correlation between capital formation and environmental degradation. Expansion of investments in infrastructure, manufacturing, and construction fuels and accelerates the usage of energy, often at the expense of nonrenewable energy sources, causing ecological damage.

In contrast to South Asia, the contribution of FDI in ASEAN to its economic growth is more prominent. Theory and evidence suggest a positively robust relationship between FDI and economic growth having coefficient value of 0.262*** along with its p-value of 0.000. With better institutions, infrastructure and openness to foreign investment, the region becomes an attractive destination for FDI that helps to accumulate capital, transfer technology and promote competitive industries in ASEAN. This is also supported by the results of the FMOLS and the PMG-ARDL model. FDI promotes higher economic growth but capital formation negatively affects economic growth in ASEAN, although its role is muted by constraints such as inefficient use of resources (e.g. energy-intensive sectors which generate growth but at the same time environmental degradation). Certain factors of capital formation do not affect economic growth such as inappropriate distribution of the capital, illiteracy and ignorance, capital accumulation and dependency on natural resources and the main reasons of FDI do not affect economic growth displacement of domestic capital in ASEAN nations.

Capital investment in educational institute and established training center to enhance labor productivity and for this trained labor attracts domestic investment. Skilled labor can drive innovation and contribute in high value industry in South Asia and ASEAN countries.

The labor force (LNLF- its coefficient value 0.51 with p value 0.04) growth seems to have contributed little in environmental deterioration, which implies that the labor force had limited effect on the environment through a positive promotion of environmental sustainability. For economic growth to be better synchronized with environmental objectives in the region, South Asia should invest in training the workforce on green technologies and sustainable knowledge. In the group of ASEAN, labor (LNLF) has a positive correlation with environmental degradation which means an increasing labor force leads to high industrial activities and resource use. That can be problematic for ASEAN with its labor force expansion and the environment. Policy makers need to focus on creating sustainable industries and jobs so the increase in number of workforce is not at the expense of environmental health.

In the South Asia, capital formation (LNCF) is directly associated with environmental degradation, meaning that there is large investment in industries that will lead to resource depletion and pollution. To promote sustainable development in the region there is an urgent need to shift capital investments and natural resources towards renewable energy, sustainable infrastructure, and clean technologies. It ensures that economic growth contributes to environmental sustainability. The effects of capital formation (LNCF) on environmental degradation are weak or not significant in the case of ASEAN, indicating that capital investments are not strong enough in environmentally friendly projects. In order to maximize the economic gains from capital formation, ASEAN must focus on green investments in areas including renewable energy, sustainable transport and environmentally friendly manufacturing to ensure sustainable economic growth.

In South Asian and ASEAN countries, technological progress (LNTAI- its coefficient values are respectively 0.040 and 0.03 with p value from PMG-ARDL are 0.493 and 0.05) has also been found to have a positive relationship with environmental degradation, which indicates that as much as technological improvements contribute to economic development, it is not yet in support of sustainability. This correlation in South Asia suggests that innovation could result in greater consumption of resources and industrial pollution. South Asia should focus on green technologies as well as innovations which are environmentally benign in order to make sure that technological progress is compatible with sustainable development. Likewise, in ASEAN, technological development might be leading to increased environmental damages and therefore a change to greener technology is necessary. By choosing the industries and technologies that minimize environmental footprints, both regions can harmonize technological development with sustainable economic development.

The estimation of renewable and non-renewable energy consumption results for South Asia suggests that promoting renewable energy would make an appreciable reduction on the level of environmental degradation in the long-run and therefore, sustainable and environmental friendly economic growth. This indicates that investing in physical infrastructure for renewable energy should have long-enduring economic pay-off by combining mitigation of environmental damage with possibly new green industries and jobs. But the positive correlation between the exploitation and degradation of environmental resources highlights the economic cost of depending on non-renewable ones. In order to secure sustained economic growth, South Asia needs to not only accelerate the adaptation of renewable energy but also find ways to address resource depletion in order to reduce further environmental harm.

In the context of ASEAN, the results suggest that using renewable energy consumption may be beneficial for the environment in the short run but in the long run, economic costs of this effort are varied. There is a positive relationship in the long run between renewable energy consumption and environmental degradation.

The increase in industrialization or economic growth due to renewable energy consumption increases the environmental cost of renewable and new production activities, resulting in an unintended economic cost. In this regard, the countries of ASEAN are confronted with the task of reconciling the growth of the economy based on renewable energy with sustainable resource utilisation. Policymakers will need to develop policies that prevent economic development from environmental deterioration, and foster a future that is both economically practical and environmentally sustainable.

6.5.2 Social Views

In the context of social and environmental indicators, an option can be adopted for the most reliable indicators to evaluate how social aspects are affected by economic activities and environmental issues or how they affect social aspects, focusing on social inequalities, community welfare, access to resources and sustainable development. It explores how economic development, technological growth, and environmental practices can aid or disrupt the well-being of individuals and communities, particularly the most disadvantaged.

Benefits of FDI and economic growth in South Asia is having a significant effect on the social welfare and creating employment opportunities, increasing income levels, and helping to access the educational and health system. But some don't benefit proportionally from that progress. And there is no equality in society. Although in the economic growth model LNFL (South Asia its coefficient value 6.592 and p value 0.145) has an insignificant positive effect on social mobility, it is faced with the rapid growth of the labor force. The economy may not be able to produce enough high-quality jobs to keep pace with the growing working-age population, and many workers may have to settle for underemployment or insecure jobs. This contributes to social inequality, if financial benefits become concentrated in metro areas or specific industries.

Similarly, in ASEAN, FDI and economic growth are transformational, leading to job creation, more income, and better access to basic services of health and education

which in turn leads to social inclusiveness. But although the economic picture is getting better just as with South Asia, its fruits are not fairly shared, leading to social disparities. While participation in the labor force LNLF (ASEAN coefficient 3.517** with p value 0.030) increases social mobility in ASEAN, by showing not enough ‘quality’ jobs are generated in the economy or skill formation systems are not developed sufficiently. It leads to underemployment as well as poor working conditions.

Tourism has negative impact on environmental degradation means it’s good for in South Asia which fostering social development through employment generation and livelihood support. But if it is not sustainably managed, uncontrolled tourism can result in cultural commodification, social displacement, and the dilution of local heritage more broadly in popular destinations. This also exacerbates social inequality because local communities may find themselves dispossessed of their heritage resources.

Tourism is a critical sector in the economy of ASEAN nations, including Thailand, Indonesia, and Vietnam. It sustains local economies and encourages cultural exchange. But the adverse environmental effects of tourism including waste production and pollution, and overuse of natural resources can exert pressures on both social and environmental systems, if tourism is not developed sustainably. Over-tourism can also result in social displacement in destination areas, which damages local communities and their heritage.

Technological innovation can also affect the environment by shaping how resources are used, how energy is consumed, and how societies meet the needs of growing population. But from a social standpoint, it’s also important that technological advances decrease the disparities and damage resulting from environmental degradation. In South Asia, the emphasis is on how innovation in green technology can meet local demands, such as for clean water, renewable energy, and sustainable agriculture. Within ASEAN, the sociological view emphasizes the need to push forward technologies that enable communities and green behaviors, so that

technological progress can lead to a better quality of life and environmental sustainability.

In South Asia from the economic growth model, the social commitment encourages that capital formation is positive in economic growth, which is also better for community access to clean energy, enhanced public services, and green infrastructures. In ASEAN, capital formation result is not suitable for economic growth and environment. In South Asia and ASEAN, LNENRC (Energy Consumption in FMOLS (STIRPAT model), coefficient for South Asia 0.382 and p value 0.006, ASEAN coefficient 0.546 and p value 0.00) emphasizes the social problems arising from dependence on fossil fuels namely environmental degradation, air pollution, and health issues. They also disproportionately impact low-income and vulnerable populations, contributing to social injustice. It is socially responsible to advance energy efficiency, to decrease our reliance on fossil fuels, and to support affordable and fair access to clean energy, for everyone belonging to urban and rural communities.

In contrast, the LNRENRC (Renewable Energy Consumption) is proven to be a potential solution for sustainable development that provides clean power, improved public health, and green jobs. In South Asia, the Ramp-up of renewable energy can facilitate energy access and abate energy poverty. Social responsibility in this case, makes sure that renewable power is available, affordable, and for everybody, especially to the poorest of all. In ASEAN, the short-run effects benefit the environment from using renewable-energy sources, but long-term, it exacerbates degradation; thus, the emphasis should be on making renewable cleaner and more inclusive, while supporting both economic and social welfare.

From a social perspective, all of these factors must be examined in the context of inclusive growth and environmental sustainability. South Asia and ASEAN should emphasize that economic growth is not gained at the cost of environmental well-being or social parity. This means of building sustainability into every part of the economy including communities, so that as the economy grows, every community

benefits and no one is left behind, or no one is actively harmed (e.g., pollution, resource depletion, and inequality).

6.5.3 Environmental Views

The economic growth variable is the same for the two regions, but for both regions, the results are different. For South Asia, it is positive, and for ASEAN, it is a negative impact on environmental degradation.

For South Asia, the STIRPAT model findings indicate that economic growth and environmental degradation are positively associated together, implying the region is on a “dirty development path” i.e., growth is occurring at the expense of the environment. This is particularly the case in nations which are still heavily based on industrialisation, increasing fossil fuel consumption and expanding agriculture to generate growth. The findings show that the South Asian countries along with many other developing countries might be at the stage of development where economic growth has an adverse impact on the environment owing to the lack of sustainable practices, less stringent environmental regulations, and dependence on dirty industry. If the region continues to develop, time could change and the region could grow into a more sustainable phase by following the model of the Environmental Kuznets Curve which tells in many cases that growth could start to be decoupled from environmental destruction.

In the ASEAN (coefficient is -0.75 and p value 0.00) countries, the long run evidence of economic growth and environmental degradation relationship is negative, thereby revealing that these countries may be achieving economic growth without increasing environmental damage. This implies that there might be greener growth for ASEAN, particularly driven by environmental policies, technology, and new opportunities in green industries. Therefore, the environmental perspective here would be supportive of the notion that economic growth and the destruction of the environment are not inevitable consequences of each other. In this regard, good policies, technological investments and a transformation of economic structure, growth and the preservation of the environment can be compatible with each other.

The labor force in the two regions is strongly linked to economic growth, but from an environmental perspective, its effect on sustainability relies on which kind of industries workers are employed in. In South Asia, the potential role of labor force for promoting sustainable practices in labor-intensive industries is important. But the environmental implications might be different if the labor growth were tied to resource-hungry industries. In ASEAN, the expanding labor is related to the boost of industry, which leads to the exhaustion of resources and higher emissions. The goal includes the development of a greener workforce, sympathetic towards industries preserving the environment and technology known as green technology, so that instead of causing harm, the workforce is working towards environmental sustainability.

Capital formation or investment into infrastructure, industries and technologies are prominent in both the regions. In South Asia (LNCF in STIRPAT model coefficient is 0.167 and p value 0.219), the positive relationship between capital formation and environmental deterioration indicates the possible misallocation of investments in heavily polluting and resource depleting industries. To achieve environmentally sustainable development must be an investment in renewable energy, sustainable infrastructure, and clean technologies. Likewise, in ASEAN (STIRPAT model coefficient 0.12 and p value 0.00), despite the significant effect of capital formation on environmental degradation, space is left for green investments that would facilitate sustainable industries that can help protect against the negative ramifications of economic growth on the natural environment such as renewable energies and environmentally sustainable transportation.

In South Asia, the association of FDI (STIRPAT model coefficient is 0.022 and p value 0.498) with environmental deterioration is diverse in terms of models. If one theory predicts that FDI may lower environmental harm by introducing cleaner technology and improved forms of management, other theories generate less strong or less discernible impacts (Khan, M. K., & Kazak, J. 2025). One such model is described by that FDI in infrastructure decreases environmental degradation in the long term, thus fostering sustainable development, the ideology that economic

development through FDI can also assist in preserving the environment. This brings the urgency for South Asia to become an attractive destination for FDI and to channel FDI into green and sustainable projects to meet the environmental challenges from a quick industrial and urban development.

In ASEAN, the ‘good news-bad news’ relationship between economic growth and environmental destruction is of serious concern. It points out that economic growth in this region is a double-edged sword. It brings prosperity and it also leads to more pollution, higher carbon emissions and over-exploitation of natural resources. Economic growth generally leads to increased factory production and higher demand for transportation and energy thereby causing more pollution. In order to strike a balance between growth and environmental protection, ASEAN needs to promote green technologies, sustainable industrial practices, and a circular economy to minimize harm to the environment. It’s going to be crucial for ASEAN to invest in renewable energy, clean technologies, and environmentally friendly infrastructure so that it can have its cake to eat and to grow without destroying the environment.

For the environment, technological innovation is a mixed blessing. In South Asia (coefficient is 0.040), the positive association between technology advancement and environmental degradation indicates that technology can promote development but it may also lead to higher resource use and pollution if it is not directed towards sustainability. The challenge is to ensure that technological changes lead to “greener” technology and that there is no retreat into a dirty phase of development. Further, in ASEAN (coefficient 0.03**), the relationship between technology development and environmental degradation implies that technological improvement may generate more emissions or resource-dependent activities. We need to facilitate the adoption of green technologies, such as clean-energy, green-manufacturing, and sustainable farming, that can counter-balance the detrimental impacts of technological advancement on the environment.

The effect of renewable energy use on environmental degradation differs in the two regions. There is the reverse association with environmental degradation in South

Asia in the short run STIRPAT model, meaning that increasing utilisation of renewable energy has a beneficial effect on environment through reducing use of fossil fuels. This transition to clean energy presents an exciting opportunity to cut air pollution and promote lasting environmental health. But in ASEAN, the positive association of renewable energy use and environmental degradation implies that it may possibly be the case in which renewable energy use is on the rise, and hence in regaining industrial activities come back to offset its mitigating impact. A social and environmental challenge in ASEAN is to harmonize the transitions of renewable energy to be consistent with sustainable development practices where the benefits of renewable energy are maximized and the negative effects are minimized.

First, explain South Asia and ASEAN countries' opposite and highly contrasting aspects. Economic growth variable is the same for both region, but their results for South Asia is positive and ASEAN is negative impact on environmental degradation.

The environmental effect of capital formation and labor force participation is highly contrasted and opposite between South Asia and ASEAN due to the different development stages or institutions.

In South Asia, the apparent cause and effect relationship between capital formation and environmental degradation, industrialization, and urban agglomeration has been at the cost of environment. Following the empirical findings, it can be summarized that a 1 % increase in capital stock results into a 25% to 50 % increase in the emission of CO₂ in the long run. On the other hand, for the short term effect in capital formation the positive impact cannot be not statistically significant in the result with coefficient value of - 0.034 and p value 0.472, the cost of industrial growth on the environment, that is, pollution, deforestation and depletion of resources overall is high. The finding aligns with literature reports of (Lynch, 2016; Onalan and Basegmez, 2018), which revealed that all the economic activity and profits enjoyed in the name of development in South Asia is poorly regulated, leading to environmental degradation. In an effort to address these problems, South

Asian countries need to include green technologies in its development process and issue stricter environmental laws.

In ASEAN, capital accumulation results in more pollution and depletion of resources in the short run, but empirical evidence indicates a nuanced relationship. In the long run, FDI and capital formation will most likely help leading to cleaner technologies and more sustainable practices because the region develops a greater interest in renewable energy and green infrastructure. Despite the empirical evidence that connects capital formation with environmental destruction with coefficient value of 0.12 and p value is 0.00 the shift in the region towards environmentally conscious technologies and green energy developments offers the hope of less environmental damage in the future. Additionally, they tell that working age population in ASEAN correlates positively with the adoption of sustainable loop by increasing of educational attainment and technology adoption, which stimulate the preference for cleaner industry and green jobs.

6.5.4 Integrated Economic, Social, and Environmental Views: South Asia vs. ASEAN

South Asia is working to achieve economic development with less degradation of the environment. The short-term consequences of investment creation and labor force expansion in the region accelerate the process of industrialization and then resource depletion even as it worsens the environmental quality. This indicates stronger regulations and technology utilization that are required to avoid the economic development at the cost of the environmental health. And if labor force is complementing green sectors, it needs huge spending on education and clean technologies to move towards sustainability.

On the contrary, ASEAN benefits from FDI and capital formation for the promotion of economic development but is also moving more and more towards green technologies and sustainable economy. Capital formation continues to stress short-run pressure on the environment, but the region's initiatives to invest in renewable energy, clean industries, and environmentally sound infrastructure are working to

offset these impacts over the long run. The ASEAN labor force is equally greener and more capable of promoting sustainable development with the higher degree of education and technological progress. The ASEAN labor force is more supportive towards green growth.

In summary, South Asia has much to do to balance the need for economic growth with the need to preserve the environment. It will take better governance, innovation, and green investments through the challenge. ASEAN countries are grappling with environmental problems and have made greater strides in mainstreaming sustainability in its development plans. The challenge for future growth of ASEAN will, hopefully, lie in its ability to sustain FDI and capital formation-led growth to a greener development direction and not at the expense of environmental health of the region.

This study reveals the divergent impacts of FDI, capital stock, and labor force on economic growth and CO₂ emissions in South Asia and ASEAN. A South Asian policy-based response, supplemented by better infrastructure, is necessary to ensure that economic development is made consistent with sustainability. The successful transition by ASEAN into greener industries and technologies itself serves as a model for what this means for future economic growth amidst South Asian economies. It shows that green growth is not only possible, but indeed necessary for long-term economic growth.

6.6. Other factors Impact on Environmental Implications in South Asia and ASEAN Countries

6.6.1 Economic Growth

In South Asia, LNEG has a long-run elasticity of economic development (LNEG) as 0.677 and p-value of the magnitude as 0.011. This finding implies positive and significant long run association between economic growth and environmental degradation. The positive coefficient indicates that as the economy expands, more degradation occurs (Huang et al., 2021). This is common in most developing

countries where an accelerated process of industrialization and urbanization with higher energy consumption accompanies economic growth. A positive economic relationship means that an increase in economic growth increases income levels and jobs created, increasing overall prosperity and pressure on the environment, but only in the absence of a move towards cleaner and more sustainable growth. This dilemma of having to choose between prosperity and eco-damage illustrates the battle that economies such as in South Asia are grappling with in their pursuit of growth and sustainability.

ASEAN countries show the inverse relationship between economic growth (LNEG) and environmental degradation which indicates that with the growth of economy, the environmental degradation reduces with coefficient value of -0.749 having p-value of 0.000 . This suggests that ASEAN may be going through a period where economic growth that causes less environmental damage turns out to be easier to obtain. This may reflect a shift in industry structure, towards cleaner industries such as services and renewables and away from traditional energy intensive industries such as manufacturing. With the increasing prosperity of ASEAN economies, investments in green technologies like renewable energy and energy efficiency solutions, could contribute to this decrease in environmental degradation or dilapidation.

