IMPACT OF INDUSTRIALIZATION ON ENVIRONMENTAL QUALITY: EVIDENCE FROM PAKISTAN

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ABSTRACT

The industrialization of Pakistan is one of the primary contributors to the country's air, water, and land pollution problems. The Industrial Revolution caused a shift in the manner that everything was made, including food, energy, sanitation, and the technology that were used to manufacture goods. In this research, to investigate relationship between industrialization and environmental quality in Pakistan. The data used in this analysis were collected on a yearly basis from 1980 to 2020 for the country of Pakistan. The application of this analytical approach in Pakistan not only offered a comprehensive overview of the repercussions of IND on the environment, but it also assisted greatly in determining the fundamental reasons of the industrial pollution that is pervasive in this nation. From different studies researcher find the relationship between emissions and FDI. Alterations to these other parameters, however, might be enough to bring about a reduction in pollution. In middle-income nations that are experiencing strong economic expansion, the influence of growth dominates all of these other factors. Growth is slower in wealthy countries, which means that countries' efforts to reduce pollution can counteract the effect of growth. These econometric results are confirmed by evidence that, in reality, efforts are being made to solve pollution problems in developing economies. On the other hand, there is no widespread agreement regarding the factors that cause changes in pollution levels.

Keywords: emission, carbon dioxide, carbon monoxide, methane, industrial growth rate, FDI etc.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Environmental quality is a broad concept that can relate to a variety of aspects, including the purity or contamination of air and water, noise, access to open space, and the visual effects of buildings, as well as the possible effects that such aspects may have on one's physical and mental health. Air pollution, water pollution, noise pollution, climate change, overuse of pesticides, soil erosion, desertification, andflooding are only some of the environmental problems that Pakistan faces.

Other difficulties include noise pollution and climate change. In the most recent edition of the Environmental Performance index (EPI) rating (Hussain et al., 2019), which was published by the Yale Center for Environmental Law & Policy in 2020, Pakistan was placed in position 142 with an EPI score of 33.1. This represents an improvement of 6.1 points over the previous decade. In terms of the quality of the air, it scored a 180.

The most concerning problems that put the lives of millions of people across the country in jeopardy are climate change and global warming. Emissions of carbon dioxide, population growth, and the destruction of forests are the primary contributors to these environmental problems (Khan et al., 2021). As Pakistan's economy develops and its population increases, the country is confronted with some very serious environmental challenges, and these challenges are only becoming worse as time goes on. Although numerous non-governmental organizations (NGOs) and government ministries have launched campaigns to halt environmental deterioration, Pakistan's environmental problems persist due to industrialization (Stern, 2017).

Industrialization refers to the process by which an economy shifts from being predominantly agrarian to being one that is based on the production of goods. This change takes place over a period. This is a procedure that must be carried out over a period. It is usual practice to replace individual manual labor with mechanical mass production, and similarly, it is normal practice to replace craftspeople with assembly lines. In the fiscal year 2021 (Shah et al., 2019), the industrial sector of Pakistan is responsible for 28.11 percent of the country's overall GDP. The manufacturing industries accounts for 12.52 percent of this total, whereas mining

Accounts for 2.18 percent, construction accounts for 2.05 percent, and power and gas account for 1.36 percent. Most of the industries is comprised of textile units, and textiles are responsible for 15.4 billion dollars' worth of exports, which accounts for 56 percent of the industries total exports (Bakhsh et al., 2017). Other divisions include a developing automobile industry as well as a chemical and surgical instrument division.

Yu & Xu (2019), the transition from a pre-industrial to an industrial stage in a human society is referred to as industrialization, and it is a process that involves both social and economic changes. It is a component of a more extensive modernization process, one in which social transformation and economic growth are inextricably linked with technological advancement, with the growth of industrial output on a vast scale in the fields of energy and metallurgy. The major shift in technological, socioeconomic, and cultural norms that occurred in the late 18th century and early 19th century as a direct result of the transition from an economy based on manual labor to one dominated by industries and the manufacture ofmachines. As a direct result of this shift, our economy has become more powerful, butour environment has become more polluted (Pazienza, 2019). There is only one factor that contributes to the quality of the ecosystem, and that factor is industrialization.

The industrialization process has several unintended repercussions and by-products, including excessive consumption and population growth. Furthermore, industrialization and consumerism are to blame for the destruction of the environment, not overpopulation or an increase in the population. The process of industrialization has put a massive amount of strain on the environment. The process of industrialization is closely intertwined with the natural world (Bakhsh et al., 2017). However, whether intentionally or not, industrialization moved forward at a faster pace without regard for the environment to win the race. The toll that industrialization takes on the environment is difficult to put into perspective for most people. Massive quantities of solids, liquids, and gaseous pollutants that are being let out into the air, water, and land are adding new layers of complexity to the linkages between man and environment. These pollutants come in a variety of forms, including gas, liquid, and solid. These contaminants can be found in a few different states, including gas, liquid, and solid. Some of the facts referring to the current state of the environment are extremely illuminating. The amount of polluted water that is currently available to humans is

Close to 70 percent. There is an annual loss of more than 73 million days owing to diseases associated with water (Ali et al., 2020).

Every second, approximately one-fifth of a hectare of land is used up. The life-supporting mechanisms that are naturally embedded in the ecosystem are almost beyond the point of no return because of the strain that is being placed on them. The push for economic development has led to detrimental effects on the environment. Mineral extraction may be quite damaging to the environment since streams and rivers often need to be rerouted so that miners can search for minerals in riverbeds. Fish and other resources are lost, and there is a slow but steady rise in erosion (Akadiri et al., 2019). The generation of energy might result in further types of damage as well. Oil spills damage marine life. In addition to producing energy, powerplants that burn coal and gas also emit pollutants.

The use of nuclear power is associated with a variety of risks. The temperature of rivers in the vicinity of nuclear power facilities is raised. The topic of radiation in general, and how it affects people, has come to the forefront of public consciousness as a direct result of worries about the perils posed by nuclear power. Additionally, radiation can change the organization of genes in human bodies (Akadiri et al., 2019).

According to Shahbaz et al. (2017), one of the challenges that industrialized civilizations must contend with is the depletion of natural resources. We are depleting natural resources at a rate that is not consistent. On the one hand, the developments in science and technology have made human existence more comfortable by providing us with automobiles, electrical appliances, better medications, and better chemicals to control hazardous insects and pests. On the other hand, the improvements in science and technology have contributed to the acceleration of climate change.

On the other hand, they have presented us with a difficult challenge to overcome, and that challenge is pollution. Together with the beginning of the industrial revolution, the ever-increasing levels of pollution have had a profound impact on the natural resources of the world. The consequent deterioration of the environment, as well as the rapid depletion of natural resources, poses a challenge to the long-term viability of economic development (Hussain et al., 2019).

One of the main causes of Pakistan's difficulties with air, water, and land pollution is its industrialization. Worldwide, just 2% of all heart and lung diseases, 7% of lung cancers, and 2% of all chest infections are believed to be caused by outdoor air pollution, according to estimates from the World Health Organization (WHO). The recent changes in the political system are advantageous for the growth of industries, but we also need to be more vigilant against potential hazards.

Even after witnessing one of the most horrific industrial disasters in the history of Baldia Town Karachi in 2015, not much progress has been made in the industrial sector. Approximately 350 people lost their lives in a single day. Even after three years have passed, the consequences still being felt by 800 people. It should come as no surprise that pollution caused by industries has a negative influence, which ultimately leads to a loss of unique genetic resources (Khan et al., 2021).

According to Shafik and Bandyopadhyay (1994), the emission of certaingases, such as methane (abbreviated as CH_4) and carbon dioxide (abbreviated as CO_2), which are together referred to as greenhouse gases, are frequently regarded to be primary contributors to the phenomenon of global warming. These greenhouse gases almost always bring about an increase in the temperature of the atmosphere, which in turn brings about global warming.

Warming of the planet has many negative repercussions, not only for the natural order of things but also for the health of people. It frequently results in the melting of icebergs and mountains covered in snow, which, in turn, leads to an increase in the level of water levels of seas and rivers, which, in the long term, raises the risk of flooding. In other words, global warming is a vicious cycle. Aside from this, global warming also commonly has several other substantial negative consequences on human health, including a rise in the incidence of diseases such as an increase in the incidence of diseases such as an increase in the incidence of diseases such as Lyme illness, malaria, cholera, dengue fever, and famine, amongst others.

As many emerging countries, like Pakistan, are undergoing a time of transition now, there is an urgent need to find a middle ground between the expansion of industries and the preservation of the natural environment in order to lessen the impact of pollution. During this study, an attempt was made to perform an analysis of the negative consequences that industrialization (Shahbaz et al., 2017) has on the contamination of the environment.

In terms of being one of the world's largest booming economies that is well on its way to being at the pinnacle of success, Pakistan has significantly surpassed the expectations that were held for it around the globe. To this day, Pakistan has made a name for itself around the world as the location with the greatest potential for skyrocketing returns on investment (Munir & Ameer, 2020).

Because of this, many national and international organizations have been enticed to take advantage of the boundless potential that the sovereign land has to offer in the name of bringing economic progress and modernization to third world nations. Since the time of British colonial rule, Pakistan has made significant strides toward becoming a powerful, independent, and modern nation, which includes taking steps down the path of economic development. Industrialization in any country is the direct cause of ontogeny in that country (Johansen, 1988).

During the time before colonial rule, Pakistan had the potential to become a center for its indigenous industries. The industrial rebellion in Punjab was largely responsible for the collapse of the homegrown, small-scale, and production-based industries that were catering to local needs. The process of industrialization not only has positive impacts, but it also has some consequences that are negative. The industrialized world's positive social and financial gains have been accompanied with severe damage to the natural environment (Stern, 2017).

The parasitic quality of the environment and the inhabitants of the environment, which posed an unavoidable long-term threat to life span, environmental condition, flora, and fauna pertaining to the industrialized belt, went undetected as Pakistan became more skilled in the modernization of its industries in various parts of the country, such as farming, manufacturing, iron ore, coal, timber, bottling plants, automobile, gas and chemical production. This threat was a result of Pakistan According to Munir and Ameer (2020), the rapid expansion of a phenomenon known as "Noble industrialization" is linked to several unfavorable results. These include the destruction of the ecological system, the increased extinction of unique animal species, the rapid loss of natural resources, and the deforestation of land.

According to Chang et al. (2018), the expansion of the economy is driven, in large part, by rapid industrialization, which, in turn, catalysis the irreversible contamination of the environment. In addition, rapid industrialization is one of the primary contributors to climate change. As a direct consequence of this, our very lives are at danger. Given that the environment has a limited capacity for both replenishment and carrying, random and unplanned actions are discouraged.

Industrialization has resulted in the destructive and unsustainable plundering of eco-systems in a sinusoidal pattern. This is because certain locations are more susceptible than others to the repercussions of poor environmental quality. Human life is not immune to such harmful changes, which reverberate over time and result in a decreased life span, premature death, and poorer health conditions in developing nations like Pakistan due to the poisoning of air and water pollution. Developing countries like Pakistan are also more likely to be affected by these changes.

The vivid and favorable climate conditions that exist in Pakistan are a great compliment to the diverse spectrum of industrialization that exists in that country. Erroneous industrial facilities are thriving across several belts in Pakistan (Hussain et al., 2019), primarily because of the ease with which land is available and the lack of awareness amongst local populations as a direct result of environmental rules that are either lax or nonexistent in the region. This is because environmental rules are either lax or nonexistent in the region.

Because of the rapidly expanding number of industries in a variety of Pakistani belts, the country's environment and the living things that call those areas home is facing an increasing number of dangers that are more complicated andmultifaceted. This complex issue calls for one-of-a-kind and individualized solutions to stop the continued depletion of natural resources, the ecological system,and most importantly, human life (Stern, 2017).

1.2 Problem Statement

The advent of industrialization greatly aided economic prosperity, but it also resulted in an increase in population, the growth of urban areas, and a definite strain on the fundamental systems that sustain life, all the while bringing environmental impacts closer to the threshold limits of tolerance. Environmental sustainability is currently playing a crucial determining role in the process of industrial development, claim Hussain et al. (2019) and Ali et al. (2020). This is due to the rise in industrial growth and the fact that there is not a lot of land mass.

The mounting evidence indicates that the problem of protecting the region's natural resources while also advancing the regional economy on an environmentally responsible basis can be successfully solved by transforming existing industries into an eco-industrial network through the effective implementation of environmentally friendly strategies.

The world around us is impacted by everything we do; from the food we consume to the electricity we use from the grid. The industrial Revolution caused a shift in the manner that everything was made, including food, energy, sanitation, and the technology that were used to manufacture goods. In this research, the researchertries to find the Impact of Industrialization on Environmental Quality in Pakistan.

1.3 Objective of the Study

The following are the objectives of this research:

- To investigate the impact of industrialization on Carbon dioxide of Pakistan.
- To examine the influence of industrialization on Carbon monoxide emission in Pakistan.
- To assess the relationship between industrialization and Methane levels in Pakistan.

1.4 Research Question

Research questions designed on the basis of objectives:

1. What is the impact of industrialization on Carbon dioxide in Pakistan?
2. What is the impact of industrialization on Carbon monoxide in Pakistan?
3. What is the impact of industrialization on Methane in Pakistan?

1.5 Significance of the Study

The significance of this study is anchored in its contribution to understanding the specific impacts of industrialization on Pakistan's environmental quality, a subject that has critical implications for sustainable development policy and practice. Unlike existing literature that predominantly explores the qualitative aspects of industrialization's environmental impact, this research adopts a quantitative approach to dissect the intricate relationship between industrial activities and environmental degradation, with a focus on CO_2, CO, and CH_4 emissions. CO_2

emission per capita in Pakistan is 0.83 ton per person so this approach aligns with the call for more empirical research in this area, as noted by Khan et al. (2021).

A key contribution of this study is its exploration of the potential for industrial restructuring towards a low carbon economy in Pakistan, an area that has received limited attention in existing academic discourse. By quantitatively assessing the impact of industrial activities on environmental quality, this research provides concrete data that can inform more effective policy and strategic decisions for sustainable industrial development.

Moreover, the study extends its significance by situating the environmental challenges faced by Pakistan in the context of global climate change phenomena, such as the melting of polar ice caps and increasing heatwaves. This global-local nexus offers a unique perspective on how localized industrial activities can have far-reaching environmental consequences.

Additionally, the research contributes to a deeper understanding of the balance between industrial development and biodiversity conservation in Pakistan. It addresses the need for sustainable practices that protect natural ecosystems and wildlife, recognizing their value to the economy and local communities, as emphasized by Pal and Tok (2019).

In essence, this study is significant not only for its contribution to the academic understanding of the environmental impacts of industrialization in Pakistan but also for its potential to influence policy-making and industrial practices. It offers insights that are crucial for guiding Pakistan, and potentially other similar contexts, towards environmentally sustainable industrialization paths.

The rationale behind focusing on carbon dioxide, carbon monoxide, and methane stems from their significance as major greenhouse gases with distinct implications for climate change and environmental degradation. These gases are key byproducts of industrial processes, and studying their impact allows for a comprehensive understanding of the environmental consequences of industrialization. Carbon dioxide is a primary contributor to global warming, while carbon monoxide and methane play crucial roles in air quality and have potent greenhouse effects. By examining these three gases, the research aims to provide insights into the multifaceted environmental consequences of industrial activities and contribute to informed policy decisions for sustainable industrial development and emissions reduction.

Studying the relationship between individual greenhouse gases and control variables is a common approach in environmental and climate research (Moemen 2017).

However, the present study has examined the impact of industrialization on three major contributors of GHG emissions (like carbon dioxide, carbon mono oxide and methane) using the latest data set available for Pakistan.

CHAPTER 2
REVIEW OF LITERATURE

2.1 Theoretical background

Grossman and Krueger (1991) conducted an empirical examination of the relationship between income per capita and environmental quality, leading to the discovery of an inverted U-shaped pattern, often referred to as the Environmental Kuznets Curve (EKC). Many other researchers, such as Shafik and Bandyopadhyay (1992), Cropper and Griffith (1994), Selden and Song (1994), Holtz-Eakin and Selden (1995), Kaufmann, Davidsdottir, Garnham, and Pauly (1998), Suri and Chapman (1998), Agras and Chapman (1999), Dinda et al. (2000), Harbaugh et al. (2002), and Begun and Eicher (2007), have attempted to test the EKC hypothesis.

However, the results concerning the shape of the relationship between income and environmental quality vary across these studies. Furthermore, when evidence of an EKC is identified, the turning points of the curve differ significantly among studies. This variation can be attributed to the absence of a single universally accepted indicator for environmental degradation. In the field of economics, various environmental indicators have been employed, which can be categorized into air quality indicators, water quality indicators, and other indicators reflecting environmental deterioration.

Pakistan has experienced periods of rapid industrialization, especially during the mid-20th century and more recently in the early 21st century. The country has a diverse industrial base, including sectors like textiles, chemicals, cement, and manufacturing. The industrial sector has played a significant role in the country's economic development. (Klaus , 2015)

In the academic literature, a conventional distinction is made between local air pollutants and global air pollutants. When it comes to local air quality pollutants, such as sulfur dioxide, nitrous oxides, and carbon monoxide, numerous studies, including those by Selden and Song (1994), Holtz-Eakin and Selden (1995), Grossman (1995), Cole, Rayner, and Bates (1997), and Panayotou (1997), tend to observe an inverted U-shaped relationship between income and environmental quality. However, it's worth noting that these studies often report significantly different turning points for these indicators.

In contrast, for global pollutants that have minimal direct impact on the local population, empirical findings frequently do not support the existence of an Environmental Kuznets Curve. Specifically, when examining global air pollutant carbon dioxide, the consensus generally indicates a continuous increase with income.

The empirical results regarding an EKC for water quality indicators are even more varied. Furthermore, the turning points on the Environmental Kuznets Curve tend to be higher for

water quality indicators compared to air quality indicators.
For certain indicators like chemical oxygen demand and biochemical oxygen demand, prior studies confirm the presence of an EKC, but the results concerning its shape and peak vary widely. Some findings from studies by Shafik (1992), Grossman and Krueger (1993), and Grossman (1995) suggest that for these water pollution indicators, pollution initially rises as income grows, then decreases, and subsequently increases again, resulting in what is known as an N-shaped curve.
In addition to air quality and water quality indicators, the literature has explored various other indicators to examine the relationship between income and environmental quality. These alternative indicators encompass factors such as deforestation, access to urban sanitation and clean water, and municipal solid waste management. In general, for most of these indicators, empirical findings tend to reveal limited or no support for the Environmental Kuznets Curve (EKC) hypothesis.
For instance, research by Shafik (1994) and Cole et al. (1997) suggests that in the case of pollutants with direct impacts on the population, environmental quality tends to improve alongside economic growth. Conversely, for environmental pollutants that can be externalized or do not have direct impacts, the curve does not exhibit a decline at higher income levels. Regarding deforestation, while Panayotou (1993) identifies evidence of an EKC with a turning point at a lower income level, Shafik (1994) concludes that per capita income does not significantly influence the rate of deforestation.
the empirical results concerning the EKC hypothesis display a considerable degree of variability. The environmental quality indicators that tend to align with an EKC pattern are primarily related to air quality. Generally, studies in the literature tend to support the EKC hypothesis for environmental pollutants that directly affect the population. Interestingly, whenever an EKC is observed empirically, the income levels at which the turning points occur differ across studies.

2.2 Environmental Impact of Industrialization and Industrial Growth

The development of a nation is often linked to its industrial progress. Like many countries, Pakistan's strength and progress are significantly influenced by its industrial capabilities. While agriculture remains vital, providing the essentials of life, it alone cannot propel a nation forward. In fact, even the advancement of agriculture in Pakistan increasingly relies on industrialization. Modern farming tools, crucial for increasing agricultural efficiency, are products of industrial advancements.
Industries contribute substantially to Pakistan's national income. They produce a wide range

of goods including medicines, processed foods, and clothing, which are integral to daily life. Given Pakistan's large population, the role of industries becomes even more crucial in maintaining a balance between demand and supply at reasonable prices.

