ANALYSIS OF THE RELATIONSHIP BETWEEN SELECTED MACROECONOMIC VARIABLES AND CARBON EMISSION IN KENYA

BY

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DECLARATION

Declaration by the Student

This Thesis is my original work. All sources of materials used for this thesis were duly acknowledged, and this work has not been presented for any other degree award in any other institution.

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DEDICATION

Special dedication to my wife, Lucy Mbaya, son, Damian Gichuki, dad, Mr. David Gichuki Mugo, and caring mum Mrs. Lucy Gichuki for their sincere love, commitment, and support towards my studies. To my beloved siblings Margaret, Nancy, Esther, Grace, and Rehema.

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ABSTRACT

Climate change and carbon dioxide (CO_2) emissions are significant threats to the agricultural sector in Kenya. While the sector is critical to the country's economy, its high demand for agricultural inputs such as fertilizers is contributing to the problem of CO_2 emissions. To address this challenge, it is necessary to understand the nexus between CO_2 emissions and macroeconomic variables. Therefore, this study aimed to analyze the relationships between selected macroeconomic variables and CO_2 emissions in Kenya using the Environmental Kuznets Curve hypothesis as a guiding theory. The study adopted a time series research design, and secondary data from the World Bank Database, Kenya National Bureau of Statistics, and the Environmental Performance Index covering the period from 1983 to 2019 were utilized. To test for unit root factors, the Augmented Dickey-Fuller Test, Phillips-Perron, and Zivot-Andrews tests were employed. The Vector Error Correction Model and Johansen Co-integration analysis were applied to estimate long- and short-run relationships between the study variables. The results showed that during the short run, only Foreign Direct Investment had a statistically significant relationship with CO_2 emissions ($z = -6.55$, $p < 0.05$). However, during the long run, all the macroeconomic variables had a statistically significant relationship with CO_2 emissions at $p < 0.05$. Specifically, the study found an indirect and statistically significant relationship between agricultural output and CO_2 emissions in Kenya during the long run ($z = -3.65$, $p < 0.01$). Moreover, Foreign Direct Investment and CO_2 emissions exhibited a direct and statistically significant relationship during the long run ($z = 10.61$, $p < 0.01$), while trade openness and CO_2 emissions had an indirect relationship ($z = -3.41$, $p < 0.01$). Additionally, inflation and CO_2 emissions had an indirect relationship in Kenya ($z = -3.12$, $p < 0.01$). The study concludes that sustainable agricultural practices should be adopted in Kenya to minimize CO_2 emissions in the short run. Additionally, Foreign Direct Investment should be geared towards investing in more efficient agricultural technologies to reduce CO_2 emissions. The findings suggest that policymakers should consider more education and awareness on sustainable agricultural practices that will minimize Carbon dioxide emission even during the short run in Kenya. Additionally, Foreign Direct Investment should be geared towards more efficient technology in agriculture to reduce Carbon dioxide emission in Kenya. Overall, this study contributes to the literature on the relationships between macroeconomic variables and CO_2 emissions in Kenya. The study has some limitations, such as data limitations and potential sources of bias. Nonetheless, the study provides important insights into the links between macroeconomic variables and CO_2 emissions, which can inform policymaking aimed at promoting sustainable development in Kenya.

LIST OF ABBREVIATIONS AND ACRONYMS

AIC	Akaike Information Criteria
ASALs	Arid and Semi-Arid Lands
BIC	Schwarz-Bayesian Information Criteria
CLT	Central Limit Theorem
CO_2	Carbon dioxide
COMESA	Common Market for Eastern and Southern Africa
CPI	Consumer Price Index
DGP	Data Generating Process
EAC	East African Community
EKC	Environmental Kuznets Curve
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
PP	Phillips-Perron
PQR	Product, Quantity, and routing approach
SDGs	Sustainable Development Goals
TO	Trade Openness
UNEP	United Nations Environmental Programme
USA	United States
VECM	Vector Error Correction Model

OPERATIONAL DEFINITION OF TERMS

Carbon dioxide Emissions: The release of carbon dioxide into the atmosphere, either as a result of human activities such as burning fossil fuels or natural processes such as volcanic eruptions (UNEP, 2011). This indicator was employed as the dependent variable in the study.

Environmental Sustainability: Responsible relationship with the ecosystem to minimize depletion of resources or deterioration and to ensure long-term quality of the environment (United Nations Economic and Social Council, 2016). Carbon emissions were employed as the dependent variable in the study to reflect on pollution problems.

Food Security: This is a situation where people have adequate, accessible, and nourished food with a balanced diet at any given time (Ngigi, Muller & Birner, 2018). The study highlighted it as one of the trending issues arising from environmental degradation.

Sustainable Development Goals: The United Nations established these global objectives in 2015 as a universal call to action to eradicate poverty, safeguard the environment, and guarantee that all people experience peace and prosperity by 2030. (United Nations Economic and Social Council, 2016). According to the report, the SDGs are the benchmark for all developing nations to achieve sustainable economic growth.

Aggregate Agricultural Output: Value-added is the net output of the agriculture industry after adding all outputs and subtracting intermediate inputs. The unit was calculated without taking into consideration asset depreciation or the depletion and degradation of natural resources. The source of value-added is determined by the

International Standard Industrial Classification (ISIC), version 3. The statistics are in US $. (World Bank, 2019). It was one of the independent factors in the research.

Foreign Direct Investment: This is the cross-border investment of funds from another nation with a known interest (Li, Huang, & Failler, 2019). It was utilized as one of the independent variables in the study, and its impact on Kenya's carbon dioxide emissions was examined.

Gross Domestic Product: This is the entire value of production (including commodities and services) generated in an economy at a given time (World Bank, 2019). It was also employed as an independent variable in the research.

Trade Openness: This is the total of imports and exports as a percentage of the country's GDP (Tran, 2018). It was employed in the study to determine its association with carbon dioxide emissions in Kenya.

Inflation: assesses an economy's aggregate prices for a bundle of consumer products and services. (Statista Inc., 2020). The analysis relied on the World Bank's yearly record of Kenya's inflation rate as a percentage of GDP.

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CHAPTER ONE: INTRODUCTION

1.0 Overview

The section focuses on the background, purpose, objectives, hypotheses, significance, and scope of the study.

1.1 Background of the Study

The agricultural industry, which includes livestock raising and crop production, is one of Kenya's most important businesses in terms of food security, foreign exchange revenues, off-farm employment, job creation, and economic growth. It is also the principal source of income for most Kenyans. Climate change is a major source of worry for the sector. Kenya's agriculture sector contributes substantially more than one-fifth of the country's GDP and more than half of the country's foreign exchange earnings. Agriculture and other associated enterprises employ 65% of the rural population (Maina & Maina, 2012). Rain-fed agriculture accounts for 75% of overall agricultural output in Kenya. Livestock production accounts for over 40% of agricultural GDP and employs roughly 50% of the agricultural labor force (Agovino et al. 2019). 2019 (Agboola and Bekun).

According to a United Nations Environment Programme (UNEP) study, mitigating the effects of climate change in Kenya would be costly (UNEP, 2011). In the context of the developing climate funding architecture, the best option for Kenya's current administration is to efficiently ensure climate financial support in accordance with its terms, domestic capabilities and skills, and national objectives to address urgent adaptation and mitigation needs. However, several obstacles may impede effective solution implementation, including an insufficient regional and national policy environment, uncontrolled financial accounting and fiduciary regulations, inconsistent and disorganized institutional structures for stewardship at the state and municipal levels, and a national private industry that is not fully engaged in environmental matters (UNEP, 2011).

Agriculture is not only impacted by climate change, but it is also a key generator of greenhouse gases (GHG) that cause climate change, underlining the importance of collaboration between adaptation and mitigation strategies and actions (Johnson et al., 2014). According to Food and Agricultural Organization (FAO) (2020), agricultural activities (connected to farmgate operations and land-use change) generated 9300 kg of CO_2 equivalent globally in 2018. Activities like fertilizer use, deforestation, wetlands draining, organic waste burning, and livestock production were identified as common contributors to CO_2 emissions in the agricultural sector (FAO, 2020).

Globally, the World Bank (2022) noted that agricultural production significantly contributes negatively to climate challenge. It is currently responsible for 19-29% of overall GHG emissions in the world. If nothing is done, that share may increase dramatically as other industries reduce their emissions (World Bank, 2022). Consequently, building synergies in poverty alleviation, nutrition and food security, mitigation, and adaptability is crucial. Agroforestry, for instance, has the capacity to eliminate 0.004 metric tons of carbon dioxide equivalent ($MtCO_2e$) by 2030 in Sub-Saharan Africa while simultaneously delivering climate resilience benefits like improved soil health and quality increased soil moisture retention, and deterioration and decreased erosion (Kuyah et al., 2019).

Climate and carbon emission variability are major challenges in most areas of economic growth, with governments striving to minimize the negative environmental effects of development and economic expansion (Haseeb and Azam, 2021; Azarkamand et al., 2020). While the Kenyan economy has seen enormous economic growth and industrialization in recent decades, there have been calls for efficient agricultural production to fulfill the nation's expanding food need in the face of periodic droughts and harsh weather conditions (McGahey et al., 2014). Economic, agricultural, and industrial progress encounter conflicting tension to decrease carbon dioxide emissions.

Studies have demonstrated that climatic changes have made a significant contribution to unfavorable rainfall and temperature variation (Lagat and Nyangena, 2018; Mwangi, 2012). Different researchers have established the relationship between economic growth and degradation (Kong'o et al., 2018; Qureshi et al., 2016).

According to Knoema (2022), Kenya's CO_2 emission in 2020 were 16.4 million tonnes. From 3.8 million metric tonnes in 1971, the value has climbed at a 3.29 percent yearly pace (Knoema, 2022). In compared to industrial nations such as the European Union members, China, and the United States, EA countries' average CO_2 per capita values are probably rather low (Knoema, 2022). Nonetheless, because EA countries learned early and were active in awareness and environmental activism, they would not have to wait as long for GDP per capita to surge to levels seen in developed countries before experiencing a healthier and cleaner environment (Climatelinks Team, 2017). These figures represented 0.13 percent of worldwide GHG emissions. The World Bank reported a 7.2 percent increase in 2016. The increase can be ascribed to a variety of variables, one of which being population growth (Climatelinks Team, 2017).