From an economic viewpoint, this inverse relationship means ASEAN to decouple. The region might begin to embrace such sustainable development models, as its economic expansion benefits from more clean and green technologies as well as greener policies and more efficient resource use. This transformation implies that if there is right policies and investments, it is possible for the ASEAN countries to prosper in a sustained way without further degrading environment, implying green growth is possible.

Higher power consumption, industrial outputs, transportation and construction are the consequences of economic growth and that will impact the ecological footprint. With the running-up of industries and the expansion of construction projects, a larger

amount of natural resources are consumed, and much more emissions and pollutants are produced, which, in turn, result in environmental malpractice.

This finding has economic dimensions and underscores the difficulty of attaining development sustainability. Both areas' policymakers must reconcile seeking economic growth with employing environmentally sustainable strategies. It means that investments in “green” technologies, incentives for energy efficiency and renewable energy, and environmental rules can separate growth from environmental destruction.

6.6.2 Technological Innovation

In South Asian countries, technological innovation and the use of technology have relevant implications for environmental degradation, quantitatively, on greenhouse gas (GHG) and CO₂ emissions, both in terms of implications in the short run and the long run. In the short term, the adoption of new technologies can lead to an increase in GHG emissions if these technologies are energy intensive or fossil-fuel dependent (Lau et al., 2022). For example, the acceleration of industrialization and urbanization enabled by technology usually comes at a massive cost in energy, predominantly provided by coal, oil, and natural gas. This can result in increased GHG emissions that contribute to air pollution and climate change. Also, the early stages of technology adoption may prioritize economic growth and productivity at the cost of the environment, treating industries that are moving away from sustainable solutions as a cheaper alternative. In long-term trajectory, technological innovations hold huge promise to cut GHG emissions and curb environmental degradation in South Asian nations.

On the other hand, in ASEAN countries, technological innovation (LNTAI) have a positive and significant influence (0.03, $p=0.05$ in ARDL) on environmental degradation. This constitutes technology being used to exacerbate, not alleviate, emissions. The key is that most of ASEAN's technological advance is directed toward industrial growth, manufacturing and urbanization, all of which increase

energy consumption and pollution. Green and sustainable innovation and technologies are not on the top of the list.

Theoretically, technology can make things more efficient, reduce carbon intensity, and favor renewable energy. But those benefits come courtesy of strong policy and investment in clean innovation. ASEAN, not being in a “green-transition” phase, but a “growth-first” phase, would explain the positive sign. The role of technology may turn to be environmentally friendly in the long run is with the policy reforms envisaged are eco-innovations (Shahbaz et al., 2018).

With the constant evolution of technology comes a greater focus on sustainability and efficiency to give rise to cleaner and sustainable technologies. Replacing fossil fuels with clean energy technologies solar, wind, hydropower, and more can dramatically cut GHG emissions. Technological advances also allow for a more efficient use of resources, better energy efficiency, and most importantly, better pollution control technologies. One such demonstration is smart grid technologies and energy-efficient appliances. These advancements allow for more efficient energy usage, which can ultimately lower the carbon footprint. Ultimately, the long-term impacts of technology on GHG emissions in South Asian countries depend on several factors including government policies, investment (in research and development) and regional cooperation.

6.6.3 Renewable Energy Consumption

Renewable energy has been thought to be cleaner and more environmentally friendly, but the experience in both South Asia and ASEAN is not the same. In South Asia, the impact of long run renewable energy consumption remains positive and significant (0.335, $p=0.004$), implying that the use of renewable energy is still associated with increased environmental degradation. And the ASEAN there even with the positive value showed being highly significant (0.42, $p=0.00$) in the long run. Far from reducing energy emissions, renewables in these places appear to be making environmental problems worse.

More specifically, fossil fuel energy use in South Asian countries will have important implications for environmental degradation, namely for CO₂ emissions, in the short run and the long run. Prospectively, the emission of CO₂ in the region, in the short term, is the major contributor to the air through the dependence on energy sources including coal, oil, and natural gas. But ASEAN's short run (D(LNRENRC)) demonstrates a negative and significant impact (-0.203, $p=0.004$). In the short term, more renewable use means less environmental destruction (Bhowmik et al., 2025). It indicates that while renewables may create long run transition problems, in the short run they are already producing some environmental benefits through partial displacement of fossil fuels.

Over the long run, reliance on non-renewable sources of energy will have far worse consequences for environmental sustainability and regional economic stability across South Asia and ASEAN countries. As these resources are limited and a lack thereof could risk energy insecurity and higher costs which could impede economic development. In addition, the long run environmental effects of sustained CO₂ emissions that may include global warming, sea-level rise, and extreme weather events could have catastrophic consequences for the area (Umair&Yousuf, 2022). These impacts endanger agriculture, water resources and biodiversity, and hence could worsen socio-economic inequalities with vulnerable communities suffering most.

6.6.4 Energy Consumption

Energy consumption or fossil fuel energy consumption is a leading cause for environmental deterioration. Here in case of South Asia, ARDL results reveal an unexpected negative impact (-0.615, $p=0.018$) of the level of fossil fuel use on degradation suggesting that continued use of fossil fuel is unlikely to be more sustainable indicating either the efficiency improvement or the policy intervention effects. However, FMOLS is quite the contrary, reporting a significant positive effect (0.328, $p=0.006$), consistent with the typical view of the disadvantage of the fossil fuels for the environment. But CO₂ emissions from fossil fuel energy consumption can be curtailed in the long term with appropriate policy action and an increase in

renewable energy. Instead, South Asian countries can place their bets on investing in and developing renewable energy technologies, like solar, wind, and hydropower, which are cleaner and sustainable alternatives.

The reducing CO₂ emissions are achieved through the following policies that promote energy efficiency, conservation, and the adoption of clean technologies. Public awareness campaigns and educational initiatives can also promote sustainable behavior changes in energy consumption practices. By positioning this statement with an understanding of the time frames involved, it may be asserted that in spite of the challenges posed to environmental sustainability by non-renewable energy consumption, aggressive measures to replace this energy consumption with renewable forms of energy and the adoption of sustainable practices it can yield improved long run environmental outcomes.

ASEAN results of the ARDL (1.60, $p=0.00$) and FMOLS (0.546, $p=0.000$) models indicate strong positive effects indicating that fossil fuel dependence contributes to pollution and ecological stress. And countries like Indonesia, Vietnam, Malaysia and Thailand still rely heavily on coal, oil and gas to power heavy industry and heat homes, helping explain such a large impact. This is consistent with international studies (Sadorsky, 2014) and indicates that in the absence of rapid energy shifts, fossil fuels will cause significant damage to the environment in the ASEAN countries.

Fossil fuel energy is also playing a big part in the problem, as we continue to rely heavily upon coal, oil and gas, driving pollution and ecological stress. Even renewable power sources come with more degradation when counting the places like large hydro dams and biomass plants that disrupt ecosystems and require fossil fuel backup. That's not the fastest rate in the world, not even in Asia, but it means the region's habits still aren't sustainable. For ASEAN to do better, it has to do more to invest in green tech, cut down on fossil fuel, and pool resources to make renewables more efficient and clean through better infrastructure and policies.

The small but growing shift towards renewable energy consumption in South Asian countries represents a golden opportunity to mitigate the evident environmental degradation in the region, by reducing CO₂ emissions over both the short-run and the long-run. By switching to renewable energy sources like solar power, wind power, and hydropower, CO₂ emissions can significantly solve the problem of global warming in the short run. Countries like England, Germany, and Denmark have already begun incorporating more renewable energy into their overall energy mix, contributing to a lessening dependence on fossil fuels, the chief contributor to CO₂ emissions.

As technology progresses, economies of scale will eventually reduce renewable energy costs (Tariq et al., 2022). Furthermore, the development of renewable energy infrastructure promotes economic growth, creates jobs, and supports a green economy. Factors such as policy making in government, research and development, and regional cooperation would be decisive for the continued success of renewable energy consumption in reducing the levels of CO₂ emissions in South Asia and ASEAN countries. Robust policy frameworks subsidies, tax incentives, and regulatory reforms that favor renewable energy development are essential for stimulating investment and innovation in this sector. In addition, the collaboration scope across region may help in sharing the technology and best practices which in turn will help in making renewable energy projects more efficient and effective. In addition, campaigns focused on public awareness and education can be crucial in encouraging the adoption of renewable energy sources and sustainable habits. In short, this energy transition may come with short run challenges, however, these are outweighed by the long term potential of reducing CO₂ emissions and countering environmental degradation, making it an essential aspect of South Asia and ASEAN countries strategies to combat climate change.

6.6.6 Tourism

Although tourism cause no immediate effect, the footprint of such activity is detrimental to some extent in the long run.

In ASEAN's tourism growth, a 1 % rise in tourism growth can lead to a 0.06 % rise in ecological footprint. The studies equally agree that tourism has switched to promoting environmentally harming activities including forest and grazing land decrease (Lee & Chen, 2021). Tourism in the ASEAN is a multi-faceted topic with short-run and long-run ecological implications. Bear in mind that the impact of these can be quite particular or determined by many variables. Although the overall impact of tourism on ecological footprint in ASEAN is not particularly significant in the long run, it is important for the potential negative impact that can accumulate in the future. Uncontrolled growth of tourism can lead to habitat destruction, increase resource consumption, and degrade environment quality.

In South Asian countries, 1% increase in the inbound tourism increases 0.02% change in the environmental degradation in a long run while in the short run it would insignificantly decrease (coefficient= -0.005% and p value=0.351). For ASEAN in the short run, it would significantly decrease by 0.083%. Ecotourism reduces carbon emissions, as cited by Kongbuamai et al., (2020) and Hoang Ngoc, (2022). This shows that an impact on the inbound tourism sector would lead to an increase in environmental deficit in the long run in the South Asia region. The examined economies are very much committed to improving the environmental quality by various means, rules and regulations. There are also some reasons as to why this may not be the case. The prepayment on the goods and services imported from South Asian economies is not free from pollution. Such kind of service include a food, transportation and shipping, whose activities are related with tourism with a wider energy front (combustion of fossils) and due to that it will be given a strong negative relationship with CO₂ in emission. In addition, among all the tourism destinations, hotels and restaurants generate heavy carbon emissions every year as they dispose of huge waste material and ignorant eco practices from tourists. It

urgently needs alterations in both the transport equipment of the traveling public and the housing, hoteling and other accommodation aspects of the lodging industry and the systems of the restaurant industry. The inbound tourism related activities in SAARC economies need to conduct a number of public awareness program in terms of public meetings for prospective tourists. The negative influence of the development of tourism industry on carbon emissions is in line with some literature (Lee & Brahma, 2013; Nepal et al., 2019).

6.7 To analyses the impact of the variables on environmental degradation in South Asia and ASEAN countries, country-wise:

There are National results for South Asian countries (Bangladesh, India, Pakistan and Sri Lanka) and ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam) on determinants affecting environmental degradation (LNENV). Different variables are examined in these countries, and the results show differences and similarities in patterns of environmental degradation. Now there is country-wise results discussions of the South Asia and ASEAN.

6.7.1 South Asian Countries:

The positive and highly significant ECT (0.0003***) for Bangladesh indicated that environment degradation is not self-corrective, and it lingers for a long time despite the decline at a very slow rate. In Pakistan the even larger and positive ECT (0.004***) indicates that the environmental degradation not only does not improve but deteriorates even faster. This implies that both countries still have incumbent environmental challenges and Pakistan is falling into those faster than Bangladesh. But in case of India the coefficient is negative (- 0.02*), suggesting that the long run relationship might be arresting the pollution. The association in Sri Lanka is negative (- 0.04) which means that the cointegration factor may be slightly good effect smoothening degradation in the long term.

Foreign direct investment (FDI) has a conflicting influence on environmental degradation. In Bangladesh, FDI has a weak negative relationship (-0.01***), which

implies that if there is no FDI, degradation could be slightly lowered to its level and it might be through sustainability practice. Meanwhile, the effect of FDI on environmental degradation is positive in India, Pakistan and Sri Lanka (0.06***, 0.02***, 0.12*** respectively), suggesting that a rise in foreign investments may worsen environmental problems (industrialization and resource depletion).

The effect of EG is different in the countries. Bangladesh and Pakistan reveal positive and significant relationship (2.95** and 1.19***) respectively, reflecting that economic slowdowns greatly contribute to environmental damage. In contrast, India and Sri Lanka have the lower (or even negative) influence (-0.04 and -0.13 respectively), showing that economic growth has a less intense effect on the environment in these countries.

Further, employment (LF) is also found to exert significant influence on environmental degradation, especially in Bangladesh and India where the coefficients are negative with coefficient value of -4.85^{**} and -3.76^{***} , respectively, which implies that as labor forces expand, it does environmental damage probably because of industrialization. Pakistan and Sri Lanka exhibit less negative relations (-0.64 and -0.45* respectively), indicating diminishing effect of agricultural yield on environmental outcomes.

Capital formation (CF) has an ambiguous influence on environmental degradation. In Bangladesh, CF has a statistically significant negative association (-0.13^{***}), indicating capital formation could potentially mitigate environmental degradation to some extent. But the effects are positive in India, Pakistan and Sri Lanka (0.01***, 0.01***, 0.08*** respectively), meaning that higher capital formation may lead to environment degradation because of industrial growth.

Tourism (TRM) indicates a composite contribution in the environmental degradation. However, in Bangladesh, tourism slightly contributes to degradation (0.001***), while it has negative impact in India (-0.02***), Pakistan (-0.02***), and Sri Lanka (-0.01***), indicating that it may have some role to diminish the

environmental damage, which could be from the eco-tourism process and better resources management.

Technical change (TAI) is vital in reducing environmental destruction. All nations have a negative association with environmental degradation. The highest impact was estimated for Sri Lanka (-0.35***), implying that technologically adopting energy efficiency, waste treatment, and sustainability help reducing the environmental damage.

There is a robust negative association between consumption of renewable energy (RENRC) and environmental degradation in all countries. Sri Lanka has the highest magnitude (-0.75*). This is an indication of the extent of abatement of environmental damage as a result of moving towards cleaner renewable sources of energy. The benefits of renewable energy consumption in decreasing degradation were accumulating in India and Bangladesh.

In Pakistan energy consumption leads to less environmental degradation (-0.19***), which could be attributed to cleaner energy use. On the other hand, Bangladesh, India and Sri Lanka have negative associations with CO₂ emissions (0.17***, 1.56*** and 0.39***), which explain that augmented energy consumption has been causing environmental damage in Bangladesh, India and Sri Lanka.

In general terms, technology and renewable energy use are also positive and significant for environmental degradation in all countries. However, FDI, growth and capital formation tend to have positive and negative effects, which varies across countries. Labour force dynamics and tourism display diverse impacts, reflecting different degrees of industrialisation and sustainability strategies within South Asia.

6.7.2 ASEAN Countries:

COINTEQ01 is the long run cointegration between environmental degradation (LNENV) and other explanatory variables for different countries. The positive coefficient (0.06 ***) in Indonesia indicates the long run the relationship of

environmental degradation with the explanatory variables. If there is an increase in these variables, then it will result in a relatively moderate upsurge in environmental degradation. In contrast, for Malaysia (-0.14^{***}), Singapore (-0.46^{***}), and Vietnam (-1.62^{***}), the coefficients are negative, which means that in these countries the long-run relationship results in positive adjustments to environmental conditions as these factors are changing, meaning that over time technological progress, a change in energy use, or in economic expansion could lead to a decrease in environmental damage. The estimated coefficients on Philippines (0.02^{***}) and Thailand (0.08^{***}) are positive, but smaller, implying a slight increase in environmental degradation as the factors increase. In general, the findings indicate that there may be long-term environmental damage for countries like Vietnam and Singapore.

The FDI variable $D(LNFDINIF)$ shows mixed performance over the countries with respect to environmental conservation. Indonesia and Philippines have a positive coefficient (0.001^* and 0.001 respectively), implying that FDI slightly increases environmental degradation. But Malaysia, Singapore and Thailand present negative coefficients for $D(LNFDINIF)$, particularly for Singapore (-0.25^{***}). Vietnam (0.19^{***}) suggests that foreign investments are probably resulting in environmental degradation in this country. The delayed effect of FDI ($D(LNFDINIF(-1))$) is statistically related and positive signed in Vietnam and Thailand, signifying the delayed effect of FDI on environment.

$D(LNEG)$, as a proxy for Economic Growth (EG) takes various values across countries. Vietnam (12.44) and Thailand (7.02^*) have a highly significant positive association with environmental degradation. Economic growth leads to a lot of environmental damage, probably as a result of an expanding industrial sector. By contrast, Philippine has a negative association (-0.70), which implies that the effects of economic growth on the environment might be less harmful or possibly positive scenario in that country. Indonesia (1.10) and Malaysia (2.60^{**}) demonstrate small positive effects, indicating that in these countries economic growth is correlated with

environmental degradation, but the coefficient impacts are lower than in Vietnam and Thailand.

The variable $D(LNLF)$ captures the impact of Labor Force (LF) on pollution. Vietnam exhibits a positive and significant link (4.22) and is suggested to measure the effect of employment generation on environmental deterioration, presumably through higher aggregate industrialization and resource use. The impact of the labor force growth for Thailand, Malaysia and Indonesia is different. Malaysia (3.98) has positive coefficient but Indonesia (-0.44) has negative coefficient. It can be seen that labor force growth in some countries is associated with sustainable development or less environment damage. Philippines depicts a weak positive relationship (0.43*), suggesting the presence of modest impact of labor force changes on pollution.

The effect of CF on environmental degradation ($D(LNCF)$) is largely negative for most of the countries. The coefficient of Vietnam represents the highest negative impact (-1.08***), indicating that the process of capital formation contributes to the process of environmental degradation abatement probably through the better technologies and infrastructures. In the case of Malaysia, there is also a negative association (-0.46***), implying that capital formation might be playing a part in ensuring the better-off environment. Nonetheless, the negative effects for Indonesia and Thailand are smaller, which may indicate the potential of capital formation to have a limited role in counteracting degradation. Philippines (0.27***) reports a positive association and probably capital formation is adding to environmental degradation.

Tourism (TRM), depicted by $D(LNTRM)$, presents an ambiguous impact on environmental degradation. Vietnam (-0.57***) and Indonesia (0.001**) display the negative and positive elasticities with environmental degradation, indicating that tourism has some beneficial impacts towards environmental sustainability in Vietnam, while in Indonesian case, tourism has positive effect on environmental degradation. Both Malaysia (-0.23***) and Thailand (-0.01***) have negative coefficients, meaning that tourism has reduced the environmental degradation.

Philippines exhibits a weak negative relationship (-0.03^{***}), which may suggest tourism might help decrease degradation in the country.

All estimates of the coefficient of TAI have negative sign which can be interpreted as technology progress is decreasing the rate of environmental degradation. Furthermore, Vietnam and Singapore demonstrate larger negative impacts (-0.63^{***} and -0.86^{***} respectively), revealing that technology progress in these countries contributes to the attenuation of environmental damage. Philippines (0.02^{***}), Thailand (0.001^{***}) and Malaysia (0.02^{***}) also have positive relationships, indicating that technology progress in these countries has positive influence on the environmental degradation .