Furthermore, Pakistani industries are not only catering to the domestic market but are also making strides in the global market. The export of high-quality goods is a testament to the country's industrial capabilities and is crucial for its economic stability and growth. This global presence is essential for Pakistan to be recognized and respected on the world stage for its manufacturing prowess.

However, with industrial progress comes the challenge of environmental pollution. The industrial sector in Pakistan, as in many countries, has been a significant source of environmental degradation and health hazards. Addressing this issue is vital for sustainable development. Integrating environmentally friendly technologies and practices, stricter pollution control measures, and a shift towards cleaner energy sources are imperative steps for Pakistan.

In essence, while industrialization is a key driver of Pakistan's progress, balancing it with environmental sustainability and health considerations is essential for the long-term welfare and growth of the nation. The path forward for Pakistan involves not just expanding its industrial base but doing so in a way that is ecologically responsible and sustainable.

According to the Environment (Protection) Act, 1986, the environment encompasses all the physical and biological surroundings of an organism, including their interactions. In this context, the environment is defined as the aggregate of water, air, and land, and the relationships among these elements with human beings, other living organisms, and materials. When considering Pakistan, this definition holds significant relevance. Pakistan's diverse environment can be understood in terms of three primary components:

- **Abiotic or Non-living Component:**

This includes the non-living elements of Pakistan's environment.

It is further subdivided into:

a) Lithosphere or Solid Earth: This refers to Pakistan's landmass, including its mountains, plains, and plateau regions, which form a critical part of its geography and impact its climate, agriculture, and natural resources.

b) Hydrosphere or Water Component: Encompassing Pakistan's rivers, lakes, and coastal areas, the hydrosphere is vital for the country's agriculture, particularly considering the significance of the Indus River and its tributaries.

c) Atmosphere or Gaseous Envelope: This covers the layers of gases surrounding Pakistan. The country's atmosphere plays a crucial role in its climate patterns, including monsoons, which significantly impact agriculture and water resources.

- **Biotic or Living Component:**

This component comprises the living organisms within Pakistan's environment.
Pakistan's rich biodiversity includes a wide range of flora and fauna, from the marine life along its southern coastline to the alpine ecosystems in the north.

- **Energy Component:**

This refers to the flow and transformation of energy within Pakistan's environment.
Energy in Pakistan's context includes solar energy, which is abundant and crucial for the country's climate and agriculture, and the energy produced and consumed in various economic activities, significantly impacting environmental health.

Understanding these components in the context of Pakistan highlights the complex interplay of natural elements within the country's unique environmental landscape. It also underscores the importance of balancing environmental protection with sustainable development to ensure the health and well-being of its ecosystems and its people.
The environment encompasses both abiotic (non-living) and biotic (living) components. Abiotic elements include soil, water, air, climate factors, while biotic factors involve flora, fauna, and humans. Energy, in various forms like solar, thermal, and others, sustains life. Complex cycles operate within these components, maintaining equilibrium crucial for nature's balance. Human activities disrupt this balance, causing environmental pollution (Naik, 2005).
The environment comprises four spheres: Lithosphere (earth's outer layer), Hydrosphere (where water exists), Biosphere (supporting life), and Atmosphere (mixture of gases above the surface). Each sphere plays a distinct role in Earth's systems (Langford, 2013).
Environmental factors, including topographic/physiographic elements (altitude, landforms, and water bodies), climate factors (light, temperature, and humidity), soil characteristics, and biotic interactions among life forms, significantly impact the environment (Naik, 2005).
Environmental pollution denotes any adverse changes in the physical, chemical, or biological aspects of air, water, or soil, causing harm to various life forms or property (Velan, 2011). Pollutants, stemming from human activities, disrupt natural environmental compositions, resulting in primary and secondary pollutants, noise, and electromagnetic waves, posing challenges due to nature's struggle to decompose them effectively.

The surge in population has heightened concerns regarding a balanced environment, particularly in densely populated areas grappling with sewage and industrial waste disposal, leading to pollution in air, water, and soil (Kaushik & Kaushik, 2010). Various pollution types—air, land, sound, dust, radiation, thermal, and light pollution—exemplify the range of environmental challenges (Bheem, 2012).

Environmental pollution, as defined by Kaushik & Kaushik (2010), refers to undesirable changes in the physical, chemical, or biological aspects of air, water, and soil, which can negatively affect life and property. This pollution, a major downside of industrialization, contaminates our environment - air is polluted with gases and particulates from industrial and vehicular emissions, contributing to problems like global warming and acid rain. Water bodies, especially near industrial areas, are heavily polluted, impacting both surface and groundwater. Soil contamination with heavy metals and pesticides is also a grave concern, affecting both land fertility and human health.

As per the World Health Organization (1948), health is not just the absence of disease but a state of complete physical, mental, and social well-being. Bhatia (2009) expands on this, suggesting health as a holistic concept, encompassing more than just the absence of diagnosable diseases. Public health, therefore, involves various aspects like water and air quality, sanitation, and disease prevention. Public health engineering applies multidisciplinary knowledge for environmental sanitation and disease control. Ensuring water supply is free from impurities, meeting standards set by organizations like BIS, WHO, or ICMR, is vital. This includes processes like filtration, coagulation, and disinfection to remove both physical impurities and disease-causing microbes.

Pakistan, amidst its strides towards becoming a formidable economy, faces a pressing concern: the environmental repercussions of rapid industrial expansion. As the nation positions itself as a global economic hub, the burgeoning industrial sector significantly contributes to environmental degradation, impacting air, water, and land quality.

The World Health Organization (WHO) estimates that industrial operations contribute substantially to pollution in Pakistan, with outdoor air pollution alone responsible for approximately 2 percent of heart and lung diseases, 5 percent of lung malignancies, and about 1 percent of chest infections worldwide.

The recent shifts in Pakistan's political landscape have signaled a favorable climate for industrial growth. However, it is crucial to exercise vigilance regarding the potential risks posed by such expansion. Despite witnessing catastrophic events like the Bhopal disaster in 1984, where around 8,000 lives were lost, progress in mitigating industrial hazards remains limited, impacting thousands even decades later.

The adverse effects of industrial pollution not only pose immediate health risks but also contribute to the erosion of unique genetic resources. As Pakistan, among other emerging nations, undergoes a pivotal phase, finding a delicate balance between industrial expansion and environmental preservation becomes paramount to mitigate the deleterious impact of pollution. Within the context of this study, efforts have been made to scrutinize the adverse effects of industrialization on the environment (Abdouli, 2017).

Pakistan's trajectory as an economic powerhouse has attracted significant attention from both national and international entities keen on leveraging its potential for fostering economic progress and modernization in developing nations. From the days of British colonial rule to its current status, Pakistan has taken significant strides towards independence and modernity, aligning itself on a trajectory of economic growth and development.

The process of ontogeny is a direct consequence of industrialization in any nation. During the time before colonial rule, Pakistan had the potential to become a center for its indigenous industries. The industrial revolution in England was the impetus for the decline of home-grown businesses that were on a smaller scale and produced goods in response to customer need.

This resulted in the fiction developing into an effort that took two forms: factory trade and plantations in modern Pakistan (Hussain et al., 2019). The process ofindustrialization not only has positive impacts, but it also has some consequences that are negative. The developed world has brought about some positive economic and community outcomes; yet this progress has been accompanied by severe ecological deterioration.

What exactly was unnoticed was the dependent quality of the environment as well as the inhabitants of the environment, which posed an inevitable long-term threat to life span, environmental condition, and native flora and fauna that are native to the industrialized belt of Pakistan. As Pakistan became increasingly adept at modernizing its industries in a variety of fields, such as agriculture, manufacturing, iron ore, coal, timber, bottling plants, automobiles, petrol, and chemicals.

According to Eskeland and Harrison (2003), the rapid expansion of a phenomenon known as "Noble industrialization" is linked to a number of unfavorable outcomes. These include the destruction of the bio system, the increased extinction of rare animal species, the rapid loss of natural resources, and the deforestation of land.

Rapid industrialization is a primary factor in the expansion of the economy. This trend, on the other hand, is a primary factor in the acceleration of the environment's irreversible contamination. As a direct consequence of this, our very lives are at danger. As a result of unplanned and impromptu industrialization, eco-systems have been subjected to damaging sinusoidal looting, which is caused by the fact that the environment has a finite capacity for both replenishment and carrying.

This is due to the fact that certain locations are more susceptible than others to the repercussions of poor environmental quality. The life of humans is not immune to such detrimental effects, which over time cause a shorter life expectancy, premature death, and worsening health problems in underdeveloped countries like Pakistan due to the harmful effects of the water and air (Ozturk and Mulali, 2015). This is due to the fact that pollution causes air and water pollution.

The diversified spectrum of industrialization in Pakistan is complementedbeautifully by the vibrant and favorable climate conditions that exist there. Erroneous industrial facilities are thriving across the several belts in Pakistan, mostly because of the ease with which land is available and the lack of awareness amongst local populations as a direct result of environmental rules that are either lax or non- existent in the region.

Because of the rapidly expanding number of industries in a variety of Pakistani belts, the country's environment and the living things that call those areas home are facing an increasing number of dangers that are more complicated and multifaceted. This complex issue calls for one-of-a-kind and individualized solutions in order to stop the continued depletion of natural resources, the ecological system,and most importantly, human life (Pal and Tok, 2019).

Because Pakistan is so well-known for the wealth of wildlife that can be foundthere, the majority of pictures that are depicted of the country feature its natural landscapes, such as its towering mountains, verdant forests, and bright meadows that are teaming with animals. However, there are a lot of people who don't seem to understand or respect the fact that the wilderness is not limitless. It will not regenerateon its own at the drop of a hat, and neither will the wildlife of Pakistan if we do nothing to stop them from being wiped out by human activity. Because of direct human participation, a great number of animal and plant species became endangered, and some of them even went extinct.

The longer-term reality of wildlife contributes positively to our economy, anda significant number of locals hold a reverent attitude toward it. As members of the biotic community, plants and animals have the same right as we have to coexist, and we should make every effort to protect that right. We do not have the authority todeny them that right. If everything in the planet were to be manufactured by humans,it would be an "urban forest," and that kind of environment is impossible to imagine (Managi et al., 2009).

If we have a propensity to be ignorant toward the earth's diminishing natural resources, then neither the world nor any of us will be able to exist in this environment. Not only the wildlife, but all forms of life, would perish if this scenario played out. The question now is, what can we do to help clean the air as our emissionscontinue to rise? What are some things that may be done to make a town cooler during the hot summer months when the sun is directly overhead?

Before it enters the underground reservoirs of freshwater, what will clean the water and make it safe to drink? What will we eat when everything has become too filthy as a result of the chemicals that we so carelessly dump into our soil and that justpile over time? There is no denying the important role that nature plays in ensuring the survival of life on Earth. They play an essential role in a wide variety of ecological and biological processes that are fundamental to the existence of humans.

Pollution of the air, water, and land are the primary contributors to the phenomenon of global warming. To begin, hazardous greenhouse gases are released into the atmosphere, which then leads to the formation of air pollution. Then, urbanization is the process by which cities expand or societies develop into more urban societies. It is also the process by which a sizable population from a rural location moves to a city for the goal of finding work or obtaining an education.

For instance, appliances such as refrigerators, microwaves, air conditioners, and other similar devices emit additional greenhouse gases and chemicals, which contribute to the phenomenon of global warming. Additionally, more people aremoving to urban areas, which will compel individuals to cut down trees in order to construct some sort of housing or shelter for themselves (Shahbaz et al., 2017).

All of the aforementioned scenarios, as well as their rationales, are extremely well known, and they correspond to the bad impacts of rapid industrialization that are rising. Even if there are numerous examples from all around the world, we still have not been able to become cognizant of the impending threat to the existence of planet earth in the future so that we can protect it.

The crucial question is whether or not we will maintain our level of ignorance regarding the continuously deteriorating state of the environment. What are the most significant adverse impacts that it has on us, our children, and the wildlife? What we require is a civilised society that is properly informed, rules that are carefully governed, and above all else, severe punishments for those who violate such laws. All of this is being done in the interest of a better tomorrow, a longer life span, and a brighter future for Pakistan and the globe (Akadiri et al., 2019).

Air pollution, water pollution, noise pollution, climate change, overuse of pesticides, soil erosion, desertification, and flooding are only some of the environmental problems that Pakistan faces. Other difficulties include noise pollution and climate change. In the most recent edition of the Environmental Performance index (EPI) rating, which was published by the Yale Center for Environmental Law &Policy in 2020, Pakistan was placed in position 142 with an EPI score of 33.1. This represents an improvement of 6.1 points over the previous decade. In terms of the quality of the air, it ranks 180. (Khan et al., 2021).

The most concerning problems that put the lives of millions of people across the country in jeopardy are climate change and global warming. Emissions of carbon dioxide, population growth, and the destruction of forests are the primary contributors to these environmental problems. As Pakistan's economy develops and its population increases, the country is confronted with some very serious environmental challenges, and these challenges are only becoming worse as time goes on. Pakistan is still dealing with environmental problems, despite the fact that a number of non- governmental organizations and government ministries have launched campaigns to halt environmental destruction (Shah et al., 2019).

Agriculture and fishing are two key economic sectors of Pakistan that are heavily reliant on its natural resources. These two sectors together provide more than one-fourth of Pakistan's total output and support more than two-fifths of all jobs in the nation.

As a result, there is a great demand placed on natural resources that are already in short supply in order to maintain current levels of economic growth. On theother hand, it is very ironic that the same thing that the country depends on for its expansion is also the thing that endangers the country's future prosperity and success. Nearly 70% of Pakistan's population, according to the World Bank, lives in rural areas, which are marked by extraordinarily high rates of poverty (Liu et al., 2018).

These individuals generate their money from natural resources, which they frequently exhaust to the point of exhaustion. Because of this, the environment will continue to deteriorate, which will ultimately result in more people living in poverty. The World Bank describes the result of this as a "vicious downward spiral of deprivation and environmental deterioration." This spiral has been caused as a direct result of the previous point.

The World Bank claims that, Pakistan is a nation that is experiencing water scarcity. There are 7 major rivers that flow into Pakistan from the states that are located further upstream, including the Kabul River, which originates in Afghanistan and flows into Pakistan, as well as the industrializations River, Jhelum River, Chenab River, Ravi River, and Sutlej River, all of which originate in industrialization.

The industrializations Waters Treaty, which was signed in 1960 by industrialization and

Pakistan, grants industrialization the right to have consumptive use of the water that comes from the rivers Ravi and Sutlej, both of which are divertedin upstream Pakistani Territory. While the agricultural plains in Punjab and Sindh receive their water supply from canal networks that originate from the main stem of the Industrializations River, the Jhelum River, and the Chenab River, the remainder of the country has very little access to other sources of fresh water.

The possibility of water shortages not only endangers Pakistan's economy but also places millions of Pakistanis' lives in grave danger. This is a double whammy for the country (Zhang and Zhou, 2016). Because of the industrializations Waters Treaty and the diversion of water to canals, the amount of dilute flow that is available in Pakistan's rivers has decreased.

On the other hand, the amount of water that is contaminated is increasing, which can mostly be attributed to the growth of both the economy and the population, in addition to the nearly nonexistent presence of water treatment facilities. The primary contributors to water pollution include the improper use of chemical fertilizers and pesticides, factory waste discharge into rivers and lakes, untreated wastewater disposal into rivers and the ocean, and the use of contaminated pipelines for water transportation.

In Pakistan, the rapid pace of industrialization has brought with it significant environmental challenges, notably in the realms of water and air pollution. These issues have far-reaching consequences, affecting not only the environment but also public health and economic stability.

Water pollution, exacerbated by industrial development, has led to widespread contamination of water sources, critically limiting access to clean water and contributing to the prevalence of waterborne diseases. This situation has severe implications for public health, as evidenced by Hussain et al. (2019), who report that nearly half of infant deaths in Pakistan are due to diarrheal diseases, often linked to polluted water. Moreover, 60% of infant mortality in the country is attributed to waterborne illnesses, underscoring the grave impact of contaminated water on the nation's youngest and most vulnerable citizens.

Air pollution, particularly in urban centers like Karachi, compounds these environmental challenges. The World Bank has identified Karachi's air quality as among the worst globally, with serious consequences for both human health and the economy. Key factors contributing to this critical situation include inefficient energy consumption, a surge in vehicles with high emissions, and the burning of waste, including plastic. This assessment is supported by findings from the Sindh Environment Protection Department, which reveal that pollution levels in major cities are significantly higher than the national average, confirming the observations made by Ali et al. (2020).

The escalating air pollution in Pakistan is closely linked to industrialization, with significant adverse effects on public health and the environment. Industrial activities are a major source of air pollution, contributing to respiratory disorders, reduced visibility, loss of vegetation, and adverse effects on plant growth. The deterioration of air quality in urban areas is largely attributed to inadequate treatment of air emissions and a lack of regulatory oversight over industrial operations. This situation is particularly acute regarding the quality of air in the vicinity of industrial zones.

In addition to industrial emissions, the practice of burning substantial amounts of solid waste, including plastics and rubber, in urban areas exacerbates the air pollution problem. This common practice among the public releases harmful gases into the atmosphere, posing severe health risks to local residents.

In response to the growing air quality crisis, initiatives like the Pakistan Air Quality Initiative, founded by Abid Omar in 2018, aim to monitor and raise awareness about air pollution in major Pakistani cities. As Bakhsh et al. (2017) noted, this project seeks to educate Pakistani citizens about the health impacts of air pollution and improve the availability of air quality data in the country. The establishment of high-standard monitoring stations by the United States Department of State in Pakistan is part of these efforts.

These initiatives have highlighted the detrimental health effects of air pollution, with studies confirming that the variability in particulate matter concentration poses a significant health hazard. Pakistani citizens are routinely exposed to unhealthy levels of air pollution, with industrialization being a key contributing factor. This link underscores the need for effective regulatory measures and industrial reforms to mitigate air pollution and protect public health in Pakistan.

To address these challenges, effective management strategies are crucial. Pazienza (2019) suggests several approaches, such as improving urban road design and transportation sustainability, enhancing government policies on pollution elimination, and transitioning to cleaner fuel alternatives like Compressed Natural Gas (CNG). These measures, while beneficial, need to be implemented in tandem with stricter regulations on industrial emissions and the promotion of cleaner industrial technologies.

The impact of industrialization on Pakistan's environment extends to its contribution to climate change, which exacerbates the country's already unstable climate. Over recent decades, industrial activities have contributed to increasing greenhouse gas emissions, leading to greater climate variability. This is evident in the melting of the Himalayan glaciers, which significantly affects several of Pakistan's major rivers, and in the heightened occurrence of heatwaves, droughts, and other extreme weather events across the country.

Therefore, the link between industrialization and environmental degradation in Pakistan is clear. While industrial growth has been crucial for the country's economic development, it has also brought about significant environmental challenges that need urgent attention and action. Strategies to combat these issues must consider both direct industrial impacts and the broader consequences of industrialization, such as climate change and its effects on natural resources and public health.

The findings of Akadiri et al. (2019) place Pakistan among the countries significantly impacted by the extreme weather conditions associated with climate change, with its ranking based on the changes in the nation's average temperature between 1999 and 2018. This highlights the vulnerability of Pakistan to global climatic shifts, a concern that ties back to the country's ongoing industrialization and its environmental repercussions.

Despite the challenges posed by climate change, Pakistan has both the technical and financial capabilities to address or mitigate its impacts. However, the prioritization of these capabilities toward addressing urgent issues such as food and water security remains a crucial need. The threat posed by climate change to these fundamental resources cannot be underestimated, despite the country's current focus on other concerns.