According to climatelinks Team (2017), the agricultural sector topped in total CO_2 emissions in the country in 2017. The sector accounted for 62.8% followed by Energy with 31.2%. Industrial manufacturing had 4.6% and waste sector was least with 1.4%. The figure below shows Kenya's CO_2 emission since 1990 to 2019 sourced from the

Trading Economics. CO_2 Emissions in Kenya averaged 7987.70 KT from 1960 until 2021, reaching an all-time high of 22980.79 KT in 2019 and a record low of 2401.89 KT in 1961 (Trading Economics, 2023).

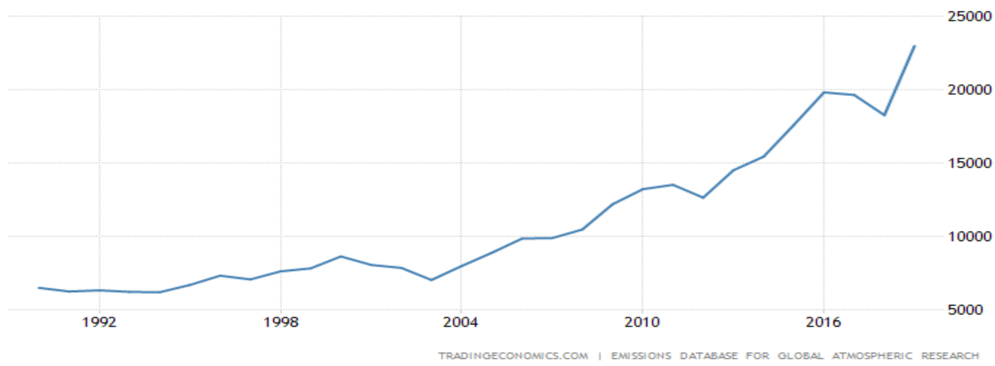

Figure 1.1 Kenya's CO_2 emission from 1990 to 2019

Source: Trading Economics (2023)

Notably, Foreign Direct Investment (FDI) is a crucial element in Kenya's economic growth and development, particularly in the agriculture sector. However, FDI has also been associated with increased carbon dioxide (CO_2) emissions due to the adoption of energy-intensive production methods and the use of fossil fuels in manufacturing and transportation of developing countries (Kastratović, 2019). According to the World Bank, FDI inflows to Kenya were $1.61 billion in 2020, highlighting the significance of FDI in the country's economic development. According to Ondieki et al. (2020) and Wamalwa et al. (2018), FDI inflows have a direct influence on the CO_2 emissions in the country indicating that FDI-led economic growth in Kenya has environmental implications.

Kenya's proposed Nationally Determined Contribution (NDC) pledged to lowering GHG emissions by 30% (143 $MtCO_2e$) compared to business-as-usual levels by 2030 in exchange for foreign money, capital, technology development and research, and capacity-building assistance (Kenya Vision 2030 (Popular Version), 2018). The NDC said that Kenya will enhance solar, wind energy production, and geothermal to build on the National Climate Change Action Plan (NCCAP) (Kenya Vision 2030 (Popular Version), 2018). The NCCAP will reduce emissions and improve soil carbon sequestration by increasing afforestation and reforestation campaigns on at least 10% of Kenyan land, implementing the 2015-2030 Climate Smart Agriculture (CSA) Structure Programme in accordance with the National CSA Structure, and striving to improve waste management (e.g., disposal recycling, landfill gas monitoring) (Kenya Vision 2030 (Popular Version), 2018).

Furthermore, inflation and carbon dioxide emissions are two crucial aspects of economic development in Kenya (Sarkodie & Strezov, 2019). Inflation, defined as the sustained increase in the general price level of goods and services in an economy, can have both positive and negative impacts on carbon emissions (Sarkodie & Strezov, 2019). On the one hand, inflation can lead to increased demand for energy and fuel, which can result in higher carbon emissions (Sarkodie & Strezov, 2019). On the other hand, inflation can also lead to a shift towards cleaner and more efficient technologies, which can reduce carbon emissions (Mukherjee & Chakraborty, 2020).

In Kenya, inflation has been on the rise over the past few years, reaching a peak of 5.9% in May 2021 (Central Bank of Kenya, 2021). This increase in inflation can have significant implications for carbon emissions, as it may lead to an increase in demand for energy and fuel, resulting in higher emissions. According to Kong'o et al. (2018), CO_2 emissions are mostly caused by energy consumption, notably the combustion of fossil fuels such as petroleum products and natural gas. Nevertheless, CO_2 emissions from emerging countries diffuse through the atmosphere to other regions. As a result, during a period of fast economic progress, a nation is likely to become less encouraged to emit CO_2 (Kong'o et al. 2018; Qureshi et al. 2016).

Moreover, Kenya heavily relies on the agricultural sector, which accounts for more than 60% of the country's carbon emissions (FAO, 2020; World Bank, 2021). To mitigate these emissions, the Kenyan government has implemented various trade incentives aimed at encouraging industries to adopt environmentally friendly practices, such as reducing greenhouse gas emissions. However, the effectiveness of these incentives in combating CO2 emissions faces several challenges. These challenges include limited resources for monitoring and enforcing compliance (McGahey et al., 2014), low levels of industry awareness (Badgley et al., 2007), and weak institutional frameworks (UNDP, 2020). Additionally, some industries prioritize economic benefits over environmental concerns, leading to non-compliance with regulations (Mekonnen & Hoekstra, 2020)

Therefore, to ensure that trade incentives effectively incentivize environmentally friendly practices and reduce CO_2 emissions in Kenya, it is crucial to address these challenges. The government needs to allocate adequate resources to monitor and enforce compliance (UNDP, 2020) while raising industry awareness of the importance of adopting environmentally friendly practices (Badgley et al., 2007; Smith et al., 2014). Additionally, stronger institutional frameworks and regulations that prioritize the environment over economic benefits need to be established to promote compliance with environmentally friendly practices (McGahey et al., 2014)

1.2 Problem Statement

Kenya's expanding economy and agriculture industry present environmental challenges like increased carbon dioxide emission due to intensified fertilizer use and increased agricultural production (Mekonnen & Hoekstra, 2020; UNDP, 2020). However, investment capital constraints and technical inexperience limit pastoralists' ability to acquire more sustainable inputs and systems, hindering efforts to build a more environmentally friendly and efficient infrastructure (UNDP, 2020), (McGahey et al., 2014) and (Badgley et al., 2007). The challenge is to balance economic development with environmental sustainability, especially as the agricultural industry, which accounts for over 60% of Kenya's CO2 emissions, is crucial to the country's economic success (FAO, 2020; Climatelinks Team, 2017). Additionally, the majority of the growing population relies on primary activities like agriculture and mining for food and income, emphasizing the need to address these challenges to ensure food security and sustainable economic growth (GoK, 2013; Kenya Vision 2030 (Popular Version), 2018; Duku et al., 2018).

The relationship between economic progress and environmental degradation is apparent, as research has shown how population increase has encroached on natural habitats to clear ground for economic activity (Lagat & Nyangena, 2018; Odero-Waitituh 2017). In addition, economic development efforts in Kenya and other developing nations have exacerbated environmental deterioration (UNEP, 2011; Climatelinks Team 2017). Thus, governments worldwide are striving to minimize the negative environmental effects of economic expansion to address the challenges posed by carbon emissions and climate change (UNEP, 2011; Kong'o et al. 2018; Wendling et al. 2018).

In Kenya, agriculture, economic expansion, and industrialization are under pressure to cut carbon emissions in different ways. Climatic changes have led to severe temperatures and an increase in the frequency of extreme weather events, which have a severe impact on agricultural output. However, there is a knowledge gap in understanding how different areas such as carbon dioxide emissions, aggregated agricultural output, foreign direct investment, inflation rate, and trade openness contribute to climate change. Therefore, this study aims to analyze their relationship with carbon dioxide emissions and determine their influence on Kenya's sustainable development by estimating the co-integration link between the selected macroeconomic variables and CO_2 emissions.

1.3 Objectives of the Study

The study objectives entailed the general and specific objectives. They are as follows.

1.3.1 General Objective

The study's primary purpose was to analyze the nexus between selected macroeconomic variables and Kenya's Carbon dioxide emissions.

1.3.2 Specific Objectives

The specific objectives that were tested in this study included the following:

i. To examine the direction and strength of the relationship between agricultural output and Carbon dioxide emissions in Kenya using statistical models.
ii. To assess the extent to which trade openness affects Carbon dioxide emissions in Kenya through an econometric model that incorporates relevant variables.
iii. To determine the impact of Foreign Direct Investment on Carbon dioxide emissions in Kenya using inferential statistics.
iv. To investigate the association between inflation and Carbon dioxide emissions in Kenya using time series data analysis methods.

1.4 Hypotheses

The study hypothesized the following:

H_1: The null hypothesis is that there is no significant relationship between agricultural output and Carbon dioxide emissions in Kenya, while the alternative hypothesis is that there is a significant relationship between the two variables.

H_2: The regression coefficient between Trade Openness and Carbon dioxide emissions in Kenya is equal to zero.

H_3: The regression coefficient between Foreign Direct Investment and Carbon dioxide emissions in Kenya is equal to zero.

H_4: The regression coefficient of Inflation is not statistically significant in the model with Carbon dioxide emissions in Kenya as the dependent variable.

1.5 Significance of the Study

The agricultural sector is the largest contributor of CO_2 emissions in Kenya (Climatelinks Team, 2017). This study aims to investigate the relationships between carbon dioxide emissions and agricultural GDP, FDI, inflation, and trade openness in Kenya. The findings will provide insight into how macroeconomic decisions affect the environment and aid in the development of long-term policies to reduce environmental deterioration and achieve sustainable economic growth.

Previous studies have highlighted the negative impact of population growth and economic development on the environment in Kenya and other developing nations (Odero-Waitituh 2017; Lagat & Nyangena, 2018). The implementation of National Appropriate Mitigation Actions (NAMA) and National Adaptation Programmes of Action (NAPAs) are critical for the East African region to contribute to global GHG emissions reductions (UNEP, 2011; Climatelinks Team, 2017; Kong'o et al., 2018). The findings of this study will aid in providing insight of how CO_2 from the selected macroeconomic variables is affecting the achievement of sustainable economic growth as per the SDGs.

Kenya's Nationally Determined Contribution (NDC) under the Paris Agreement includes both mitigation and adaptation commitments. The country plans to cut GHG emissions by 30 percent by 2030 and incorporate climate crisis into Intermediate Term Plans to achieve Vision 2030. The findings of this study will aid in the implementation of strategies to achieve these commitments and reduce environmental deterioration in specifically the agricultural sector.