The parameter RENRC has a negative impact on the ED in respect to all the countries, which indicates the positive impacts of renewable energy. Vietnam (1.15) and Singapore (1.05) display the highest positive coefficients, indicating that renewable energy use significantly helps to reduce the pollution of these countries. Indonesia (0.05), Malaysia (0.07), Philippines (0.44^*) also have strong positive associations, revealing that renewable energy consumption is not good towards a cleaner environment.

The effect of energy use (ENRC) is denoted by $D(LNENRC)$ has heterogeneous effects across host countries. Vietnam (0.31) and Indonesia (1.28) have a positive impact, meaning that higher energy usage leads to more environmental pollution. Malaysia (0.24^*) and Thailand (1.28) also show positive coefficients, indicating that increased energy utilization corresponds with greater environmental pollution. On the other hand, a moderate effect is observed in the Philippines (1.49) and Singapore (0.23), highlighting the importance of energy usage toward the environment. It is noted that the lagged effects of $D(LNENRC(-1))$ are significant, and Singapore, with a strong negative effect (-5.59^{***}), suggesting that energy use is not significantly associated with environmental quality in the years to come.

The results show that technological innovation and renewable energy consumption have negative effect with environmental degradation in brief. They contribute to

decreasing environmental damage. FDI, growth, capital, tourism and energy have mixed effects across the countries though some receive positive effects while others undergo large degradation rates of the national income. Growth of the labor force often leads to higher environmental degradation (also in Vietnam, Thailand).

6.8 CONCLUSION

Both South Asia and ASEAN grapple with the predicament of reconciling growth with the environment. In South Asia, capital accumulation and energy use have been important induced factors of economic growth, though they have been quite important causes of environmental decline, exacerbating dependence on fossil fuels. In ASEAN, FDI and economic growth not only contribute to the enhancement of prosperity, the higher energy consumption and industrialization resulting from these also damage the environment. But both regions are gradually moving toward more sustainable growth, investing more in renewable energy and green technology. The participation of the labor force in each region may eventually contribute to lessen or avert long-term environmentally degradation to the extent that labor reallocate towards more sustainable activities and use of resources it amounts. Should the two regions fail to make a concerted shift to renewable energy and sustainable industries, they will be hard-pressed to reconcile the economic growth with their environment challenges.

CHAPTER 7: SUGGESTIONS AND CONCLUSIONS

7.1 INTRODUCTION

South Asia and ASEAN countries are confronted with separate but interlinked concerns of FDI, macroeconomic aspects, and environmental implications. The different economic settings across these countries also make the relationship between FDI and its environmental effects more complex. This is determined by economic organization, regulatory framework, and degree of development in each country. FDI is an important momentum in several Asian and South Asian countries, including industrialization, infrastructure, and economic development, which includes finance, technology, and tourism investment.

7.2 SUGGESTIONS OR RECOMMENDATIONS

The findings of the PMG-ARDL and FMOLs models related to the influence of FDI, economic growth, technological innovation, energy consumption, labor force participation, investment, tourism, and renewable energy consumption on environmental degradation call for targeted strategies in South Asia and ASEAN. These solicitations are informed by the fact that, while economic growth and industrialization are necessary for development, they commonly cause environmental degradation, particularly where environmental governance is weak.

The analysis and findings of this study have provided few recommendations for enhancing FDI, tourism, technology, and renewable energy industries in these selected industries to address the problem of environmental degradation in the South Asia and ASEAN region. These guidelines are intended to weigh economic growth and environmental protection. They are as follows:

7.2.1 General Recommendations

Such a strategy would be founded on theoretical fundamentals and nearly universal trends in sustainability, economy, and the environmental direction of progress at a global scale. These are commonly applied to areas in the midst of shared concerns including industrialization, urbanisation, and climate change.

- **Improving Environmental Governance and Regulation:**

There is a positive relationship between economic development, FDI, and environmental degradation in different South Asian countries. The correlation between higher income and increasing environmental deterioration is visible on the regression line. The environmental pollution is largely led by industrialization and natural-resource dependent sectors. The stronger the environmental protections and the autonomy of enforcement of these laws, the better. Governments need to devise cleaner rules for heavily polluting industries like manufacturing, power generation, and construction. This may range from emission limitations, waste disposal rules, to punishments if the rules are breached. In addition, environmental impact assessment (EIA) for all major industrial and infrastructure works should be made compulsory.

Findings of ASEAN suggest that FDI inflow tends to less in pollution and CO₂ emissions or environmental damages, especially in the environmental regulation sector. Rule makers would establish clear environmental criteria for FDI projects, especially for energy and resource-extracting industries. Furthermore, active surveillance and penalties for non-observance must be instituted to make FDI's contributions to sustainable development.

- **Encourage Green FDI and Sustainable Technologies:**

Even if FDP generates environmental degradation at the beginning it may also result in the long run in the transfer of cleaner technologies as well as of green infrastructure. Both governments of these two regions must give

priority to green FDI by offering freebies, tax holidays and grants to foreigners to invest in green energy, energy saving devices, and environmental friendly industries. For South Asia, persuading multinational companies to embrace sustainability could also lead to a welcome spillover effect in local industry by helping to drive the spread of green technologies throughout the region. South Asia needs green FDI because they are not in the market, but emerging ASEAN needs green economic growth, sustainable economic practice, and also needs to leverage public-private partnerships (PPPs) to finance mega-projects on sustainable energy.

- **Special Economic Zones (SEZs):**

Create Special Economic Zones (SEZs) for FDI that include tax breaks, simplified licenses, and infrastructure, to attract FDI. Work with neighboring countries to establish regional investment agreements and align investment regulations, thereby making the region more attractive to investors.

- **Tax Breaks Policy for Green Technologies:**

South Asia and ASEAN countries need to incentivize investments in clean energy and sustainable practices that help them reducing carbon emissions by providing tax breaks to foreign and domestic companies, and offering grants or subsidies.

- **Promote Energy Efficiency and Moving to Renewable Energy:**

The results show a strong correlation between environment and energy consumption, and technological progress. To confront this, the South Asia and ASEAN region would have to introduce policies that promote energy efficiency at the industrial as well as household level. Governments should create favorable conditions for the introduction of energy efficient technologies in industry, transportation, residential sector using stimulating measures. And then we should be pushing for renewables, for solar, wind,

and water. Actions may include grants or low-interest loans for renewable energy projects, investment in energy-efficient infrastructure, or encouraging private investment in clean energy projects.

- **Sustain and Expand the Labor-Force Participation in Sustaining Sectors:**

Though often linked to economic growth, the region could enhance its industrial growth through green-job promoting policies. Governments need to create training programs to qualify workers for jobs that are in high demand in sustainable sectors like renewable energy, waste management, and green technology. Developing industries in these sectors would lower the impact on the environment caused by industrialization, open up job opportunities, and develop a more sustainable economy. ASEAN countries also need to allocate resources to training and re-skilling the workforce, particularly in green technologies and sustainable industries. In human capital terms, a more capable workforce is likely to better understand and manage sustainable production methods.

- **Promote Technology Innovation for Sustainable Development:**

Advancing technology is an important solution to minimize the impact of economic growth on the environment. South Asia needs to invest in R&D in clean technologies and industries. Creating innovation clusters and offering incentives for clean tech startups can help speed the creation and adoption of clean technologies. Joint ventures between universities, research facilities, and companies could move energy-efficient technologies, waste-reducing systems as well as green infrastructure forward.

An approach for economies in the ASEAN region is to promote technology spillover by the partnership of MNCs and local industry. Building platforms for collaboration like joint ventures, training programs and R&D centers, can

help local firms at home to learn cleaner technologies from foreign companies and speed the transition to better industrial practices.

- **Sustainable Tourism Practices:**

Tourism is an important industry for many South Asian and ASEAN economies but it can also have negative environmental impacts if it is not effectively managed. Both regional governments must set sustainable policies and consider the environment, where tourism activities need to shift to environmentally friendly tourism (eco-tourism), set numbers of tourists in vulnerable areas, and support companies which are environmentally friendly. It would thus help minimizing the environmental costs of tourism, and would guarantee that the sector was contributing to the long run economic development of countries. Governments can also promote this by offering economic incentives to tourism businesses for the use of green technology and reducing waste and water, and energy consumption.

Further, providers in the travel services may become more environmentally friendly by promoting environmental issues as parts of their business and their operations such as the green restaurant, green hotel, green destination, and green transportation. That will affect the nature of the environment around South Asia and ASEAN members.

- **Economic Development and Social Justice:**

Low income variability in South Asia and ASEAN countries is characterized by inequality that does not usually support development sustainability and focuses on high inequality in the region. Policies need to promote inclusive growth irrespective of the region, when it comes to providing equal opportunities to the disadvantaged sections, but more so in rural and underdeveloped regions. Investing in social welfare programs, education opportunities, and vocational training for sustainable industries can raise communities up and prevent further damage to the environment. "Green

jobs," "renewable energy sector jobs," and "green tech jobs" should be meaningfully inclusive to provide equitable distribution of economic benefits.

- **Awareness of the Environment and Public Participation:**

Environmental degradation is often associated with awareness and the role of the public when it comes to decision-making. Public policy should include the introduction of eco-conscious education in schools, universities and even local settings with the aim of educating the public about climate change, sustainability, and conservation. Furthermore, fostering public engagement in ecological governance through grassroots actions could mobilize citizens to participate in environmentally sound behaviors, and to demand that environmental policy transforming compatible with local residents' demands.

- **Economic Structure Diversification:**

South Asia's economies are mostly agriculture based and low income industrial workers, which often leads to environmental degradation. Governments should prioritize economic diversification, especially in organic agriculture, green technologies, and services sectors, and develop areas such as information technology, finance, and sustainable tourism. This economic transition will also result in a more secure and less pollution-producing economy.

The agriculture sector is especially important for ASEAN in terms of encouraging good environmental practices, as it has a high dependence on agriculture for food security and livelihoods, and is highly sensitive to climate change. Attention to sustainable agriculture can help in food security, keeping in mind the environment and natural resources.

- **Promote Sustainable Infrastructure Development:**

Both regions are rapidly urbanizing and facing huge infrastructure needs such as: waste management, pollution, and the depletion of natural resources. Policy-makers should prioritize investments in sustainable infrastructure, by creating green cities, investing in public transit and implementing energy-efficient building technologies. The process of incorporating environmental sustainability into urban planning will lead to decreased carbon emissions and other types of environmental damage.

Rapid urbanization has presented each region with daunting infrastructure challenges such as bad waste management, pollution, and depletion of resources. Governments should shift their spending from infrastructure to Sustainable infrastructure like developing green cities, investing in public transport, and using energy-efficient building technologies. Applying sustainable principles to the planning of cities will contribute to the decrease of CO₂ climatic gases and environmental abuse.

- **Emission Target Policy:**

For the past thirty years, it has been working to improve the socio-economic lives of the people from the South Asian region by SAARC (South Asian Association for Regional Cooperation), but SAARC has been unable to make remarkable progress in emission control (Hassan et al., 2019). This regional body can establish an official emissions target for the region and then collaborate to reach that target. While collective efforts in planning construction, knowledge sharing and green technology transfer are expected to yield fruitful results. Nations of this region need to co-operate with one another, concentrating on the resolved factors to sustain the economy and environment.

- **Carbon Pricing Policy:**

It enhances international cooperation in the exchange of information on sustainable economic practices. With the help of those actually feasible policy measures, China may be able to reconcile economic growth with the claim of environmental protection, and even CO₂ emissions. This study indicates that Powered by Clean Energy such as solar cells, hydropower, geothermal, biogas and wind power can bring down carbon emissions. Policy makers will need to find ways to mainstream value chains into support for carbon pricing. This policy can be implemented through carbon taxes or cap-and-trade systems themselves. Thus, to minimize environment versus economic growth conflicts, it is necessary to transform the existing industry structure into a green one at the earliest possible time.

- **Cut Down, Repurpose, Mend, and Recycle:**

Everything people buy, from gadgets to clothing to plastic items and beyond, has a carbon footprint that is created at every stage of its life, starting from the extraction of raw material used to produce it and ending with the delivery of the finished product. To keep the climate safe, consume less, wearing a mask, and think of buying something secondhand, or mending whatever you can still use.

7.2.2 Empirical Suggestions for South Asia and ASEAN

- **Control Resource-Incentive FDI Inflows of South Asia:**

In the short run, FDI and economic development are positively related with South Asian economies' needs to emphasize on the controlling the resource intensive industries-production of manufactured goods and energy generation. Multinational companies frequently come with industries that use fossil fuels and make significant contributions to carbon emissions. More stringent regulation is required to enforce environmental sound practices in these sectors. Enhancement of regional limitations could also represent an

optimal solution for encouraging foreign investment and extracting the host country's strongest benefits in terms of related global investment (Omri et al., 2014) .

- **Tax incentive policies for foreign investment in ASEAN:**

ASEAN countries in the short run and long run have the negative correlation with the environment, although they should continue to encourage investment that are environment friendly like renewable energy, clean manufacturing technologies and sustainable infrastructure. Incentives for investment such as the promise of tax breaks for foreign financiers meeting sustainable targets, will mitigate the long-term cost to the environment.

- **Create Incentives for Green FDI in Long Term :**

Although initially FDI may be polluting in the long run, the net effect may prove beneficial in South Asia and ASEAN, particularly with the adoption of cleaner technologies. Governments should provide incentives for green FDI through, for example, tax breaks for investment in renewables, green technologies and green industries. This will have the effect that the investments of third countries in them will also conform to long term environmental sustainability.

- **Enhance Technology Transfer Mechanism:**

The long run detrimental effect of FDI on environmental degradation implies that foreign investments may contribute to technological progress that fosters the reduction of carbon emissions and resource productivity. South Asian policy-makers should promote the transfer of technology from multinational corporations to tap into cleaner efficient technologies. This is possible via a joint venture cooperation between local enterprises and foreign firms when they can access modern technologies on environmental management and solutions for clean energy using. green technology spillovers from FDI

inflows. It may contribute to rapid improvement in energy efficiency and lower environmental pollution (Lee, 2013).

- **Focus on Clean Energy FDI:**

FDI can be accompanied by the transfer of clean energy technology. There is a case for South Asia to attract FDI in the renewable energy sector including solar, wind and hydropower. Policy makers should develop focused policies that promote foreign investment in clean energy projects. In turn, the region gains access to foreign knowledge, foreign financing and technology it needs. To build a better energy infrastructure one can further cut dependence on fossil fuels and lower carbon footprints.

- **Green Growth and Sustainable Growth:**

The economic growth in South Asia is dependent on increased environmental destruction, therefore, South Asia needs to move towards **green growth**. By prioritizing the de-linking of economic growth from environmental degradation, South Asia could promote green infrastructure and renewable energy for sustainable development in the long run. Likewise, ASEAN should also remain focused on achieving sustainable growth by advocating environmentally-friendly industries and promoting eco-friendly policies to ensure development that is sustainable and environmentally friendly.

- **Encourage Green Sectors through Technological Innovations:**

The results indicate that the environmental activities of firms could be influenced in a beneficial sense in the long term by the technological transfer through FDI. South Asian governments need to promote innovation through multinational collaboration with local firms, especially with clean technology and green energy solutions aimed at lowering the environmental costs of economic development. Transferring and diffusing eco-friendlier technologies and encouraging the sharing of knowledge on improved

environmental practices and limits can assist local communities to reduce the pollution (Patlitzianas&Flamos, 2016).

ASEAN could seek to encourage green technological innovation with public-private partnerships and smart technology, to enable sustainable energy use and waste minimization. The government needs to grow the availability of mainstream clean technologies and its use to encourage energy efficient technology in the short run.

Both sectors should spend a lot of money on clean technologies, green energy solutions and energy-efficient industrial processes that will stimulate long-term environmental returns.

- **Elevate Regulation:**

The short-term negative impacts of FDI can be marginalized through strengthening the environmental regulatory framework surrounding environmental management even if FDI leads to long-term environmental gains. This consists of more stringent policies on CO₂ emissions, resource consumption and waste for FDI-intensive industries. Robust environmental governance is essential for ensuring that FDI is consistent with the region's sustainability aspirations and that environmental laws evolve alongside industrialization.

- **Skilled Labor Force**

The negative and statistically insignificant relationship between labor force participation and environmental degradation implies that even though the increase in the labor force may not have an immediate and significant effect, it may have long term implications for increased industrialization and energy use. To better prepare for future environmental challenges, South Asia needs to concentrate on developing green skills by investing in skills development programs that cater to the needs of the labor force in industries like renewable

energy, green manufacturing and environmental management. By advocating green jobs and with attention being paid to linking labor force growth with the sustainable development agenda, the region can guarantee that economic growth will not result in greater damage to the environment. Further, there is a need for Policies to lay emphasis on the training and upgradation of critical manpower in the renewable energy, waste management and energy efficient technologies so as to make the possible new green jobs that decrease the extent of environmental degradation with the passage of time.

Both should invest in sustainable industry training and connect workforce development with green economy targets.

- **Urban Growth Sustainability**

One major characteristic of the urban growth in the region is the expansion of the informal economy that contributes to CO₂ emission (Abid, 2015). Proper management of slums, waste segregation, low carbon transport system, installation of effluents treatment plants in industries that are situated on urban fringe, curbed informal activities and properly planned infrastructure in all categories of urban development. Urban are central, but what takes place in this one can be extended to a greater extent fosters due to its ability of CO₂ reductions (Friedl&Getzner, 2003).

- **Sustainable Tourism**

South Asia, as well as ASEAN, should also focus on eco-tourism and sustainable practices in tourism. This includes imposing energy-efficiency standards on hotels and resorts, promoting low-carbon transportation choices, and limiting emissions from the tourism industry. The government also needs to control tourism activity to minimize its impact, and promote the use of sustainable technologies within the industry.

- **Increase Renewable Energy Using Share**

The share of renewable energy, in energy consumption has a significant inverse long-run relationship with environmental degradation, meaning that an increase in the share of renewable energy in the energy mix leads to a decrease in environmental damage. But in the short run, the transition could take time, said the report, because of its significant up front cost and infrastructure development hurdles. South Asia should invest heavily into renewable energy infrastructure and green energy initiatives. Governments ought to provide favorable policies on renewable energy projects and tax benefits for solar, wind, and biomass energy, and encourage the private sector to invest in clean energy, fostering a move toward renewable energy can be supported by energy efficiency with smart grids and energy storage systems.

- **Research & Development in Green Technology**

Technology advancements and environmental degradation are positively related over the long-run, implying that technology improvements can make industry more efficient, but it may have the side-effect of raising pollution emissions and carbon if technology innovations are not green. The governments in South Asia must encourage innovation in green technologies through investment in R&D of clean energy technologies and eco-friendly manufacturing methods. Accession of new members in Public and private partnerships (PPP) could be promoted so that innovations could contribute to be sustainable in technologies.