In the agricultural sector, which is a significant contributor to Pakistan's GDP, there has been resilience against the impacts of climate change. This resilience can be attributed to Pakistan’s unique climatic conditions and agricultural advantages. The country benefits from having four distinct growing seasons and arable land, providing a comparative advantage over many other nations. Pakistani scientists are actively engaged in projects aimed at enhancing the nation's agricultural productivity and food security, acknowledging the importance of this sector in the face of environmental changes.

Therefore, while industrialization in Pakistan has contributed to environmental challenges and heightened its vulnerability to climate change, the country's natural resources and capabilities present an opportunity. By strategically leveraging these assets and focusing on sustainable industrial practices, Pakistan can address the environmental issues it faces while maintaining its economic growth and ensuring the security of vital resources like food and water.

Pakistan's susceptibility to the impacts of climate change extends beyond the decline in major crop yields, as indicated by Shah et al. (2019). While the anticipated changes in water consumption per capita may not be significant, the country faces broader environmental and natural disaster challenges that are intertwined with the effects of climate change and its diverse geography.

Pakistan's varied landscape makes it vulnerable to a wide range of natural disasters, including earthquakes, floods, tsunamis, droughts, cyclones, and hurricanes. This vulnerability is compounded by the country's geological complexity. Regions like Gilgit-Baltistan (GB), Baluchistan, and Azad Jammu and Kashmir (AJK) are particularly prone to seismic activities, increasing the risk of devastating earthquakes. Meanwhile, the low-lying areas of Sindh and Punjab frequently experience flooding, posing persistent challenges to these provinces.

Historically, Pakistan has faced several catastrophic natural disasters. Notable events include the 1974 Hunza earthquake, the 2005 Kashmir earthquake that claimed over 73,000 lives and affected millions, and the 2010 floods impacting 20 million people. Earlier disasters, such as the 1935 Quetta earthquake and the 1950 floods, also had profound impacts, causing thousands of deaths and displacing large numbers of people.

These historical events, as outlined by Ozturk and Mulali (2015), underscore Pakistan's vulnerability to natural disasters, a situation likely to be exacerbated by climate change. The predicted increase in extreme weather events, such as hotter days and nights, and potential shifts in rainfall patterns, could further intensify these challenges. Therefore, Pakistan's approach to addressing the impacts of climate change and industrialization must also encompass strategies for disaster preparedness and mitigation to safeguard its population and economy. Pakistan's susceptibility to the impacts of climate change extends beyond the decline in major crop yields, as indicated by Shah et al. (2019). While the anticipated changes in water consumption per capita may not be significant, the country faces broader environmental and natural disaster challenges that are intertwined with the effects of climate change and its diverse geography.

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The Pakistani government's efforts to address environmental challenges have evolved since the early 1990s, marked by the establishment of new legislative frameworks and organizations such as the Pakistan Environment Protection Council. Despite the government's recognition of environmental threats to the nation's social and economic development, challenges remain, particularly in terms of funding and enforcement.

A significant portion of the environmental protection budget in Pakistan relies on international lenders, with the government allocating a minimal fraction (0.04%) of its development budget to this cause. This financial constraint limits the government's ability to enforce environmental regulations effectively. Additionally, private businesses often struggle to comply with international environmental standards due to limited funding.

In response to these challenges, the Pakistani government initiated the Clean and Green Pakistan programme in 2019, as noted by Ali et al. (2020). This initiative aims to foster environmental consciousness and action among the populace. It includes a competitive element among Pakistani cities to promote cleanliness and greening efforts. The program leverages a web-based platform that allows citizens to register and track their environmentally friendly activities, earning points and potentially receiving medals for their contributions.

Parallel to these efforts, the government of Khyber Pakhtunkhwa (KPK) launched the ambitious Billion Tree Tsunami programme in 2014 to combat climate change. This initiative has been successful in replanting and restoring 350,000 hectares of land and forests, exceeding Pakistan's commitment to the Bonn Challenge. These governmental initiatives reflect a growing acknowledgment of the need for proactive and participatory approaches to environmental conservation and climate change mitigation in Pakistan.

The efforts to combat environmental degradation in Pakistan, including the Billion Tree Tsunami programme and the strategies outlined in the Conservation Strategy Report, are intrinsically linked to the country's industrialization. As Pakistan has industrialized, the increased demand for agricultural production and the expansion of urban areas have contributed to environmental challenges, such as deforestation, pollution from agricultural activities, and soil erosion.

Industrialization often leads to intensified agricultural practices to meet the growing food and raw material needs. This intensification can result in increased use of fertilizers and pesticides, contributing to water pollution through runoff and seepage, as described by Bakhsh et al. (2017). Additionally, the expansion of urban and industrial areas encroaches on forest lands and natural habitats, necessitating initiatives like the Billion Tree Tsunami to counteract the loss of green cover.

The Conservation Strategy Report's emphasis on sustainable development and efficient resource management is particularly relevant in the context of industrialization. It calls for a balanced approach that supports economic growth while preserving natural resources. This includes addressing pollution from both industrial and agricultural sources and promoting practices that are environmentally sustainable.

The environmental challenges Pakistan faces, particularly from agricultural activities exacerbated by industrialization, have significant implications for water quality and ecosystem health. The erosion caused by intensive agricultural practices and inadequate grazing not only leads to sediment deposition in water bodies, harming fish habitats and wetlands, but also carries excess agricultural chemicals. This results in contaminated runoff, altering aquatic ecology by increasing temperatures and reducing oxygen levels, as outlined by Shahbaz et al. (2017).

The most common nonpoint sources of excess nutrients in surface waters, such as synthetic fertilizers and animal manure from farming operations, lead to eutrophication. This process, whereby nutrients enter surface water, creates an environment conducive to algal blooms, which deplete oxygen and harm aquatic life. Similarly, the use of pesticides in agriculture poses a risk of contaminating both surface water and groundwater.

These environmental challenges are directly linked to the broader context of Pakistan's industrialization and economic development. As the country has pursued industrial growth, agricultural practices have intensified, often without adequate consideration for environmental impacts. This has led to increased pollution and degradation of natural water sources.

The National Conservation Strategy of Pakistan recognizes the need for a fundamental shift in values and practices to address these environmental challenges. It emphasizes the importance of rehabilitating communal spirit and responsibility (Haqooq ul Ibad) and restoring a conservation ethic drawn from Islamic moral principles (Qantas). This holistic approach acknowledges that environmental protection and sustainable development are not just technical or regulatory issues but also involve cultural and ethical dimensions.

The National Conservation Strategy Report of Pakistan emphasizes the crucial need for a shift in attitudes and practices to achieve conservation goals. This shift is a prerequisite for the successful implementation of the fourteen prioritized program areas identified in the report, as noted by Chang et al. (2018). These areas align with the United Nations' Sustainable Development Goals (SDGs) and include objectives like enhancing energy efficiency, protecting the environment, developing renewable resources, reducing pollution, managing urban waste, aiding institutions in common asset management, and integrating population and environmental concerns.

The strategy outlines sixty-eight distinct programs across these categories, each aimed at fulfilling long-term goals with clearly defined physical capital outputs and investment estimates for the next decade. The completion of these programs within the specified timeframe is crucial. The report also highlights the significant roles that various organizations, including non-governmental organizations (NGOs), women's groups, international NGOs, and environmental NGOs, can play in collaboration with the government to drive conservation efforts. These recommendations were incorporated into Pakistan's Eighth Five-Year Plan (1993-1998).

Amidst these efforts, Pakistan faces escalating environmental challenges due to its growing economy and population. A report by the Global Clean campaign reveals a concerning trend: Pakistan's average temperature has risen by 0.2 degrees in just the past two years, attributed to an increase in greenhouse gas emissions. This change underscores the urgency of addressing climate change.

Despite various initiatives by NGOs and government bodies to curb environmental degradation, as pointed out by Akadiri et al. (2019), Pakistan continues to grapple with environmental issues. The nation’s expanding economy and population exacerbate these challenges, highlighting the need for sustained and effective environmental management strategies. The implementation of the National Conservation Strategy’s programs is therefore critical in addressing these environmental challenges and steering Pakistan towards a sustainable future.

Natural resources are extremely important to the expansion of any economy and are necessary to foster growth in the areas of industries and service provision. However, in recent decades, these resources have been severely impacted by the process of urbanization and rapid economic growth, particularly in economies that are still in the process of developing. As a result of this, the emerging nations are very concerned about environmental issues such as deforestation, water scarcity, air pollution, water pollution, loss of biodiversity, and the decline in the population of wildlife.

The poor quality of the environment has a negative impact on human beings and results in societal losses, economic losses, and ecological losses. In spite of the fact that the developing world is being affected by the ever-increasing rate of environmental devastation, the detrimental effects of this phenomenon are already seen in OIC member states and will become even more pronounced in the future (Abdouli, 2017).

Based on their performance in the environmental sphere, twenty-four out of fifty-seven countries were classified as poor and vulnerable countries in the OIC Environment Report, which was produced by Hussain et al. (2019). Despite the fact that Qatar is regarded as having one of the highest ranks in terms of creating greenhouse gases, it is the country that has the best overall performance in terms of environmental sustainability (Hussain et al., 2019). Although Bangladesh is currently in first place on this list, Qatar is currently the nation that excels the most in terms of environmental sustainability.

2.3 Foreign Direct Investment (FDI) and Environmental Sustainability

In a study conducted by Ging Lee (2009), it was found that there exists a short-term causal connection between Foreign Direct Investment (FDI) inflows and pollution in terms of output, as measured by GDP per capita, in Malaysia. However, the linkage between output and FDI inflows is only confirmed over the long term. Interestingly, the study suggests that this causality between FDI, pollution, and output may differ from one country to another. The findings imply that FDI inflows can serve as a positive catalyst for Malaysia's economic growth in the short term but may not sustainably drive growth in the long run. Furthermore, the study indicates that GDP per capita exerts a positive influence on FDI inflows in the long term, as economic growth creates larger and expanding markets for foreign companies. Notably, in the short term, FDI inflows appear to play a significant role in environmental degradation.

In another research by Abdo (2020), the investigation focused on the relationship between FDI and environmental pollution in Arab countries. The study also uncovered a direct correlation between FDI and increased CO_2 emissions and environmental degradation. In a study conducted by Apergis (2023), the focus was on the relationship between Foreign Direct Investment (FDI) flows and CO_2 emissions in developing countries, specifically the BRICS countries (Brazil, Russia, India, China, and South Africa). The study recognized that while FDI brings about knowledge spillovers, improved institutional quality, and economic growth, it also contributes to increased environmental degradation. (Knowledge spillovers refer to the unintended transfer or sharing of knowledge, expertise, or ideas from one entity to another, often occurring when Multinational Enterprises [MNEs] introduce new technologies, management practices, or research and development [R&D] to the host country. These knowledge spillovers can benefit the local economy by fostering innovation, productivity, and competitiveness. Additionally, employees of MNEs may gain new skills and knowledge, which can later be used to start their businesses or contribute to the local economy. Hence, knowledge spillovers resulting from FDI can have positive effects on the host country's economic growth and development.) The study suggested that future research could delve into whether FDI flows into specific sectors lead to environmental degradation in the host country, as recent research by Casino (2021) indicated that the PHH primarily applies to primary and manufacturing sectors rather than when considering aggregate FDI inflows.

Tang (2015) conducted research revealing that countries with more stringent environmental regulations than the United States tend to exert a more substantial influence on FDI. Furthermore, the study observed that export-oriented FDI is more sensitive to local environmental regulations than locally market-oriented FDI. (Export-oriented FDI occurs when MNEs invest in a host country to produce goods or services for export to other markets.) In the realm of Foreign Direct Investment (FDI), there are two primary orientations: export-oriented and local market-oriented. Export-oriented FDI seeks to leverage lower production costs in the host country, such as cheaper labor, land, or raw materials, with the objective of exporting the produced goods or services back to the home country or other markets where they can fetch higher prices. On the other hand, local market-oriented FDI involves MNEs investing in a host country primarily to cater to the local market, selling goods or services to local customers. This form of FDI aims to expand market share by tapping into the host country's market, offering growth opportunities for the corporation.

Moving to Bulus (2021), the study delves into the relationship between FDI and CO_2 emissions in Korea over the period of 1970-2018. The findings indicate that increased FDI, per capita GDP, energy consumption, and imports have contributed to higher per capita CO_2 emissions in Korea. Conversely, government expenditures, the adoption of renewable energy sources, and exports have been associated with reduced per capita CO_2 emissions. Notably, government expenditures exhibited a negative long-term effect on CO_2 emissions, while renewable energy and exports displayed environmentally beneficial characteristics. On the other hand, imports were linked to a positive long-term effect, indicating that they lead to increase per capita CO_2 emissions. Overall, the study suggests that in Korea, FDI, GDP, energy consumption, and imports tend to elevate per capita CO_2 emissions, whereas government expenditures, renewable energy adoption, and exports tend to reduce per capita CO_2 emissions. However, the study did not provide strong evidence in support of the PHH in the Korean context.

Waldkirch (2008) conducted a study analyzing the relationship between pollution intensity in production and Foreign Direct Investment (FDI) in Mexico. The findings revealed a significant positive correlation between FDI and sulfur dioxide emissions, particularly in highly regulated industries. Sectors demonstrating a positive link between FDI and pollution received a substantial share, up to 30%, of both total FDI and manufacturing output. The study also considered factors like skilled labor and capital endowment, which significantly influence industrial location and a country's export composition. While identifying evidence of a pollution haven effect for sulfur dioxide emissions and large firms, the study cautioned that tightening regulations in one or a few countries might merely shift pollution-intensive production to other favorable developing nations over time.

Solarin (2017) delved into the connection between Foreign Direct Investment (FDI) and CO2 emissions in Ghana from 1980 to 2012. The study incorporated various determinants of CO2 emissions, such as GDP, energy consumption, renewable energy usage, and institutional quality, urbanization, and trade openness. The results highlighted a positive impact of GDP, FDI, urban population, financial development, and international trade on CO2 emissions, while institutional quality was found to decrease emissions in Ghana. Additionally, the study investigated the Environmental Kuznets Curve (EKC), indicating that as a country's income grows, environmental degradation initially increases before decreasing. Notably, it emphasized the positive association between energy consumption and CO2 emissions, advocating for reductions in energy usage to mitigate carbon emissions. The study underscored the contributions of the transportation sector, household energy consumption, and the dominance of fossil fuels in emissions, with minimal contributions from renewable energy. Ultimately, it recommended Ghana strengthen its environmental policies to counterbalance the adverse impacts of FDI on emissions.

Khan (2020) delved into the causal relationship between CO2 emissions, Foreign Direct Investment (FDI), economic growth (real per capita income), and trade openness across 17 Asian countries from 1980 to 2014. The study observed a significantly positive impact of inward FDI on environmental pollution. It highlighted the importance of economic policy reforms to steer foreign capital towards more environmentally sustainable avenues. Despite acknowledging economic growth's role in poverty reduction, the study emphasized its concurrent contribution to environmental degradation and public health concerns.

Singhania (2021) explored FDI's impact, institutional factors, financial development, and sustainability. Using data from the World Development Indicators covering 21 developed and developing high-carbon-emitting countries (1990–2016), the study unveiled a notable positive influence of FDI on environmental degradation, particularly evident in developing nations. The research underscored multinational enterprises' utilization of international advantages, potentially leading to environmental deterioration. Moreover, it highlighted how lower infrastructural standards in developing countries might encourage the adoption of more polluting technologies to attract FDI. Both studies emphasized the necessity of considering financial development, institutional frameworks, and foreign capital inflows for achieving sustainable development. They stressed the urgency of economic policy reforms to steer foreign investments toward more environmentally conscious avenues.

Contrarily, Manderson (2012) contested the evidence supporting FDI outflows and differential regulations between countries, considered heterogeneous firm behavior—an overlooked. Despite acknowledging the importance of varied firm characteristics within industries. It highlighted that firms with higher environmental compliance costs did not show a greater tendency to establish foreign subsidiaries in countries with relaxed environmental policies compared to firms with lower compliance costs. The study concluded that the absence of widespread evidence for pollution havens stemmed from overlooking within-sector differences in firm characteristics, thereby accentuating the significant disparities in FDI behaviors between high and low environmental cost firms.

This investigation delves into the intricate interplay among industrialization, Foreign Direct Investment (FDI), and environmental quality within OIC (Organization of Islamic Cooperation) nations. The study aims to unravel how industrial activities influenced by FDI shape the environmental terrain. While industrialization is a cornerstone of economic advancement, it also poses environmental challenges, including pollution and resource depletion. FDI assumes a dual role: it propels economic growth but can simultaneously exacerbate environmental degradation due to heightened industrial pursuits. However, FDI also holds the potential to introduce cleaner technologies, potentially enhancing environmental standards. The research endeavors to dissect these complex dynamics to comprehend the comprehensive impact of industrialization and FDI on environmental quality within OIC countries.

In scrutinizing the relationship between industrialization, FDI, and environmental quality, this study acknowledges the expansive effects of globalization elucidated by Mishkin (2009). Globalization, encompassing economic, social, and political dimensions, profoundly influences the dynamics of industrialization and FDI. However, the primary focus of this research remains on the economic facets of globalization, particularly their nexus with industrialization and FDI concerning environmental quality.

Industrialization, integral to economic globalization, significantly shapes the environmental panoramas of nations. While fostering economic growth, it can also trigger substantial environmental deterioration. This decline manifests in various forms, notably heightened pollution levels and the depletion of natural resources.

Latif et al. (2018) point out that increased economic activity and investment, often associated with industrialization and Foreign Direct Investment (FDI), lead to higher energy consumption and contribute to environmental degradation. This scenario is particularly evident in nations with insufficient regulations to manage pollution. Additionally, Antweiler et al. (2001) studied the impact of industrial activities and FDI on the environment. They found that these factors can lead to reduced production costs but often at the expense of environmental quality. FDI, closely linked to industrial activities, has varied effects on the environment. Earlier research focused on the relationship between FDI and pollution, leading to diverse conclusions. Despite the fact that a number of academics were opposed to the idea and said that foreign direct investment causes pollution halos by disseminating high-quality management practices and cutting-edge technology that are beneficial to the environment, which in turn causes pollution to decrease (Eskeland and Harrison, 2003), we decided to go ahead and implement our plan. The findings of some other study, such as the one conducted by Tamazian et al. (2009), have also been shown to be consistent with one another, and at least one person is on record as supporting the notion that FDI is good for the environment.

The primary objective of the current study is to ascertain the overall effect that globalized processes and FDI have on environmental quality in OIC states using a breakdown of economies into Low-Income and High-Income Countries. This study will use a panel data collection for forty-seven OIC states using the generalized method of moments (GMM) to assess the effects of globalization. Globalization and FDI (as measured by capital inflows) on the deterioration of the environment through the utilization of CO2 emissions as a proxy variable. This investigation will be carried out in order to determine whether or not globalization and FDI (as measured by capital inflows) contribute to the degradation of the environment. When conducting an investigation into the combined effects, it is important to take into account the interactional relationship that exists between globalization and FDI.

Ozturk and Mulali (2015) highlight the relatively underexplored aspect of how institutional quality can impact environmental outcomes, suggesting that stronger institutions might enhance environmental quality. Similarly, Povtkina (2018) indicates that a lower level of corruption, particularly in democratic systems, can correlate with reduced CO2 emissions. This research will investigate these variables within the context of FDI and industrialization, examining how they collectively affect environmental degradation. The study aims to provide insights that are crucial for policy development, particularly in the areas of industrialization, energy consumption, and FDI, and their combined impact on the environment.

This research aims to provide insights that could assist policymakers in formulating policies that foster both economic and environmental sustainability within the Organization of Islamic Cooperation (OIC) economies. It addresses a notable gap in existing literature by focusing on how Foreign Direct Investment (FDI) impacts environmental quality, particularly in OIC nations, a subject not extensively explored before. This investigation, as emphasized by Pal and Tok (2019), is significant due to the scarcity of comprehensive studies on the environmental implications of FDI in the OIC region.