1.6 Scope and Limitation of the Study

The aim of this study was to examine the connection between specific macroeconomic indicators and carbon dioxide emissions in Kenya. The primary variables analyzed were inflation, foreign direct investment, agricultural gross domestic product, and trade openness, based on data collected from various sources including the Kenya National Bureau of Statistics, the Environmental Performance Index, and the World Bank Development Indicators, spanning the years 1983 to 2019. The study's results, therefore, are limited to the context of Kenya during the given period.

Conducting a comprehensive investigation of the relationship between macroeconomic factors and carbon dioxide emissions in Kenya necessitated significant resources, including access to various databases and specialized skills in data collection and analysis. However, limited funding restricted the study's scope and scale, leading to the utilization of only freely available data and potentially limiting the number of variables and time periods that could be analyzed, thereby affecting the study's external validity.

The study also encountered several challenges, including missing data in some series and the use of different measurements across various databases, requiring adjustments such as the estimation of missing values using the mean method of the entire series and the alignment of all series to a similar measurement of weighted average and as a percentage of the GDP in a specific year. These limitations affected the study's analysis and could have increased the results of the statistical regression analysis, making them less meaningful.

Despite these limitations, the study's outcomes could still inform policymakers in Kenya regarding the development of long-term policies aimed at reducing environmental degradation while promoting economic growth. However, the findings should be interpreted with caution, and future research could address these limitations to provide a more accurate and robust analysis of the relationship between macroeconomic factors and carbon dioxide emissions in Kenya.

CHAPTER TWO: LITERATURE REVIEW

2.0 Overview

This section focused on macroeconomic concepts, theoretical framework, empirical literature, and the study's conceptual framework.

2.1 Macroeconomic Concepts

Macroeconomics is a broad field of study. The concepts of macroeconomics that the study focused on are Foreign Direct Investment, Inflation, Agricultural output, and Trade Openness.

2.1.1 Foreign Direct Investment in Kenya

The economic contribution of FDI towards Kenyan economic growth is depicted through the funding of different agricultural projects and sources of capital for business operations. The transfer of management skills is thus realized, and technology adoption generates job opportunities in the long run. However, a host country suffers environmental degradation by trade-offing economic growth and environmental sustainability (To *et al*., 2019).

Foreign Direct Investment (FDI) has been identified as a crucial driver of economic growth in Kenya, particularly in the manufacturing sector (Kariuki et al., 2019). However, FDI can also lead to increased carbon dioxide emissions due to increased industrial activities (Arvis et al., 2010).

2.1.1.1 Foreign Direct Investment and Carbon dioxide Emission

Foreign direct investment (FDI) has been identified as a critical driver of economic growth in many developing countries. However, its potential environmental impacts have raised concerns among scholars and policymakers. While some argue that FDI may facilitate the implementation of cleaner and greener production processes, others assert that the increase in carbon emissions associated with FDI may offset its economic advantages. Despite this debate, empirical evidence suggests that the relationship between FDI and environmental quality depends on the level of development and environmental consciousness of the recipient country (Islam et al., 2021).

Mahalik et al. (2021) found that foreign aid inflows aimed at financing energy exploration were harmful to India's environmental quality. However, other types of FDI, economic growth, and globalization were identified to reduce carbon dioxide emissions significantly. To promote environmentally sustainable development, the study recommended that most of the total FDI be channeled towards long-run investment in clean energy production. Similarly, Leal and Marques (2021) analyzed the environmental performance of African countries and showed that non-renewable energy had the most significant impact on CO_2 emissions.

The surge in FDI inflows has played a critical role in environmental and economic development in the context of global trade. However, it has also raised concerns about the potential environmental costs associated with higher carbon emissions (Owusu-Brown, 2017; Huang et al., 2022; World Bank, 2021; Chen & Feng, 2020; Ghazali & Lean, 2018). The relationship between FDI and environmental pollution has been the subject of numerous studies, some of which suggest contradictory results (Huang et al., 2022).

While some argue that FDI may be a driving factor for technical innovation and the implementation of cleaner and greener ways of production (Neequaye and Oladi, 2015), others suggest that the environmental costs associated with higher emissions may offset its economic advantages (Bakhsh et al., 2017; Demena and Afesorgbor, 2020). The EKC model suggests that the relationship between FDI and environmental quality may depend on the recipient country's level of development and environmental consciousness (Ochoa-Moreno et al., 2021).

In summary, the relationship between FDI and carbon emissions is complex and indirect, as it depends on the type of investment and the recipient country's level of development and environmental consciousness. FDI may facilitate the implementation of cleaner and greener production processes or promote environmentally unsustainable activities such as oil and fossil fuel exploration.

2.1.2 Trade Openness in Kenya

The relationship between market liberalization and environmental quality varies across different countries. Developed countries tend to experience milder effects on environmental degradation, while low and middle-income countries are more likely to suffer detrimental consequences (Le et al., 2016). In fact, Le et al. (2016) identified that the possibility of developed countries dumping their pollution on developing countries significantly increases following trade liberalization.

The impact of international trade on the environment has been studied extensively in the literature, with some studies showing positive effects, others negative effects, and some presenting ambiguous findings (Debnath & Bose, 2020). For low and middle-income countries, international trade and bilateral treaties play a significant role in promoting economic growth (Tran, 2018), and agriculture often serves as a key sector to enhance their trading capacity. Kenya, for instance, actively participates in various trade blocs, such as the East African Community (EAC), African Union, and Common Market for Eastern and Southern Africa (COMESA), as well as United Nations programs, to leverage its agricultural production and compete fairly in these markets.

2.1.2.1 Trade Openness and Carbon dioxide Emission

The impact of trade openness on environmental degradation has attracted scholarly attention. While trade liberalization is known to enhance economic growth, it may contribute to environmental pollution, especially in developing countries. In Asia, for instance, trade openness has been identified as one of the causal factors that contribute to carbon emissions (Luo et al., 2021; Jena & Grote, 2020; Wan, et al., 2019). Addressing environmental degradation is an urgent global concern that has significant implications for human well-being. However, constraining economic activity is unsustainable in the long run. This raises the question of how policymakers can combine strategic initiatives with low-carbon measures to ensure sustainable societal growth (Luo et al., 2021).

Studies have found a positive correlation between trade openness and carbon footprints in Asia, where most countries rely heavily on international commerce (Dodson et al., 2020). The growing percentage of the foreign market has increased the usage of industrial resources and energy, contributing to carbon emissions. However, Europe's experience with trade openness differs from that of Asia. Being a technologically advanced country, Europe's trade openness is associated with low carbon emissions in the long run but may lead to more emissions in the short run. In the long run, Europe's carbon emissions are low up to a certain turning point, after which emissions may lead to adverse environmental pollution effects. However, Europe's focus on outcome-oriented measures has limitations. To enhance the repair of European openness on carbon dioxide emissions, better measures should be used (Ho and Lyke, 2019).

Notably, the effects of market liberalization and international trade on the environment are complex and multifaceted. While developed countries tend to experience milder impacts, low and middle-income countries are more vulnerable to environmental degradation, particularly due to the possibility of developed countries dumping their pollution on them. Nonetheless, international trade remains a critical factor for economic growth, and many developing countries rely on agriculture as a key sector to enhance their trading capacity, as exemplified by Kenya's active participation in various trade blocs and United Nation programs. Notably, trade openness also plays a crucial role in the agricultural sector's growth and development. International trade can provide access to new markets and resources, including technology, knowledge, and capital, which can enhance the sector's productivity and competitiveness (Jena & Grote, 2020).

In summary, while trade openness enhances economic growth, it may contribute to environmental degradation, especially in developing countries. However, the relationship between trade openness and environmental degradation varies across regions and depends on various factors, such as a country's level of technological advancement.

2.1.3 Kenyan Agricultural Output

Kenya, with a population of approximately 51.39 million people, has a Gross Domestic Product (GDP) of 95.50 billion USD as of 2019, according to the World Bank. The country's GDP growth rate is currently at 5.3 percent, which represents a decline of 1 percent from 2018. However, over the past decade, Kenya has experienced an average decline in annual growth rates, although there have been notable improvements in the agricultural sector, as well as in telecommunications and transportation infrastructure. Despite this, there are still economic prospects for the country, with the possibility of even higher growth rates over the next five years.

Agricultural output and carbon dioxide emissions are two interrelated concepts that have gained significant attention from policymakers and environmentalists due to their impact on sustainable development. Agricultural output is a measure of the quantity of agricultural produce that a country or region produces within a specific time frame, such as a year.

2.1.3.1 Agricultural Output and Carbon dioxide Emission

According to the World Bank, CO_2 emission in Kenya were increasing gradually. In 2016, the country recorded 0.323 kg per 2010 US$ of the country's GDP. The rate was a 9.6% increase since 2014. The country also recorded an increase in fuel consumption between the two years. Therefore, part of the carbon emission was also attributed to this effect (World Bank, 2019).

Agriculture contributes 51 percent of Kenya's GDP (26 percent directly and 25 percent indirectly), employs 60 percent of the workforce, and accounts for 65 percent of exports (World Bank, 2019). Smallholder production on 0.2 to 3 hectares farms dominates the industry, accounting for 78 percent of overall agricultural production and 70 percent of commercial production. Horticulture and cash crops boost agricultural GDP, but productivity is poor, notably for grains. Given that agriculture employs most of the poor, productivity is also crucial for poverty alleviation. Between 2005 and 2015, agricultural sector growth accounted for the most significant poverty reduction (World Bank, 2019).

The agricultural sector is a crucial component of a country's economic development, food security, and social welfare, providing food, raw materials, and employment opportunities, and contributing to the GDP (FAO, 2021). However, agricultural activities have significant environmental costs, one of which is carbon dioxide emissions. Carbon dioxide is a greenhouse gas responsible for global warming and climate change. Agricultural practices, such as land use change, fertilizer use, and livestock production, release large amounts of carbon dioxide into the atmosphere, contributing to the overall increase in greenhouse gas emissions (IPCC, 2019).

Moreover, the increasing use of mechanized farming practices has led to a rise in carbon dioxide emissions associated with the burning of fossil fuels used in tractors, harvesters, and other farming machinery (Hertel et al., 2010). This trend negatively impacts the environment and can have long-lasting effects on the planet.

Therefore, policymakers and researchers are exploring various solutions to mitigate the environmental impacts of agricultural production while ensuring that the sector continues to grow and contribute to a country's economy. These solutions include the use of renewable energy sources in farming, reducing the use of chemical fertilizers, promoting sustainable land use practices, and increasing the use of agroforestry systems (FAO, 2021).