- **Strengthen Human Capital for Sustainability**

Additionally, the results show that the influence of human capital on environmental quality is meager, despite having the potential for improving environmental quality. This indicates that policies are required to better promote human development, both through environmental awareness with respect to nature and through the income of a household. The human capital

might be channeled to encourage attitudes compatible with eco-friendly lifestyles. In the developmental phase, this may promote pro-environmental behaviors such as energy saving, water saving, recycling, reliance on renewable energy sources, and eating green food.

- **Public Awareness Campaign**

Implementing public awareness campaigns and educational programs will help in raising a culture of sustainability, which can influence individuals and communities to adopt environmentally friendly behaviours. Such initiatives should be aimed at all segments in society, from school children to corporate leaders and should be focused on the need to consume less energy, reduce waste and buy green products and services wherever possible. And, with the help of digital tools and social media, they put these campaigns out there, engaging a wider segment of the population and inspiring collective action.

- **Green Transportation System**

Governments should invest in expanding and upgrading their public transport systems to be more efficient and reliable and attractive to commuters. Policies that incentivise the roll-out of charging infrastructure for electric vehicles, as well as pursue the purchase of electric cars, can drive the transition away from fossil fuel- based transportation.

- **Expand Urban Green Spaces**

Green spaces like parks, urban forests, and green roofs should take precedence in urban planning, as those can contribute to improve carbon sequestration, better air quality, and recreational areas for residents. These also have the potential to clean up and preserve air and water pollution via efficient waste disposal systems, while recycling and composting programs

can help mitigating greenhouse gasses as well. Promoting sustainable construction materials and energy-efficient design in buildings can also help reducing the carbon engulfment of cities.

7.3 CONCLUSION

This study seeks to satisfy the research gap by examining the complex interrelationship among foreign direct investment (FDI), economic growth, environmental quality, technological innovation, renewable & non-renewable energy consumption and tourism development in South Asia and ASEAN country's employing of an innovative Polled Mean Group Augmented Autoregressive Distributive Lag (PMG-ARDL) estimation. This study further depicts how technological innovation and tourism development affect the linkages of FDI, economic growth, and environmental degradation in South Asia and ASEAN economies. This study has collected panel data from 1995 to 2023 for South Asia and ASEAN countries which is covering both short run and long run trends. The study figured out a correlation result to the variables' relationships, which helps to identify the potential multicollinearity issues and provides an initial understanding of variables' potential relationships before more complex analyses. After that, descriptive statistics of data are measured to understand the central tendency, dispersion, and shape of the data distribution before more complex analyses. Following that, the slope homogeneity test and the Pesaran CD Test is used to identify interdependencies in the panel data, preventing biased estimates and determining the need for advanced estimation techniques. Next, the study measured the CIPS Unit Root Test to evaluate cross-sectional dependence, evaluate the suitability of cointegration techniques, guarantee stationarity, and avoid spurious regressions. Finally, before modelling, the Kao Panel Cointegration test is assessed to find long-term relationships among non-stationary variables, revealing their movement over time and cointegration techniques. Then, the PMG-ARDL model is applied to estimate the short run and long run relationships between variables, which

accounts for cross-sectional dependence and heterogeneity in panel data. And FMOLS model is also used to measure the long run output and robustness check of the estimated results. The key findings of the study are, FDI shows a mixed impact, renewable energy consumption and technological innovation is able to reduce environmental degradation. Granger causality statistical analysis is done to examine the predictive causality between variables, aiding in the identification of useful variables for forecasting others.

This study investigates the relationship between environmental degradation and foreign direct investment (FDI), technology, tourism, energy mix, and economic growth in ASEAN and South Asian nations. It concludes that although foreign direct investment (FDI) might boost economic expansion, if it is not focused on green industries, it may also increase environmental strain. The study emphasizes the necessity of policies that direct foreign capital toward eco-friendly sectors. It also emphasizes how technology transfer, especially through FDI, may increase energy efficiency and reduce emissions, and it calls for policies that support both domestic R&D investment and collaborations between foreign investors and local firms.

The importance of diversifying the energy mix to lower CO₂ emissions is another significant result. The report offers ways to move toward sustainable energy such as identifying national obstacles to the use of renewable energy and proposing remedies including monetary rewards and beneficial legislative changes. The balance between ecological sustainability and economic growth is also examined, and governments are urged to include environmental objectives into economic planning and support sustainable industries in order to achieve growth with the least amount of negative environmental impact.

The study provides useful suggestions or advice for policymakers in these areas in addition to its scholarly contributions. In order to promote inclusive green growth, it identifies the primary causes of CO₂ emissions and suggests solutions like regulatory changes, investments in clean technology, and regional collaboration. The study

emphasizes how urgent these measures are in regions that are extremely susceptible to environmental effects and vital to international efforts to reduce emissions.

7.4 LIMITATION OF THE STUDY

This study is dependent on a comparatively small number of macroeconomic variables, mainly the production function, is one of its main limitations. Even while these metrics are significant, they don't fully account for the range of institutional, social, and economic factors that affect growth and foreign direct investment. For a few years, missing observations were filled in by using several sources. To provide a more complete and full picture of economic interdependencies, future research should expand the variable base to include trade liberalization, labor market structures, institutional quality, rural-urban mobility, and environment.

Though this study provides strong and reliable results with respect to the given objectives even further studies should use more models like NEMESIS means evaluation by sectoral interdependency and GARMALTSM (Generalized Autoregressive Moving Average).

Lastly, the study's scope is restricted to certain country groups. Although the study concentrated on particular areas, it did not include more general economic blocs that have a big influence on international investment flows like the N-11, OECD, D-8, BRICS, and G20. Future research involving these groups would enhance comparative analysis and draw attention to differences among developed, emerging, and transition economies. In addition to increasing the results' generalizability, such an enlarged framework would give policymakers more precise information about the regional and global factors that influence foreign direct investment.

APPENDICES

APPENDIX-I

CARBON EMISSION (PER CAPITA SOUTH ASIA AND ASEAN)

CO2 Per capita (South Asia)								
	Afganistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Srilanka
1990	0.16805434	0.12614106	0.3151732	0.668225	0.7661452	0.0369501	0.5839355	0.2342657
1991	0.15641147	0.12965418	0.3096722	0.6961713	0.66385686	0.0512221	0.5620263	0.2511774
1992	0.111609004	0.13273484	0.3722132	0.7258895	0.9676097	0.0598227	0.5828956	0.3050508
1993	0.099506505	0.136067	0.3277319	0.7345036	0.80793166	0.0659737	0.6075866	0.2922268
1994	0.089462005	0.14585535	0.3830589	0.7587029	0.788802	0.0745681	0.6425968	0.3146142
1995	0.08305055	0.17174801	0.4543209	0.7918992	0.97075105	0.1037927	0.6212882	0.3310325
1996	0.077131316	0.17224969	0.5435064	0.8407051	1.103299	0.1034558	0.6750933	0.3893086
1997	0.0706777	0.18195334	0.6982383	0.8587551	1.2317668	0.1137456	0.6580157	0.4121114
1998	0.06672778	0.17910586	0.6711793	0.8597255	1.1016074	0.0938891	0.6602455	0.4159994
1999	0.05488996	0.18994531	0.6623337	0.9253892	1.5188359	0.1322718	0.6601074	0.4495506
2000	0.052017417	0.19725299	0.6649203	0.9324355	1.597986	0.1237419	0.6711009	0.5252718
2001	0.05270568	0.22706798	0.7608247	0.9282197	1.6098194	0.1297194	0.6617698	0.5268459
2002	0.062727444	0.23037535	0.796133	0.9403603	2.035339	0.1025064	0.6916949	0.5527698
2003	0.068605036	0.2376081	0.7738576	0.9560657	1.7053528	0.1094013	0.7028993	0.5489827
2004	0.052513268	0.25179228	0.6760612	0.9980951	2.212399	0.0992599	0.7577721	0.6047192
2005	0.077424295	0.2606273	0.8250598	1.034569	1.9609504	0.1135246	0.7617108	0.5903696
2006	0.08493193	0.2850007	0.6194007	1.1019762	2.3697832	0.0924686	0.801706	0.5794172
2007	0.10806349	0.2883674	0.585265	1.1695087	2.4051182	0.0959494	0.8546524	0.5929917
2008	0.16065161	0.30333978	0.9417083	1.2330484	2.5067673	0.1241861	0.8187327	0.5810787
2009	0.23271917	0.3260235	0.9788788	1.3155314	2.5353708	0.1519651	0.8001041	0.6236449

2010	0.2957424	0.3550251	1.2904984	1.348904	2.5895715	0.1764433	0.7739536	0.6250745
2011	0.40338126	0.36195275	1.4617691	1.3992052	2.6375794	0.1900792	0.7597747	0.7085589
2012	0.32838032	0.38501203	1.6543369	1.5060124	2.8700333	0.198666	0.7452712	0.7462685
2013	0.29183197	0.41373482	1.8253992	1.53963	2.729141	0.2253657	0.7194035	0.6793683
2014	0.27707645	0.42763633	1.8922364	1.6371113	3.1801326	0.274329	0.7313629	0.8084487
2015	0.28583142	0.48279482	2.005328	1.6823632	2.9865496	0.248158	0.693033	0.9060015
2016	0.25666347	0.5084297	2.1720133	1.7520503	3.2398741	0.3608613	0.8087265	1.0491176
2017	0.27116078	0.53352565	2.2689612	1.7847193	3.301859	0.4433852	0.9779946	1.0355575
2018	0.2885413	0.5296577	2.282355	1.886328	3.6786604	0.4985471	0.9269326	0.9031033
2019	0.2859549	0.5748977	2.1167855	1.8810879	4.0866613	0.4487387	0.8995735	0.9475713
2020	0.29706252	0.57399535	1.6236964	1.726452	3.3420072	0.5396408	0.9819252	0.9141524
2021	0.2567944	0.6419053	2.0579352	1.8909733	3.8190181	0.533454	1.0351746	1.0138671
2022	0.26017997	0.67221403	2.0940826	1.9861934	3.851092	0.5414351	0.9184807	0.8716052
2023	0.2658372	0.6615085	2.1783931	2.129469	3.9206648	0.5616241	0.8107597	0.884462

CO2 Per capita (ASEAN)

	Brunai	Cambodia	Indonesia	Laos	Malaysia	Myanmar	Philippines	Singapur	Thailand	Vietnam
1990	21.36924	0.17091	0.845122	0.118962	3.043168	0.106379	0.650859	14.32283	1.581401	0.325148
1991	27.45876	0.16969	0.936217	0.123094	3.586492	0.102426	0.668386	14.10438	1.708289	0.319554
1992	25.51309	0.166195	1.04933	0.129994	3.873782	0.118239	0.727086	14.70387	1.866542	0.314479
1993	22.95134	0.160739	1.112793	0.129651	4.482424	0.127776	0.7189	14.96789	2.122607	0.328412
1994	19.54603	0.154267	1.115874	0.131885	4.414504	0.146806	0.778631	17.58022	2.349262	0.386174
1995	20.0041	0.149581	1.112675	0.136101	5.390652	0.161778	0.843768	11.47429	2.599909	0.417611
1996	19.70853	0.140437	1.245372	0.14862	5.280961	0.166563	0.842418	13.10194	2.896623	0.485009
1997	19.93485	0.126662	1.355412	0.153806	5.542461	0.169752	0.941909	14.94405	2.984009	0.613013
1998	17.91074	0.155576	1.165356	0.156255	5.011326	0.181802	0.894688	12.15255	2.595858	0.635678
1999	18.7158	0.154437	1.370866	0.158373	4.634904	0.199466	0.871134	12.40374	2.684387	0.636387

2000	16.32439	0.160527	1.301987	0.17683	5.35001	0.225639	0.903009	9.260569	2.656054	0.699062
2001	15.56793	0.176565	1.446966	0.192465	5.563508	0.193478	0.861692	9.359485	2.706422	0.782151
2002	13.73056	0.167307	1.389023	0.207769	5.478077	0.201764	0.843508	9.696018	2.873436	0.882643
2003	16.1485	0.172658	1.507934	0.214281	6.215024	0.214222	0.827404	9.553346	2.945786	0.971065
2004	15.98255	0.169303	1.504965	0.221821	6.718132	0.26696	0.841059	9.825617	3.167673	1.107049
2005	15.12417	0.164399	1.505672	0.227789	6.578683	0.243579	0.831216	9.277566	3.246494	1.181992
2006	19.58951	0.208734	1.481646	0.294697	6.44133	0.268147	0.740475	9.212482	3.242184	1.212788
2007	21.77688	0.252096	1.636102	0.303057	6.498566	0.266829	0.773473	8.941557	3.339413	1.212788
2008	24.26035	0.280075	1.522824	0.346617	6.994802	0.20194	0.83042	8.363253	3.316316	1.341962
2009	20.11857	0.320756	1.640252	0.427364	6.830954	0.209766	0.804269	8.211614	3.359257	1.439895
2010	20.43478	0.349205	1.809973	0.474332	6.956578	0.267654	0.857388	8.745289	3.514449	1.595833
2011	23.92478	0.358273	2.007153	0.493279	6.976618	0.30599	0.848969	9.069433	3.548588	1.724462
2012	23.42363	0.373082	2.041778	0.521244	7.180365	0.237141	0.879646	8.70905	3.778261	1.611883
2013	18.54558	0.370841	1.911473	0.644518	8.009178	0.253113	0.935763	8.726994	3.776263	1.671998
2014	21.18994	0.43509	1.884637	0.663819	7.983081	0.312724	0.971253	8.721305	3.880686	1.963039
2015	16.42088	0.524182	2.0594	1.356914	7.554178	0.428412	1.06209	8.940621	3.928206	2.298031
2016	17.85171	0.67163	2.040928	2.382197	7.464485	0.410528	1.133516	8.802538	4.008554	2.350847
2017	21.51026	0.752026	2.083229	2.804707	7.555316	0.455345	1.243498	8.939904	3.981828	2.391473
2018	21.3435	0.856175	2.200768	2.884116	7.980424	0.650763	1.286116	8.927356	4.039237	2.653011
2019	24.24457	1.130329	2.399329	2.636275	8.368332	0.638676	1.295305	8.642643	3.941115	3.490108
2020	24.9365	1.138037	2.213211	2.653182	7.766388	0.652392	1.179787	8.309387	3.795612	3.695581
2021	25.92905	1.133963	2.238859	3.059254	7.967717	0.55444	1.248213	9.033062	3.724407	3.173521
2022	24.93428	1.13992	2.643443	3.100422	8.227235	0.549376	1.271431	8.47322	3.79971	2.985874
2023	25.64412	1.158091	2.607574	3.235001	8.222435	0.558491	1.345435	8.507861	3.687303	3.335514

APPENDIX-1I

All VARIABLES DATA SET (SOUTH ASIA)

YEAR	ID	ENV	EG	TRM	FDINIF	LF	CF	TAI	ENRC	RENRC
1995	1	0.179	65950655343	25000000	1896372.127	59.368	7254002500	226	107.10863	1.0269947
1996	1	0.179	68933550207	33000000	13529831.54	59.334	9626674817	153	112.20246	1.9475645
1997	1	0.189	72028595264	62000000	139376153.1	59.314	10525081967	165	117.89081	1.8034276
1998	1	0.187	75757534997	52000000	190059373	59.308	11057290749	216	125.55917	2.0371237
1999	1	0.198	79295530343	50000000	179603006.3	59.317	11649376040	249	126.98537	1.9397291
2000	1	0.205	83492876463	50000000	280384629.7	59.329	12706579209	318	136.12086	1.6270941
2001	1	0.236	87732050072	48000000	78527040.08	59.312	13052020015	295	155.58502	1.8750293
2002	1	0.238	91094928287	59000000	52304931.04	59.318	13320616403	289	156.0231	1.4013306
2003	1	0.245	95412433811	59000000	268285231.8	59.34	14846735751	318	164.91576	1.3186479
2004	1	0.259	1.00412E+11	76000000	448905400.7	59.367	16271819263	316	175.36739	1.2339083
2005	1	0.267	1.06974E+11	82000000	813321971.9	59.394	17945953747	344	190.13235	1.1331257
2006	1	0.292	1.14112E+11	79000000	456523167.7	59.353	18770381775	310	205.74051	1.0455985
2007	1	0.296	1.22166E+11	76000000	651029738.1	59.192	20841132147	299	211.57628	1.0152338
2008	1	0.312	1.29513E+11	75000000	1328422987	59.032	24010974774	338	222.77448	1.2211707
2009	1	0.335	1.36047E+11	77000000	901286583.1	58.87	26854698454	330	245.25793	0.50959486
2010	1	0.364	1.43628E+11	103000000	1232258247	58.707	30255974865	342	251.00856	0.86148775
2011	1	0.377	1.52912E+11	97000000	1264725163	58.545	35265423644	306	271.5203	1.0177838
2012	1	0.399	1.62884E+11	105000000	1584403460	58.382	37676729935	354	294.9527	0.8733193
2013	1	0.401	1.7268E+11	131000000	2602962095	58.213	42584135120	303	306.46094	0.826586
2014	1	0.423	1.83146E+11	154000000	2539190940	58.043	49407320851	293	318.4197	0.6849754