The study will explore the varied effects that FDI can have on the environment in OIC member states. It is recognized that FDI, depending on its implementation and the regulatory framework of the host country, can lead to different environmental outcomes. These range from potential deterioration in environmental quality due to industrial expansion, to positive impacts stemming from the transfer of green technologies and sustainable practices.

By concentrating on the specific context of OIC nations, this research will contribute to a deeper understanding of the relationship between economic investment and environmental sustainability. The findings are expected to be pivotal in shaping policies that aim to balance economic growth with environmental stewardship in the OIC member states. This study, therefore, promises to fill a critical void in the current body of research and offer a nuanced perspective on the interaction between economic investments and environmental quality in the OIC region.

Foreign Direct Investment (FDI) can have varied effects on a country's CO_2 emissions, with the impact being contingent upon the specific circumstances of the country in question. Research by Managi et al. (2009) indicates that in certain contexts, economic activities associated with FDI can lead to a decrease in certain types of emissions in developed countries, while potentially increasing them in developing nations. This finding underscores the complexity of the relationship between FDI and environmental impact, highlighting how economic investments can differently influence environmental quality based on a country's development status and regulatory framework.

In their study, Chang et al. (2018) observed a nuanced relationship between economic factors and CO_2 emissions. They discovered that in high-income countries, certain economic activities are linked to an increase in CO_2 emissions, while in low and middle-income countries, these activities might lead to a reduction in emissions. This finding suggests a complex interplay between a country's economic status and its environmental impact.

Further exploring the environmental effects of economic activities, Shahbaz et al. (2016) conducted a study focused on 19 African countries. Their research concluded that these economic activities are generally associated with a decrease in CO_2 emissions across the sample, but the impact varies significantly from one country to another. This variance underscores the importance of considering a country's unique economic and environmental context when assessing the effects of economic activities on CO_2 emissions.

Koengkan et al. (2020) conducted a study on environmental impact in Latin American and Caribbean states, concluding that certain aspects of economic activities negatively affect the environment. This degradation was linked to factors such as energy consumption and specific economic policies. The study's findings align with those of Acheampong et al. (2019), who observed that while certain economic activities can harm the environment, the use of renewable energy and specific investment strategies, like Foreign Direct Investment (FDI), can have a mitigating effect on carbon emissions.

In a similar vein, Le and Oztruck (2020) investigated the effects of various economic factors, including the quality of institutions, public expenditure, and economic growth, on CO_2 emissions in 47 developing and emerging countries between 1990 and 2014. Their research found an inverse relationship between economic growth and environmental quality in the selected economies. They noted that factors such as governance practices, financial development, and energy consumption contributed to an increase in CO_2 emissions. Despite these negative impacts, the study also acknowledged the importance of Foreign Direct Investment (FDI) in promoting growth, enhancing productivity, facilitating technology transfer, and generating capital, even when considering environmental quality as a variable. This underscores the complex interplay between economic development and environmental sustainability.

Since the middle of the 1990s, an increasing number of academics and industry experts have taken an interest in getting a deeper comprehension of the relationship that exists between the level of nearby environmental quality and foreign direct investment. In the annals of written history, two distinct schools of thought have been advanced: on the one hand, it is thought that foreign direct investment (FDI) has a positive impact on the environment of the host country, but on the other hand, it is said to have a negative spillover effect on the environment of the receiving country. Both schools of thought have been advanced throughout the course of written history.

Several studies, including research by Ali et al. (2020), have focused on the relationship between Foreign Direct Investment (FDI) and environmental quality in OIC countries. In their study, Ali et al. used environmental path as a measure of environmental quality and examined the impact of FDI and institutional performance on this measure. Their findings indicate a significant positive correlation between environmental quality and the level of FDI. However, they also observed a negative relationship between the performance of institutions and environmental conditions, suggesting that the effectiveness of governance and regulatory frameworks plays a crucial role in determining the environmental impact of economic activities. This research highlights the multifaceted nature of the relationship between economic investment and environmental sustainability.

Bakhsh et al. (2017) conducted research in Pakistan to determine how economic growth and foreign direct investment affect CO_2 emission levels. They found that one component influences the other in a way that is positively correlated with the other factor. In Munir and Ameer's (2020) study, the non-linear distributed lag model was applied in order to ascertain the short-run effects of a given variable as well as the long-term, non-linear effects that foreign direct investment (FDI), industrialization, and economic growth had on CO_2 emissions in Pakistan between the years 1975 and 2016, respectively. They discovered that there was a large and positive link between increasing levels of foreign direct investment and CO_2 emissions. On the other hand, they found that there was a negative and negligible association between declining levels of foreign direct investment and CO_2 emissions. Both of these associations were significant.

Abdouli and Hammammi (2017) used panel data and the ordinary least squares, difference-generalized method of moments, and system-generalized method of moments to analyses the effects of foreign direct investment (FDI), environmental quality, and stock of capital on the economic growth of 17 MENA countries from 1990 to 2012. This study covered the years 1990 through 2012 and the years 1990 through 2012. They found that rising capital stock levels and FDI inflows both contributed to economic growth, which in turn raised GDP.

They did, however, also find that one unfavorable side effect of this stronger economic growth was that it led to a decline in the environmental quality of MENA countries. This was found to be an adverse impact of rapid economic expansion. (Pazienza, 2019) also looked at the negative effects of FDI on CO_2 in OECD member states, but interestingly, They discovered that when FDI inflows rise, the negative effect gradually reduces, which is advantageous as a catalyst for raising environmental quality. The findings of this study were published in the journal Pazienza.

Industrial CO_2 emissions in China, which already rank among the worst in the world, are made worse by foreign direct investment (FDI) on the national level and are negatively connected on the regional level. This is because industrial CO_2 emissions in China are negatively associated to regional economic development. According to Yu and Xu (2019), the procedure recovers CO_2 emissions on a national as well as a regional scale. This pertains to research and development. (Bakirtas & Cetin, 2017) and (Masood et al. 2015) arrived at the same findings, namely that foreign direct investment (FDI) contributes to an increase in CO_2 emissions and lowers the quality of the environment.

On the other hand, there are studies that support the idea that CO_2 emissions may have some beneficial effects on the overall quality of the environment. These researchers found that foreign direct investment (FDI) enhanced environmental quality in a number of different countries and in a variety of scenarios by lowering the amount of CO_2 emissions. The results of a few other studies lend credence to this line of reasoning.

High institutional quality can minimize CO_2 emissions and improve the quality of nature, in contrast to low level of institution which can slow down the process of expansion and decline environmental quality. In order to summarize the earlier research, we may state that various studies each contributed with conflicting findings. Because of this, it is still unclear how and to what degree globalization and FDI affect environmental quality in a positive or negative way. This is the main driving force behind the research (Shah et al., 2019).

2.4 Energy Consumption and Environmental Degradation

Energy is a fundamental necessity in human life. Prior to the industrial revolution, humans primarily relied on natural energy sources, animal power, and human effort to meet their needs for heat, light, and work. At that time, the per capita energy consumption did not surpass 0.5 tonnes of oil-equivalent (toe) annually.

However, a significant transformation occurred as the global total primary energy supply more than doubled between 1971 and 2010, primarily driven by the utilization of fossil fuels (as reported by the International Energy Agency (IEA 2012). Over a longer historical period, spanning from 1850 to 2005, the production and consumption of energy surged more than 50-fold, increasing from a global total of approximately 0.2 billion toe to 11.4 billion toe (as documented by the IEA in 2007). This remarkable growth was particularly pronounced in industrialized societies, which became highly reliant on the abundant availability of energy. On a per capita basis, individuals in these societies now use over 100 times the amount of energy that their ancestors relied upon before harnessing the energy potential of fire (as indicated by the United Nations Development Programme (UNDP 2000).

According to the Global Energy Statistical Yearbook 2011, global energy consumption exhibited a 2.5% increase in 2011, roughly in line with historical averages but significantly lower than the 5.1% growth observed in 2010. The report "World Energy Use in 2011" attributes this deceleration to factors such as the global economic crisis, particularly impacting OECD countries, as well as record-high oil prices, which constrained the growth in global oil consumption even in energy-intensive nations like China and India.

In OECD nations, energy consumption rebounded due to increased economic activities following the financial crisis of 2008, which had led to a sharp decline in demand in 2009 (as highlighted by the IEA in 2011a). Despite a 1.3% reduction in energy consumption in OECD countries in 2011, these nations remained significant energy consumers, collectively accounting for 41% of the world's total energy consumption.

The literature contains a substantial body of research investigating the causal relationship between energy consumption and economic growth. A seminal contribution to this field is the work of Kraft and Kraft (1978), who identified a unidirectional causality from income to energy consumption in the United States using a bivariate model. Subsequent to Kraft and Kraft (1978), numerous studies have explored the causality link between energy consumption and income, yielding varying results.

For example, some studies have found no causal relationship between economic growth and energy consumption, aligning with the neutrality observed by Erol and Yu (1987) and Yu and Jin (1992) in the context of the United States, as well as Soytas and Sari (2003) for countries like Indonesia, Poland, Canada, the US, and the UK, and Joyeux and Ripple (2007) for seven East Indian Ocean countries. Conversely, evidence of unidirectional causality from income to energy consumption is consistent with the findings of Yu and Choi (1985) for South Korea, Al-Iriani (2006) for Gulf Cooperation Countries, Joyeux and Ripple (2010) for a set of 30 OECD countries and 26 non-OECD countries, Zhang et al. (2012) for OECD countries. Additionally, unidirectional causality from energy consumption to income has been identified in studies such as Yu and Choi (1985) for the Philippines, Fatai et al. (2004) for Indonesia and India, Wolde-Rufael (2004) for Shanghai, and Zhang et al. (2012) for newly industrialized countries.

Furthermore, bidirectional causality between income and energy consumption has been observed in studies such as those conducted by Glasure and Lee (1997) for South Korea and Singapore, Yang (2000) for Taiwan, Soytas and Sari (2003) for Argentina, Fatai et al. (2004) for Thailand and the Philippines, Erdal et al. (2008) for Turkey, and Fuinhas and Marques (2012) for southern European countries. These diverse findings underscore the complexity of the relationship between energy consumption and economic growth and emphasize the importance of considering specific country contexts in analyzing this causal link.

Numerous studies have delved into the relationship between energy consumption and economic growth, employing multivariate models to analyze this nexus. However, the findings across these studies remain inconclusive. Masih and Masih (1996) identified a neutral connection between income and energy for Malaysia, Singapore, and the Philippines, while Stern (1992) found unidirectional causality from energy to income in the US. Similarly, Bidirectional causality between income and energy was observed by Asafu-Adjaye (2000) for Thailand and the Philippines.

Moreover, some studies have sought to decompose total energy consumption by source, such as coal, natural gas, and oil (petroleum), to gain further insights. For instance, Zou and Chau (2006) highlighted the predictive nature of oil consumption on the Chinese economy from 1985 to 2002. Yoo (2006) demonstrated bidirectional causality between oil consumption and economic growth in Korea spanning from 1968 to 2002.

However, despite employing more complex models and examining specific energy sources, the consensus within the literature remains elusive. The bivariate model, often critiqued for omitting crucial variables, has contributed to the controversy surrounding empirical results. Furthermore, studies such as Zhao et al. (2008) in China and Aktas in Turkey have found evidence of bidirectional causality between oil consumption and economic growth. Yuan et al. (2008) also found bidirectional causality between oil consumption and GDP alongside unidirectional causality from GDP to coal consumption in China from 1963 to 2005.

Jinke et al. (2008) conducted a comparative study encompassing major OECD and non-OECD countries from 1980 to 2005. Their research pointed to unidirectional causality from GDP to coal consumption in Japan and China, while no causal relationship was found between coal consumption and GDP in India, South Korea, and South Africa. However, Jinke et al.'s reliance on a bivariate model raised concerns about potential bias in their results.

Contrastingly, Apergis and Payne (2010a) employed a multivariate panel framework and discovered a negative impact of coal consumption on long-term economic growth across 25 OECD countries during the same period. Their panel vector error correction model revealed bidirectional causality between coal consumption and economic growth in both the short and long run.

Wolde-Rufael (2009) utilized the Toda-Yamamoto causality test across six major coal-consuming countries from 1965 to 2005. Their findings indicated unidirectional causality from coal consumption to economic growth in India and Japan, while China and South Korea displayed the opposite causal direction. South Africa and the US showed bidirectional causality between economic growth and coal consumption.

Apergis and Payne (2010b) studied emerging market economies from 1980 to 2006 and established bidirectional causality between coal consumption and economic growth in both the short and long term.

Bloch et al. (2012) focused on China from 1965 to 2008, exploring coal consumption's relationship with income through supply-side and demand-side frameworks. They revealed unidirectional causality from coal consumption to output in both the short and long run in the supply-side analysis. Conversely, under the demand-side analysis, they found a unidirectional causal link from income to coal consumption in both short and long terms.

Pradhan (2010) observed mixed results across different countries: unidirectional causality from oil consumption to economic growth in Bangladesh and Nepal, from economic growth to oil consumption in India and Sri Lanka, and bidirectional causality between oil consumption and economic growth in Pakistan.

Payne (2011) in the US (1949 to 2006) found unidirectional causality from petroleum consumption to economic growth. In contrast, Chu and Chang (2012) identified a unidirectional causal link from economic growth to oil consumption in the US, with a similar direction observed in Germany and Japan from 1971 to 2010.

Examining crude oil consumption and economic growth across twenty-seven OECD countries from 1976 to 2009, Bashiri Behmiri and Pires Manso (2012) established bidirectional causality between crude oil consumption and GDP, supporting the feedback hypothesis. They highlighted that crude oil conservation policies could significantly impact economic growth rates in the short and long term for OECD countriThe empirical evidence from Asumadu−Sarkodie, S.; Owusu, P.A. (2016) revealed an intriguing inverse relationship between economic growth and carbon dioxide emissions, contrary to conventional expectations. Their findings suggested that as economic growth increased, carbon dioxide emissions decreased, challenging the conventional belief in a direct positive correlation between economic advancement and environmental harm. Moreover, their research identified Granger causality between carbon dioxide emissions, energy use, and financial development. Similarly, investigations in Sri Lanka and Vietnam indicated bidirectional causality between industrialization, energy consumption, and carbon dioxide emissions, portraying the intricate interplay among economic activities, energy utilization, and environmental impact.

The complexity of these relationships was further underscored by Khan et al.'s (2019) study in Pakistan, emphasizing the multifaceted influence of economic activities and energy consumption patterns on carbon dioxide emissions. Interestingly, their research suggested a nuanced impact of Foreign Direct Investment (FDI) on CO2 emissions, revealing a mixed effect over varying time frames - increasing emissions in the long term while reducing them in the short term.

Shahbaz et al. (2018b) expanded on these observations by conducting a comprehensive study encompassing 25 developing economies over a 44-year period from 1970 to 2014. Their extensive investigation provided a panoramic view of the intricate relationship between economic activities, policies, and environmental quality, highlighting the significant impact these factors exert on the overall environmental health of nations. This extensive duration of analysis offered valuable insights into the long-term implications of economic activities and policies on environmental conditions across developing nations.

2.5 GDP and its Environmental Implications

Grossman and Krueger's studies in 1991 and 1995 stand out as key investigations that delved into the income-environment relationship through various environmental quality indicators. Their analysis encompassed factors like sulfur dioxide, dissolved oxygen, smoke, suspended particles, fecal coliform, and biological oxygen demand. Contrary to their initial hypothesis, they discovered that countries engaged in extensive trade exhibited notably lower levels of sulfur dioxide, a finding that challenged their assumption linking trade liberalization to diminished environmental standards. However, for other pollutants, their research didn't reveal a significant correlation with trade volumes.

The literature exploring the relationship between trade and the environment employs diverse methodological approaches, leading to multifaceted empirical results shaped by several factors such as research methods, sample sizes, data selection, and the time frames under study. The examination of the trade-environment link often involves investigating contrasting hypotheses like the Factor Endowment Hypothesis versus the Pollution Haven Hypothesis.

Studies like Mani and Wheeler (1998) and Suri and Chapman (1998) support the Pollution Haven Hypothesis, suggesting that differences in environmental regulations between regions can result in the shift of pollution from environmentally stringent regions (North) to those specializing in pollution-intensive products (South). However, other research, including Grossman and Krueger (1993) and Gale and Mendez (1998), challenges this notion by favoring the Factor Endowment Hypothesis. They propose that trade patterns are influenced more by factor endowments than differences in environmental regulations.

Lucas, Wheeler, and Hettige (1992) conducted an investigation into the impact of trade liberalization on the toxic intensity of output growth rates. Their findings pointed towards a positive correlation, indicating that trade liberalization had a favorable effect on reducing the toxic intensity of output growth.

Antweiler, Copeland, and Taylor (2001) conducted a comprehensive analysis that breaks down the influence of trade on the environment into three distinct effects: scale, technique, and composition. The scale effect arises from increased economic activity, leading to higher resource utilization and waste production, thus impacting environmental quality. Conversely, the technique effect suggests that as income rises, there's a heightened demand for cleaner production processes, ultimately resulting in a net reduction in pollution. The composition effect, driven by varying pollution intensities across economic sectors, also contributes to environmental quality changes. Surprisingly, their combined findings indicate that freer trade tends to benefit the environment, despite concerns about shifts in production toward pollution-intensive goods in less affluent nations.

Examining the environmental consequences of trade liberalization in China using provincial-level water pollution data, Judith M. Dean (2002) found that while trade liberalization adversely affects the environment through terms of trade, it also positively impacts environmental conditions through income growth. The overall impact of trade liberalization on China's environment seems to lean towards a positive outcome, considering the combined effect of these two factors.

Frankel and Rose (2005) employed cross-country data and various environmental quality indicators to investigate the trade-environment relationship. Their research revealed that trade openness correlated with reduced local air pollutants like sulfur dioxide, nitrous oxides, and suspended particulate matter. However, concerning carbon dioxide, the association with trade openness had a positive sign. Additionally, their findings suggested that trade openness curbed deforestation and energy depletion. Moreover, in rural areas, increased access to clean water was linked to trade liberalization.

The relationship between trade and the environment is complex and multifaceted, as evidenced by numerous studies exploring the income-environment and trade-environment connections using diverse research methodologies. Despite criticisms regarding the Environmental Kuznets Curve analysis' lack of a solid theoretical foundation, a structural approach proposed by Kaufmann et al. (1998), Arrow et al. (1995), and Grossman and Krueger (1995) remains unexplored in empirical studies. Nonetheless, the reduced-form models applied provide an essential preliminary step in unraveling the intricate relationship between income, trade liberalization, and their impact on the environment. Panayotou (1997) underscores the value of this approach, offering a comprehensive understanding of how income and other factors influence environmental dynamics without the complexities of structural equations and extensive data requirements.

Panayotou (1997) undertakes an analysis to dissect the economic structural elements that influence SO2 emissions, a pollutant commonly showcasing a U-shaped relationship with income. In this study aimed at exploring the impact of trade liberalization on the income-environment correlation across five Southeast Asian nations, we adopt a similar approach to Panayotou's methodology. We construct a fundamental model incorporating per capita GDP, GDP growth rate, and specific variables of interest. Our primary objective involves testing the presence of the Environmental Kuznets Curve (EKC) and making a modest endeavor to integrate economic growth, trade intensity, and foreign direct investment into the EKC framework. This effort aims to investigate how trade liberalization influences the environment within the context of the EKC.

CHAPTER 3

DATA AND METHODOLOGY

3 Introduction

This chapter presents the theoretical framework, model, and estimation methodologies that were used for the models used in the present investigation. In addition, both the descriptions of the data and the sources of the data are discussed. There are several subsections contained within this chapter. The first part of the paper is broken up into several talks regarding the study's theoretical foundation. Next, the research paper includes the data source and variables, and the same section describes the particulars of the variables that were chosen. The next section that presents the important connections between the different aspects of the model of study. In the third half of this chapter, we will discuss the model and methods that were used for this particular study. The unit root test and the various forms it might take are covered in the second-to-last section of this chapter. The ARDL cointegration test and all of its components are discussed in the subsequent and final section of this chapter.