In summary, while agricultural output is vital for a country's economic growth and food security, it is essential to consider the environmental impact of agricultural activities, particularly carbon dioxide emissions. The development of sustainable agricultural practices that limit carbon dioxide emissions and mitigate environmental damage is crucial for the long-term health of the planet. The link between agricultural output and Carbon dioxide emission was established directly through methane emissions from the livestock sector and other greenhouse gas emissions from the crop sector. The study expected a positive relationship between the two variables.

2.1.4 Inflation in Kenya

Inflation is defined as the general increase in the level of prices for goods and services over time, leading to a decrease in purchasing power. According to Statista, Kenyan inflation rates were fluctuating over the past three decades since 1985. The lowest recorded inflation rate was in 1995 at 1.55%, while the highest was in 1993 at 45.98% (Statista Inc., 2020). In 2018, Kenya had an inflation rate of approximately 4.69 percent compared to the previous year. The value was a significant decrease from 7.99 percent.

According to Statista forecast, Kenya's inflation will level at around five percent shortly. The Central Bank of Kenya (CBK) projections are also in agreement with the expected inflation rate. CBK recorded a 5.41% inflation rate by the end of 2020, a slight increase from the previous year at 5.20%. Notably, the CBK evaluates the inflation in Kenya by the percentage change in the consumer price index (CPI) every month. This study also used CPI as the Kenyan economy's inflation rate index (Statista Inc., 2020).

The inflation rate is inevitable in the financial world and impacts both developed and developing countries positively or negatively. The inflation rate is a crucial element contributing to social and economic disruption, and it has been theoretically and experimentally examined extensively. The influence of the inflation rate can also be observed in other economic factors, such as product demand. Inflation rate changes are challenging to quantify, but a reliable forecast is critical for monetary and fiscal policy. Money power never remains static in the economic environment, emphasizing the significance of the inflation rate (Musarat *et al*., 2021).

2.1.4.1 Inflation and Carbon dioxide Emission

Inflation and carbon dioxide emissions are two important concepts that can impact economic growth and environmental sustainability. Carbon dioxide emissions refer to the release of carbon dioxide gas into the atmosphere due to human activities such as burning of fossil fuels, transportation, deforestation, and agriculture. These emissions contribute to climate change, which can have significant environmental impacts.

Although inflation and carbon dioxide emissions are not directly related, they can have indirect impacts on each other. Economic growth and increased industrial activity can lead to a rise in carbon dioxide emissions due to increased energy consumption. The increase in carbon dioxide emissions can lead to environmental damage and climate change, which can impact economic growth and inflation through the loss of productivity and increased costs associated with mitigating and adapting to environmental changes (IPCC, 2018).

On the other hand, inflation can impact carbon dioxide emissions through changes in consumer behavior and economic activity. When inflation increases, the cost of goods and services rises, leading to a decrease in consumer spending and investment. This decrease in economic activity can lead to a reduction in carbon dioxide emissions due to decreased energy consumption and industrial activity. (International Energy Agency, 2020).

Therefore, policymakers and researchers need to consider the complex relationships between inflation and carbon dioxide emissions and develop strategies to manage both issues simultaneously. The promotion of energy-efficient technologies, increased investment in renewable energy, and policies that incentivize sustainable production and consumption are some of the solutions being explored. (World Bank, 2020).

The construction industry is particularly vulnerable to inflation due to its reliance on materials whose prices tend to increase with inflation (Musarat & Muhamed, 2020; Musarat et al., 2021). However, a decrease in inflation can lead to an increase in construction activity and subsequent carbon emissions, as evidenced in Malaysia. While research has yet to identify a distinct pattern linking inflation and carbon emissions, some studies suggest that inflation has a negative impact on economic growth and that the correlation between the two variables is indirect (Hussain et al., 2019). Strategies to address both inflation and carbon dioxide emissions requires a comprehensive understanding of their complex relationships and the development of integrated strategies that prioritize sustainable economic growth and environmental protection.

2.2 Theoretical Framework

This section explains the study’s theory that guided the research.

2.2.1 Environmental Kuznets Curve (EKC)

According to the EKC hypothesis, pollution levels rise as a country grows but begin to fall once growing earnings reach a tipping point. Economic growth, according to the idea, is predicted to gradually restrict the environmental deterioration caused during the early phases of development. The link between environmental deterioration and wealth is often exponential, with the turning point appearing at the highest degree of degradation. Thus, the link is visually represented as an inverted U-shaped relationship (Kaika & Zervas, 2013), (Kong'o et al., 2018), and (Dinda, 2004, 2005).

Considering a closed economy in which one portion of the capital is utilized for factors of production, which produces pollution that destroys the current environment, while the other part is used for remediation (i.e., upgrading the environment). Sufficient abatement action improves/restores environmental quality. Only a significant abatement activity (connected with commodities production) might best lead to a stable state. In the off-steady state, the capital allocation ratio between two industries (production and remediation) is stable along the ideal path but changes along the non-optimal path. The capital allocated for remediation activities varies over time in economic principles. As a result, a transition from inadequate to adequate capital allotment (i.e., investment) for remediation activities serves as the foundation for an inverted U-shaped link between environmental stewardship and economic expansion (Carson, 2010). The EKC will be used as the framework for the study to examine the impact of Foreign Direct Investment, GDP, and Trade Openness.

2.3 Conceptual Framework

The study analyzed the relationship between selected macroeconomic variables and CO_2 emission in Kenya. The independent variables used in the study were AgGDP, FDI, Trade Openness, and Inflation. CO_2 emission in Kenya was used as the dependent variable. Figure 2:2 shows a relationship between the independent and dependent variables.

INDEPENDENT VARIABLES **DEPENDENT VARIABLE**

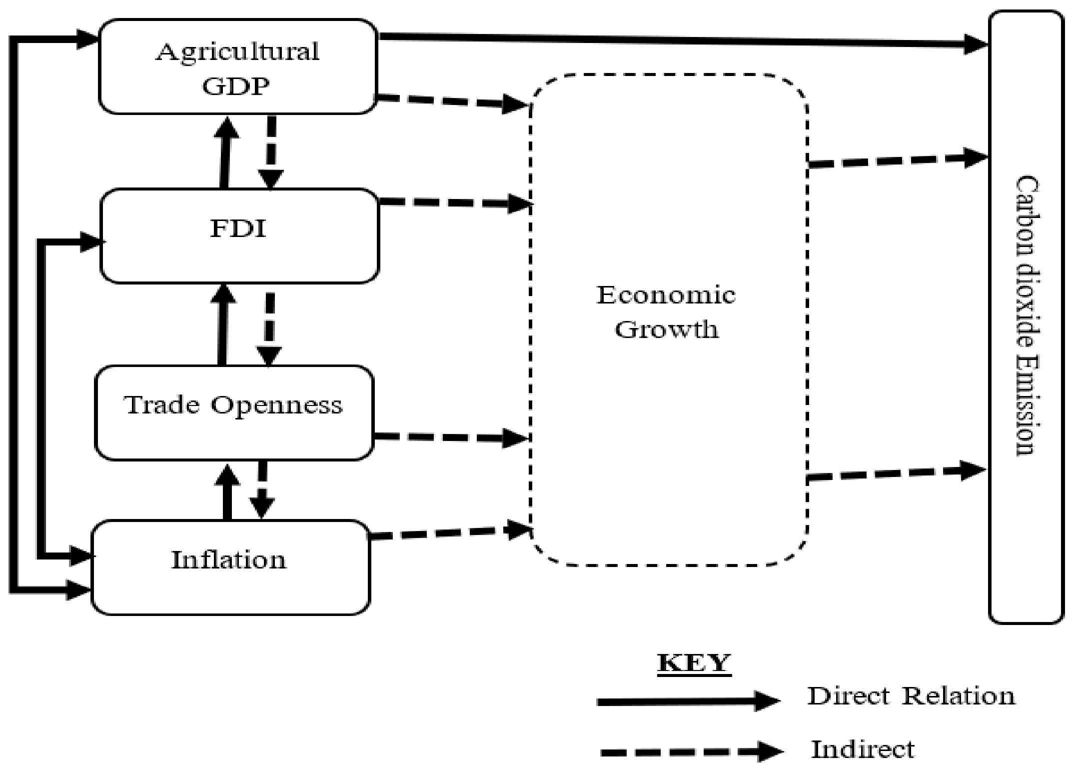

Figure 2.2 Conceptual Framework

Source: Author, 2021.

In the context of the selected macroeconomic variables (Agricultural GDP, FDI, Trade Openness, and Inflation) and CO_2 emission in Kenya, there are direct and indirect relationships (Figure 2.2).

The direct relationships can be observed between CO_2 emissions and the Agricultural GDP, FDI, and Trade Openness. Agricultural GDP, FDI, and Trade Openness contribute directly to CO_2 emissions in Kenya (Omri & Kahouli, 2014). Agricultural activities, industrialization, and transportation associated with FDI and trade openness contribute to the increase in CO_2 emissions. On the other hand, Inflation can have an indirect impact on CO_2 emissions by affecting economic growth and development, which, in turn, can influence the level of carbon emissions in Kenya.

Furthermore, the selected independent variables (Agricultural GDP, FDI, Trade Openness, and Inflation) can also be interrelated (Omri & Kahouli, 2014). For instance, an increase in agricultural GDP can lead to an increase in trade openness, which can attract FDI, ultimately leading to increased CO_2 emissions. Alternatively, inflation can affect the agricultural GDP, trade openness, and FDI, and hence their effect on CO_2 emissions.

In summary, the relationship among the selected macroeconomic variables (Agricultural GDP, FDI, Trade Openness, and Inflation) and CO_2 emissions in Kenya is complex and interdependent. The impact of each variable on CO_2 emissions is either direct or indirect.

2.4 Empirical Literature

Foreign direct investment (FDI) is often seen as a way to stimulate economic growth in developing nations. However, its impact on the environment can be detrimental, as seen in the case of Formosa Chemicals Corporation in Vietnam, which resulted in environmental degradation, dead fish, and destroyed coral reefs (To et al., 2019; Keho & Alimi, 2020). Nevertheless, some studies suggest that FDI can have a positive influence on the environment and CO_2 emissions. For example, Al-Mulali and Tang (2013) found that FDI inflows into Gulf Cooperation Council nations had a long-run negative relationship with CO_2 emissions, while Zarsky (1999) observed that foreign enterprises in host nations applied greater environmental norms and greener technology.

Studies have also used macroeconomic models to estimate the cost of environmental degradation. Panagos et al. (2018) estimated the annual cost of erosion to the European Union agricultural sector to be approximately 0.43% of annual loss, leading to a loss of €155 million in GDP. On the other hand, Kaenchan et al. (2019) used a recursive dynamic general equilibrium modeling to assess sustainable bioethanol production in Thailand and found that economic growth could be enhanced by improving the efficiency of feedstock cultivation.