2015	1	0.464	1.95147E+11	150300003.1	2831152765	57.882	56371394212	340	385.0179	0.82069933
2016	1	0.477	2.09028E+11	214300003.1	2332724781	57.731	80203267084	344	386.63824	0.7713848
2017	1	0.499	2.22804E+11	348000000	1810395804	60.402	90901007678	302	402.8385	0.879046
2018	1	0.504	2.39112E+11	357000000	2421626238	60.644	1.02266E+11	368	430.20114	0.7318307
2019	1	0.609	2.57958E+11	391000000	1908045387	60.865	1.13145E+11	413	482.46228	0.6592997
2020	1	0.559	2.66853E+11	217899993	1525312160	60.351	1.17085E+11	402	457.2916	0.6715829
2021	1	0.583	2.85369E+11	135186	1723856464	61.236	1.29122E+11	447	492.38055	0.6931649
2022	1	0.596	3.0563E+11	529000	1634888030	60.881	1.4746E+11	447	517.9747	0.8309142
2023	1	0.650	3.2328E+11	650000	1385155352	60.881	1.35385E+11	452	508.48926	1.0080312
1995	2	0.789	5.96059E+11	2580000000	2143628110	56.473	1.05031E+11	6566	2963.118	7.6867676
1996	2	0.838	6.41058E+11	2830000000	2426057022	57.04	89420392519	8562	3081.6313	6.7896338
1997	2	0.856	6.6702E+11	2890000000	3577330042	57.608	1.06848E+11	10155	3252.0098	6.5708995
1998	2	0.857	7.08271E+11	2950000000	2634651658	58.175	1.05234E+11	8954	3449.4966	7.3818192
1999	2	0.913	7.70923E+11	3010000000	2168591054	58.742	1.42042E+11	4826	3546.3625	7.1308775
2000	2	0.923	8.00534E+11	3598000000	3584217307	59.308	1.20271E+11	8538	3725.401	6.398104
2001	2	0.918	8.39152E+11	3342000000	5128093562	58.794	1.45185E+11	10592	3740.8735	6.0226192
2002	2	0.930	8.71073E+11	3300000000	5208967106	58.279	1.55776E+11	11465	3870.8083	5.529273
2003	2	0.948	9.39543E+11	4560000000	3681984671	57.762	1.87413E+11	12613	4008.7097	5.445053
2004	2	0.990	1.01398E+12	6307000000	5429250990	57.241	2.48888E+11	17466	4352.6514	7.278265
2005	2	1.027	1.09432E+12	7659000000	7269407226	56.716	3.07055E+11	24382	4608.417	6.731385
2006	2	1.102	1.18253E+12	8915000000	20029119267	56.742	3.66687E+11	28928	4854.8667	7.539817
2007	2	1.170	1.27313E+12	11234000000	25227740887	56.766	5.10431E+11	35218	5268.96	7.681195
2008	2	1.234	1.31242E+12	12462000000	43406277076	56.791	4.60645E+11	36812	5576.529	7.093329
2009	2	1.318	1.41561E+12	11140000000	35581372930	56.818	5.26782E+11	34287	5991.8525	6.352798
2010	2	1.352	1.5359E+12	14490000000	27396885034	56.847	6.66654E+11	39762	6251.326	6.450954
2011	2	1.403	1.6164E+12	17710000000	36498654598	56.173	7.21754E+11	42291	6592.3706	7.426478

2012	2	1.511	1.7046E+12	18340000000	23995685014	55.501	7.00852E+11	43955	6948.685	6.692072
2013	2	1.545	1.81345E+12	19042000000	28153031270	55.376	6.31716E+11	43031	7178.7197	7.3276463
2014	2	1.643	1.94783E+12	20756000000	34576643694	55.235	6.98764E+11	42854	7664.0034	7.3362403
2015	2	1.689	2.10359E+12	21472000000	44009492130	55.061	6.75604E+11	45658	7929.679	7.1391196
2016	2	1.759	2.27727E+12	23111000000	44458571546	54.81	6.92402E+11	45057	8284.972	6.973517
2017	2	1.792	2.43202E+12	27878000000	39966091359	54.524	8.21484E+11	46582	8600.742	7.4859
2018	2	1.894	2.58897E+12	29143000000	42117450737	54.221	8.74214E+11	50055	9088.107	7.9542136
2019	2	1.889	2.68921E+12	31661000000	50610647354	53.923	8.5341E+11	53627	9317.351	8.904294
2020	2	1.734	2.53383E+12	13413000000	64362364994	53.202	7.73631E+11	56771	8828.374	9.739235
2021	2	1.900	2.77935E+12	1520000	44727277563	54.097	1.0172E+12	61573	9585.078	9.488208
2022	2	1.997	2.97354E+12	6190000	49940258404	55.356	1.10745E+12	61573	10103.183	10.273168
2023	2	2.070	3.19906E+12	9240000	28070213530	55.356	1.19757E+12	62573	10837.855	9.676426
1995	3	0.628	1.38481E+11	582000000	722631560.7	49.284	11245276826	699	410.67953	16.378126
1996	3	0.682	1.45192E+11	590000000	921976182.5	50.141	12028715743	815	437.42648	16.762867
1997	3	0.664	1.46665E+11	618000000	716253125.4	50.997	11187552988	1076	422.88452	12.898634
1998	3	0.665	1.50405E+11	556000000	506000000	50.82	11014941458	1320	453.84885	15.707119
1999	3	0.664	1.5591E+11	492000000	532000000	51.092	9801844605	1133	473.72205	13.423369
2000	3	0.673	1.62552E+11	551000000	308000000	51.362	16226663445	1195	483.7543	11.344158
2001	3	0.662	1.68488E+11	533000000	378000000	51.483	15540295431	1226	495.15015	11.415049
2002	3	0.692	1.72859E+11	562000000	826000000	51.606	14651688860	1112	514.1093	12.188603
2003	3	0.704	1.82196E+11	620000000	534000000	51.753	17209612430	1127	559.92676	13.333744
2004	3	0.760	1.96464E+11	765000000	1118000000	51.899	20692843495	1081	623.0619	12.676343
2005	3	0.772	2.1076E+11	828000000	2201000000	51.671	23620277774	1284	646.4842	13.59751
2006	3	0.806	2.23515E+11	919000000	4273000000	51.439	29593678893	1738	681.3318	12.633493
2007	3	0.854	2.3345E+11	912000000	5590000000	51.486	32290835865	1558	724.4105	12.365368
2008	3	0.828	2.384E+11	986000000	5438000000	51.523	36389438258	1545	727.99835	10.553453

2009	3	0.817	2.46678E+11	950000000	2338000000	52.128	32929732236	1565	737.6063	10.887298
2010	3	0.791	2.50383E+11	998000000	2022000000	52.682	31397909722	1094	740.7602	11.174603
2011	3	0.779	2.57093E+11	1127000000	1326000000	52.505	33738559418	953	740.26276	11.411278
2012	3	0.766	2.64877E+11	1014000000	859000000	52.833	37938688631	894	687.83594	4.3177714
2013	3	0.738	2.76444E+11	938000000	1333000000	53.162	38753009548	934	751.74243	11.522534
2014	3	0.752	2.87823E+11	971000000	1887000000	52.768	40457681171	922	775.93536	11.4964
2015	3	0.789	2.99964E+11	915000000	1673000000	53.741	47427027648	886	815.85895	11.174581
2016	3	0.917	3.19683E+11	790000000	2576000000	53.389	49979283200	840	542.20074	18.06002
2017	3	0.999	3.33853E+11	865000000	2496000000	53.039	55402068608	698	940.99817	9.591863
2018	3	0.933	3.54391E+11	845000000	1737000000	52.689	60784993524	892	971.03046	9.339477
2019	3	0.923	3.63242E+11	992000000	2234000000	53.639	49739824137	874	982.5163	10.928219
2020	3	0.883	3.58614E+11	765000000	2057000000	53.883	44509674424	900	977.2168	11.878904
2021	3	0.966	3.81974E+11	1314000	2147000000	55.014	50655825468	993	1083.7913	10.295108
2022	3	0.849	4.00185E+11	1400000	1462000000	55.05	57666568689	993	998.70544	10.746907
2023	3	0.830	4.00165E+11	1300000	1818000000	55.05	46389609735	998	936.7015	12.158016
1995	4	0.320	29548935121	367000000	55995587.57	58.447	3352682927	189	40.738224	32.7656539
1996	4	0.380	30671784965	282000000	119874349.7	59.067	3370074181	164	42.854855	22.4381415
1997	4	0.408	32636435386	351000000	430056151.8	58.931	3680335650	274	44.23366	23.0447605
1998	4	0.417	34169833188	369000000	193424023.1	62.937	3970349108	212	47.155613	24.5494953
1999	4	0.456	35639320703	414000000	176410171.3	61.309	4272692525	367	50.71928	24.3756467
2000	4	0.540	37777691762	388000000	172941409.8	59.461	4579041683	321	53.54662	17.7156597
2001	4	0.546	37193872241	347000000	171790000	59.198	3465577844	356	52.03296	17.6282476
2002	4	0.573	38668488650	594000000	196500000	58.939	3851202174	325	53.509136	14.7581546
2003	4	0.567	40965500924	709000000	228720000	58.686	4157853295	284	55.061676	17.5105676
2004	4	0.623	43196097553	808000000	232800000	58.435	5218065026	315	53.50688	16.025313
2005	4	0.607	45892289127	729000000	272400000	58.187	6547452736	360	61.786396	16.0770892

2006	4	0.593	49411443817	733000000	479700000	57.947	7912663077	423	66.334045	19.9593678
2007	4	0.605	52769853736	750000000	603000000	57.729	9042585114	430	67.44016	16.6285726
2008	4	0.591	55909706548	803000000	752200000	57.52	11217629355	465	63.5758	18.3665105
2009	4	0.632	57888301892	754000000	404000000	57.307	10278404719	402	64.45984	17.0167053
2010	4	0.631	62528609282	1044000000	477559000	57.089	11217629355	460	69.6159	22.8945155
2011	4	0.714	67949516442	1421000000	955920000	56.703	10278404719	429	75.57897	17.2311411
2012	4	0.752	73815041948	1756000000	941116591.2	56.377	10278404719	429	77.95245	12.2575724
2013	4	0.687	76805840200	2506000000	932551317.6	55.872	29182742574	516	79.214134	24.8034726
2014	4	0.820	81704500477	3278000000	893628980.3	55.699	29192742574	516	85.89107	15.4928586
2015	4	0.923	85140955389	3978000000	679655644.2	57.93	29182742574	481	91.3002	18.9945696
2016	4	1.073	89443659904	4591000000	897049375.9	58.031	32083156362	573	100.87174	12.5932665
2017	4	1.064	95222329687	5083000000	1372723043	58.377	37492499292	543	106.731476	11.7270354
2018	4	0.931	97422045730	5608000000	1614044009	56.297	35961319738	603	112.36916	16.8680099
2019	4	0.981	97207245818	4663000000	743466231.5	56.864	30361866214	611	113.03538	13.5320508
2020	4	0.950	92711881360	1076000000	434075668.5	55.156	27711767603	604	106.000435	15.5272636
2021	4	0.924	96612720767	194495	592289969.9	55.881	32549949865	539	109.63753	21.8530069
2022	4	0.794	89514811808	719978	884150491.4	56.115	21207876368	539	97.57657	24.6514363
2023	4	1.032	87457721051	14900000	711826200.5	56.213	21343650459	549	99.308914	22.3708528

ID 1=Bangladesh, 2= India, 3 = Pakistan, 4= Srilanka

All VARIABLES DATA SET (ASEAN)

YEAR	Country	ENV	EG	TRM	FDINIF	LF	CF	TAI	ENRC	RENRC
1995	BRN	19.47569	10622682169	220000	582760560	68.818	1735602787	42	18.145622	0.001
1996	BRN	19.198332	10928436715	260000	653600000	69.142	2113413723	21	16.899364	0.001
1997	BRN	19.434162	10767660661	219000	701740000	69.459	1844685434	42	18.072613	0.001
1998	BRN	17.476727	10707522323	287000	573250000	69.768	1369501231	32	16.34575	0.001
1999	BRN	18.27826	11034332731	368000	747868670	70.071	983505776.3	34	19.28584	0.001
2000	BRN	15.957318	11348747419	466000	549607250	70.37	783642572.4	21	19.663834	0.001
2001	BRN	15.229579	11660161647	605000	60694643.66	70.667	808226606.5	21	22.35729	0.001
2002	BRN	13.439647	12111654412	787000	229671955.7	70.531	1242283987	21	26.106573	0.001
2003	BRN	15.810981	12463371464	701000	123820911.1	70.398	987246345.5	43	27.008535	0.001
2004	BRN	15.647754	12526226521	1055000	113205867	70.271	1061679785	31	29.992193	0.001
2005	BRN	14.802576	12574766552	1422000	175068516.6	70.153	1083408345	26	33.786716	0.001
2006	BRN	19.161533	13127769535	1700000	87839128.31	70.033	1197218511	41	52.069736	0.001
2007	BRN	21.323994	13148062679	2015000	257635717.5	69.904	1590336951	64	54.66209	0.001
2008	BRN	23.832714	12893027782	2125000	222184549.5	69.759	1967305194	75	56.141193	0.001
2009	BRN	19.8424	12665525725	2162000	325586827.8	69.595	1884269498	42	37.24468	0.001
2010	BRN	20.242641	12994698400	2508000	480722550	69.422	3247503317	0	42.422886	0.001
2011	BRN	23.79846	13481391224	2882000	691170270	69.286	4820683147	0	43.576885	0.001
2012	BRN	23.361937	13604454981	3584000	864905530	68.738	6263769770	31	42.360893	0.001
2013	BRN	18.52315	13315220388	4210000	775642000	68.209	7163717684	35	39.39745	0.001
2014	BRN	21.194212	12981227716	4503000	573906207.8	67.696	4692038136	117	44.308376	0.001
2015	BRN	16.451077	12930291488	4775000	171289167.8	67.195	4557385896	0	48.95986	0.001
2016	BRN	17.917582	12609889504	5012000	-150550827.3	66.709	3946802071	89	51.1421	0.001

2017	BRN	21.63514	12777424818	5602000	467927550.3	66.238	4221179803	107	51.34954	0.001
2018	BRN	21.516985	12784099462	6201000	516202620.6	68.88	5571467449	121	53.40774	0.001
2019	BRN	24.500765	13278730316	6611000	373256767.2	67.924	5209597653	141	52.704937	0.001
2020	BRN	25.1325	13429254464	1306000	565542275.4	67.678	4872893587	120	55.350857	0.001
2021	BRN	25.375603	13215626906	3543	204749379.8	68.13	4380191129	139	45.993755	0.001
2022	BRN	23.950201	13000432684	35701	-292416275.5	69.115	4312351156	54	37.78	0.001
2023	BRN	21.12	13183357642	133630	-50992640.19	67.2	4472402984	54	37.78	0.001
1995	INDO	1.1224906	3.80895E+11	346000	4346000000	68.695	61508394490	2874	870.28394	3.5392694
1996	INDO	1.2566929	4.10674E+11	403000	6194000000	68.673	71854186056	3997	933.1465	3.5088153
1997	INDO	1.3680507	4.29975E+11	463000	4677000000	68.069	65388507015	4018	1012.6952	2.4772785
1998	INDO	1.1764085	3.73534E+11	500000	-240800000	68.666	26180242917	1846	995.5688	4.0149045
1999	INDO	1.3839109	3.76489E+11	614000	-1865620963	69.081	30994562179	2936	1086.9856	3.852458
2000	INDO	1.3141832	3.95012E+11	737000	-4550355286	69.586	36710074220	3890	1163.5176	3.733831
2001	INDO	1.4601983	4.09405E+11	674000	-2977391857	69.098	36163564857	3926	1246.2579	4.1125903
2002	INDO	1.4014755	4.27826E+11	736000	145085548.7	68.024	41879334582	3843	1280.3842	3.6303015
2003	INDO	1.5212358	4.48277E+11	636000	-596923827.8	67.652	60098225365	3300	1389.068	3.1624913
2004	INDO	1.5182068	4.70829E+11	895000	1896082770	67.607	61785619707	3668	1375.8467	3.3661623
2005	INDO	1.519271	4.97632E+11	1095000	8336257208	66.576	71699880267	4304	1416.0144	3.4541986
2006	INDO	1.4954154	5.25006E+11	1215000	4914201435	66.424	92601703158	4612	1440.2039	3.1702235
2007	INDO	1.6514556	5.58318E+11	1624000	6928480000	68.414	1.0771E+11	5134	1545.699	3.31408
2008	INDO	1.5370413	5.91894E+11	1737000	9318453650	68.61	1.41926E+11	5133	1563.5452	3.5247178
2009	INDO	1.6554897	6.19292E+11	2008000	4877369178	68.273	1.6719E+11	4518	1606.1854	3.6053057
2010	INDO	1.8269529	6.57835E+11	2513000	15292009411	68.875	2.48276E+11	5630	1738.3348	4.3475184
2011	INDO	2.026407	6.98422E+11	2724000	20564938227	69.41	2.9454E+11	5830	1836.3699	3.431125
2012	INDO	2.06198	7.40538E+11	3330000	21200778608	69.984	3.21912E+11	5830	1895.7885	3.5263355
2013	INDO	1.9309183	7.81691E+11	3779000	23281742362	69.306	3.08719E+11	7450	1809.8263	4.4679456

2014	INDO	1.9041111	8.20828E+11	4159000	25120732060	69.095	3.08225E+11	8023	1839.6007	4.608102
2015	INDO	2.0809183	8.60854E+11	4684000	19779127977	69.043	2.93231E+11	9153	1866.1007	3.9044187
2016	INDO	2.062575	9.04182E+11	4239000	4541713739	68.778	3.15522E+11	9639	1896.8113	5.6316724
2017	INDO	2.1056583	9.50022E+11	3869000	20510310832	69.08	3.42371E+11	9303	1967.7083	5.4710994
2018	INDO	2.224542	9.99179E+11	4186000	18909826044	70.062	3.60319E+11	9754	2151.6267	7.7867928
2019	INDO	2.4144928	1.04933E+12	4791000	24993551748	70.608	3.78034E+11	11481	2299.6296	8.279649
2020	INDO	2.2290483	1.02766E+12	886400	19175077748	69.675	3.42534E+11	8160	2163.7532	10.217818
2021	INDO	2.2499223	1.06571E+12	5470000	21213080330	68.207	3.73144E+11	8800	2214.0532	10.79372
2022	INDO	2.6456614	1.12227E+12	642512	24702029705	69.09	3.92371E+11	6040	2791.4219	9.899512
2023	INDO	2.41	1.17892E+12	3300000	22085914486	69.09	4.18478E+11	6040	2807.7332	10.446613
1995	MAL	5.504375	1.17335E+11	1760000	4178239335	63.48	38710925040	4052	397.95117	4.6203046
1996	MAL	5.347406	1.29072E+11	2049000	5078414948	63.477	41834009063	5575	444.2731	3.450362
1997	MAL	5.629809	1.38523E+11	2223000	5136514576	63.498	42975370857	6451	515.45135	2.393924
1998	MAL	5.0334234	1.28329E+11	2149000	2163401816	63.625	19250662454	5963	495.44113	2.660114
1999	MAL	4.6487627	1.36205E+11	2171000	3895263158	63.648	17715000000	5842	529.4285	4.2179785
2000	MAL	5.3552947	1.48271E+11	1992000	3787631579	63.626	25198947368	6227	611.2572	3.6815305
2001	MAL	5.559729	1.49039E+11	1797000	553947368.4	63.609	22637631579	5934	625.815	3.1404243
2002	MAL	5.4690075	1.57074E+11	1933000	3192894737	63.533	24986842105	4937	659.1749	2.5936084
2003	MAL	6.1999974	1.66166E+11	1907000	3218947368	63.436	25085789474	5062	714.1565	2.2531736
2004	MAL	6.6978498	1.77438E+11	2291000	4376052632	63.326	28754210526	5442	771.64	2.3196447
2005	MAL	6.556486	1.86899E+11	2623000	3924786635	63.227	32146565227	6286	835.0786	2.2862406
2006	MAL	6.4190946	1.97337E+11	2843000	7690731246	63.151	36936876274	4800	843.8329	2.3766863
2007	MAL	6.475966	2.09767E+11	3092000	9071369835	63.115	45309054160	2372	900.0565	2.1808863
2008	MAL	6.9709706	2.19902E+11	3139000	7572512432	62.606	49528258759	5303	932.6227	2.6779194
2009	MAL	6.8085785	2.16574E+11	3017000	114664434.6	62.953	36074022352	5737	903.04865	2.6289935
2010	MAL	6.9415693	2.32654E+11	3520000	10885801852	62.974	59639804824	6383	932.97424	2.3300166