3.1 Theoretical Framework

Industrialization refers to the process of economic development that involves the growth of industries in a country. In the case of Pakistan, the country has undergone significant industrialization since the 1960s, and this has had a considerable impact on the environment. The purpose of this theoretical framework is to analyze the impact of industrialization on environmental quality in Pakistan by using long-term ARDL and short-term ECM models.

The dependent variables in this study are CO2, CO, and CH4. These three gases are known as greenhouse gases and are responsible for climate change. The emissions of these gases have been increasing globally, and Pakistan is no exception. The increase in emissions of these gases has led to a rise in global temperatures, which has resulted in various environmental issues such as melting glaciers, sea-level rise, and changes in weather patterns.

The following discussion (Yu & Xu, 2019; Pazienza, 2019; Akadiri et al., 2019) will focus on the theoretical argument in favour of our research design, which serves as the basis for this study and provides support for it. First, what is known as the Environment Kuznets curve examined the relationship between the deterioration of the environment and the expansion of the economy.

The Environment Kuznets curve predicts that as GDP increases, environmental pollution will initially climb, reach its peak, and then start to fall, which would likely look like an inverted U-shaped curve (Shafik & Bandyopadhyay, 1994). This is because environmental pollution is a function of GDP. This hypothesis is supported by the fact that in the beginning, when the economy grows, there is no improvement in technology, which leads to a worsening of the environment.

The independent variables in this study are IND, IGR, Net Export, Energy Consumption, and FDI. These variables have been chosen because they are closely linked to industrialization and have a significant impact on the environment. IND represents industrialization, IGR represents economic growth, Net Export represents trade, Energy Consumption represents energy use, and FDI represents foreign investment.

Industrialization has been one of the most significant drivers of economic growth in Pakistan over the past few decades. However, this rapid industrialization has had adverse effects on the environment, including air pollution, water contamination, deforestation, and climate change. The purpose of this theoretical framework is to explore the impact of industrialization on environmental quality in Pakistan, with a focus on the emissions of carbon dioxide, carbon monoxide, and methane.

There are both positive and negative effects that industrialization has had on carbon dioxide, carbon monoxide, and methane emissions, and these effects vary from country to country. If we narrow our focus to economic growth, we see a reduction in carbon monoxide, carbon dioxide, and methane. Later research on the same link found that an increase in trade openness boosts CO, CO_2, and CH_4 discharge in high income states (Wang et al., 2013), but the inverse is true for low and middle income countries.

However, as the development goes on, technology gets better, and people with higher living standards demand an environment that is cleaner (Grossman & Krueger, 1991). As a result, pollutant levels drop, environmental quality improves, and carbon dioxide and carbon monoxide emissions fall as a result.

Due to the nature of the study, it is necessary to gather and conduct analysis on primary and secondary data regarding the environmental, technological, economic, and policy aspects of industrial pollution. Therefore, in order to acquire first-hand information, it is necessary to have direct relationships with the government as well as local non-governmental organizations that are actively involved in the subject of environmental contamination and work closely together.

3.2 Data Source

The data used in this analysis were collected on a yearly basis from 1980 to 2020 for the country of Pakistan. The application of this analytical approach inPakistan not only offered a comprehensive overview of the repercussions of industrialization on the environment, but it also assisted greatly in determining the fundamental reasons of the industrial pollution that is pervasive in this nation. The information came from the International Financial Statistics (IFS), the World Development indicator (WDI), the 21 Years Statistics of Pakistan issued by the Federal Bureau of Statistics, and the Economic Survey of Pakistan (Table 3.1).

Table 3.1: Variables Description

Variables	Description	Data Source
CO_2	CO_2 Emissions	WDI
CH_4	Methane	WDI
CO	Carbon Monoxide	WDI
IND	Industrialization	IFS
FDI	Foreign Direct Investment	IFS
ENG-C	Energy use as a percentage of GDP	WDI
GDP-pc	Gross domestic product	WDI
IGR	Industrial Growth Rate	WDI

Time-series data is used in this study which covers the duration from 1980 to 2020.

A situational analysis and the gathering of the necessary data from primary and secondary sources, such as journals, feature articles, magazines, and publications from pertinent government agencies, non-profit organizations, academic & research institutions, and business associations, was the first phase of the work. This was done after receiving the necessary approval from the Department of Science, Technology, and Environment and the Pakistan Pollution Control Committee. This was carried out to find out the existing situation.

The effects of industrialization on the ecology of Pakistan, including its water, air, and biodiversity, as well as the factors that led to these effects, were thoroughly investigated, and the findings were documented using a causal chain. Table 3.2 provides a listing of the selected variables as well as the data sources that were used.

Table 3.2: List of Selected Variables

Variables	**Full Name**	**Description**	**Measure mint**	**Data Source**
CO2	CO2 Emissions	Carbon dioxide emissions, often known as CO2 emissions, are those that are produced when cement is manufactured as well as when fossil fuels are consumed for energy. Cement production also produces emissions of carbon dioxide. These emissions consist of the carbon dioxide created when solid, liquid and petrol fuels are consumed, as well as the carbon dioxide created when petrol is flared at high temperatures.	Units of carbon dioxide emissions are kilograms per US dollar of GDP.	WDI
CO	Carbon monoxide	Gas known as carbon monoxide is flavorless, odorless and colorless and is created when fuels are burned inefficiently.	We quantify carbon monoxide in kilograms per US dollar of GDP.	WDI
CH4	Methane	The atmosphere contains trace amounts of a gas known as methane. Methane is the most basic type of hydrocarbon, as it only has one carbon atom and four hydrogen atoms in its structure.	Methane emission from fixed points based on flow rate and methane composition .	WDI
IND	Industrialization	In Pakistan industrial production measure the output of businesses integrated in industrial	Value of production of industrial sector in	IFS

		sector of the economy such as manufacturing, mining, and utilities.	total production of country in (constant US$)	
IGR	Industrial Growth Rate	Industrial growth rate refers to the rate at which the industrial sector of an economy is expanding or growing over a certain period of time.	Industrial growth rate can be estimated (US$)	WDI
FDI	Foreign Direct Investment	The term "foreign direct investment" (FDI) refers to an investment that is made from one country into another country by a corporation or a person from the first country with the intention of establishing a business operation or acquiring a controlling interest in a firm that is already in existence.	Foreign direct investment inflows at constant (US$)	IFS
ENG-C	Energy Consumption	Kilowatt hours (KWH) are used to measure energy consumption, which is the entire amount of energy required for a specific process.	Energ consumptio n can be estimated in (khw)	WDI
GDP	Gross Domestic product	GDP per capita is measure of the average economics output per person in a specific geographic area, often a country. It is calculated by dividing the total GDP of that area by its population.	Currant US dollar	WDI

3.3 Critical Relation

3.3.1 CO_2 Emissions

The burning of fossil fuels is the primary contributor to greenhouse gas emissions. In 2014, the combustion of fossil fuels was responsible for the release of 95.3% of the total CO2 emissions; this figure does not take into account the increase in CO2 emissions due to deforestation and the decrease in biomass. Since 2018, Pakistan has total CO2 *and* CH4 emissions that are greater than those of the United States, and the country now ranks second in the world, behind only China. Since 2015, Pakistan has concurrently held the top spot in both the rankings for industrial added value and emissions of carbon dioxide. Because of Pakistan's energy structure, which is dominated by coal, the country's social and economic development has resulted in a significant increase in the amount of pressure exerted on the environment (Abdouli, 2017).

3.3.2 Methane

The atmosphere contains trace amounts of a gas known as methane. Methane is the most basic type of hydrocarbon, as it only has one carbon atom and four hydrogen atoms in its structure. Methane is one of the most potent greenhouse gases (Hussain et al., 2019). Methane is potent greenhouse gas that has significant impact on the environment and climate change. While it stays in the atmosphere for a shorter period compared to carbon dioxide, methane is much more effective at trapping heat.

3.3.3 Carbon Monoxide

Carbon monoxide (CO) is a tasteless, odorless, and colorless gas that is produced when fuels are burned in an inefficient manner. When people are exposed to CO gas, the CO molecules that are already present in their bodies will begin to displace the oxygen, which will eventually result in poisoning (Ozturk and Mulali, 2015).

Carbon monoxide is an air pollutant that can have various adverse effects on the environments like air quality, impact on plants and it also contribute to climate change.

3.3.4 Industrialization

Industrialization is the process by which an economy is transforms from primarily agrarian or rural based to one dominated by manufacturing and industrial activity. It typically involves the development of industries such as textile, steel, and transportation, which use advanced technology and large scale production method.

The impact of industry on the environment can be significant. Industrial activities can result in air pollution, water pollution, and soil contamination, as well as the depletion of natural resources such as fossil fuels and minerals. The release of pollutants such as carbon dioxide, sulfur dioxide and nitrogen oxides can contribute to climate changes, acid rain, and other environmental problems.

3.3.5 Industrial Growth Rate

The industrial growth rate (IGR) measures how quickly an economy's industrial sector is developing or rising over a specific time period. It is frequently expressed as a rise in industrial output or value added as a percentage. This also refers to the realization of financial gains inside a certain industry or sector of the overall economy (Managi et al., 2009).The impact of IGR on the environment can be both positive and negative. On one hand, industrial growth can bring about economic development, job creation, and technological advancements that can improve living standards and contribute to the overall growth of the economy. However, industrial growth can also have negative environmental impacts, such as air pollution, water pollution, deforestation, and the natural resource depletion. Industrial activities often involve the emission of pollutants such as carbon dioxide. Which contribute to air pollution and climate change.

3.3.6 Foreign Direct Investment

The term "foreign direct investment" (FDI) refers to the investment that is made by a firm or an individual from one nation into another country with the purpose of starting a business operation or acquiring a controlling interest in an existing business. FDI can also refer to the investment that is made by a country into another one. Foreign direct investment (FDI) may have either a good or a detrimental effect on the surrounding environment.

3.3.7 Energy Consumption

Consumption of energy is directly correlated to real GDP. An impulse reaction to real GDP can be attributed to energy consumption, with this response being primarily embodied in the early years of the phenomenon. The amount of energy that is consumed is an essential factor in determining economic expansion. When it comes to the formation of energy policy, the many types of energy are important (Yu & Xu, 2019).

3.3.8 Gross Domestic Products (GDP)

GDP per capita is measure of the average economics output per person in a specific geographic area, often a country. It is calculated by dividing the total GDP of that area by its population.

Model Specification

The model regarding Industrialization and Environment Quality formulated as follows:

CO_2 = f (IND, ENG-C, GDP, $GDP^{2,}$ FDI, IGR)

CO= f (IND, ENG-C, GDP, $GDP^{2,}$ FDI, IGR)

CH_4 = f (IND, ENG-C, GDP, $GDP^{2,}$ FDI, IGR)

Dependent Variable:

- Carbon Dioxide =CO_2
- Methane =CH_4
- Carbon Monoxide =CO

Independent Variable:

- Industrialization = IND
- Industrial Growth Rate = IGR
- Foreign Direct Investment = FDI
- Energy Consumption = ENG-C
- Gross domestic product = GDP

Model 1: Environmental quality in the perception of carbon dioxide emission:

$$CO_2 = \alpha + \beta 1IND + \beta 2IGR + \beta 3ENG\text{-}C + \beta 4GDP + \beta 5\ FDI + \varepsilon$$

Model 2: Environmental quality in the perception of carbon monoxide emission:

$$CO = \alpha + \beta 1IND + \beta 2IGR + \beta 3ENG\text{-}C + \beta 4GDP + \beta 5\ FDI + \varepsilon$$

Model 3: Environmental quality in the perception of Methane emission:

$$CH_4 = \alpha + \beta 1IND + \beta 2IGR + \beta 3ENG\text{-}C + \beta 4GDP + \beta 5\ FDI + \varepsilon$$

3.4 Method to Estimate the Model

In the field of methodology, the term "provide such technique in which to analyses and systemize the data by (Scandura & Williams, 2000)" refers to an approach that can be used. According to (Ruiz et al., 2013), It is said that the investigation is completed in terms of sample size and methodology, data collection practices and techniques, and data analysis procedures. The primary objective of this study is to investigate the ways in which industrialization has influenced the quality of the environment in Pakistan. Therefore, in order to estimate the model, one should employ the method of dynamic modelling. During the testing of hypotheses and examination of economic variables in long-run equilibrium, the dynamic modelling approach is utilized. This methodology was utilized in the research project to investigate the long-run and short-run correlations that exist between the variables. The next section will continue with the stationarity tests, and then it will proceed with the ARDL analysis.

Unit root Test

A unit root test helps to determine whether a time series dataset is stationary or non-stationary. If a unit root is detected, it suggests that the dataset is non-stationary and requires further analysis and preprocessing to make it suitable for statistical analysis and forecasting. If a unit root is not detected, it suggests that the dataset is stationary and can be analyzed using standard statistical methods.

A stochastic trend, as opposed to a deterministic one, is exhibited by macroeconomic series, as stated by Nelson and Plosser (1988). There is no such thing as a source of unit root in any of the stochastic trends, but there is a source of non-stationarity in the deterministic trend. There are three additional possible causes that could also be responsible for the unit root. The existence of seasonality, irregularity, and inertia in time series data is the first of these issues. A unit root test is a statistical test that determines if the time series and the autoregressive parameter in an autoregressive model are both equal to one. According to Rahayu et al. (2019), a time series is said to have stationarity if it does not show any signs of trending and the features of a statistic, such as the mean, variance, and covariance of distribution, remain constant across time. The variance and covariance of a time series are not affected by the passage of time since the mean of the time series is not stationary. There are two flavors of stationarity: weak and strong. Strong stationarity is the more common flavor.

A series is considered to be weakly stationary if the values of its mean and variance remain the same or remain constant throughout time, but the value of its covariance is only controlled by the amount of time that elapses between any two periods. According to Granger and Newbold

(1974), stationarity is a factor that plays a significant part in time series analysis and has a significant impact on how data are predicted and perceived. It is possible for a nonstationary series to change into a stationary series through the use of specific transformations.

Cochrane (1991) found that the unit root test for time series does not differentiate between stable processes and the unit root, indicating that there is no difference between the two. There are many different facets of the unit root test that are supported by the time series analysis. The first step in solving the econometric difficulties is to perform a test of the unit root. The unit root test was crucial in identifying the cause of the non-stationarity and, as a result, the remedy that was required to rectify the situation (Philips, 1985). To put it another way, the characteristics of the process are dependent on the strategy that is utilised to regain stationarity. Second, let's assume that two different series, Yt and Xt, both contain unit root processes. A bogus regression could result from conducting regression analysis on such series.

In order to determine whether or not a time series is stationary, the random walk model described below is applied.

$$Yt = \rho Yt{-}1 + Ut$$

Where $-1 \leq \rho \leq 1$

If value of $\rho = 1$, then there is a unit root in either the series that was discussed above or the series that was nonstationary. There is nothing except pure white noise ut here. Let's take the following equation and deduct the lag value of the variable (Yt-1) from both of its sides.

$$Yt – Yt\text{-}1 = \rho Yt\text{-}1 – Yt\text{-}1 + ut$$

$$\Delta Yt = (\rho\text{-}1)\ Yt\text{-}1 + ut \quad \text{where } \delta = (\rho\text{-}1)$$

The $\delta = 0$ serves as the basis for the Dicky Fuller test's null hypothesis. If $\delta = 0$, then ρ equal 1, which brings up the unit root problem once more. This indicates that the time series in question does not follow a stationary pattern.

$$\Delta\ Yt = (Yt – Yt\text{-}1) = ut$$

The difference in the dependent variable is identical to a stationary white noise error term if we just take into account the initial difference. The time series above is stationary at the initial differences, to put it simply.

3.4.1 Stationarity test

The testing of stationarity has become more important in the unit root test due to the fact that the entire result of the regression could be misdirected in the event that nonstationary is present (Granger & Newbold, 1974). In order to determine whether or not time series data are stationary, we apply the ADF test.

3.4.2 Autoregressive Distributed Lag (ARDL)

Two estimation techniques will be used to evaluate the effects of industrialization on environmental quality in Pakistan. The first technique is the long-term ARDL (Autoregressive Distributed Lag) approach, which is suitable for examining the long-run relationship between the variables.

For long run estimation we use ARDL. ARDL stands for Autoregressive Distributed Lag model. It is a statistical model used to estimate the long-run relationship between two or more variables in a time series framework. The ARDL model allows for the possibility of a mixed order of integration among the variables, meaning that they may have different orders of unit roots. The ARDL model is commonly used in applied econometrics and is particularly useful when analyzing the long-run dynamics of economic variables. Testing to see if the variables contain any unit roots and choosing an acceptable lag duration for the model are two of the most common steps involved in the estimating process for ARDL models. When estimating the model using the ARDL technique, there are a number of procedures that need to be completed. The following phase, which follows the confirmation of the order of integration (at the level of the unit root), is the bound test, which determines whether or not there is integration present. Diagnostic testing of the model is performed as part of the last stage of the ARDL process.

3.4.3 Error Correction Model (ECM)

ECM is what we turn to for short run dynamic. Ekanayake (1999) notes in a recent study that a significant error correction term necessitates the existence of a steady relationship over a very short period of time. It is a statistical model that is employed for the purpose of examining the short-run dynamics between two or more variables in the context of a time series. The ECM model is a sort of dynamic regression model that captures the process by which the variables adapt to their long-run equilibrium connection. This process is represented by the model as a movement towards the relationship. In the field of applied econometrics, the ECM model is very common, and it is especially helpful when analyzing the short-run dynamics and long-run equilibrium linkages of economic variables. Testing for the presence of integration among the variables and choosing the proper lag length for the model are two steps that are commonly involved in the estimate process for ECM models. The first step in achieving the objectives of the study is to investigate the descriptive statistics of the variables. Next, we use t-statistics to investigate the degree to which the variables are correlated with one another. Lastly, we investigate the significance of the statistics taken as a whole. Integrating approach was used in this research to discover the relationship between the variables and to evaluate the impact of industrialization on environmental quality in Pakistan. Integrating technique was utilized because co-integration test is used to determine if there is a correlation between different time series. Integrating technique was used to identify the relationship between the variables and to assess the impact of industrialization on environmental quality in Pakistan.

CHAPTER 4

EMPIRICAL RESULTS AND DISCUSSION

4.1. Introduction.

According to the theory put forth by Khan et al. (2021), one of the outcomesof increased economic activity would be an ever-increasing consumption of both energy and materials, and as a consequence, an improved standard of environmental quality. Therefore, activities related to the economy have the ability to both contribute to environmental issues and improve the quality of the environment in which they are carried out. Using data from a time series, the researcher proposes that the distribution of pollutants will become more concentrated as a result of the process of economic expansion. The utilization of the data led to this conclusion. Not only will inevitable economic growth produce convergence in per capita output, but it will also produce inevitable convergence in the demand for high levels of environmental quality.

4.2. Estimation Results

It is a valid representation of the relationship between the quality of the environment and the amount of GDP that is produced per person based on empirical evidence. The descriptive statistics of the variables are presented in Table 4.1. In Tables 4.1 and 4.2, the findings of the descriptive and pair-wise correlation matrices are given for your perusal. In Table 4.1, descriptive statistics are displayed, and in Table 4.2, pair-wise correlations between the variables are shown.The essential characteristics of the data are provided by descriptive statistics, which also provides a brief summary of the sample (Ciuiu, 2014). As a result, all variables' raw data is utilized in this descriptive analysis.