The Environmental Kuznets Curve (EKC) is often used to validate its hypothesis in different economies. The model's hypothesis was validated in China and Indonesia by analyzing the effects of FDI, economic development, and energy consumption in developing countries (Sarkodie & Strezov, 2019). FDI was identified to increase the level of CO_2 emissions in Indonesia. The study used the Product, Quantity, and Routing (PQR) approach to examine the effect of the variables, which Cheng et al. (2018) and (2019) also applied. The PQR analysis helps in identifying the value streams and sorting them out. Overall, while FDI can have a positive impact on economic growth, its impact on the environment and CO_2 emissions must also be carefully considered.

In recent years, studies have been conducted to examine the relationship between sustainable development, production, and consumption, and their impact on the environment. One popular method used in these studies is the Autoregressive Distributed Lag (ARDL) model, which allows for the examination of both short-run and long-run relationships among variables.

Shahbaz et al. (2016) utilized the ARDL model to explore the relationship between energy consumption and globalization in India. By applying the co-integration test proposed by Bayer-Hanck, the study estimated a long-run demand function for energy consumption in India. Similarly, Sinaga et al. (2019) also used the ARDL model to investigate the long-run relationship between environment, economic development, biomass energy consumption, and other economic variables in Indonesia. The findings of the study suggested that biomass energy consumption has a positive and significant impact on economic growth in both the long and short run. Similarly, Gokmenoglu et al. (2019) used the ARDL model to evaluate the long-run equilibrium link between CO_2 emission, real income, energy usage, and agriculture in China. The study examined the existence of the agricultural-induced environmental Kuznets curve theory and found that real income and energy usage had a positive, elastic influence on CO_2 emissions, while agricultural productivity had a positive, inelastic impact. The study also found that squared real income had a negative, inelastic impact on air pollution.

Additionally, Burakov (2019) investigated the link between carbon dioxide emissions and their primary factors, such as real income and energy usage, in Russia. The ARDL bounds test technique was used to estimate the short- and long-run associations, and the findings supported the Environmental Kuznets Curve hypothesis. The study found that real income and energy consumption had a statistically significant positive impact on carbon emissions, while its square had a significant negative impact on carbon emissions in both the short and long run. The agricultural sector was also found to be a statistically significant predictor of carbon emissions in Russia. The findings of these studies highlight the importance of examining the relationship between sustainable development, production, and consumption, and their impact on the environment. The Auto regressive models provide useful tools for analyzing both short-run and long-run relationships among variables and can help inform policies aimed at promoting sustainable development and reducing the negative impact of production and consumption on the environment.

Recent studies have also applied the Autoregressive Distributed Lag (ARDL) to explore the impact of production and consumption on the environment, specifically in the context of sustainable development. The findings of these studies provide insights into the relationships between economic development, renewable energy consumption, agriculture, and CO_2 emissions.

Shahbaz et al. (2016) investigated the relationship between energy consumption and globalization in India using the ARDL technique. Their analysis revealed a long-run demand function for energy consumption in India. Sinaga et al. (2019) utilized the ARDL bound testing co-integration to assess the presence of a long-run relationship between environment, economic development, biomass energy consumption, and other economic variables in Indonesia. They found that biomass energy consumption has a positive and significant impact on economic growth in both the long and short run.

Gokmenoglu et al. (2019) evaluated the long-run equilibrium link between CO_2 emission, real income, energy usage, and agriculture in China. Their analysis found that real income and energy usage had a positive, elastic influence, while agricultural productivity had a positive, inelastic impact on CO_2 emissions. Burakov (2019) investigated the link between carbon dioxide emissions and their primary factors, which included real income and energy usage in Russia. The study found that real income and energy consumption had a statistically significant positive impact on carbon emissions, while its square had a significant negative impact on carbon emissions in both the short and long run. The agricultural sector was also found to be a statistically significant predictor of carbon emissions in Russia.

Liu et al. (2017) investigated the influence of per capita renewable energy consumption and agricultural value added on CO_2 emissions in four ASEAN-4 nations. Their study found that growing renewable energy and agriculture reduces CO_2 emissions, whereas non-renewable energy increases emissions. Zafeiriou et al. (2017) explored the intertemporal causal association between environmental harm from agricultural carbon emissions and agricultural economic performance for three new EU member countries. Their findings revealed that the environmental Kuznets hypothesis was proven in the long run for Bulgaria and the Czech Republic, but only in the short run for the Czech Republic.

The results of these studies provide policy implications for sustainable development. Increasing sustainable agriculture may boost renewable energy while lowering emissions, as demonstrated by Liu et al. (2017). Additionally, the findings suggest that adopting environmentally friendly farming practices and crop selection does not ensure simultaneous high economic and environmental performance, necessitating the modification of agri-environmental measures to make the two targets complementary rather than mutually exclusive, as highlighted by Zafeiriou et al. (2017).

Studies have also focused on the development of sustainable agricultural production techniques and methodologies for assessing agricultural sustainability at both the farm and macro levels. One such study by Vlontzos et al. (2017) developed a synthetic Eco-(in)efficiency index using a directional distance function- data envelopment analysis (DEA) model to evaluate the sustainability of the EU agriculture industry on a country-by-country basis from 1999 to 2012. The study also examined the link between eco-(in)efficiency, energy usage, and greenhouse gas (GHG) emissions on the gross domestic product (GDP) of EU nations to test for the presence of an environmental Kuznets curve (EKC) link. The findings of Vlontzos et al. (2017) indicated that efficiency gains in production development and GHG emissions reduction are achievable. Moreover, the capacity of EU countries to implement more sustainable production techniques was found not to be entirely dependent on their economic development since Eco-inefficiency and GDP levels in EU nations showed an N-shaped curve relationship.

Another study by Parajuli et al. (2017) used the Environmental Kuznets Curve (EKC) methodology to assess the impacts of forests and agricultural land on CO_2 emissions. The study employed country-specific panel data from 1990 to 2014 for 86 different nations and a dynamic panel data technique. The findings demonstrated that forests play a significant role in reducing CO_2 emissions globally, although the impacts differ by area, with a 0.11% decrease in CO_2 emissions per 1% increase in forest area estimated globally. Conversely, the agriculture sector was found to be a significant CO_2 emitter, emphasizing the importance of sustainable agricultural practices. The study added to the empirical evidence supporting forests' responsibilities in controlling atmospheric CO_2 and highlighting the relevance of forests in global climate change strategies.

These studies demonstrate the importance of sustainable agricultural practices and the role of forests in reducing CO_2 emissions. By implementing more sustainable agricultural production techniques, countries can achieve efficiency gains and reduce their GHG emissions. However, achieving sustainability in agriculture is a complex process that requires careful consideration of various factors, such as economic development, environmental impact, and social equity.

The role of modernization in the context of CO_2 emissions remains an area of active investigation. Ridzuan et al. (2020) investigated the impact of modernization on CO_2 emissions and discovered that modernization does not have a direct influence on CO_2 emissions. Instead, the study proposed that incorporating renewable energy into the agriculture sector is an effective measure to mitigate CO_2 emissions. The authors used the Environmental Kuznets Curve (EKC) hypothesis to examine the relationships between different attributes in Malaysia. By analyzing data from 1978 to 2016, Ridzuan et al. (2020) found that renewable energy, fisheries, and crops significantly reduced emissions during the study period. Furthermore, the relationship between CO_2 emissions and economic development followed an inverted U shape, suggesting that CO_2 emissions gradually decrease after reaching a certain level of economic growth. The findings of the study were consistent with the EKC theory for Malaysia.

Similarly, Aziz et al. (2020) investigated the EKC hypothesis based on the quantile behavior of the link between agricultural productivity, forest area, economic development, environmental deterioration, and renewable energy in Pakistan. Previous literature relied on single indicators to address environmental concerns, which fails to assess overall environmental conditions or indicate that environmental issues are generally improving. The authors used ecological footprint (EF) as an indicator and employed a modern method of quantile autoregressive distributed lag (QARDL) to test the EKC hypothesis for Pakistan. The results of the study verified the EKC hypothesis for Pakistan and revealed a quantile-dependent link, suggesting that standard approaches may provide biased results. The Wald test supported the rejection of the null hypothesis of parameter constancy. Moreover, renewable energy consumption and forest area demonstrated substantial negative impacts on ecological footprints in the long term, indicating that boosting renewable energy use and forest area can avoid ecological footprints. This work by Aziz et al. (2020) was the first to use EF as an indicator to test the EKC hypothesis for Pakistan, contributing to the literature on addressing environmental concerns using multiple indicators.

Overall, the studies by Ridzuan et al. (2020) and Aziz et al. (2020) add to the growing body of literature on the relationships between different attributes and environmental concerns. The findings from these studies suggest that incorporating renewable energy into the agriculture sector can effectively mitigate CO_2 emissions and that utilizing multiple indicators is necessary to comprehensively address environmental issues. Furthermore, the EKC hypothesis can help explain the relationships between different attributes and environmental concerns, with both studies providing support for the hypothesis in their respective contexts.

Environmental degradation has become a critical issue among economists and environmentalists, with increasing attention being paid to the relationship between economic development and CO_2 emissions. Lau et al. (2014) aimed to test the validity of the Environmental Kuznets Curve (EKC) theory in Malaysia, taking into account foreign direct investment (FDI) and trade openness in the short and long run between 1970 and 2008. The study utilized the bounds testing approach and Granger causality methods to examine the interrelationships between economic growth, CO_2 emissions, FDI, and trade. After controlling for FDI and trade, the results showed an inverted-U shaped relationship between economic growth and CO_2 emissions in both the short and long run in Malaysia, thereby providing important policy recommendations for policymakers.

Similarly, Haisheng et al. (2005) investigated the impact of FDI and trade on the EKC in China, using data from economic development, environmental conditions, FDI, and trade in China's 30 provinces from 1990 to 2002. The study revealed that trade did not have a direct impact on the EKC in China; however, it significantly contributed to economic growth and facilitated the introduction of advanced pollution prevention technologies and environmental management practices. Thus, a proactive trade strategy can help to address the environmental pollution problem caused by economic expansion. Conversely, FDI had a significant association with pollutant emissions, indicating that FDI had a negative impact on the environment in China due to the rapid influx of foreign capital and China's weak environmental governance system.

It is important to note that these studies provide valuable insights into the relationship between economic development and environmental degradation in the context of the EKC theory. The findings of these studies have important policy implications for policymakers in their efforts to achieve sustainable economic development while mitigating the negative impact of economic activities on the environment.