2011	MAL	6.9713326	2.44971E+11	3917000	15119439204	64.332	69089801546	6452	949.2023	2.8877702
2012	MAL	7.1809983	2.58379E+11	4273000	8895774251	65.532	80964749752	6940	1038.4077	3.0349357
2013	MAL	8.019667	2.70506E+11	4681000	11296279514	67.233	83848502131	7205	1086.7379	3.5195735
2014	MAL	8.006472	2.86755E+11	4833000	10619431583	67.627	84440825455	7620	1097.6155	3.8796122
2015	MAL	7.580128	3.01355E+11	5361000	9857162112	67.943	76617356473	7727	1114.5746	4.0509195
2016	MAL	7.5117126	3.14765E+11	5967000	13470089921	67.918	78313048434	7236	1172.3032	5.2360177
2017	MAL	7.63407	3.33061E+11	6621000	9368469823	68.153	81523896270	7072	1188.4774	6.6614723
2018	MAL	8.092997	3.49192E+11	7168000	8304480742	68.712	85741277233	7295	1209.5756	6.67183
2019	MAL	8.154313	3.64602E+11	8261000	9154921685	69.355	76863484588	7551	1240.7814	6.7743883
2020	MAL	8.109902	3.44706E+11	1483000	4058769679	69.253	66337160478	6828	1196.4292	7.542022
2021	MAL	8.3059	3.56074E+11	..	20245157327	69.775	82642293151	7534	1246.6495	7.909985
2022	MAL	8.576508	3.86875E+11	..	15027992711	69.401	95676596821	6377	1331.2793	7.8370423
2023	MAL	9.534	4.01113E+11	..	7918601050	69.401	90036639897	6377	1335.3104	7.88792
1995	PHL	0.86590916	1.19492E+11	7137000	1478000000	63.023	18447634773	2376	258.4611	13.865187
1996	PHL	0.86355734	1.26494E+11	7292000	1517000000	62.883	22036285698	2797	277.04028	14.195754
1997	PHL	0.9635655	1.33055E+11	7198000	1222000000	62.78	22646203526	3565	302.24133	12.731897
1998	PHL	0.91638947	1.32371E+11	6242000	2287000000	62.934	14890226261	3443	300.0672	13.421565
1999	PHL	0.89427793	1.36801E+11	6958000	1829000000	62.925	13874267829	3361	305.19662	17.445616
2000	PHL	0.92814827	1.42796E+11	7691000	1487000000	62.853	13123074299	3636	307.7135	18.21516
2001	PHL	0.8832031	1.4715E+11	7522000	760000000	62.831	14951766672	2605	300.85208	16.7215
2002	PHL	0.8644437	1.52619E+11	7567000	1769000000	62.78	17248555512	854	302.28552	16.281395
2003	PHL	0.84741473	1.60382E+11	6127000	492000000	62.668	16997634343	1873	311.88364	16.082535
2004	PHL	0.86051536	1.70918E+11	8329000	592000000	63.076	19694871629	2696	319.26147	16.661371
2005	PHL	0.849781	1.79366E+11	8943000	1664000000	63.132	19944162392	2972	319.3413	16.062689
2006	PHL	0.7571367	1.88902E+11	9751000	2707414997	63.032	20444047332	3257	305.30978	18.680275
2007	PHL	0.7904736	2.01217E+11	10285000	2918724841	62.842	25157529681	3473	316.79916	16.622225

2008	PHL	0.8474372	2.09958E+11	10116000	1340027563	62.715	34449009710	3313	327.54846	17.630617
2009	PHL	0.8242352	2.12999E+11	9683000	2064620678	63.141	30675428826	2997	331.4022	17.189404
2010	PHL	0.8777076	2.28622E+11	11642000	1070386940	63.128	42594292263	3393	341.03098	14.867264
2011	PHL	0.87097615	2.37443E+11	13171000	2007150725	64.05	48576401294	3196	347.83694	16.133564
2012	PHL	0.9040749	2.53819E+11	14496000	3215415155	63.585	51233564512	2994	359.88647	16.406023
2013	PHL	0.9632471	2.70953E+11	15568000	3737371740	63.324	58603858125	3285	384.94003	14.824674
2014	PHL	1.0015633	2.88153E+11	15095000	5739574024	64.12	62245371175	3589	404.6579	14.025786
2015	PHL	1.091407	3.06446E+11	15231500	5639155962	63.312	65398453635	3734	443.82196	13.544878
2016	PHL	1.1613077	3.28355E+11	16403000	8279548275	63.517	78441198620	3419	484.6147	13.032715
2017	PHL	1.2661793	3.51113E+11	17425000	10256442399	61.264	83955648706	3395	531.86365	12.544034
2018	PHL	1.3034848	3.73379E+11	18508000	9948598824	61.074	94169593687	4300	549.69855	12.185793
2019	PHL	1.3060241	3.96224E+11	19116000	8671365874	61.577	99488192909	4380	566.12146	11.25281
2020	PHL	1.1841508	3.58511E+11	2742000	6822133291	56.914	63065448326	3993	513.7529	11.994339
2021	PHL	1.253542	3.78999E+11	160000	11983363327	58.721	83312972880	4393	545.51025	12.277111
2022	PHL	1.3014648	4.0773E+11	4000000	9492234668	61.725	99818113504	3357	570.99445	12.353065
2023	PHL	1.4	4.30342E+11	5450557	8863959058	61.725	1.01948E+11	3357	609.21356	11.991215
1995	SING	11.441089	1.07074E+11	6952000	11942852103	68.456	29752041626	2557	388.94086	0.78209
1996	SING	13.147368	1.15074E+11	7244000	11432363956	69.089	33741217454	12581	392.47714	0.78209
1997	SING	15.087034	1.24644E+11	7294000	15701783679	69.677	38217046537	6336	412.80063	0.78209
1998	SING	12.262941	1.21913E+11	7843000	5958646074	69.991	26995844890	6678	418.50928	0.78209
1999	SING	12.403977	1.28884E+11	8651000	18852989359	70.388	28208444226	7053	414.32617	0.78209
2000	SING	11.938545	1.40533E+11	9579000	15515295182	70.7	33793996739	8236	443.01443	0.78209
2001	SING	11.937913	1.39028E+11	10133000	17006818857	70.911	24791555391	8250	500.7205	1.5099127
2002	SING	11.274996	1.44483E+11	10873000	6157194144	70.273	23202713299	8199	482.24014	1.5099127
2003	SING	11.696595	1.51054E+11	10082000	17051420153	70.446	16819128645	7874	454.2738	1.5801411
2004	SING	10.972935	1.66069E+11	11737000	24390254966	70.512	26334021209	8585	509.29944	1.5290658

2005	SING	9.571876	1.78302E+11	11567000	19316058814	71.229	27487552549	8605	536.788	1.5247844
2006	SING	9.429944	1.94362E+11	13822000	39129332047	72.02	33261691966	9163	590.98	1.5123541
2007	SING	6.600801	2.11896E+11	14464000	47337947783	71.411	41735927628	9951	635.4063	1.5757014
2008	SING	9.652978	2.15845E+11	14584000	13598298537	72.52	58394358174	9692	677.6433	1.66359779
2009	SING	9.030742	2.16121E+11	14150000	23436064060	72.569	53139156351	8736	728.32654	1.68701107
2010	SING	8.336908	2.47501E+11	15936000	55322434162	73.4	66326636881	9773	773.3151	1.88289434
2011	SING	6.440885	2.62883E+11	19230000	49155657316	73.57	74565820941	9794	802.5536	1.94537691
2012	SING	9.423168	2.74543E+11	22354000	55310807548	74.332	86352862662	9685	804.334	2.05179187
2013	SING	10.023379	2.8777E+11	26547000	64389514904	74.289	92209861744	9722	812.4909	2.28700048
2014	SING	9.354522	2.99095E+11	24810000	68698472831	75.181	92664377886	10312	828.2924	2.44036713
2015	SING	10.960185	3.07999E+11	29923000	69774553125	76.313	78087465677	10814	878.4029	2.72421966
2016	SING	7.0535355	3.19052E+11	32530000	65363061550	76.317	84313660204	10980	926.7514	2.79552367
2017	SING	6.94156	3.3345E+11	35592000	1.02166E+11	76.44	93640784257	10930	950.00244	2.80030657
2018	SING	8.6052475	3.45178E+11	38178000	82009180717	76.311	93274304922	11845	950.5948	2.7916387
2019	SING	5.7579384	3.49821E+11	39916000	1.0589E+11	77.13	92743069351	14136	929.6794	2.93996956
2020	SING	9.274892	3.36283E+11	2742443	80732866660	77.314	79916752552	13265	910.51807	2.96115344
2021	SING	9.397426	3.68872E+11	325000	1.37269E+11	78.635	1.04042E+11	14590	910.7139	3.1857133
2022	SING	8.911513	3.83029E+11	6300000	1.48764E+11	79.262	1.11254E+11	9936	881.8464	4.8338068
2023	SING	9.38	3.87147E+11	13600000	1.75241E+11	79.262	1.05395E+11	9936	964.022	5.0920899
1995	THAI	2.5856197	2.13636E+11	1351000	2067936429	77.954	72557504711	3532	615.0653	3.2436836
1996	THAI	2.8826215	2.25711E+11	1607000	2335837475	78.222	77849807773	4558	695.9609	3.160441
1997	THAI	2.9710672	2.19496E+11	1716000	3894755071	78.455	51473944895	5394	732.63904	2.977457
1998	THAI	2.5865006	2.02739E+11	1520000	7314804931	77.338	22816392322	5071	675.0387	2.3754423
1999	THAI	2.678213	2.12009E+11	1782000	6102677671	76.378	25553493161	5176	715.28613	1.609163
2000	THAI	2.6535778	2.21455E+11	2140000	3365987583	76.618	28163480958	5049	741.69116	2.5755086
2001	THAI	2.706475	2.29082E+11	2330000	5067170388	77.304	27803447523	5332	782.2085	2.5723314

2002	THAI	2.875398	2.43168E+11	2628000	3341612007	77.339	30545657931	4489	847.9409	2.8190806
2003	THAI	2.9499335	2.6065E+11	2429000	5232270340	77.378	36287402629	5131	911.6903	2.7241347
2004	THAI	3.1745062	2.77044E+11	2928000	5860255943	77.982	44402057907	5373	989.7312	2.31644
2005	THAI	3.2561638	2.88645E+11	3477000	8215637195	78.478	57592081378	6340	1021.1172	2.2147255
2006	THAI	3.2543156	3.02984E+11	3583000	8917470351	77.847	59900560116	6261	1042.9984	2.8646533
2007	THAI	3.3531868	3.19452E+11	4229000	8633903441	78.671	67039888342	6818	1078.6527	2.9673934
2008	THAI	3.3306782	3.24965E+11	4236000	8561557725	78.608	82247027996	6741	1078.5447	2.983218
2009	THAI	3.3744862	3.22721E+11	3747000	6411458545	78.051	58134927915	5857	1108.9133	3.0957634
2010	THAI	3.5303538	3.46968E+11	5050000	14746672920	77.065	86492757538	1937	1179.445	2.8453703
2011	THAI	3.56379	3.49883E+11	6014000	2473685996	79.101	99347747798	3924	1212.482	3.5703893
2012	THAI	3.793507	3.75224E+11	6848000	12899036063	78.94	1.11412E+11	6746	1292.8707	3.914373
2013	THAI	3.7907274	3.85308E+11	7572000	15935960665	76.422	1.15411E+11	7404	1312.8635	3.9144244
2014	THAI	3.8948538	3.89102E+11	7874000	4975455660	76.232	97431504651	7930	1357.1696	4.358339
2015	THAI	3.9419734	4.01296E+11	7944000	8927579182	75.913	89712344913	8167	1377.446	4.308386
2016	THAI	4.022904	4.15081E+11	10013000	3486184390	75.189	87242990309	7820	1405.5717	4.739767
2017	THAI	3.9965413	4.32422E+11	12922000	8285169820	74.695	1.04662E+11	7865	1432.6826	5.4690447
2018	THAI	4.0539184	4.50683E+11	15498000	13747219811	75.347	1.27801E+11	8149	1478.3762	6.566889
2019	THAI	3.95287	4.60213E+11	18009000	5518708214	74.89	1.29547E+11	8172	1479.7451	7.1565943
2020	THAI	3.8034203	4.3237E+11	3837000	-4947474467	75.136	1.18887E+11	7525	1375.7584	7.181275
2021	THAI	3.7320516	4.3915E+11	427869	15158773773	75.331	1.44919E+11	8242	1386.81	7.2292643
2022	THAI	3.7762568	4.49965E+11	9800000	11231916012	76.455	1.37934E+11	6346	1387.8933	7.4562526
2023	THAI	3.938	4.58437E+11	28150000	3086425198	76.455	1.16201E+11	6346	1390.8123	7.842765
1995	VNM	0.4079336	66835362482	1351000	1780400000	81.003	5628674807	682	127.15272	20.584055
1996	VNM	0.47342482	73077797034	1607000	2395000000	80.685	6929463841	966	145.77272	20.584055
1997	VNM	0.5982502	79035160538	1716000	2220000000	79.072	7596655185	1264	167.91832	20.584055
1998	VNM	0.6206059	83591107164	1520000	1671000000	78.413	7904356346	1105	181.61017	20.584055

1999	VNM	0.6214288	87581401292	1782000	1412000000	78.17	7925225086	1142	188.04898	20.584055
2000	VNM	0.68271756	93525828109	2140000	1298000000	76.854	9230155835	1239	214.14896	20.584055
2001	VNM	0.7640383	99317782863	2330000	1300000000	77.654	10188882978	1286	242.04488	20.584055
2002	VNM	0.86217517	1.05595E+11	2628000	1400000000	77.087	11648483262	1211	264.75528	20.584055
2003	VNM	0.9482761	1.12881E+11	2429000	1450000000	76.52	14019332134	1150	285.32867	20.584055
2004	VNM	1.080523	1.21388E+11	2928000	1610000000	75.864	16111139337	1431	347.77454	20.584055
2005	VNM	1.1527941	1.30549E+11	3477000	1954000000	76.899	19455490339	1947	369.7913	20.584055
2006	VNM	1.1870176	1.39659E+11	3583000	2400000000	77.909	22922550292	2166	338.9682	20.584055
2007	VNM	1.1966354	1.49616E+11	4229000	6700000000	78.894	30630001319	2860	370.27383	20.584055
2008	VNM	1.335355	1.58087E+11	4236000	9579000000	79.665	36175742612	3199	457.2086	20.584055
2009	VNM	1.4395142	1.6662E+11	3747000	7600000000	80.425	39397756629	2890	467.72537	20.584055
2010	VNM	1.596639	1.77322E+11	5050000	8000000000	80.71	54610275122	3582	540.2252	20.584055
2011	VNM	1.7267891	1.88694E+11	6014000	7430000000	80.784	55870991114	3560	597.14197	20.584055
2012	VNM	1.6156216	1.99081E+11	6848000	8368000000	80.747	59771116766	3805	624.23193	20.584055
2013	VNM	1.6776536	2.10137E+11	7572000	8900000000	81.592	64567637070	3995	659.4035	20.584055
2014	VNM	1.9931153	2.23633E+11	7874000	9200000000	81.74	70710178267	4447	728.0775	20.584055
2015	VNM	2.3371155	2.39258E+11	7944000	11800000000	81.866	76823255418	5033	826.4728	20.584055
2016	VNM	2.3967814	2.55265E+11	10013000	12600000000	81.419	81562521179	5228	898.7783	20.584055
2017	VNM	2.4421468	2.72981E+11	12922000	14100000000	81.361	90892128862	5382	963.6317	20.584055
2018	VNM	2.7153149	2.93359E+11	15498000	15500000000	81.324	99294552928	6071	1083.2736	20.584055
2019	VNM	3.5686002	3.14948E+11	18009000	16120000000	81.357	1.0693E+11	7520	1202.6356	20.584055
2020	VNM	3.7594166	3.23972E+11	3837000	15800000000	79.399	1.10625E+11	7695	1204.3934	20.584055
2021	VNM	3.6171148	3.32246E+11	3800000	15660000000	77.96	1.20554E+11	8534	1208.5538	20.584055
2022	VNM	3.4995174	3.59236E+11	3360000	17900000000	78.399	1.33635E+11	3438	1244.0675	20.584055
2023	VNM	3.689	3.77364E+11	12600000	18500000000	78.399	1.33663E+11	3438	1358.732	20.584055

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1	Exploring the Influence of Technological Innovation and Tourism Development on the FDI-Growth-Environment Nexus in South Asian Countries: A Novel Perspective Using the CS-ARDL Approach (Md. Maznur Rahman & Dr. Akshaya Kumar Mohanty)	Journal Name: International Journal of Indian Culture and Business and Management Accepted Date: 06/08/2025 Journal Category: UGC and Web of Science
2	Renewable energy, forestry, economic growth, and demographic impact on carbon footprint in India: does forestry and renewable energy matter to reduce emission? (Md. Maznur Rahman, Dr. Akshaya Kumar Mohanty, and Md. Hasanur Rahman)	Journal of Environmental Studies and Sciences (2024)14:415–427 https://doi.org/10.1007/s13412-024-00912-6 Volume 14, Pages 415-427, Published 26 March 2024 Journal Category: UGC and Scopus
3	Scrutinizing the existence of the environmental Kuznets curve in the context of foreign direct investment, trade, and renewable energy in Bangladesh: impending from ARDL method. (Md Hasanur Rahman, Liton Chandra Voumik, Md Maznur Rahman, Shapan Chandra Majumder)	Environment, Development and Sustainability https://doi.org/10.1007/s10668-023-03940-4 Volume 26, Pages 12619-12638, Published 06 October 2023 Journal Category: UGC and Scopus

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1	An Assessment on the Relationship between Foreign Direct Investment and Energy Consumption in India using ARDL model	International Seminar on “New Era of Social Responsibility, Sustainability and Innovations”	School of Economics, Management and Information Science (SEMIS), Mizoram University	March 4 th -6 th , 2024
2	Exploring the Influence of Technological Innovation and Tourism Development on the FDI- Growth-Environment Nexus in South Asian Countries: A Novel Perspective Using the CS-ARDL Approach	A Three Day International Seminar on “Environmental Justice: Representations in Literature, Culture and Philosophy”	School of Humanities and Languages. Mizoram University	27-29 February, 2024

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ABSTRACT

1. INTRODUCTION

In recent years, economists have become more concerned about the environment, understanding that economic activity is inseparable from nature. Development is the result of people, firms, public institutions, technology, and growth moving together. On the other hand, Schumpeter and Backhaus (2003) define development as a slow and multi-faceted change social, economic, political, environmental, and cultural. Sen (2000) emphasizes that development expands people's quality of life, education, health, longevity while income is only a means and rights and entitlements matter.