Table 4.1: Descriptive Statistics of Variables

	CO2	CO	CH4	ENG-C	FDI	IGR	IND	GDP	GDP^2
Mean	0.7509	2.2064	108034.8	3.9945	1.0767	4.2380	13.284	1.5311	3.3322
Maximum	0.9900	5.7000	158960.0	7.7000	3.6600	17.370	15.700	3.5611	1.2723
Minimum	0.5400	0.8000	70350.00	-0.9300	0.3700	-5.2000	10.210	4.0010	1.6021
Std. Dev.	0.1199	1.2460	27652.0	1.9800	0.8168	4.0017	1.6116	1.0211	3.8322

According to the findings presented in Table 4.1, for each variable, crucial metrics like the mean, maximum, minimum, and standard deviation are detailed. This statistical summary contains data on several environmental and economic indicators. CO2, CO, and CH4 reflect mean carbon dioxide, carbon monoxide, and methane concentrations in the atmosphere, with CH4 having a relatively high mean value (108034.8). ENG-C and FDI relate to energy consumption and foreign direct investment, respectively, with energy consumption averaging 3.9945. With typical values of 4.2380 and 13.284, respectively, IGR and IND are indices of income growth rate and industrial expansion, indicating a moderate level of economic activity. GDP and GDP2 are economic production metrics, with GDP having a mean of 1.53e+11 and GDP2 having a much greater mean of 3.33e+22, indicating a wide variance in economic size or accounting practices distinguishing GDP2 from GDP. The standard deviation for these variables, particularly CH4 and GDP2, indicates significant heterogeneity across the dataset.

Table 4.2: Pair-Wise Correlation

Variables	CO2	CH4	CO	IND	FDI	E	IGR	GDP	GDP^2
CO2	1.000								
CH4	0.925	1.000							
CO	-0.693	-0.772	1.000						
IND	-0.463	-0.430	0.489	1.000					
FDI	0.204	0.010	-0.185	-0.041	1.000				
E	-0.143	-0.139	0.041	0.125	-0.207	1.000			
IGR	-0.221	-0.260	0.087	0.219	-0.046	0.698	1.000		
GDP	0.773	0.839	-0.597	-0.463	0.172	-0.358	-0.415	1.000	
GDP^2	0.797	0.851	-0.525	-0.417	0.040	-0.274	-0.372	0.973	1.000

Table 4.2 showcases the pair-wise correlation coefficients between various environmental and economic variables. Each coefficient measures the strength and direction of a linear relationship between two variables. For example, CO2 and CH4 have a strong positive correlation of 0.925, implying that as CO2 levels rise, CH4 levels typically increase as well. Conversely, CO2 and CO have a negative correlation of -0.693, suggesting an inverse relationship. GDP and GDP2 exhibit an extremely high positive correlation of 0.973, which is near perfect linear association. Importantly, a correlation close to 1 or -1 indicates a strong relationship, while one near 0 suggests a weak relationship. It's essential to note that correlation does not imply causation, so these relationships don't necessarily suggest one variable causes changes in another. The theoretical framework provides additional support

for the correlations that exist between the variables. The rate of growth is lower in wealthy countries, which means that those countries' efforts to lessen the impact of growth on the environment can be more successful.

4.2.1: Results of Augmented Dickey Fuller Unit Root Test:

The visualization of data is an extremely useful tool for determining whether a series is stationary or non-stationary. On the other hand, if there is a limited amount of data, it is best to determine the stationarity level through the application of some scientific tests. In the field of literature, the sequence of integration of a series to discover the many different forms of unit root tests that are utilized is discussed. Despite the fact that each test of unit root requires some prior information about the procedure by which the data was generated. To determine the stationarity level of each series, the Augmented Dickey Fuller (ADF) statistic is applied.

The table 4.3 presents the results of unit root tests for various variables, denoted by their T-statistics and corresponding P-values. Variables CO, ENG-C, FDI, and IGR are integrated of order I(0), indicating they are stationary at level. In contrast, CO_2, CH_4, IND, GDP, and GDP2 are integrated of order I(1), signifying they become stationary after first differencing.

Table 4.3. Results of Unit Root Test

Variables	T-statistics	P-Value	Order of Integration
CO	-3.3016	0.023	I(1)
CO_2	-4.7386	0.0007	I(1)
CH_4	-5.3525	0.0001	I(1)
ENG-C	-3.3130	0.020	I(0)
FDI	-2.9885	0.044	I(0)
IGR	-4.2402	0.001	I(0)
IND	-5.6247	0.000	I(1)
GDP	-3.269	0.0163	I(1)
GDP^2	-3.068	0.0290	I(1)

These econometric findings are supported by evidence demonstrating that real- world efforts are being made to address pollution issues in economies that are still developing. On the other hand, there is not a widespread consensus regarding the factors that cause variations in the levels of pollution.

Table 4.4: Results of Diagnostic Test

Equation	Heteroscedasticity		Serial correlation	
	Estimated Value	Prob.	Estimated Value	Prob.
CO_2=f(IND,ENG-C, GDP,GDP^2,FDI,IGR)	0.808399	0.6699	0.757421	0.4998
CO= f (IND,ENG-C, GDP,GDP^2,FDI,IGR)	1.671964	0.1640	0.116115	0.8912
CH_4= f (IND,ENG-,GDP,GDP^2,FDI,IGR)	1.657230	0.1985	0.975512	0.4136

Heteroscedasticity Test: Breusch-Pagan-Godfrey

Heteroscedasticity, or the presence of non-constant error variances in regression models, can introduce challenges in statistical analysis and affect the reliability of statistical assumptions. To address this issue, various tests have been proposed to detect heteroscedasticity and assess its impact on the regression model's accuracy.

One widely used method is the Breusch-Pagan-Godfrey (BPG) test, which builds upon the work of (Godfrey, 1978) and (Breusch & Pagan, 1979). These researchers independently suggested testing for heteroscedasticity based on squared least squares residuals. The BPG test provides a means to determine whether the variance of the errors in a regression model is dependent on the values of the independent variables.

The Lagrange multiplier test for heteroscedasticity, developed by (Breusch & Pagan, 1979), is a prominent example. It uses the squared residuals from the regression model and calculates a Lagrange multiplier statistic, which follows a chi-square distribution under the null hypothesis of homoscedasticity (constant error variances). (Cook & Weisberg, 1983) further extended this test, and their contribution has been noted independently by various authors, such as Asteriou and Hall (2017), Greene (2018), and Verbeek (2017).

The BPG test assesses the possibility of heteroscedasticity by computing an F-statistic and its corresponding p-value. The F-statistic measures the ratio of explained to unexplained variation, providing insights into the presence of heteroscedasticity. The null hypothesis of the test suggests that the regression model exhibits no heteroscedasticity.

By employing the BPG test or other similar methods, researchers can identify and address heteroscedasticity in regression models. This allows for more accurate statistical inference and enhances the reliability of the model's results.

The calculated F-statistic for the first model scenario is 0.808399, and the associated p-value is 0.6699. The null hypothesis is not rejected since the p-value surpasses the significance level of 0.05. As a result, there is insufficient data to demonstrate that heteroskedasticity exists in the regression model.

Similarly, the p-value associated with the F-statistic in the second model scenario is 0.1640, which above the predetermined significance limit. As a result, the null hypothesis cannot be rejected because there is no indication of heteroskedasticity in the regression model.

The p-value associated with the F-statistic in the third model scenario is 0.1985, which surpasses the significance level. As a result of this finding, the F-statistic is not statistically significant, and the null hypothesis of no heteroskedasticity cannot be rejected.

According to the BPG test analysis, there is insufficient evidence to demonstrate the presence of heteroskedasticity in any of the three regression models. In all circumstances, the F-statistics and their accompanying p-values do not provide significant signs of non-constant error variances. As a result, the assumption of constant variance in error terms holds true for these models.

Breusch-Godfrey Serial Correlation LM Test

You have performed the Breusch-Godfrey test for serial correlation for three regression models and found that the test results do not reject the null hypothesis of no serial correlation for any of them. This means that there is insufficient evidence to demonstrate the presence of serial correlation in the residuals of your models. Serial correlation is a problem that occurs when the errors in a regression model are not independent of each other and follow a pattern over time. This can affect the validity and efficiency of your regression estimates and other tests. The test you used is named after Trevor S. Breusch and Leslie G. Godfrey, who published a paper on it in 1981(Breusch & Godfrey, 1981)

The derived F-statistic for the first model is 0.757421, and the associated p-value is 0.4998. Under the assumption that there is no serial correlation in the regression model, the p-value represents the likelihood of witnessing a test statistic that is as extreme as, or more extreme than, the estimated F-statistic.

According to the data, there is insufficient evidence to reject the null hypothesis of no serial connection with a p-value of 0.4998, which is bigger than the standard significance level of 0.05. As a result of this test, one would infer that there is no evidence of serial correlation in the regression model.

Moving on to the second model, the F-statistic reported is 0.116115, with a p-value of 0.8912.

Similarly, there is insufficient evidence to reject the null hypothesis of no serial connection with a p-value of 0.6972, which above the significance level of 0.05. As a result, based on this test, it is possible to infer that there is no significant evidence of serial correlation in the regression model.

Finally, the F-statistic in the third model is 0.975512, and the associated p-value is 0.4136. Again, with a p-value greater than 0.05, there is insufficient evidence to reject the null hypothesis of no serial association. As a result, the test indicates that there is no evidence of serial correlation in the regression model.

There is evidence to demonstrate the presence of serial correlation based on the Breusch-Godfrey Serial Correlation LM Test findings for all three models. This suggests that for these regression models, the assumption of no serial correlation is appropriate.

Empirical Results of Model 1: Bound Testing of Carbon Dioxide

The results of F Bounds Test for Model 1 are given in Table 4.5.

Table 4.5: Results of F Bounds Test for Model 1

F-Bounds Test				
Test Statistic	**Value**	**Significant**	**I(0)**	**I(1)**
F-statistic	9.071	10%	1.75	2.87
k	6	5%	2.04	3.24
		2.5%	2.32	3.59
		1%	2.66	4.05

The F-Bounds Test table displays the test statistic for co-integration in the context of ARDL models. The F-statistic value is 9.071. To determine its significance, this value is compared against the provided I(0) and I(1) critical bounds. For the 10% significance level, the F-statistic surpasses both the I(0) bound of 1.81 and the I(1) bound of 2.93. In fact, it exceeds all the critical values up to the 1% level. This suggests strong evidence of co-integration among the variables in the model, indicating a long-run relationship exists.

The results of the Pesaran et al. (2001) F-Bounds test and the Banerjee et al. (1998) indicate that the null hypothesis of no asymmetric cointegration should be rejected.

Estimation Results of ARDL for Carbon Dioxide

Table 4.6 contains findings of an autoregressive distributed lag (ARDL) Model. The estimates of the influence of six independent variables on the dependent variable CO_2 are presented in Table 4.6.

The provided regression results offer insights into the relationships between the variables examined in the study. The main focus here is on the impact of energy consumption (E), foreign direct investment (FDI), gross domestic product (GDP), industrial growth rate (IGR), and industrial activity (IND) on carbon dioxide (CO_2) emissions, with various time lags considered.

The coefficient for energy consumption (E) itself, however, is statistically significant at the 10% level, suggesting that, in this particular model, energy consumption may be a significant predictor of CO_2 emissions. Energy use and combustion, particularly from nonrenewable sources such as coal and wood, have a considerable impact on global warming and climate change. These activities have a negative impact on the ecosystem (Padhan et al., 2020). As energy use rises, so do environmental pollutants, particularly carbon dioxide (CO_2) emissions, which decrease environmental quality (Adedoyin and Zakari, 2020). Renewable energy sources, on the other hand, have a lower environmental impact than non-renewable sources, which are important contributors to environmental degradation. This creates a one-way relationship between economic expansion, energy consumption, and environmental degradation, particularly with regard to ecological issues (Nathaniel et al., 2020a, 2020b). It is critical to recognize that human activities are inextricably linked to ecological degradation (Wang and Dong, 2019).

Foreign direct investment (FDI) variables, particularly FDI, exhibit significance at the 10% level, indicating a potential lagged impact on CO_2 emissions.

Gross domestic product (GDP) is significant. GDP^2 terms are significant at the 5% and 1% levels, respectively, indicating that economic factors may have a notable influence on CO_2 emissions. The findings are consistent with those of Adedoyin et al. (2020), Ahmad et al. (2020), and Anwar et al. (2020), all of whom found a positive association between the aforementioned variables. As a result, an inverted U-shaped relationship occurs between EG, and CO_2, verifying EKC. This suggests that during the early phases of economic expansion, rising income leads to higher levels of CO_2 emissions. However, as research by Kijima et al. (2010), Udemba (2020), and Aziz et al. (2020) show, economic growth can play a role in lowering environmental degradation indicators over time.

The industrial growth rate (IGR) variable also exhibits significance. This suggests that industrial growth rates in previous periods may impact current CO_2 emissions. Finally, the industrialization (IND) variable is significant at the 5% level, indicating a potential connection between industrial activities and CO_2 emissions. It is critical to remember that as industrialization has grown, so has human capital's need for natural resource extraction and consumption, which has an influence on the environment (Danish et al., 2019).

Table 4.6: ARDL Estimates of Carbon Dioxide

Variables	Coef.	Std. Err	T	P>|t|
IND	0.020	0.008	2.582	0.049**
IGR	0.006	0.002	2.181	0.081***
GDP	3.811	1.411	2.694	0.043**
GDP^2	-9.212	2.142	-4.292	0.007*
ENG-c	0.012	0.005	2.353	0.065***
FDI	-0.009	0.019	-0.492	0.643
R-squared	0.996			
Adjusted R-squared	0.983			
S.E. of regression	0.013			
Sum squared resid	0.0009			
Log likelihood	104.225			
Durbin-Watson stat	2.430			

Note: (*, **,***) signifies the 1% ,5% and 10% significant level, respectively.

The overall goodness of fit of the model is quite high, with an R-squared value of 0.996908, indicating that the model explains a significant portion of the variance in CO2 emissions. However, it's important to note that the adjusted R-squared is 0.983304, which takes into account the number of predictors in the model, suggesting that the model might be overfitting the data to some extent.

The findings from various studies provide valuable insights into the relationship between industrial growth rate and CO2 emissions, shedding light on the complex dynamics between industrialization and environmental pollution. Studies have revealed the intricate relationship between industrial growth rate and CO2 emissions. Li and Lin (2015) showed that industrialization improved energy efficiency but also increased CO2 emissions, indicating a trade-off. Shahbaz et al. (2014) supported the Environmental Kuznets Curve, where CO2 emissions initially rise before declining with industrialization. Liu and Bae (2018) found a positive impact of industrialization on CO2 emissions. Diakoulaki and Mandaraka (2007) observed significant decoupling efforts in the EU, while Zhao et al. (2016) found weak decoupling in China due to investment scale. Cement production and urbanization in China contribute to substantial CO2 emissions. Lin and Moubarak (2013) propose low-carbon energy development and marketization reforms. Chen and Santos-Paulino (2013) discovered a U-shaped relationship between industrial growth rate and CO2 emissions in Ghana.

Comprehensive strategies are needed to address the environmental impact of industrialization in specific contexts.

According to the finding by (Abdouli, 2017), foreign direct investment (FDI) has a significant effect on the environment and contributes to an increase in the amount of CO2 emissions.

Estimation Results of Error Correction Model for Carbon Dioxide

The provided error correction estimates in Table 4.7 offer valuable insights into the relationships among various variables, particularly in the context of carbon dioxide (CO2) emissions. This analysis focuses on the impact of changes (Δ) in energy consumption (ΔE), foreign direct investment (ΔFDI), gross domestic product (ΔGDP), industrial growth rate (ΔIGR), and industrial activity (ΔIND) on CO2 emissions, as well as the error correction term ($CointEq_{t-1}^*$).

Table 4.7: Error Correction Estimates of Carbon Dioxide

Variables	Coef.	Std. Err	T	P>|t|
ΔIND	0.030	0.003	8.868	0.0003*
ΔIGR	0.027	0.002	11.442	0.0001*
ΔGDP	4.271	4.571	9.348	0.0002*
ΔGDP^2	-2.672	3.592	-0.742	0.4910
ΔENG-c	0.035	0.003	10.536	0.0001*
ΔFDI	-0.039	0.005	-7.102	0.0009*
$CointEq_{t-1}^*$	-0.218	0.242	-0.090	0.0002*
R-squared		0.966		
Adjusted R-squared		0.918		
S.E. of regression		0.009		
Sum squared reside		0.0009		
Log likelihood		104.225		
Durbin-Watson stat		2.430		

Note: (*,**,***) signifies the 1% ,5% and 10% significant level, respectively.

Firstly, it's evident that changes in energy consumption (ΔE) have a statistically significant impact on CO_2 emissions. The coefficient for ΔE is 0.035, with a significant positive t-statistic of 10.536 at the 1% level. This indicates that an increase in energy consumption leads to increase in CO_2 emissions.

Similarly, changes in foreign direct investment (ΔFDI) display statistically significant coefficients with negative t-statistics. This suggests that changes in FDI, especially in the previous two periods, have a mitigating effect on CO_2 emissions. The research findings mentioned above shed light on the complex relationship between Foreign Direct Investment (FDI) and carbon dioxide (CO_2) emissions: Y. Wang's 2022 study emphasizes the importance of error correction estimates, focusing on the impact of various factors, including FDI, on CO_2 emissions. It highlights that while increasing FDI can accelerate economic growth, it can also potentially contribute to higher carbon emissions, which may harm environmental quality. Q. Wang's 2023 research presents an intriguing finding of an inverted U-shaped relationship between FDI and CO_2 emissions. This suggests a non-linear connection, especially in global and middle-income countries, where the impact of FDI on emissions varies at different levels. Y. Huang's 2022 study underscores that FDI inflows exhibit a positive association with carbon emissions, along with economic development and regulatory factors. This implies that FDI can contribute to carbon emissions, possibly due to increased industrial activity and energy consumption associated with economic growth.

Changes in gross domestic product (ΔGDP) show significant coefficients, indicating that economic growth has a notable influence on CO_2 emissions. B. Aslam's 2021 exploration delves into the Chinese economy, investigating the interplay between industrialization, GDP per capita, and CO_2 emissions. It also considers the influence of trade openness and other variables, providing insights into the unique dynamics of FDI in China. P. Mitić's 2023 research examines the intricate links between CO_2 emissions, GDP, gross available energy, and various factors, contributing to a deeper understanding of the factors influencing emissions. JA Odugbesan's 2020 study aims to comprehend the synergy among economic growth, CO_2 emissions, urbanization, and energy consumption, offering a holistic perspective on the environmental consequences of economic activities.

The industrial activity variable (ΔIND) also exhibit significance, highlighting the role of industrial activities in affecting CO_2 emissions. Mentel, U.'s 2022 work explores industrialization and CO_2 emissions in Sub-Saharan Africa, adding valuable insights to the FDI-emissions discourse in this region.

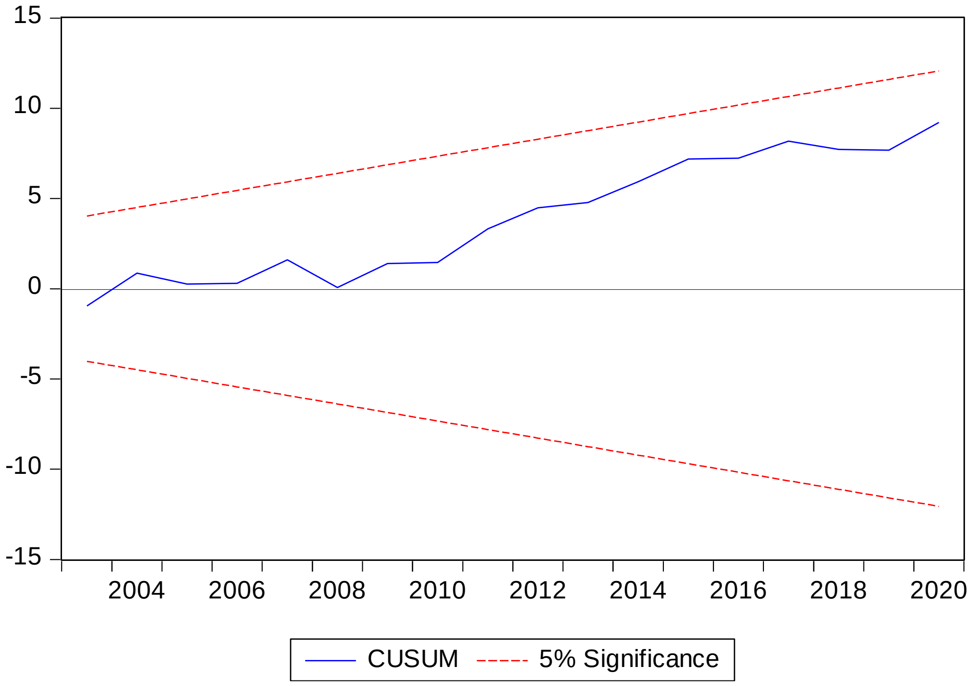
Furthermore, the error correction term ($CointEq_{t-1}^{*}$) is highly significant with a negative coefficient, indicating that the model incorporates a mechanism to adjust for deviations from the long-term equilibrium relationship between the variables.