In recent years, the association between economic development, foreign direct investment (FDI), and environmental deterioration has received considerable attention in academic circles. Balibey (2015) conducted research to analyze the causal relationships between these variables and evaluate the validity of the Environmental Kuznets Curve (EKC) hypothesis in Turkey from 1974 to 2011. The study employed various methods, including Impulse-Response Test, Johansen Cointegration Test, Granger Causality Test, and Variance Decomposition Analysis of the Vector Autoregression Model (VAR), to examine the causality linkages. The results showed that FDI and economic development had a significant influence on carbon dioxide emissions, supporting the causality correlations between the variables. Furthermore, the

EKC hypothesis was examined using the Regression Model technique for various EKC model forms, such as linear, cubic, and quadratic. The findings demonstrated that economic expansion led to environmental deterioration and the depletion of natural resources, emphasizing the need for sustainable economic growth by reducing CO_2 emissions and energy consumption. Therefore, policymakers must consider exogenous influences, such as foreign investments, while planning energy regulations and maintaining economic development in the face of global climate change.

Similarly, He and Yao (2016) investigated the effects of economic development and FDI on air pollutant emissions in several Chinese provinces. The study employed a panel smooth transition regression and demonstrated regime-switching effects in the income-pollution connection. The link between per capita income and two air pollutant emissions, soot, and dust, was shown to have an inverted-U shape, confirming the EKC theory. Moreover, the study discovered a significant FDI effect on EKC connections, providing evidence that the pollution haven theory was valid to a certain degree in the selected Chinese provinces.

Overall, these studies highlight the importance of sustainable economic growth and the need for policymakers to consider various factors, including FDI and environmental regulations, while planning economic development strategies.

The concept of the Environmental Kuznets Curve (EKC) has attracted considerable attention in environmental economics as it postulates that economic development can result in improved environmental quality once a certain income threshold is surpassed. To investigate the presence of the EKC, several studies have analyzed the causal linkages between economic development, carbon dioxide emissions, and foreign direct investment. For instance, Balibey (2015) examined the causal linkages between economic development, carbon dioxide emissions, and foreign direct investment in Turkey from 1974 to 2011. The study employed several econometric techniques such as the Impulse-Response Test, the Johansen Cointegration Test, the Granger Causality Test, and the Variance Decomposition Analysis of the Vector Autoregression Model (VAR). The findings revealed that foreign direct investment and economic development have significant impacts on carbon dioxide emissions. Similarly, He and Yao (2016) investigated the effects of economic development and FDI on air pollutant emissions in Chinese provinces using a panel smooth transition regression. The study confirmed the presence of the EKC theory for two air pollutant emissions, soot, and dust, indicating an inverted-U shape relationship with per capita income.

Another study by Villanthenkodath and Arakkal (2020) examined the presence of the EKC in New Zealand using annual time series data from 1970 to 2017. The study used the Vector Error Correction Model to investigate cointegration among the variables, which included trade openness, financial development, foreign direct investment, economic growth, and CO_2 emissions. The study found that trade openness, financial development, and foreign direct investment have positive impacts on environmental quality. Moreover, the scatter plot of CO_2 emissions and economic growth showed an inverted U-shaped relationship between the two variables, with a turning point in 1987. The findings recommended a range of strategies to achieve sustainable economic growth and environmental quality in New Zealand.

Maroufi and Hajilary (2022) sought to examine the long and short-term affiliation between carbon dioxide emissions, energy consumption, foreign direct investments, and gross domestic product in Iran over a 40-year period using an autoregressive distributed lag (ARDL) model. The study's estimation findings supported the EKC theory for Iran, indicating a U-shaped relationship between economic expansion and carbon dioxide emissions. Additionally, the study found that Iran's reliance on gas as a clean energy source has contributed to a reduction in carbon and ecological footprints in a short period. The empirical results suggested that economic expansion and foreign direct investment have helped reduce pollutant and carbon emissions in Iran over the long and short terms.

In summary, the studies reviewed in this text provide evidence for the existence of the EKC theory in different countries and highlight the importance of developing sustainable economic growth strategies that consider environmental sustainability objectives. Policymakers need to consider exogenous factors like foreign investments while planning energy regulations and maintaining economic development in the face of global climate change.

Ridzuan et al. (2022) have examined Malaysia's sustainable development in the context of foreign investment and the environmental consequences of increased carbon emissions. The study has identified the role of foreign direct investment (FDI) from countries such as China, Japan, and the United States in Malaysia's economic growth. However, the authors have also highlighted the adverse environmental impact of this development, which has resulted in a deterioration of the country's ecological conditions. The authors have utilized the Environmental Kuznets Curve (EKC) and the Pollution Haven Hypothesis (PHH) to analyze the impact of FDI and other macroeconomic factors on carbon emissions, using data from 1971 to 2019. The study has found that Malaysia's environmental quality exhibits a U-shaped EKC, indicating that FDI inflows have exacerbated the country's environmental degradation. This finding suggests that policymakers must be more vigilant about the impact of economic development on carbon emissions and that stringent environmental regulations should be enforced on foreign investors.

Similarly, Liu et al. (2019) have examined the impact of economic development and FDI on carbon emissions in China, utilizing province panel data from 1996 to 2015. The study has demonstrated a reverse U-shaped relationship between economic growth and CO_2 emissions, as well as an inverted N-shaped association between FDI and CO_2 emissions. The authors have also highlighted the accelerating impact of energy consumption on carbon dioxide emissions generation. The study has recommended updating industrial infrastructure, spreading technologies, and liberalizing commerce to reduce carbon dioxide emissions. However, the authors have also recommended future research to examine regional disparities in China and the mechanism of the inverted N-type relationship between FDI and carbon emissions. Moreover, comparison research between developed and developing countries has been recommended to evaluate and validate the universality and adaptability of the study's findings.

Both studies have highlighted the adverse environmental impact of economic development and FDI on carbon emissions. The studies have recommended that policymakers should take a more active role in regulating FDI and enforcing stringent environmental regulations. The studies have also suggested the need for further research to examine the impact of economic development on carbon emissions in different regions and countries. Overall, these studies have significant implications for policymakers, highlighting the importance of balancing economic growth and sustainable development.

Recently, a growing body of literature has focused on the interplay between economic development and environmental degradation. Koilo (2019) explored this relationship in eleven emerging Eastern European and Central Asian countries from 1990 to 2014. The findings revealed the existence of a carbon emission Kuznets curve, indicating that not every country had achieved the tipping threshold for reducing CO_2 emissions. Furthermore, positive CO_2 income elasticities were observed in all eleven nations, with Ukraine and Kazakhstan experiencing the most significant change in economic growth in relation to CO_2 emissions. Koilo (2019) suggested that the transition to a low-carbon economy would provide significant prospects for economic development and employment creation. However, the industry 4.0 initiative needs to be complemented by the development and introduction of new technologies throughout Eastern European and Central Asian nations, and the "sustainable development" paradigm should be regarded as critical. In addition, the policy implications made by other emerging nations in achieving sustainable growth should be considered.

Similarly, Ergun (2020) examined the relationship between GDP per capita, foreign direct investment (FDI), energy usage per capita, and environmental deterioration in Uruguay using data from 1971 to 2014. The findings revealed a negative association between environmental deterioration and FDI, while environmental deterioration was favorably associated with energy usage per capita in the long term. The Environmental Kuznets Curve (EKC) hypothesis was also verified due to the inverted U-shaped relationship between GDP per capita and environmental deterioration. The policy proposals included efforts to increase energy savings and efficiency, investments in cleaner and more efficient technology, and regulations to increase the percentage of current renewable sources in energy usage.

Both Koilo (2019) and Ergun (2020) highlight the importance of technology use in reducing environmental degradation. Koilo (2019) noted that the relationship between technology use and CO_2 emissions requires further investigation. Ergun (2020) suggested that investments in cleaner and more efficient technology should be made to reduce environmental degradation. Thus, it is clear that technology plays a critical role in achieving sustainable economic growth while mitigating the negative impacts of economic development on the environment.

Agboola and Bekun (2019) conducted a study to validate the Environmental Kuznets Curve (EKC) hypothesis in Nigeria, using the Vector Error Correction Model (VECM). The study employed various statistical tests such as Phillips-Perron (PP), Augmented Dickey-Fuller (ADF), and Zivot and Andrews to test for a unit root in the annual time series data. The Bayer and Hanck co-integration technique and Granger Causality test were also utilized. The EKC model served as a guide throughout the project, with some modifications made where necessary.

On the other hand, Kastratovic (2019) estimated a dynamic econometric model to examine the impact of foreign direct investment (FDI) on greenhouse gas (GHG) emissions in agriculture in developing countries. The study employed a system-generalized method of moments for the estimation. The findings revealed a significant effect of foreign direct investment in agriculture on the intensity of carbon dioxide equivalent emissions in developing nations. The results provided limited evidence for the pollution haven hypothesis and underscored the importance of aligning foreign direct investment and environmental policies.

Both studies provide valuable insights into the relationship between economic development, foreign direct investment, and environmental degradation in developing countries. The findings of Agboola and Bekun (2019) and Kastratovic (2019) highlight the potential for environmental degradation to follow a non-linear trajectory as economies develop. These studies also underscore the significance of environmental policies and the need to align them with economic development and foreign direct investment. Further research is required to investigate the impact of technology use on carbon emissions in developing countries, as identified by Koilo (2019).

The agriculture industry is essential for economic growth, but it also contributes to environmental degradation and greenhouse gas (GHG) emissions. The impact of agricultural activities on environmental deterioration has gained prominence in the environmental Kuznets curve (EKC) literature in recent years (Selcuk et al., 2021). Selcuk et al. (2021) conducted research to investigate the impact of trade openness, foreign direct investment (FDI), agricultural activities, and energy consumption (EC) on CO_2 emissions in the Next Eleven nations between 1991 and 2019, within the framework of the EKC hypothesis. The study utilized the common correlated effects mean group estimator (CCEMG) to generate panel and country-specific outcomes. In addition, the Dumitrescu-Hurlin panel causality test was employed to investigate the pairwise causal link between variables.

The findings of Selcuk et al. (2021) showed that an inverted U-shaped relationship exists between CO_2 emissions and GDP in Mexico, Nigeria, Turkey, Bangladesh, and the panel. However, in South Korea and the panel, FDI exhibited a strong positive relationship with CO_2 emissions. The study revealed that trade openness had a significantly negative association with CO_2 emissions in Mexico, Indonesia, Bangladesh, and the panel, but a significantly positive link with CO_2 emissions in the Philippines. Furthermore, for Turkey, Bangladesh, and the panel, the variable of agricultural activities had a significantly negative connection with CO_2 emissions, but a significantly positive link with CO_2 emissions for Mexico. Thus, the findings highlight the complex nature of the relationship between economic growth, agriculture, and the environment across different countries.