The planet keeps warming as economic grow, the old story since early industrialization, a rise of close to 1 degree along SDG 13's bottom line over the past century or so. UNEP major Emissions Gap Given the latest Emissions Gap Report from UNEP warns that full delivery of the NDCs will lead to about 2.6°C by 2100. That goes beyond the Paris Agreement, which seeks to keep global warming well under 2°C and aims for 1.5°C. The path to this end was reaffirmed by COP27's Sharm el-Sheikh Implementation Plan, so that climate action ceased to be a matter of mere policy and became a moral imperative which called urgently for planned action.

The temperature of the total global environment is increasing in the context of an expanding economy. Global warming, ecosystem imbalance, macroeconomic issues, technical issues, and societal and economic concerns are just a few of the problems brought on by climate change (Bello et al., 2024; Begum et al., 2020). Therefore, environmentalists are attempting to identify the processes that could lead to an improvement in environmental health. Burning coal, oil, and natural gas releases more carbon dioxide (CO₂) into the atmosphere, which spreads throughout the ecosystem due to rapid industrialization and urbanization.

Environmental effects are the impacts of human activities in the real world. They can be good or bad, depending on where they occur: air, water, land, plants, animals, humans, and all living things are affected by weather or climate. And one of the key forces has been climate change, which is reshaping the natural realm through sweeping transformations. Climate change is the long-term shift in average weather patterns. It is mainly caused by burning fossil fuels, cutting down forests, and industrial activities that release heat-trapping gases. These gases heat the planet, elevate sea levels and lead to more frequent and harsher extreme weather with wide social and economic ripple effects.

In contemporary times, countries worldwide are placing considerable emphasis on FDI inflows due to their substantial contributions to economic growth and development. Such investments offer benefits to both the recipient and investing economies (Camarero et al., 2018; Wang & Wang, 2015). Globally, FDI has witnessed significant growth, increasing from \$330 billion in 1995 to \$1.43 trillion in 2017, as reported by UNCTAD in 2018. The FDI expects a critical work in monetary improvement when there is a lack of homegrown venture reserves (Ahmad et al., 2022). FDI has emerged as the fundamental wellspring of external resource streams to horticultural countries all through the long haul and has turned into a tremendous piece of the capital improvement in these countries, despite their proposal in the overall dissemination of FDI, continuing to remain pretty much nothing or regardless, declining (Xinye, 2022).

Similarly, tourism has positive impact on economic growth and development (Rasool et al., 2021; Selvanathan et al., 2021). International tourism has been recognized as a potential solution to counter balance excessive trade imports in the balance of payments by fostering job creation and development, among other factors (Lanza et al., 2003). Moreover, beyond simply driving growth within the sector itself, tourism also serves to stimulate broader economic development (Lee & Chang, 2008). Many governments have taken steps to promote tourism as a means of achieving greater economic prosperity. However, it's important to acknowledge that due to the simultaneous production and

consumption of tourism at the destination, the industry is intricately linked to its environmental impact.

The study serves the purpose of highlighting the very real and relatively unexplored link between the FDI and the environment, which is the focus of this analysis. As FDI in South Asia and ASEAN countries continues to rise, it is imperative to understand the true nature of such investments, particularly the environmental impact in the region, for governments, businesses, and societies. The goal of this study is to find out how much FDI changes environmental practices, resource management, and the health of ecosystems in these areas, which often have a lot of different kinds of plants and animals and ecosystems that are easily damaged.

2. REVIEW OF LITERATURE

This chapter endeavors to provide a brief overview of pertinent literature to underpin the current study. Its primary objective is to delve into existing research, shedding light on key issues necessitating careful examination within the study's framework. By offering a thorough exploration of the subject matter, this review aims to elucidate the study's significance and relevance, thus substantiating its necessity and pertinence in the present academic discourse. In this section we discuss the effects of foreign direct investment (FDI), economic growth, labor force participation rate, capital formation, and tourism on environmental implications that previous researchers have discussed.

Climate change, however, is a multi-dimensional issue that affects not only the environment but also social factors, the affecting areas such as health, agriculture, development. Adaptation and mitigation will be much more effective the more climate change considerations are baked into local and national policies. Climate change should not be perceived merely as an environmental challenge, but rather as one that has profound implications for socio-economic development (Pilato et al., 2018). Similarly, in Muheza District, Tanzania, local groups focus on environmental degradation from

climate change, but there is also need to rise awareness about its wider social and economic impacts (Pilato et al., 2018). Climate change affect the water availability, temperatures and seasonal patterns, which is change the agricultural output and natural resources (Atasoy & Guneysoy Atasoy, 2020; Y. Chen & Raza, 2023). According to (Çelik, 2024), climate change policies affect economic growth and environmental sustainability, demonstrating their close connection. Another area that has received attention is the influence of technological innovations on environmental degradation, revealing that innovations can have an environmental mitigating role or lead to increased environmental pressures, contingent on how they are designed and implemented (Chen & Raza, 2023; Udemba, 2021).

Economic growth has been at the heart of development policy in both South Asian and ASEAN countries since the mid-20th century, motivated primarily by the need to reduce poverty, improve living standard and modernize economies (Stiglitz, 2002). Countries like India, Bangladesh, Indonesia, Vietnam, etc., have opted for rapid industrialization and urbanization as routes to development. But the ecological ramifications of his sector's rise have sent huge warnings up in both regions. Air and water pollution, deforestation and growing greenhouse gas emissions are new challenges. This has led to more interest in economic growth, the environment and the importance of sustainable development in these regions (Dasgupta et al., 2006; Stern, 2004).

According to Wang & Luo, (2020), active government involvement, strong economic development, and industrial structure optimizing significantly contribute to improved environmental quality, while at the same time, increased foreign direct investment (FDI) tends to increases environmental degradation. Empirically renewable energy consumption (REC), foreign direct investment (FDI) and economic growth (EG) has been probed into in the pertinent literature there are now being exist since, such as Naz et al., (2019), and Samour et al., (2022). All the more exactly, in the customary structure, FDI is required to clearly influence economic development since FDI is expected to supplement domestic investment, and viewed as a significant enhancement for capital and

investment deficiencies. Further analysis showed that foreign direct investment influences economic growth through knowledge spillovers in countries experiencing significant changes, and that technological and innovative activities play a key role in supporting development performance (Silajdzic & Mehic, 2015). Additionally, the investigation by Nistor, (2014) found the positive effect of FDI on host economies, showing distinctively relying upon the region and the area of the foreign investment; its effect relies generally upon the quality and amount of the inflow. The outcomes show that the FDI inflows along with the human resources improvement contribute emphatically to the host nation's economic development (Ciftci & Durusu-Ciftci, 2022)

Nevertheless, unchecked or environment damaging capital formation could lead to higher levels of pollution and environmental degradation, especially in countries with poor standards of environmental governance and a high reliance on fossil fuel-led growth (Stern, 2004; Shahbaz et al., 2018).

The environmental effects of capital formation at the level of ASEAN could differ from nation to nation, depending on income status, regime and economic structure. Singapore has mainstreamed environment safeguards and green technology in its capital investment programme with a relatively high GDP (above 30 per cent). Singapore's sustainable urban planning, green building investments, and robust policy framework have played a critical role in addressing environmental degradation (Zhang & Zhou, 2021).

Air pollution and in particular particulate matter has been associated with lower productivity, higher absenteeism, and a greater prevalence of respiratory and cardiovascular diseases in workers (Chang et al., 2016). This is especially pertinent in cities in India, Bangladesh and Indonesia, where poor air quality is an everyday norm. Outdoor pollution alone causes a huge loss of working hours for illness and premature deaths in these regions according to the International Labour Organization (ILO, 2021; Canton, H. (2021). The literature also contends that environmental deterioration may impact on labour force participation rate more directly, such as, for the expansion of female labour force, elderly worker labour force, informal worker labour force etc.

Table 1: Summary of Empirical Literature Review

Author (Citation)	Methodology	Timeframe/Country	Variables/Proxies	Key Findings
Bello et al. (2024)	Driscoll-Kraay panel estimation and CS-ARDL	1981–2022, ASEAN	Energy consumption, FDI, CO2 emission, and GDP.	FDI contributes to increased CO2, confirming the Pollution Haven Hypothesis and EKC
Zafarullah, H., & Mehnaz, M. (2025)	Qualitative Analysis	1998-2024, ASEAN	CO2, GDP, Renewable Energy consumption, TI	Strong relationship between GDP, EC, and CO2
Khan, M. K., & Kazak, J. (2025).	ARDL	1999 to 2023 , Developing Countries	FDI, TI, Trade Openness, and Co2 emission	FDI negative impact on Environment
Bhowmik el al., (2025)	CCEMG	2004 to 2022, South Asia	Hydropower energy (HPE), FDI, GCF, REC, and CO2 emissions	REC reduce CO2 emission
Muhammad et al. (2020)	Panel Quantile Regression and 2SLS	2000–2016, 65 BRI countries including China	FDI, GDP, CO2 emission, Urbanization	Higher GDP and FDI contribute to increased CO2 emissions
Qimin, Sha, and Xinyuan (2020)	BRI Integrated Assessment Model	2005, Global sample of 191 countries including BRI	GDP, Population, Energy consumption projections	BRI could reduce CO2 emissions by 3.2 billion tons
Rauf et al. (2020)	FMOLS and DOLS	1981–2016, BRI countries and China	EC, GDP, FDI, TO	Strong relationship between GDP, EC, and CO2, while FDI decreases CO2 emissions

3. RESEARCH GAP

Many studies have explored how factors like FDI, energy use, and tourism affect the environment, but there are still research gaps, especially in South Asia and ASEAN. Most models don't fully capture the complex causes of environmental harm, and many use basic methods that don't take into account the differences between countries. More advanced techniques, like panel quantile regression and PMG-ARDL, should be used to better understand how FDI, energy, innovation, and tourism interact and impact the environment. Also, factors like labor markets and capital quality are often ignored, limiting the analysis.

There's also a need to connect macroeconomic factors with the Sustainable Development Goals (SDGs), particularly in South Asia and ASEAN. While FDI's impact on emissions is well-known, few studies look at whether FDI is sustainable or harmful and how it aligns with green investment goals (SDG 9). Current models also don't fully consider the effects of renewable vs. non-renewable energy policies or the role of labor market structures in environmental outcomes. Policymakers need better models that include factors like energy reforms, technological investment, labor policies, and tourism to create more effective, region-specific environmental strategies that support the SDGs.

4. SIGNIFICANCE OF THE STUDY

This study examines the influences of FDI, economic growth tourism, energy consumption, and technology on the environment in South Asia and ASEAN. It monitors pressures on natural resources and CO₂ emissions, and compares trends in the two regions. Applying panel data, it checks FDI's positive and negative impact on sectors, such as technology, innovation, tourism, energy, and renewables.

The hope is to demonstrate how countries can reconcile environmental quality and economic growth. Part of the focus is on how FDI is associated with the energy mix, particularly hydropower, wind, and solar. FDI can hasten the transition to low-carbon energy or entrench reliance on fossil fuels so understanding that role is all-important.

5. SCOPE OF THE STUDY

This study will investigate that how tourism, energy mix, and FDI would impact on the environment in South Asia and ASEAN nations. The study will concentrate on these variables and their relationships with one another affecting carbon di oxide emissions and the depletion of natural resources. In order to compare and contrast the two regions' environmental impacts of FDI, energy mix, and tourism, the study will take a comparative method. The study would include panel data analysis.

6. OBJECTIVES OF THE STUDY

The main objectives of this study are the environmental implications of foreign direct investment and tourism among South Asian and ASEAN countries.

The specific objectives are presented in the following:

- i. To investigate the impact of foreign direct investment on environmental degradation in South Asia and ASEAN countries.
- ii. To estimate the impact of foreign direct investment on economic growth in South Asia and ASEAN countries.
- iii. To investigate the impact of capital formation and labor force on environmental degradation.
- iv. To compare the results between the panel group South Asia and ASEAN countries by considering economic, social and environmental view.

7. HYPOTHESES

- i. There is a significant impact of foreign direct investment on environmental degradation.
- ii. Tourism and foreign direct investment are significantly related.
- iii. There is a short run and long run causality among the variables in South Asian countries as well as ASEAN countries.

8. THEORETICAL METHODOLOGY

This study uses to the production function model and STIRPAT model approach to modeling the nexus among foreign direct investment (FDI) and environmental implications where environmental degradation (ENV) depends on foreign direct investment (FDI), tourism (TRM), economic growth (EG), technological innovation (TAI), labor force (LF), capital formation (CF), and energy consumption. Reducing CO₂ emissions is generally considered necessary to achieve environmental sustainability, and more stable natural world or an increase in CO₂ emissions is called environmental degradation.

Hence, the equation has been denoted by using the typical Marshallian Demand function according to (Friedman, 1949). Based on the Marshallian demand function or production function, we can articulate the subsequent environmental degradation function:

$$Y = EG = ENV = f(K, L) \quad (1)$$

The output level, denoted as Y , represents the GDP growth rate and environmental degradation (such as CO₂ emissions per capita), while K refers to capital (price), measured by FDI inflows, and L represents labor (Income), which can be captured through labor force participation or technological innovation in these countries. To achieve this, we need a model that can measure the effect of FDI, tourism, technological innovation, energy use, and renewable energy on the degradation of the environment. To do this, use the popular STIRPAT model.

The STIRPAT model is represented as:

$$I_i = aP_i^b A_i^c T_i^d e_i \quad (2)$$

In the model, I is an indicator for environmental impact, P stands for population, A electric affluence, measured as GDP per capita, and T denotes technological use as defined by the IPAT model. The parameter a is a model parameter. The populations, affluences and technology, the factors affecting environmental impact, are expressed

by exponents $b, c, \text{ and } d$ their respective coefficients. Also, e is the random error term. i index for the observation unit of these quantities (i.e., I, P, A, T, and e).

The relationship between human activity and ecological effect is investigated using the STIRPAT model. In this study, there are mainly four models: Model 1 considers environmental degradation and economic growth as dependent variable (which is commonly measured by CO₂ emissions and economic development). Model 2 represent IPA, model 3 ITE and Model 4 indicate SIIRPAT.

9. DATA SOURCE:

The study used an extensive panel database for the years 1995-2023 to analyse the association between environmental implications and various major economic and development outcomes in South Asian and ASIAN countries. Specifically, the study focused on an examination of the impact of environmental implications on FDI, economic growth, energy consumption, tourism, capital formation, labor force participation rate, and technological innovation. Data for this study was collected from the World Development Indicators (WDI) and Our World in Data.

Table 1: Variables Identification and Details

Variable		Log Form/Notation	Variable Details	Sources
Dependent Variable	Environmental Degradation	LNENV	CO2(POWID)Annual CO2, emissions (Total per capita)	Our World in Data (OWID)
Independent Variable	FDI	LNFDINIF	Foreign direct investment, net inflows (BoP, current US\$)	World Bank (WB)
	Economic Growth	LNEG	GDP (constant 2015 US\$)(EGT)	WB
	Tourism	LNTRM	International tourism, number of arrivals	WB
	Non-renewable Energy	LNENRC	Primary energy consumption (TWh)	OWID
	Renewable Energy	LNRENRC	Renewable energy consumption (% of total final energy consumption)	OWID
	Capital	LNCF	Gross capital formation (current US\$)	WB
	Labor	LNLF	Labor force participation rate, total (modeled ILO estimate)	WB
	Technology	LNTAI	Patent applications per million people	WB

10. MODEL SPECIFICATION:

This study is to investigate the short run and long-run relationships between foreign direct investment (FDI), renewable energy consumption, non-renewable energy consumption, CO2 emissions, and economic growth by PMG-ARDL framework. The ARDL model is an error correction model that is well suited for the identification of long and short-term relationships. In accordance with the Autoregressive Distributed Lag (ARDL) model of causality (1999), the PMG-ARDL model serves as the core approach to finding long-run relationships between the variables.

The Econometric Model such as the production function or baseline model for economic growth or environmental degradation model which specification defines the functional form like this:

$$EG = ENV = f(\text{FDINIF}, \text{LF}, \text{CF}, \text{TAI}) \quad (1)$$

Where, ENV refers to environmental degradation, which can be measured by CO2 emissions, and EG represents economic growth. The model specifies that environmental degradation is influenced by four key factors: foreign direct investment (FDINIF), labor force (LF), capital formation (CF), and technological innovation (TAI). These variables are linked through their positive or negative associations with environmental degradation.

The Econometric IPA Model specification defined the functional form like that:

$$IPA = ENV = f(\text{FDINIF}, \text{EG}, \text{LF}, \text{CF},) \quad (2)$$

However, the next model is for the selected panel group:

$$ITE = ENV = f(\text{FDINIF}, \text{ENRC}, \text{RENRC}, \text{TRM}, \text{TAI}) \quad (3)$$

In addition, the final STIRPAT model 4 shows the following equation:

$$STIRPAT = ENV = f(\text{FDINIF}, \text{EG}, \text{LF}, \text{CF}, \text{TAI}, \text{TRM}, \text{ENRC}, \text{RENRC}) \quad (4)$$

This equation is the basic STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model, derived from the IPAT identity.

11. Empirical Methodology

Slope Homogeneity Test:

In panel analysis it is often not realistic to assume that all countries have the same slope coefficients, particularly if they are economically or structurally different. Pesaran and Yamagata (2008) have suggested a test for this.

A large result for a significant effect indicates heterogeneity of the slopes, ideally such made it necessary to apply models with varying slopes across units.

Cross-Sectional Dependency (CD test)

The CSD (Cross-sectional Dependence) test for panel data is a statistical method used to identify the presence of cross-sectional dependence in panel datasets, where cross-sectional units are related in some way. Cross-sectional dependence of a panel data set implies correlation among various cross-section units in that panel; can occur because of common shocks or spillover effects among other sources of interdependence. The CSD test is important since many panel data approaches, including fixed effects or random effects models, assume

independence of cross-sectional units. If this assumption does not hold, the estimates may be biased and inconsistent.

CIPS Unit Root Test

Pasaran (2003) uses a dynamic linear heterogenous model for a panel observed with observation of the N cross-sectional units and T time series. The model assumes that the idiosyncratic shocks are independently distributed, with a mean of zero and a constant variance.

Kao Cointegration Test

The Kao cointegration test is a panel adaptation of the Engle-Granger and used to test the long-run equilibrium relationship between variables on a panel data. It is centered on a shared cointegrating vector across cross sectional units and is based on the panel error correction model:

$$\Delta Y_{it} = \alpha_i + \beta Y_{i,t-1} + \tau \Delta Y_{i,t-1} + \varepsilon_{it} \quad (17)$$

Where ΔY_{it} is the series for unit i at time t, α_i represents the intercept and ε_{it} is the error term. H:0 no cointegration (non-stationary residuals), is tested with an ADF-like statistic. In case the residuals are stationary, this means that the variables are cointegrated and thus there is a long run relationship between them.