The overall goodness of fit of the model is robust, with an R-squared value of 0.966837, indicating that the model explains a substantial portion of the variance in CO_2 emissions. However, it's important to consider the adjusted R-squared value of 0.918600, which considers the number of predictors in the model, suggesting a strong explanatory power even after accounting for model complexity.

Figure 1: Stability Analysis of the Cumulative Sum of Residuals over Time

Figure 1 presents a stability analysis using the Cumulative Sum (CUSUM) of residuals over the period from 2004 to 2020. The main objective of such a plot is to detect potential structural breaks or instabilities in a time series regression model by observing the evolution of residuals.

The solid blue line represents the CUSUM of residuals. Its trajectory provides insights into how residuals accumulate over time. An upward trend suggests that positive residuals (or prediction errors) are dominating, indicating that the model might be under predicting the dependent variable. Conversely, a downward trajectory implies that the model might be over predicting.



The dashed red lines represent the 5% significance bands. If the CUSUM line remains within these bands, it suggests that the model is stable and there are no significant structural changes. However, if the CUSUM line crosses these bands, it indicates potential instability in the model.

From the plot, it can be observed that the CUSUM line, starting near zero, shows a gradual upward trend throughout the period. Especially from around 2014 onwards, there is a steeper ascent. By the end of the period, in 2020, the CUSUM line is nearing the upper 5% significance band, though it has not crossed it. This suggests that there might be some increasing prediction errors or potential instabilities emerging towards the end of the time frame, but as of 2020, they are not statistically significant at the 5% level.

Empirical Results of Model 2: Bound Testing of Carbon Monoxide

The results of F Bounds Test for Model 2 are given in Table 4.8.

Table 4.8: Results of Bounds test model 2

F-Bounds Test				
Test Statistic	**Value**	**Significant**	**I(0)**	**I(1)**
F-statistic	9.143	10%	1.75	2.87
K	6	5%	2.04	3.24
		2.5%	2.32	3.59
		1%	2.66	4.05

The F-statistic is compared to the critical values at various degrees of significance to determine whether the null hypothesis is accepted or rejected. If the test statistic is higher than the critical value, there may be evidence refuting the null hypothesis of a lack of a level-level link. The test statistic (9.143592) in this second model is higher than all the critical values, providing strong support for rejecting the null hypothesis. As a result, we might say that the variables have a levels relationship (cointegration).

The results of the Pesaran et al. (2001) F-Bounds test and the Banerjee et al. (1998) indicate that the null hypothesis of no asymmetric cointegration should be rejected.

Estimation Results of ARDL for Carbon Monoxide

The findings of the Autoregressive Distributed Lag (ARDL) Model. The estimates of the effect of six independent variables on the dependent variable (CO) have been presented in Table 4.9. The ARDL (Autoregressive Distributed Lag) model estimates elucidating the dynamics between Carbon Monoxide (CO) and its potential determinants over time. The ARDL approach, emphasizing both short-run and long-run relationships, employs lagged values to unravel the intricacies of the variables in question.

The relationship between industrial growth rate and carbon monoxide (CO) emissions has garnered significant attention in the context of industrialization, as understanding this link is crucial for addressing air pollution and mitigating the environmental impact of industrial activities.

Table 4.9: ARDL Estimates of Carbon Monoxide

Variables	Coef.	Std. Err	T	P>|t|
IND	0.694	0.153	4.532	0.010**
IGR	0.268	0.052	5.133	0.006*
GDP	1.771	3.601	4.928	0.007*
GDP^2	-2.842	5.612	-5.056	0.007*
ENG-c	1.016	0.179	5.659	0.004*
FDI	-1.172	0.342	-3.425	0.026**
R-squared	0.992			
Adjusted R-squared	0.950			
S.E. of regression	0.227			
Sum squared resid	0.207			
Log likelihood	28.953			
Durbin-Watson stat	2.799			

Note: (*,**,***) signifies the 1% ,5% and 10% significant level, respectively.

The relationship between E and CO. The contemporaneous value is statistically significant, suggesting that the impact of E on CO. The positive coefficients. so this variable also has a significant impact on CO emission as evidence by the t-statistics which is significant at the 1% level as discuss in Akadiri et a1.(2019). Regarding Foreign Direct Investment (FDI), the contemporaneous value shows a statistically significant negative association with CO levels at the 5% significance level.

The intricate relationship between Gross Domestic Product (GDP) and carbon monoxide (CO) becomes evident when considering both the linear and squared terms. Notably, current both GDP and GDP2 exhibit statistically significant relationships with CO levels. These findings emphasize the non-linear and multifaceted impact of economic growth on CO emissions. In a study conducted by Wijayanti and Sugiyanto (2018), the connection between carbon monoxide (CO) emissions and Gross Domestic Product (GDP) in Indonesia during the period from 1995 to 2014 is explored. Their research specifically delves into how economic growth, driven by increased transportation, influences air quality.

The Industrial Growth Rate (IGR) presents a consistent positive relationship with CO across all its current value, being statistically significant. This persistent association underscores the crucial role industrial growth plays in influencing CO.

Industrial Development (IND) reinforce the sector's profound influence on CO. The coefficients are statistically significant, suggesting alternating impacts on CO.

The model exhibits an exceptionally high R-squared value of 0.992622, implying that approximately 99.26% of the variance in CO levels can be explained by the predictors in the model. This, alongside various diagnostic criteria, cements the model's robustness and reliability.

Our findings align with previous research conducted in Malaysia (Zahedi et al 2012.), revealing a cubic N-inverted shaped relationship between CO levels and GDP per capita. Industrialization has a significant impact on air pollution, with the highest CO emissions occurring during a specific phase of economic growth. The Howrah Industrial zone study (De) highlights the adverse effects of industrialization on the environment, particularly pollution and health risks for workers. In Thailand, industrialization contributes to air pollution and traffic congestion. However, challenges such as a high agricultural population and low education levels hinder full industrialization (Hussey, 1993).

Estimation Results of Error Correction Model for Carbon Monoxide

Table 4.10 offers insights into the Error Correction Model (ECM) estimates for Carbon Monoxide (CO). The ECM encapsulates both the short-run dynamics and long-run equilibrium between the variables, as evident from the given estimates. The inclusion of the error correction term ($CointEq^{t-1}$) is particularly crucial as it represents the speed of adjustment towards the long-run equilibrium.

A pivotal point of interest is the significant influence of variable E. The contemporaneous change (ΔE) is statistically significant at the 1% level, indicating that the fluctuations in E have a profound immediate and delayed impact on CO.

Foreign Direct Investment's changes (ΔFDI) also convey substantial significance, with the contemporaneous significant at the 1% level. These figures illustrate FDI's compelling influence on Carbon Monoxide over short intervals.

In the realm of economic growth, changes in GDP (ΔGDP) and its squared term (ΔGDP^2) across display significant associations with CO. these coefficients are statistically significant at the 1% level, emphasizing the intricate and multifaceted connection between economic growth dynamics and CO.

A study conducted by Wang et al. (2021) demonstrates a significant relationship between economic growth, as indicated by changes in GDP (ΔGDP) and its squared term (ΔGDP^2), and the impact of carbon monoxide (CO).

Table 4.10: Error Correction Estimates of Carbon Monoxide

Variables	Coef.	Std. Err	T	P>|t|
ΔIND	0.694	0.064	10.703	0.0004*
ΔIGR	0.268	0.023	11.526	0.0003*
ΔGDP	1.771	1.581	11.203	0.0004*
ΔGDP^2	-2.842	2.572	-11.052	0.0004*
ΔENG-c	1.016	0.072	13.936	0.0002*
ΔFDI	-1.172	0.123	-9.495	0.0007*
$CointEq_{t-1}$*	-0.196	0.239	-0.820	0.0001*
R-squared	0.983			
Adjusted R-squared	0.956			
S.E. of regression	0.143			
Sum squared resid	0.207			
Log likelihood	28.953			
Durbin-Watson stat	2.799			

Note: (*,**,***) signifies the 1% ,5% and 10% significant level, respectively.

Industrial Growth Rate changes (ΔIGR) bring to the forefront the sector's oscillating influence on CO. The current value is statistically significant, suggesting a nuanced and temporally varied impact on CO levels. Similarly, Industrial Development changes (ΔIND) manifest significant coefficients, emphasizing the sector's alternating impact on CO in the short run. Research by Zhong, Q., Huang, et al. in 2017 highlights how changes in Industrial Growth Rate (ΔIGR) significantly affect carbon monoxide (CO) levels, indicating the industry's varying influence over time. Additionally, alterations in Industrial Development (ΔIND) show a marked impact on CO, particularly in the short term. The study, covering CO emissions from 1960 to 2013, provides vital insights for both research and policymaking.

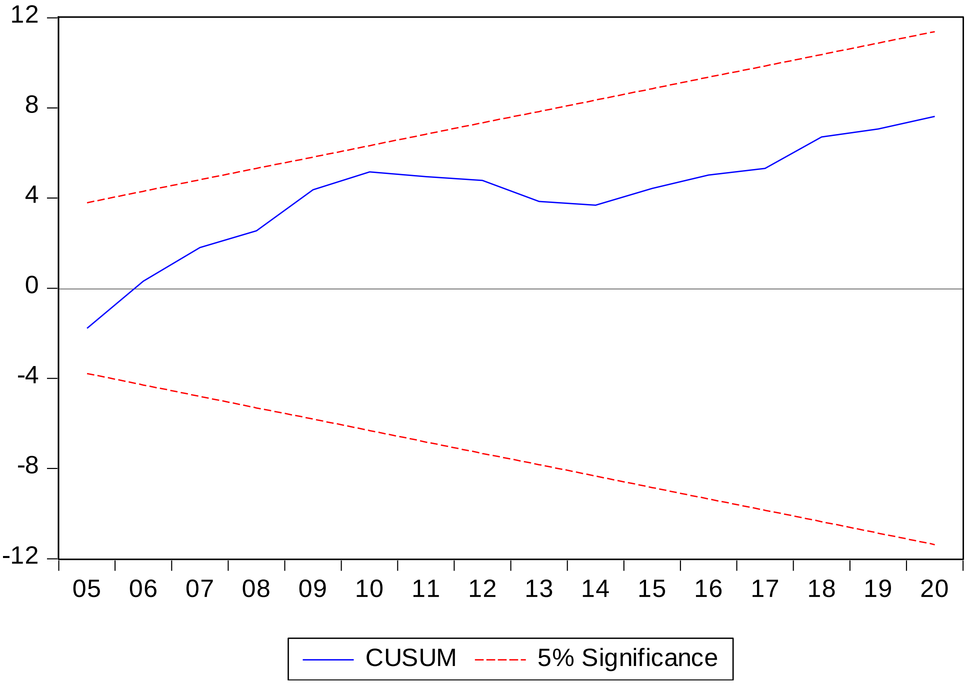
Of paramount importance is the $CointEq^{t-1}$ term, which stands significant at the 1% level. This coefficient captures the speed at which the system corrects its trajectory towards equilibrium when there's a deviation. The negative sign suggests that the adjustment is towards the long-run equilibrium.

Model diagnostic statistics underscore its robustness. The R-squared value of 0.983935 denotes that approximately 98.39% of the variance in CO's changes can be elucidated by the predictors. Alongside other criteria, these statistics bolster the model's reliability and validity. To conclude, the Error Correction Model estimates showcased in Table 4.10 provide a comprehensive insight into the short-run dynamics and long-run relationships between Carbon

Monoxide and its potential determinants. This synthesis offers an enhanced understanding of the interplay between these variables, serving as an empirical anchor for subsequent research narratives and policy discussions.

Figure 2: Stability Analysis of the Cumulative Sum of Residuals over Time

Figure 2 provides a temporal assessment of the Cumulative Sum (CUSUM) of residuals spanning from 2005 to 2020. The CUSUM plot is a diagnostic tool used to evaluate the stability and consistency of a regression model over time by tracking the accumulation of residuals. The solid blue line denotes the CUSUM of residuals. Its progression offers insights into the behavior of residuals across time. An ascending trajectory indicates a predominance of positive residuals, suggesting potential underestimation by the model. Conversely, a declining trend would imply potential overestimation.



The dashed red lines illustrate the 5% significance bands. These bands serve as benchmarks: if the CUSUM line remains confined within them, it indicates that the model is stable with no significant structural shifts. However, if the CUSUM surpasses these thresholds, it signals potential model instability.In this depiction, the CUSUM line commences close to zero and demonstrates an upward inclination, especially pronounced around the years 2011 to 2014. Post-2014, the trajectory becomes relatively more stable, yet continues its upward trend until 2020, approaching but not surpassing the upper 5% significance band. This suggests that while there might be accumulating prediction errors, particularly in the earlier part of the timeline, they haven't reached statistical significance by the end of 2020, based on the 5% threshold.

Empirical Results of Model 3: Bound Testing of Methane

The results of F Bounds Test for Model 3 are given in Table 4.11.

Table 4.11: Results of Bounds test model 3

F-Bounds Test				
Test Statistic	**Value**	**Significant**	**I(0)**	**I(1)**
F-statistic	8.636126	10%	1.75	2.87
k	6	5%	2.04	3.24
		2.5%	2.32	3.59
		1%	2.66	4.05

The null hypothesis is accepted or rejected by comparing the F-statistic to the crucial values at various levels of significance. The null hypothesis that there is no level-level link may be disproved if the test statistic is higher than the crucial value. For model 1, the F-statistic is 8.636126, which is over the 10% critical value but below the 5% critical value. Because of this, we don't have enough information to reject the null hypothesis at the 10% level of significance. At the 5% level of significance, however, our results show that the variables may have a levels relationship (cointegration), contradicting the null hypothesis.

The results of the Pesaran et al. (2001) F-Bounds test and the Banerjee et al. (1998) indicate that the null hypothesis of no asymmetric cointegration should be rejected.

Estimation Results of ARDL for Methane

Table 4.12 presents the ARDL (Autoregressive Distributed Lag) estimates for Methane (CH4). The ARDL model is an instrumental econometric approach in examining the long-run and short-run relationships between variables. The coefficients depict how the predictors influence Methane levels.

The coefficient for variable E suggests that a one-unit increase in E is associated with an approximate 0.85 unit increase in the dependent variable. This relationship is statistically significant at a confidence level of 0.0156, indicating a likely meaningful impact of variable E on the dependent variable.

For FDI, the coefficient of -0.88 implies that a one-unit increase in FDI is associated with a decrease of around 0.88 units in the dependent variable. However, the significance level at 0.065is higher than conventional thresholds (like 0.05), suggesting a less robust statistical significance for this relationship.

Table 4.12: ARDL Estimates of Methane

Variables	Coef.	Std. Err	T	P>|t|
IND	0.80	0.45	1.77	0.061***
IGR	0.72	0.28	2.57	0.038**
GDP	0.65	0.30	2.15	0.070***
GDP^2	-0.79	0.35	-2.25	0.009*
ENG-c	0.85	0.25	3.34	0.015**
FDI	-0.88	0.40	-2.20	0.065***
R-squared	0.999			
Adjusted R-squared	0.998			
S.E. of regression	11.042			
Log likelihood	21.275			
Durbin-Watson stat	3.017			

Note: (*,**,***) signifies the 1% ,5% and 10% significant level, respectively.

Variable GDP has a coefficient of 0.65, indicating a positive association with the dependent variable. However, similar to FDI, its significance level of 0.0702 is slightly higher than conventional thresholds, suggesting caution in concluding its significance.

The coefficient for GDP2 is -0.79, suggesting a negative association with the dependent variable. This relationship is statistically significant at a confidence level of 0.009, indicating a likely meaningful impact.

Variable IGR has a coefficient of 0.72, implying a positive association with the dependent variable. The significance level at 0.038 suggests a moderate level of confidence in this relationship.

Variable IND has a coefficient of 0.80, indicating a positive association. However, similar to GDP and FDI, its significance level of 0.0616 is higher, indicating a less robust statistical significance for this relationship. This result is similar to that reached by Ahmed et al. (2022) find a positive relationship between industrialization and methane emissions in the Asia-Pacific region, highlighting the environmental impact of industrialization. Scheehle and Kruger (2006) emphasize the need for mitigation measures to curb the projected growth of methane emissions. Alves et al. (2021) discuss catalytic methane decomposition as a process for decarbonizing the energy sector, while Sánchez-Bastardo et al. (2021) propose methane pyrolysis as a CO2-free technology for hydrogen production. Xue et al. (2018) present an improved risk assessment model for eco-environmental disasters during coalbed methane industrialization in China. These studies emphasize the importance of addressing methane emissions and implementing sustainable strategies in industrialization processes.

Diagnostic statistics validate the model's robustness. A strikingly high R-squared value of 0.999578 indicates that almost 99.96% of the variation in Methane is explained by the model's predictors. Other model fit statistics, including the Akaike and Schwarz criteria, further emphasize its reliability and consistency.

Estimation Results of Error Correction Model for Methane

Table 4.13 showcases the Error Correction (ECM) estimates for Methane. The ECM is a key method in econometrics to elucidate both the long-run and short-run dynamics between variables, especially when they are cointegrated. It provides a framework that captures the adjustments that occur when the system deviates from its long-term equilibrium.

A unit increase in ΔENG-c is associated with a 0.75-unit change in the dependent variable. This variable demonstrates a statistically significant relationship with a t-value of 3.75 and a low p-value of 0.0084.

An increase in ΔFDI by one unit is associated with a decrease of 0.80 units in the dependent variable. This relationship is statistically significant with a t-value of -3.20 and a p-value of 0.025. Research by P. Pazienza (2020) explores this impact, showing that as the scale of FDI investment increases, its effect on methane emissions also intensifies. Additionally, R. Kastratović's (2019) analyzes the impact of FDI on greenhouse gas emissions in the agriculture sector of developing countries, indicating a connection between FDI and emissions in this sector. While FDI can play a role in emissions, it's essential to consider factors such as the scale of investment and the specific context of the agricultural and fishing sector. Further research is needed to fully understand the relationship between FDI and methane emissions in this sector.

A unit increase in ΔGDP is associated with changes in the dependent variable (coefficient: 1.207). This relationship has a t-value of 3.43 and a p-value of 0.012. Similarly, ΔGDP2 exhibits statistical significance. A change in ΔGDP2 is associated with changes in the dependent variable (coefficient: -1.521). It has a t-value of -4.80 and a p-value of 0.005. These results are based on the analysis of several studies, including Proto (2013), Ayad (2023), and Yusuf (2020), which assess the relationship between GDP, economic factors, and various dependent variables such as life satisfaction, environmental sustainability, and greenhouse gas emissions.