Similarly, Dogan (2016) investigated the long-term relationship between agricultural performance and carbon dioxide emissions in Turkey. The study utilized the Bounds test strategy for co-integration and the Autoregressive Distributed Lag (ARDL) method with yearly data from 1968 to 2010. The results showed a significant positive relationship between real GDP and carbon emissions in both the short and long run, consistent with the EKC theory. Additionally, agricultural activities were found to have a significant detrimental influence on the level of carbon dioxide emissions in both the short and long run. The findings suggest that policies or changes that promote agricultural production may assist in reducing carbon dioxide emissions in the countries investigated.

Overall, the studies discussed in this text demonstrate the importance of considering the relationship between economic growth, agriculture, and the environment. The results suggest that a nuanced approach is required to balance economic development and environmental sustainability. Policies that promote sustainable agriculture practices, reduce GHG emissions, and increase energy efficiency may help countries achieve sustainable economic growth.

The Environmental Kuznets Curve (EKC) literature has seen an increasing interest in the influence of economic activities on environmental degradation. Mahmood et al. (2019) used cointegration to investigate the EKC-augmented CO_2 emissions model for Egypt over the period from 1990 to 2014. Their study revealed cointegration in the model, and empirical testing verified the EKC hypothesis. While energy use was found to increase CO_2 emissions per capita, Foreign Direct Investment (FDI) was shown to have a beneficial effect in reducing CO_2 emissions per capita. In contrast, the impact of trade was found to be small. According to Mahmood et al. (2019), the Egyptian government should seek additional foreign investment to promote a clean and green environment.

Similarly, Liu et al. (2022) examined the EKC link between travel and tourism and ecological footprint in Pakistan from 1980 to 2017. The authors explored the influence of tourist development, economic growth, energy consumption, trade openness, and foreign direct investments on ecological footprint within the EKC paradigm. The ARDL and Bayer and Hanck tests showed that the variables in the study exhibited long-term cointegration. Liu et al. (2022) found an inverted U-shaped relationship between travel and tourism and Pakistan's ecological footprint, confirming the tourist-led growth hypothesis. Furthermore, the authors' ARDL and Toda-Yamamoto non-causality findings revealed that energy usage and trade liberalization came at the cost of environmental impact. Additionally, the infusion of foreign direct investment was found to contribute to environmental degradation and supported the pollution haven hypothesis. Hence, Liu et al. (2022) suggested that governments should prioritize sustainable tourism, fuel mix diversification, and foreign direct investment in the services sector to promote a sustainable environment.

Agozie et al. (2022) have contributed to the ongoing discussion on energy efficiency and environmental sustainability in emerging economies, such as Russia, South Africa, India, China, and Brazil, by investigating the dynamic relationship between economic complexity index (ECI), foreign direct investment (FDI), renewable energy, urbanization, natural resources, and CO_2 emissions. Their study utilized robust econometric techniques, such as Fully Modified-Ordinary Least Squares estimators with Augmented Mean Group as estimate’s methodologies.

The empirical findings of Agozie et al. (2022) indicated that both the inverted U-Shaped and N-Shaped EKC relationships between ECI and CO_2 emission were valid. Moreover, the results also supported the Pollution Haven Hypothesis, which suggested that FDI played a role in environmental degradation in the aforementioned emerging economies. Additionally, renewable energy and the relationship between ECI and urbanization were found to have a negative influence on emissions. Conversely, natural resources and urbanization were seen to have a positive impact on the environment. The Dumitrecu and Hurlin causality results demonstrated a bi-directional causation between economic complexity and CO_2 emissions. Similar causation was found between the economic complexity index, urbanization, and CO_2 emissions, while a one-way causality was observed from FDI to CO_2 emissions during the research period.

The study's findings encourage authorities in the researched countries to formulate comprehensive energy policies that prioritize renewable energy sources to improve the environmental quality of these nations. Additionally, there should be a focus on economic policies that promote sustainable manufacturing activity that can generate environmental sustainability without compromising economic prosperity.

The Pollution Haven Hypothesis has been the subject of recent economic debates that examine the role of FDI in increasing environmental deterioration in host nations, as reported by Waqih et al. (2019). In contrast, the Environmental Kuznets Curve theory has been extensively researched under the topic of environmental deterioration since 1991. Waqih et al. (2019) investigated the influence of FDI, economic development, and energy consumption in increasing carbon dioxide concentrations in the South Asian region using panel data from 1986 to 2014. They utilized panel ARDL and FMOLS techniques in their study. In the short term, their results confirmed the presence of the Pollution Haven Hypotheses and the Environmental Kuznets Curve. However, in the long run, their panel data research indicated the absence of the Pollution Haven Hypotheses and the presence of the Environmental Kuznets Curve. Furthermore, the study found that energy consumption in the region significantly contributed to environmental deterioration. Due to a large portion of energy in South Asian nations being generated from non-renewable energy resources, these countries will continue to rely on these energy sources to meet their energy needs, adding to the carbon dioxide levels in the environment.

A study by Ozturk and Acaravci (2013) examined the relationship between FDI and carbon dioxide emissions in Kenya using annual data from 1970 to 2010. The study found a positive and significant relationship between FDI and carbon dioxide emissions in Kenya, indicating that increased FDI leads to increased carbon dioxide emissions. The authors suggest that this may be due to the fact that the majority of FDI in Kenya is concentrated in the manufacturing sector, which is known to be a significant contributor to carbon dioxide emissions. Another study by Ali et al. (2018) also examined the impact of FDI on carbon dioxide emissions in Kenya. The study used panel data from 1980 to 2014 and found that FDI has a positive impact on carbon dioxide emissions in the short run, but the effect becomes negative in the long run. The authors suggest that this may be due to the fact that FDI can lead to the transfer of clean technology, which eventually helps to reduce carbon dioxide emissions.

Ondieki and Nyangena (2017) examined the impact of FDI on carbon dioxide emissions in Kenya from 1980 to 2012 using an autoregressive distributed lag (ARDL) approach. The study found a positive long-run relationship between FDI and carbon dioxide emissions, suggesting that FDI inflows contribute to increased carbon dioxide emissions in Kenya. Similarly, a study by Kioko and Mwabu (2017) investigated the relationship between FDI and carbon dioxide emissions in Kenya using a panel data approach. The study found that FDI inflows have a positive effect on carbon dioxide emissions in Kenya, particularly in the manufacturing and services sectors. However, other studies have provided mixed results. Kinyua et al. (2019) found that FDI inflows have a negative effect on carbon dioxide emissions in Kenya, particularly in the energy and transport sectors. The study attributed this to the fact that FDI inflows tend to lead to the adoption of cleaner technologies and practices in these sectors. Therefore, the relationship between FDI and carbon dioxide emissions in Kenya is complex and depends on several factors, including the sector in which the FDI is concentrated and the technology transfer that accompanies it. While some studies have found a positive relationship between FDI and carbon dioxide emissions, others have provided mixed or even negative results.

Agriculture is one of the main contributors to carbon dioxide (CO_2) emissions in Kenya. According to a study by Onduru et al. (2010), the agricultural sector contributes about 42% of the country's total CO_2 emissions. This is mainly due to the use of fossil fuels in agriculture, such as diesel and petrol for irrigation, transportation, and machinery. Furthermore, livestock production in Kenya has been identified as a significant source of greenhouse gas emissions, particularly methane and nitrous oxide, due to enteric fermentation and manure management (Onduru et al., 2010; Nyberg et al., 2020). A study by Ng'ang'a et al. (2020) found that the livestock sector in Kenya contributes to approximately 20% of the country's total greenhouse gas emissions.

In addition, land-use change and deforestation for agricultural purposes also contribute to CO_2 emissions in Kenya. According to a study by Omoyo et al. (2014), the conversion of forests and grasslands for agriculture accounts for about 17% of the country's total CO_2 emissions. Several measures have been proposed to mitigate the carbon footprint of agriculture in Kenya. These include promoting the use of renewable energy sources such as solar and biogas for irrigation and other farm activities, reducing the use of synthetic fertilizers, and implementing sustainable land management practices such as agroforestry and conservation agriculture (Onduru et al., 2010; Nyberg et al., 2020). Overall, addressing the contribution of agriculture to CO_2 emissions in Kenya is essential in achieving the country's commitment to reducing its carbon footprint and mitigating the impacts of climate change.

The relationship between the agricultural output, selected macroeconomic variables and Carbon dioxide emission will be evaluated through the Environmental Kuznets Curve (EKC). The aim of this study was not to show evidence of the EKC in Kenya. Instead, the study used it as a framework or guide of the research (Figure 2.3) (Stern, 2018) and (Özokcu & Özdemir 2017).

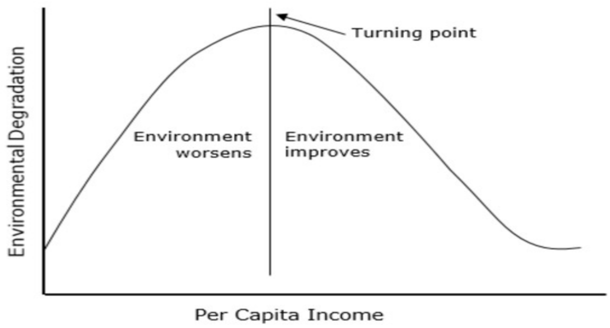

Figure 2.3 Environmental Kuznets Curve

Source: Agboola & Bekun (2019).

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Overview

This section covers the study area, research design, target population, data types and sources, data collection procedures, model specification, data analysis, unit root test, cointegration analysis and the Vector Error-Correction Model.

3.1 Study Area

Kenya, located in Eastern Africa, was selected as the study area due to its unique economic and environmental factors. As one of the fastest-growing economies in Africa, Kenya's growing demand for energy and increasing industrialization have led to high levels of carbon dioxide emissions, which exacerbate the country's vulnerability to climate change. According to the World Bank (2021), Kenya's GDP was $98.3 billion in 2020, with a FDI inflow of $1.1 billion, and a trade openness rate of 27.2 percent.

Kenya's political and social landscape also influences the relationship between macroeconomic variables and carbon emissions. The country has a multi-party democratic system, but its history of tribalism, corruption, and political instability presents challenges to sustainable economic development and environmental conservation. Additionally, Kenya's diverse population of over 40 ethnic groups and income inequality can affect investment in green technology and environmental protection initiatives (UNEP, 2021).