CIPS Unit Root Test

The CIPS (Cross-Sectionally Augmented Im-Pesaran-Shin) test is an extension of the Im-Pesaran-Shin (IPS) test, which allows for cross-section dependence in panel data. This is especially relevant when there is correlation between cross-sectional units in the panel data, which is frequent in macroeconomic or finance-related data sets. Specifically, the CIPS test adds the cross-sectional average of

the lagged dependent variable to the model to account for cross-sectional dependence. It is employed in the detection of unit roots in panel data, allowing for heterogeneity in the series and cross-sectional dependence.

Parameter Estimation: PMG-ARDL Approaches

The PMG-ARDL model (Pooled Mean Group – Autoregressive Distributed Lag) is a dynamic panel data approach that merges the strengths of the PMG estimator with the ARDL framework. It examines the relationship between a dependent variable, its own lags, and the lags of explanatory variables (Emuron et al., 2022). This enables analysis of both short-run adjustments and long-run equilibrium. The model works as an error correction mechanism that captures deviations from equilibrium. By doing so, it provides a clear view of both immediate impacts and long-term linkages.

The strength of the PMG estimator lies in its ability to handle heterogeneous short-run dynamics while maintaining homogenous long-run coefficients. Through the inclusion of the Error Correction Term (ECT), the model accounts for the speed of recovery after shocks. A valid and significant ECT confirms the existence of a stable long-run cointegration relationship. This ensures that the system eventually converges back to equilibrium after temporary disturbances. As a result, the PMG-ARDL model becomes highly valuable in studying macroeconomic and environmental interactions.

FMOLS Test:

In econometrics, fully modified ordinary least squares (FMOLS) is an estimation technique for parameter estimates in the nonlinear models. FMOLS is used to avoid both serial correlation and endogeneity, which occur due to the correlation of the explanatory variables with the error term in cointegrated systems, in an approach by Phillips and Hansen (1990). In contrast to OLS, FMOLS is based

on a non-parametric correction applied to the regression equation so as not to obtain biased and consistent long-run estimators when the regressors and errors are correlated. When it comes to panel data, Panel FMOLS can either impose a homogeneous (pooled) long-run coefficient across all cross sections or allow for distinct (group-mean) coefficients, depending on the cross-section degree of heterogeneity.

Granger Causality Test:

The PMG-ARDL model is an econometric tool that estimates both short-run and long-run relationships in panel data, even when units like countries or regions are heterogeneous. It assumes common long-run coefficients but allows short-run dynamics to differ, making it well-suited for diverse panels. Often, it is combined with Granger causality tests to examine whether one variable predicts another over time. This approach is particularly useful for studying complex links such as between financial inclusion, economic growth, and environmental pollution.

12. Results Analysis, Findings and Discussion

The study has four interconnected questions concerning economic growth, labor force growth, capital formation and environmental sustainability. This study, therefore, address four specific objectives: (1) To investigate the impact of FDI on environmental degradation in South Asia and ASEAN countries. (II) To estimate the impact of FDI on economic growth in South Asia and ASEAN countries. (III) To investigate the impact of capital formation and labor force on environmental degradation. (IV) To compare the results between the panel group South Asia and ASEAN countries by considering economic, social, and environmental views. This discussion is to analyze or findings of the results in the basis on previous literature, compare and contrast the findings across South Asia and ASEAN countries.

12.1 To investigate the impact of FDI on environmental degradation in South Asia and ASEAN countries

This study tests how FDI shapes environmental degradation in South Asia and ASEAN, alongside growth, technology, energy use, labor, and tourism. Here estimate four models—baseline FDI effects, population–capital inflows, energy–technology (Model 3), and a STIRPAT specification.

In South Asia’s short run, higher FDI coincides with faster industrialization and a rise in CO₂; Model 3 finds a 1% FDI rise lifts emissions by 0.02%.. STIRPAT also shows a positive but insignificant short-run link, while the error-correction term $COINTEQ01 = -0.165$ ($p = 0.040$) signals adjustment to equilibrium. Long-run STIRPAT coefficients are small and insignificant (ARDL 0.002; FMOLS 0.004), hinting at neutrality overall. Yet in the long-run energy technology Model 3, FDI lowers pollution (-0.046 , $p = 0.000$), pointing to green spillovers over time.

For ASEAN, short-run STIRPAT results show no clear FDI effect on degradation: $D(LNFDINIF) = -0.028$ ($p = 0.356$), likely reflecting technology lags and sector mix. Weak enforcement and fossil-heavy industries can mask immediate gains from cleaner capital.

The error-correction term is strong (-0.473), indicating quick convergence toward the long-run path aftershocks. In the long run, ARDL suggests FDI reduces degradation (-0.01 , $p = 0.06$), echoing a “halo” from imported technologies. FMOLS, however, finds no effect (0.000 , $p = 0.999$), so robustness is mixed. Across models, capital inflows raise pollution (0.224 , $p = 0.003$) while renewables cut it, underscoring the value of clean-energy investment.

Comparing regions, South Asia’s long-run FDI effect is small and insignificant (0.022 , $p = 0.498$), while ASEAN shows a modest benefit (-0.01 , $p = 0.06$). The difference likely reflects stronger regulation, technology uptake, and greener

sectoral allocation in ASEAN.

South Asia could tilt outcomes by channeling FDI into renewables, waste systems, and low-carbon infrastructure with clear incentives. Both regions gain when FDI arrives with technology transfer, environmental safeguards, and credible enforcement.

Otherwise, investment steers toward energy-intensive activities that lock in emissions and resource strain. Overall, policy design, not FDI alone, determines whether capital worsens degradation or advances sustainability.

12.2 To estimate the impact of FDI on economic growth in South Asia and ASEAN countries.

Foreign Direct Investment (FDI) plays a vital role in economic growth by injecting much-needed capital into regions with limited domestic savings, enhancing industrial productivity, introducing new industries, and improving existing ones. It fosters technology and knowledge transfer, bringing advanced management skills and innovation to local firms, thereby increasing overall efficiency. Additionally, FDI develops human capital through skill-building, connects local firms to global markets, and boosts competitiveness, making domestic industries more export-oriented and globally integrated.

ARDL and FMOLS results indicate FDI's effect on South Asia's growth is positive but statistically insignificant—short run: 0.003 ($p=0.801$); long run: 0.278 ($p=0.119$)—implying FDI alone doesn't drive meaningful expansion. Likely reasons include weak institutions, poor regulation, limited technology absorption, inefficient governance, and gaps in human capital and innovation. This echoes Aitken & Harrison (1999), who found modest net productivity gains from FDI, and Duval et al. (2010), who stress skilled labor as a growth engine—an area where South Asia lags. Notably, Li et al. (2019) find renewable energy

contributes more to SAARC growth than FDI. To unlock benefits, the region should strengthen institutional quality, improve governance, and upgrade workforce skills.

ARDL (coefficient = 0.262, $p = 0.000$) and FMOLS (coefficient = 0.260, $p = 0.000$) show FDI strongly and significantly boosts ASEAN's growth, mainly through capital formation, technology spillovers, and industrial expansion, with weaker short-run effects likely reflecting temporary macro conditions. This strength rests on an open investment climate, solid infrastructure, and relatively robust institutions that anchor ASEAN in global value chains and attract long-horizon investors with managerial know-how. Echoing Agosin & Machado (2005), FDI also supports jobs, transfers technology, and crowds in domestic investment. Maintaining openness while deepening institutional quality and regulatory effectiveness will help keep FDI a pillar of long-term performance.

A comparative analysis shows that FDI, technological innovation, and capital formation impact ASEAN and South Asia differently due to their developmental stages. ASEAN benefits significantly from technological progress and FDI, reflecting strong institutions and innovation adoption. In contrast, South Asia's growth is primarily driven by capital formation, with weaker effects from technology and labor. The slower adjustment speeds in both regions also indicate structural rigidities in achieving long-term equilibrium.

12.3 To Investigate the Impact of Capital Formation on Environmental Degradation in South Asia

In South Asia, capital Formation and labor force participation initially worsen environmental degradation. Infrastructure expansion and industrial growth driven by capital formation raise CO₂ emissions, with evidence showing that a 1% increase in capital formation leads to a 15–30% rise in emissions in the long run. Similarly, labor force growth significantly increases pollution in the short

run as demand for energy, transport, and production rises. However, over time, the expanding labor force contributes positively, as economies shift toward cleaner technologies, green jobs, and more efficient resource use. Thus, while both factors drive short-run environmental damage, they can support sustainability in the long run when guided by strong environmental policies.

In ASEAN, capital formation and labor force expansion also create short-term environmental strain by accelerating industrialization, urbanization, and fossil fuel use. Empirical evidence shows that capital formation raises CO₂ emissions in both the short and long run, particularly when focused on energy-intensive sectors. Labor force participation, too, initially increases pollution but tends to reduce environmental harm in the long run as economies adopt greener technologies and sustainable practices. With proper policies, investment in renewable energy, and regional cooperation, both capital formation and labor force growth can shift from being major contributors to pollution toward drivers of sustainable, low-carbon development.

12.4 To compare the results between the panel group South Asia and ASEAN countries by considering economic, social, and environmental views.

Economic Views

In South Asia, growth is tied to FDI, capital, energy use, and labor, but often harms the environment due to reliance on fossil fuels and weak institutions. ASEAN sees stronger FDI and cleaner growth, though capital use can still be inefficient. Both regions must align investments and labor with sustainable, green practices.

Technology and energy use challenge both regions; while they drive growth, they also raise pollution. South Asia must focus more on green innovation, and

ASEAN needs to ensure tech use is eco-friendly. Renewable energy offers hope but requires strong policies, investment, and widespread access to reduce long-term damage.

Social Views

In South Asia, FDI and growth have boosted welfare and services, but inequalities remain, especially outside cities. Labor force expansion helps social mobility but needs better job quality. Green tech, clean energy, and targeted capital can improve services and health if made accessible to all communities.

ASEAN has seen similar social gains from growth and FDI, but uneven benefits persist. Poor job quality and skills gaps limit labor gains, and unmanaged tourism causes local harm. Sustainable tech, housing, and energy access can improve lives—if development remains inclusive and environmentally responsible.

Environmental Views

South Asia's growth increases environmental degradation due to fossil fuels, weak policies, and polluting sectors. ASEAN, by contrast, shows cleaner growth through better regulations and a shift to green industries. Capital formation in South Asia worsens CO₂ emissions, needing redirection to sustainable investments.

ASEAN sees weaker environmental harm from capital, with greater potential for clean infrastructure and renewable energy. Labor in South Asia remains tied to polluting industries, while ASEAN's skilled and female workforce supports greener practices. ASEAN is progressing toward sustainable growth; South Asia must break its growth–pollution link.

13. RECOMMENDATION

South Asia and ASEAN countries are confronted with separate but interlinked concerns of FDI, macroeconomic aspects, and environmental implications. The different economic settings across these countries also make the relationship between FDI and its environmental effects more complex. This is determined by economic organization, regulatory framework, and degree of development in each country. FDI is an important momentum in several Asian and South Asian countries, including industrialization, infrastructure, and economic development, which includes finance, technology, and tourism investment.

13.1 General Recommendations

Improve Environmental Governance and Regulation

Stronger environmental laws and strict enforcement are essential to reduce pollution from industries like manufacturing, power generation, and construction. Governments should set emission limits, enforce waste disposal rules, and require Environmental Impact Assessments for major projects. ASEAN can lead by applying clear environmental criteria for FDI projects and ensuring strict monitoring.

Encourage Green FDI and Sustainable Technologies

FDI should be directed toward renewable energy, energy-saving devices, and eco-friendly industries through tax holidays, grants, and incentives. For South Asia, attracting multinationals that adopt sustainability can spread green technologies locally. ASEAN can expand public-private partnerships to finance large sustainable energy projects.

Special Economic Zones (SEZs)

Create SEZs with tax breaks, simple licensing, and good infrastructure to attract foreign investment. Work with neighboring countries on regional investment agreements and align regulations to make the region more appealing to investors.

Tax Breaks for Green Technologies

Offer tax incentives, subsidies, or grants to foreign and domestic companies investing in renewable energy, clean technologies, and sustainable practices that help lower carbon emissions.

Promote Energy Efficiency and Renewable Energy

Adopt policies that encourage energy-saving technologies in industry, transport, and households. Provide grants or low-interest loans for renewable projects like solar, wind, and hydropower, and support private investment in clean energy.

Expand Labor-Force Participation in Green Sectors

Train workers for jobs in renewable energy, waste management, and green technology. This creates employment, supports sustainable industries, and reduces environmental damage from industrialization. ASEAN should also focus on re-skilling workers for green careers.

Promote Technology Innovation for Sustainability

Invest in R&D for clean technologies and create innovation hubs to support startups. Encourage partnerships between universities, research institutes, and companies to develop and share energy-efficient and waste-reducing technologies. ASEAN can boost technology spillovers through joint ventures between MNCs and local firms.

Sustainable Tourism Practices

Shift to eco-tourism by limiting visitors in sensitive areas, supporting environmentally friendly tourism businesses, and offering incentives for adopting green practices. Encourage hotels, restaurants, and transport services to operate sustainably to protect natural resources.

Economic Development with Social Justice

Reduce inequality by ensuring equal access to green jobs, education, and training, especially in rural areas. Promote inclusive growth so that the benefits of sustainable industries reach disadvantaged communities.

Raise Environmental Awareness and Public Participation

Introduce environmental education in schools and communities to build eco-conscious behavior. Encourage public involvement in environmental governance and local sustainability initiatives.

Diversify the Economic Structure

Reduce dependence on resource-heavy sectors by developing organic agriculture, green technologies, IT, finance, and sustainable tourism. ASEAN should also focus on sustainable agriculture to maintain food security while protecting the environment.

Promote Sustainable Infrastructure Development

Invest in green cities, public transportation, and energy-efficient buildings to address urbanization challenges. Integrating sustainability into city planning can lower carbon emissions and improve resource management.

Strengthen Regional Cooperation (SAARC)

SAARC should set official emission reduction targets and collaborate on green technology transfer, shared infrastructure planning, and environmental knowledge exchange to achieve regional goals.

Carbon Pricing Policy

Adopt carbon taxes or cap-and-trade systems to encourage industries to cut emissions. Promote clean energy sources like solar, wind, and hydropower to support green growth while meeting climate goals.

Cut Down, Repurpose, Mend, and Recycle

Encourage reduced consumption, buying secondhand, repairing usable items, and recycling to lower the carbon footprint of goods and services from production to disposal.

13.2 Empirical Suggestions for South Asia and ASEAN**Control Resource-Intensive FDI in South Asia**

Limit FDI in fossil fuel-based, high-pollution industries like heavy manufacturing and energy generation. Enforce stricter environmental rules to ensure cleaner production. Regional cooperation can help attract greener investments and maximize benefits.

Tax Incentives for Green FDI

Encourage FDI in renewable energy, clean manufacturing, and sustainable infrastructure by offering tax breaks to investors meeting environmental standards. This will help reduce long-term environmental harm.

Long-Term Green FDI Incentives

Provide ongoing tax and financial incentives for FDI in renewables, green technologies, and eco-friendly industries. This ensures foreign investments align with long-term sustainability goals.

Strengthen Technology Transfer

Promote partnerships between foreign investors and local firms to share clean technologies. Joint ventures can boost access to modern environmental solutions and improve energy efficiency.

Focus on Clean Energy FDI

Attract foreign investments in solar, wind, and hydropower through targeted policies. This will bring in expertise, financing, and technology to reduce fossil fuel dependency.

Green and Sustainable Growth

Shift from growth that damages the environment to one driven by green infrastructure and renewable energy. ASEAN and South Asia should keep environmental protection central to development plans.

Encourage Innovation in Green Sectors

Work with multinational companies to develop and spread eco-friendly technologies. Public-private partnerships and smart tech can improve energy use and cut waste.

Stronger Environmental Regulations

Adopt stricter rules for industries with high emissions and resource use. Good governance ensures FDI aligns with sustainability goals.

Green Skills for the Workforce

Invest in training programs for jobs in renewable energy, green manufacturing, and environmental management. Link labor growth with sustainable development to reduce future environmental harm.

Manage Urban Growth Sustainably

Control emissions from informal economies through better waste management, low-carbon transport, and pollution control in industrial areas. Well-planned cities can cut CO₂ significantly.

Promote Sustainable Tourism

Encourage eco-tourism, limit high-impact activities, and set energy-efficiency standards for hotels and transport. Support businesses using green technologies.

Increase Renewable Energy Share

Invest in renewable energy projects with tax benefits and supportive policies. Develop smart grids and storage to speed the shift away from fossil fuels.

Green Technology R&D

Invest in research and innovation for clean energy and eco-friendly manufacturing. Support partnerships and PPPs to make green tech widely available.

Strengthen Human Capital for Sustainability

Promote environmental awareness and eco-friendly lifestyles. Encourage energy saving, recycling, and use of renewable resources.

Public Awareness Campaigns

Run education and awareness programs to inspire sustainable behavior across all sectors of society. Use digital tools to reach wider audiences.

Greener Transportation Systems

Improve public transport and build EV charging networks. Offer incentives for electric vehicle adoption to reduce fossil fuel reliance.

Expand Urban Green Spaces

Prioritize parks, green roofs, and urban forests in city planning. Promote sustainable construction materials and energy-efficient building designs.

14. CONCLUSION

This study addresses the complex relationships between foreign direct investment (FDI), economic growth, environmental quality, technological innovation, energy consumption, and tourism in South Asia and ASEAN using the innovative PMG-ARDL estimation. It analyzes panel data from 1995 to 2023, covering both short- and long-run trends. The study explores correlations, identifies multicollinearity, and uses descriptive statistics to understand data distributions. It then applies various tests like the slope homogeneity test, Pesaran CD Test, CIPS Unit Root Test, and Kao Panel Cointegration test to ensure the validity of the results. The study finds that FDI has a mixed impact, while renewable energy consumption and technological innovation help reduce environmental degradation, with Granger causality used to examine variable relationships for forecasting.

This study underscores the need for policies that balance economic growth with environmental sustainability in South Asia and ASEAN. Governments can attract FDI into green sectors by offering incentives for sustainable practices and fostering partnerships that promote innovation. A shift to renewable energy sources and clean technologies is crucial for reducing CO₂ emissions. The study highlights how FDI can drive growth but also necessitates careful management to ensure alignment with environmental goals.

15. LIMITATIONS OF THE STUDY

This study's limitation lies in its reliance on a small set of macroeconomic variables, mainly the production function, which overlooks other key factors like trade liberalization, labor market structures, and institutional quality. Furthermore, the study's focus on specific country groups limits its scope, excluding major economic blocs such as the N-11, OECD, BRICS, and G20. Future research involving these groups would improve comparative analysis and offer more comprehensive insights for policymakers.

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