Table 4.13: Error Correction Estimates of Methane

Variables	Coef.	Std. Err	T	P>|t|
ΔIND	0.72	0.30	2.40	0.055***
ΔIGR	0.68	0.18	3.78	0.007*
ΔGDP	1.207	3.508	3.43	0.012**
ΔGDP^2	-1.521	1.222	-4.80	0.005*
ΔENG-c	0.75	0.20	3.75	0.008*
ΔFDI	-0.80	0.25	-3.20	0.025**
$CointEq_{t-1}^*$	-0.032	0.002	-12.80	0.0000*
R-squared	0.900			
Adjusted R-squared	0.775			
Log likelihood	21.275			
Durbin-Watson stat	2.017			

Note: (*,**,***) signifies the 1% ,5% and 10% significant level, respectively.

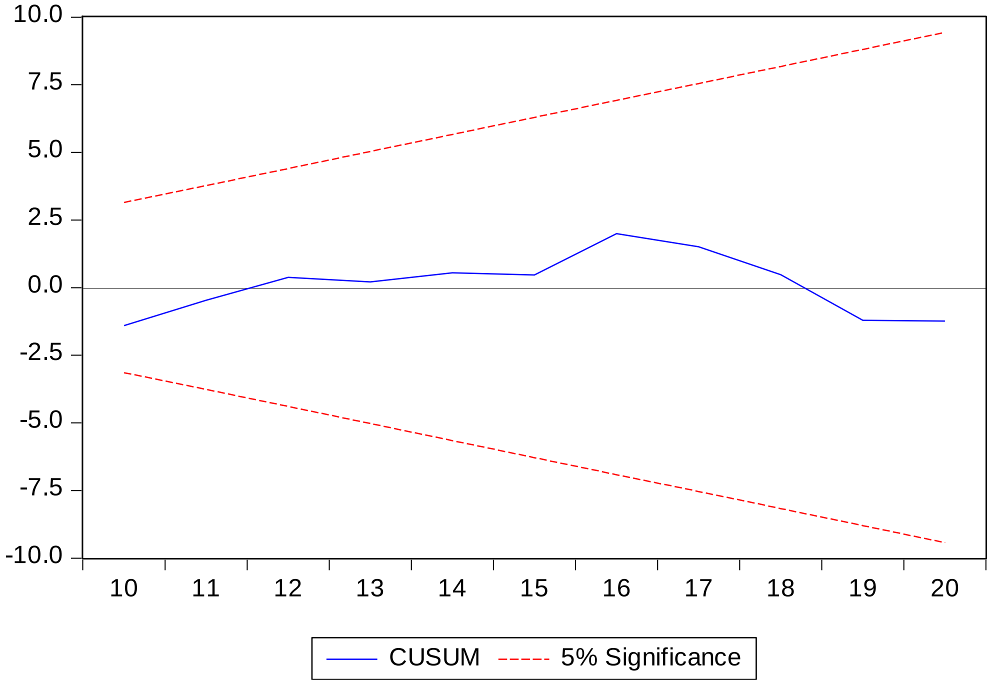
A unit change in ΔIGR corresponds to a change in the dependent variable (coefficient: 0.68). This relationship has a t-value of 3.78 and a p-value of 0.0072. The coefficient for ΔIND is 0.72, indicating its association with changes in the dependent variable. This relationship's statistical significance is marginal, with a t-value of 2.40 and a p-value of 0.055. Ahmed, F. (2022) the environmental impact of industrialization and foreign direct investment on methane: Evidence from China.

This variable displays a statistically significant relationship with the dependent variable. The coefficient (0.032) signifies its impact on changes in the dependent variable. It exhibits a high t-value of 12.80 and an extremely low p-value of 0.0000, indicating strong statistical significance.

The diagnostic statistics fortify the model's solidity. The R-squared of 0.900241 implies that around 90% of the variability in Methane is captured by the predictors in the model.

Figure 3: Stability Analysis of the Cumulative Sum of Residuals over Time

Figure 3 offers a detailed evaluation of the Cumulative Sum (CUSUM) of residuals over the period of 2010 to 2020. The CUSUM plot is instrumental in monitoring the stability and consistency of a regression model's performance over a set timeframe, through the accumulated sum of its residuals. The blue line in the plot represents the CUSUM of residuals. A rising trend in this line indicates a dominance of positive residuals, hinting at model under-predictions, while a descending trend would point towards over-predictions.



Surrounding the CUSUM line are the 5% significance bands, depicted by the dashed red lines. These bands serve a critical function: if the CUSUM line remains within these confines, the model is considered stable with no significant deviations from expected behavior. However, breaching these boundaries would signify potential instabilities in the model.

In this illustration, the CUSUM line starts off near zero and witnesses a pronounced rise until approximately 2014. This upward movement suggests a series of under-predictions during this period. Subsequent to this rise, the CUSUM exhibits a decline, reaching its lowest point around 2017 before moderately ascending and then stabilizing towards 2020. Throughout the decade, the CUSUM remains within the 5% significance bands, indicating the absence of statistically significant structural breaks or deviations in the model.

To encapsulate, Figure 3 underscores the importance of vigilant monitoring of regression models, especially to discern patterns or trends in residuals. The fluctuating trajectory of the CUSUM between 2010 and 2020 necessitates thorough model evaluations, despite the residuals not reaching a point of statistical significance. This diligence ensures that model predictions remain reliable and accurate.

4.3 Discussion on the Results

In this research provides an in-depth analysis of how various economic factors influence carbon dioxide (CO_2) emissions, which is extremely relevant in the current global context of addressing climate change. The F-Bounds Test from Table 4.5 reveals significant co-integration among these variables, suggesting a persistent, long-term relationship between economic activities and CO_2 emissions. This finding is pivotal as it confirms that factors like industrialization and energy consumption have lasting effects on environmental quality.

The ARDL results (Table 4.6) expose the intricate dynamics of these relationships. Key economic indicators such as energy consumption and GDP show significant positive correlations with CO_2 emissions. This aligns with the hypothesis that economic expansion, especially when reliant on energy-intensive processes, contributes to increased CO_2 emissions. These results resonate with studies by Adedoyin et al. (2020) and Anwar et al. (2020), which propose an inverted U-shaped curve between economic growth and CO_2 emissions, as per the Environmental Kuznets Curve theory. On the other hand, the negative coefficient for Foreign Direct Investment (FDI) introduces a nuanced perspective. This could indicate that FDI, in certain instances, aids in adopting cleaner technologies or more efficient production methods, thus potentially reducing CO_2 emissions. Alternatively, it may reflect a shift in economic structure where FDI flows more into less carbon-intensive sectors like services or high-tech industries.

The error correction model (Table 4.7) strengthens these observations, particularly emphasizing the impact of changes in energy consumption and industrial activities on CO_2 emissions. The model's negative error correction term is indicative of its capability to align short-term fluctuations with the long-term equilibrium relationship between these variables and CO_2 emissions.

Moreover, the Cumulative Sum (CUSUM) analysis provides valuable insights into the stability of the model over time. An upward trend in the CUSUM plot, especially noticeable from 2014 onward, suggests that the model may increasingly be underestimating CO_2 emissions. This trend could be signaling changing dynamics in the relationship between economic factors and CO_2 emissions, indicating a need for continuous model evaluation and adaptation to evolving economic and environmental contexts.

The F-Bounds Test results presented in Table 4.8 demonstrate a significant co-integration among the examined variables in the context of Carbon Monoxide (CO) emissions. This finding indicates a stable, long-term equilibrium relationship between industrial and economic activities and CO levels, underscoring the enduring effects of these activities on CO emissions.

In the ARDL model outlined in Table 4.9, the positive coefficients for the Industrial Growth Rate (IGR) and Industrial Development (IND) strongly link industrial activities to increased CO emissions. This correlation aligns with the common understanding that industries, especially those dependent on fossil fuels, are substantial contributors to CO emissions. Contrarily, the negative relationship between Foreign Direct Investment (FDI) and CO levels suggests that FDI may be influencing the adoption of cleaner, less polluting technologies or industries. Additionally, the significant impact of both GDP and its squared term (GDP_2) on CO emissions indicates a complex, potentially non-linear relationship, which could reflect the dynamics proposed by the Environmental Kuznets Curve hypothesis.

The Error Correction Model (ECM) detailed in Table 4.10 highlights both the short-term fluctuations and the long-term stability in the relationship between these economic variables and CO emissions. The significant impacts of changes in industrial growth, GDP, and energy consumption (ΔENG-c) on CO emissions are noteworthy, signifying both immediate and lasting effects. The negative coefficient of the error correction term (CointEqt-1*) further points to the model's capacity to adjust and realign with the long-term equilibrium.

The Cumulative Sum (CUSUM) analysis provides insights into the model's stability over time. While the model generally appears stable, the upward trend observed in the residuals suggests a potential underestimation of CO emissions during certain periods. This observation emphasizes the necessity of ongoing monitoring and updating of the model, especially in light of evolving industrial practices and economic conditions.

The F-Bounds Test displayed in Table 4.11 reveals that at a 10% significance level, the null hypothesis of no level-level link between the variables and Methane (CH_4) emissions cannot be conclusively rejected. However, at a 5% significance level, the test indicates potential cointegration, suggesting a long-standing equilibrium relationship between these variables and Methane emissions.

The ARDL analysis in Table 4.12 provides essential insights into the factors affecting Methane emissions. Notably, the positive coefficients for Industrial Growth Rate (IGR) and Industrial Development (IND) indicate their substantial role in driving CH_4 emissions. Conversely, the negative coefficient for Foreign Direct Investment (FDI) suggests that increasing FDI might contribute to a decrease in Methane emissions, though this relationship shows marginal statistical significance. Additionally, the positive correlation of GDP with Methane emissions, albeit slightly above the conventional significance thresholds, suggests that economic activities are contributors to CH_4 emissions. The negative relationship with GDP2 could point to a potential reduction in Methane emissions at higher economic output levels, aligning with the Environmental Kuznets Curve hypothesis.

The Error Correction Model (ECM) detailed in Table 4.13 further illustrates the short-term fluctuations and the long-term equilibrium dynamics between these variables and CH_4 emissions. The notable coefficients for changes in energy consumption (ΔENG-c), FDI (ΔFDI), GDP (ΔGDP), and its squared term (ΔGDP_2) emphasize the immediate and ongoing effects of these variables on Methane emissions. The error correction term's negative coefficient (CointEqt-1*) signifies the model's ability to adjust and align with the long-term equilibrium state.

The CUSUM analysis represented in Figure 3 indicates the general stability of the model across the examined period, although there are observable fluctuations. Remaining within the 5% significance bands, the model does not show significant structural breaks or deviations, yet the varied trends underscore the necessity for ongoing monitoring and adjustments to the model.

In essence, this study significantly enhances the understanding of the relationship between economic factors and Methane emissions. It lays a robust foundation for policymakers and stakeholders to devise strategies aimed at sustainable development while addressing environmental impacts. The insights into the roles of industrial growth, economic activities, and FDI are particularly valuable for shaping policies to mitigate emissions and promote sustainable economic progress. The methodology and outcomes of this study also open avenues for future research, particularly in exploring the dynamics of economic growth and Methane emissions and underline the importance of continuous model evaluation for effective policy formulation and environmental planning.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Environmental quality is a broad concept that can relate to a variety of aspects,including the purity or contamination of air and water, noise, access to open space, and the visual effects of buildings, as well as the possible effects that such aspects may have on one's physical and mental health. The objective of this research was to investigate relationship between industrialization and environmental quality in Pakistan.

The effects of industrialization on the environment, evaluated in terms of industrial and manufacturing factors, were found to be significantly connected with the environment, but the extent of the influence is small. This was determined by the fact that industrialization was significantly associated with manufacturing variables. The fact that industrialization has a strong relationship with the environment led to this conclusion. Independent variables have, for the most part, been able to adequately explain the hypotheses that hypothesis that economic expansion is a cause for the degradation of the environment by increasing emissions of gases like as carbon dioxide, methane, and carbon monoxide. This hypothesis postulates that economic growth is a cause for the degradation of the environment.

From the outset, descriptive statistics provided an understanding of the variables in play, helping to set the stage for further analysis. The strong positive correlation observed between CO_2 and CH_4 is a testament to the interconnected nature of greenhouse gas emissions. In contrast, the relationship between CO_2 and other variables like CO offers a window into the multifaceted nature of environmental impacts.

Firstly, the presence of a robust co-integration among the model's variables emphasizes the persistent long-term relationship between CO_2 emissions and economic indicators such as FDI and GDP. This persistent tie suggests that the economic growth of a region or a country will invariably influence its carbon emissions, directly or indirectly. The ARDL model further reinforces this by offering a snapshot of lagged interactions, underlining that both past economic actions and contemporary ones carry lasting effects on the environment.

The ECM's revelations are particularly noteworthy. As economies ebb and flow, short-term fluctuations can often get lost in the long view. Yet, the ECM's findings underline the immediacy of some impacts. It especially brings to light the system's intrinsic ability to self-correct over time, nudging CO_2 emissions back towards a state of equilibrium in response to economic and industrial changes.

Figures like the CUSUM Stability Analysis and the Environmental Kuznets Curve provide visual affirmations of the research's key takeaways. While the former offers a warning against complacency by highlighting emerging prediction inaccuracies, the latter serves as a beacon of hope. The EKC illustrates the potential for societies to find a middle ground where economic prosperity does not come at the environment's expense.

Conclusively, this research accentuates a vital truth: our economic actions carry ecological consequences, and the vice-versa holds true as well. As nations and economies march forward, balancing industrial growth with environmental health is paramount. The EKC's turning point might be symbolic of an aspirational future where sustainable growth isn't a mere buzzword but a tangible reality. Through this study, policymakers, businesses, and environmentalists are equipped with a nuanced understanding to drive change, fostering a future where growth and green coexist harmoniously.

In the intricate interplay of environmental and economic domains, Carbon Monoxide (CO) emerges as a critical point of focus, reflecting the broader challenges and opportunities of sustainable development. This research, through methodological precision and depth, unveils the multifaceted interactions shaping CO emissions, thereby guiding potential interventions and strategies.

The bound tests emphasize a long-standing relationship between CO and its key determinants. The revelation that such connections persist over time should urge policymakers to recognize the legacy of past decisions and anticipate the future implications of current choices.

The ARDL model paints a nuanced picture of these determinants and their respective contributions. Notably, the role of the variable 'E' and the consistent influence of the Industrial Growth Rate and Industrial Development resonate with global narratives of rapid industrialization and its concomitant environmental impacts. Furthermore, findings related to FDI and GDP iterate the intricate dance of economic prosperity and environmental responsibility.

In the evolving discourse on environmental sustainability, Methane (CH_4) emerges as a potent indicator, mirroring the broader challenges of balancing economic progress with ecological stewardship. Through a meticulous blend of statistical rigor and interpretive analysis, this study unveils the intricate dynamics that govern CH_4 emissions, serving as a compass for informed decision-making.

The bounds tests performed, echoing those of Carbon Monoxide (CO), underscore the lasting interrelations between CH_4 and its determinants. While the F-statistic cautiously treads the line of significance, the T-Bounds test confidently advocates for a cointegrated relationship. This finding emphasizes the importance of recognizing enduring associations that persistently shape our environmental landscape.

The ARDL model presents a rich tapestry of insights. Methane's historical levels, as indicated by its significant lagged term, remind us of the inertia in environmental systems. The diverse and evolving influences of Energy, FDI, GDP, and industrial factors on methane emissions spotlight the multifaceted nature of the challenge. Each determinant, with its unique temporal dynamics, necessitates distinct policy interventions. Particularly intriguing is the nuanced role of FDI, revealing the double-edged sword of foreign investments in shaping environmental outcomes.

The ECM model emphasizes the immediacy of some impacts, like the influence of Energy and FDI dynamics, while also hinting at the slower, steadfast adjustments that bring the system back into balance. The significant 'CointEqt-1*' term, suggestive of a 3.15% adjustment toward equilibrium each period, injects a sense of optimism about the system's resilience and adaptability.

To encapsulate, this research underscores the intricate dance between economic development and methane emissions, a delicate balance that nations must strike as they march toward a sustainable future. The oscillations between determinants, their lagged impacts, and the broader trajectory depicted by the EKC, all advocate for a nuanced, holistic approach. In an era where the global community grapples with pressing climate concerns, this study serves as a beacon, emphasizing that while the path to sustainability is complex, with informed strategies and interventions, harmonizing economic growth with environmental preservation is not just an ideal but a tangible reality.

5.2 Policy Recommendation

In light of the findings obtained from the analysis of time series data, industrialization, FDI, IGR, GDP, GDP^2, and Energy consumption were all linked to CO_2 emissions. The most significant proximal indicator of environmental quality is CO_2 emissions. Statistically speaking, the majority of the coefficients are significant. In addition to CO_2, emissions of CO and CH_4 have been found to significantly and favorably correlate with industrialization. It appears from the research (Zhang and Zhou, 2016) that industrial growth will lead to an increase in the quantity of emissions that degrade the environment.

The following polices was recommended after this research.

- Incentives should be given to industries that integrate green technologies into their operations. This would not only reduce CO_2, CO, and CH_4 emissions but would also pave the way for sustainable industrial growth. Technologies such as carbon capture and storage, waste-to-energy conversion, and efficient recycling methods can significantly reduce the environmental impact.
- The government should provide grants and subsidies for research and development projects aimed at discovering innovative solutions to reduce industrial emissions. Encouraging research in sustainable manufacturing processes can be a game-changer.
- Workshops, training sessions, and seminars should be conducted for industrialists and factory managers to educate them about the detrimental effects of emissions and the benefits of sustainable industrial practices. Such capacity-building measures will ensure that industries are well-equipped to implement eco-friendly practices.
- Partner with international environmental organizations to gain insights, access resources, and adopt best practices that have been successful in curbing industrial emissions globally.
- Encourage public-private partnerships for green projects. Collaborations between the government and private sector can lead to the implementation of large-scale projects that have a significant positive impact on the environment.
- Invest in infrastructure that supports the use of renewable energy sources in industries. Whether it's solar, wind, or hydropower, making it easier for industries to switch to cleaner energy sources will greatly reduce CO_2 emissions.
- The government can identify and develop specific zones or clusters where industries

operate on eco-friendly principles. These clusters can serve as models for sustainable industrial development.

- Conduct campaigns to educate the public about the importance of supporting industries that follow eco-friendly practices. A well-informed consumer base can exert pressure on industries to adopt sustainable measures.
- Protect and incentivize whistleblowers who report industries that violate environmental standards. Such mechanisms will deter industries from bypassing regulations.

In light of the profound interconnection between industrialization, emissions, and environmental quality, it's clear that a multi-pronged approach that involves both regulation and encouragement is essential. The recommendations provided aim to foster an environment where industrial growth and environmental sustainability coalesce for a brighter, greener future.

5.3: Limitation of study

The limitation of the study lies in its exclusive focus on aggregate-level analysis rather than conducting a detailed examination at the disaggregate level, specifically at the industrial level for carbon dioxide, carbon monoxide, and methane emissions. The time constraints imposed on the study, due to the simultaneous operation of three models targeting different pollutants, hindered the ability to delve into a more granular analysis. As a result, the research failed to capture the nuances and specificities associated with emissions patterns within individual industries. Consequently, the study's findings may lack the depth required to inform targeted interventions and policies aimed at mitigating emissions from specific industrial sources, thereby limiting the practical applicability of the research in addressing the complexities of greenhouse gas emissions.

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APPENDIX.A

Multicollinearity Test of Carbon dioxide:

Variable	Coefficient Variance	Centered VIF
IND	1.75	1.19
IGR	4.24	1.78
GDP	4.58	1.24
ENG-c	1.60	1.65
FDI	5.93	1.04

Multicollinearity Test of Carbon Monoxide:

Variable	Coefficient Variance	Centered VIF
IND	0.01	1.19
IGR	0.00	1.78
GDP	2.74	1.24
ENG-c	0.00	1.65
FDI	0.03	1.04

Multicollinearity Test of Methane:

Variable	Coefficient Variance	Centered VIF
IND	313246.5	1.19
IGR	75900.06	1.78
GDP	8.20	1.24
ENG-c	287031.6	1.65
FDI	106113.9	1.04