This study aims to contribute to the existing literature on the relationship between macroeconomic variables and carbon emissions in Kenya, providing insights for policymakers and stakeholders. Sustainable development strategies must address the unique economic and environmental challenges facing Kenya, promoting economic growth while also reducing carbon emissions and adapting to the impacts of climate change.

3.2 Research Design

The choice of research design is critical in any empirical investigation, and in this study, we employed a longitudinal time-series design to evaluate the short- and long-term relationship between macroeconomic factors and CO_2 emissions in Kenya. Longitudinal designs allow researchers to assess the correlations between variables measured at regular intervals over time (Liu et al., 2020). Time series analysis, as noted by Pérez-Rodríguez and Torre-Sánchez (2019), can uncover essential dynamics and changes that occur over time and can evaluate the consequences of planned or unplanned interventions.

While longitudinal studies involve following the same group of individuals over time, panel research involves gathering data from the same individuals over multiple time points, making it a related design. Unlike longitudinal studies, panel research includes both cross-sectional and longitudinal data. As such, panel studies can be particularly useful in social sciences when the same group of individuals is monitored over a period (Allison, 2019). However, for this study, we chose to use a longitudinal design as it was the most appropriate for evaluating the relationship between macroeconomic factors and CO_2 emissions in Kenya.

By employing a longitudinal design, we were able to capture variations in the macroeconomic variables and CO_2 emissions over time, providing a more accurate assessment of the relationship between these variables. This research design has been used in previous studies to assess the relationship between environmental degradation and economic development (Tang et al., 2020; Wu et al., 2019). Furthermore, it is wellsuited to studying the impact of macroeconomic policies on CO_2 emissions (Chen et al., 2020).

3.3 Data Type and Sources

The study utilized secondary data from the Environmental Performance Index, Kenya National Bureau of Statistics, and the World Bank. The data collection was conducted using a diagnostic approach to determine the frequency of structural breaks in the variables. The time-series data covered a period from 1983 to 2019, recorded annually.

Additionally, the use of annual data for the period from 1983 to 2019 allowed for the capture of long-term trends and changes in the variables. This timeframe is adequate for evaluating the impact of macroeconomic factors on CO_2 emissions as it covers a period of significant economic growth and development in Kenya.

Notably, the choice of data type and sources is a critical aspect of any empirical investigation as it affects the validity and reliability of the study findings. In this study, secondary data were used from reliable sources. These sources are recognized globally for their extensive coverage and reliability of data on environmental performance, economic indicators, and social development. The use of such sources enhances the credibility of the study findings and ensures that the results are generalizable to other settings.

3.3.1 Unit of Analysis

In this study, CO_2 emissions were the dependent variable, while Agricultural GDP, FDI, Trade Openness, and Inflation were the independent variables. The unit of analysis refers to the level of analysis that is being examined in the research study (Babbie & Mouton, 2018). In this case, the unit of analysis is the country, and the analysis was done at the aggregate level.

The use of the country as the unit of analysis in this study is in line with previous studies that have evaluated the impact of macroeconomic factors on environmental degradation at the country level (Al-Mulali et al., 2015; Alam et al., 2019). This approach allows for a comprehensive evaluation of the relationship between the independent and dependent variables at the national level.

3.3.2 Assumptions of Time-series Data

The study used time-series data relying on the following assumptions.

i. **Decomposition:** This means that time-series data can be separated through seasonal effects, trends, and variability.
ii. **Stationarity:** The study assumed that the time series data had a normal distribution with a consistent mean and variance over a prolonged period.
iii. **Uncorrelated random error:** The research also assumed that the error term was distributed randomly and that the mean and variance were stable throughout time.
iv. **No outliers:** To prevent erroneous results, the research also assumed that there were no outliers in the series.
v. **Random shocks:** Shocks were assumed to be randomly distributed with a constant variance and a mean of zero if they were existent.

3.4 Data Collection Procedure

The Environmental Performance Index, Kenya National Bureau of Statistics, and the World Bank database were accessed through the internet. The databases have a simplified interface to help individuals extract their desired data. In preparation for further investigation, extracted data were saved in excel sheets and cleaned.

3.5 Model Specification

The research employed the Vector Error Correction Model to analyze and interpret the data obtained. The typical VECM model computed in the study is presented below (Equation 3.1).

$$\Delta Y_t = P_i \varepsilon_{t-i} + \sum_{i=0}^{p} \beta \Delta Y_{t-i} + \sum_{i=0}^{p} \alpha \Delta X_{t-i} + \cdots + \sum_{i=0}^{p} \lambda \Delta G_{t-i} \ldots \ldots (Eq\ 3.1)$$

Where ΔY_t was the dependent variable (CO_2 emission ($MtCO_2e$)); ΔX_t was the regression vector composed of agricultural output, foreign direct investments, trade openness, and inflation rate; ε represents the error term; P was the estimated coefficient of the lag error term; G denoted the study's final regressor vector; t represents the time lag; α and β depicted the estimated coefficients of the variables that were utilized.

Other studies have employed the VECM model to analyze univariate time series including (Agboola and Bekun, 2019), (Kong'o et al. 2018), and (Mahalik et al., 2021). In evaluating how each univariate time series variable would affect carbon dioxide emissions, the model fits the analysis. Furthermore, when compared to other models such as exponential smoothing approaches, the model quickly regresses the data and produces exact findings that can be read.

3.6 Data Analysis

The STATA statistical program was used to examine the collected data and information. Inferential statistics allowed the researcher to create a judgment on the economy based on the facts, whereas descriptive statistics were used to summarize and characterize data. To find the Unit Root factor in the series, the Phillips-Perron (PP) and Zivot-Andrews (Zivot-Andrews) tests were used. The VECM and Johansen Co-integration studies calculated the long and short-run relationships between the variables.

First, univariate data series time series plots or curves were displayed or graphed to highlight the nature of the Data Generating Process (DGP). All DGP data presents three types of charts based on the stochastic process. The graph might be a random walk with a trend, a random walk with drift, or a completely random process.

3.7 Unit Root Test

The subsequent phase was to run a unit root test on all the series data. The DGP directed the examination. The null hypothesis was ***H_{01}:*** There was a unit root, indicating that the variables were not stationary. There are various Unit Root tests, however this study only employed two;

a. Augmented Dickey-Fuller test and
b. Phillips-Perron Unit Root Test.

3.7.1 Augmented Dickey-Fuller Test

A nested time series model was used to handle serial autocovariance, covariance, and autocorrelation. The estimated model was as follows (Equation 3.2).

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{p} \propto_i \Delta Y_{t-1} + \varepsilon_t \ldots\ldots (Eq\ 3.2)$$

Where;

ΔY_t Represents the initial differenced dependent variable

β_1 Represents the Y-intercept

$\beta_2 t$ Represents the trend in time factor

$\boldsymbol{\delta}$ indicates the lagged variable's coefficient.

$\sum_{i=1}^{p}$ The letter "P" stands for the Optimal lag length and was chosen by.

Akaike Information Criteria (AIC) and

Schwarz-Bayesian Information Criteria (BIC).

If $\boldsymbol{\delta > \delta_t}$, reject the null hypothesis.

3.7.2 Phillips-Perron Test

The PP test was designed to address serial correlation in the ADF test (Phillips & Perron, 1988). (Agboola & Bekun, 2019). The null hypothesis was that there was a unit root, and the alternative hypothesis was that there was no unit root. The following is the model form that was estimated (Equation 3.3).

$$Y_y = \delta_t + \gamma Y_{t-1} + \gamma_1 \Delta Y_{t-2} + \cdots + \gamma_p \Delta Y_{t-p} + \varepsilon_t \ldots \ldots (Eq\ 3.3)$$

Where;

The current value is represented by Y_y .

The intercept is represented by δ_t.

γ Indicates the lagged variable's coefficient.

The error term is represented by ε (white noise).

p the optimal lag duration as calculated by AIC and BIC.

If the variables have a unit root, the subsequent phase is differencing. The variables that differed were plotted to check if they became stationary. Following the charting, a unit root test was performed on the differenced variables. If the unit root test revealed that the differenced variables were stationary, it was determined that they were integrated of order 1.

3.7.3 Zivot-Andrews Model

".... A difficulty shared with standard unit root tests — like the DF-GLS, PP, and ADF tests — is that they do not account for the potential of a structural break…" (Waheed et al.,2006). Perron demonstrated that when the stationary alternative was valid and a structural break was disregarded, the ability to reject a unit root diminished when the moment of the break was assumed to be an exogenous phenomenon. Zivot and Andrews developed a variant on Perron's initial test where the exact moment of the breakpoint remained unclear. The Zivot and Andrews (1992) endogenous structural break test is a sequential test that uses the entire dataset and a new dummy variable for each possible break date. The break date is selected such that the t-statistic from the ADF root test is as relatively small and reasonable (most negative). As a result, a break date would be selected when the evidence favors the null unit root the least.

Zivot and Andrews therefore tested three models for a unit root:

1) Model A, which allowed for a one-time modification in the series' level (Equation 3.4);
2) Model B, which permitted for just a one-time adjustment in the trend function's slope (Equation 3.5), and
3) Model C, which included one-time modifications in the level and slope of the series' trend function (Equation 3.6).

As a result, Zivot and Andrews employed the multiple regressions corresponding to the above three models to test for a unit root against the alternative of just one structural break (Zivot & Andrews, 1992) and (Agboola & Bekun, 2019).

$$\Delta Y_t = \beta_0 + \alpha Y_{t-1} + \beta_t + \gamma DU_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \ldots\ldots Model\ A \ldots\ldots (Eq\ 3.4)$$

$$\Delta Y_t = \beta_0 + \alpha Y_{t-1} + \beta_t + \theta DT_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \ldots\ldots Model\ B \ldots\ldots (Eq\ 3.5)$$

$$\Delta Y_t = \beta_0 + \alpha Y_{t-1} + \beta_t + \gamma DU_t + \theta DT_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \ldots\ldots Model\ C \ldots\ldots (Eq\ 3.6)$$

Where;

$DU_t = \{1 \ldots\ if\ t\ > Tb, and\ \ 0 \ldots\ otherwise\ \}$

$DT_t = \{t - TB \ldots if\ t\ > Tb, and\ 0 \ldots\ldots.. otherwise\ \}$

DUt is an indicator dummy variable for a mean shift occurring at each possible break-date (Tb), while DTt is the corresponding trend shift variable and k is the number of lags according to the ADF general to the specific methodology for lag selection.

In all three models, the null hypothesis is α=0, implying that the series Y_t It has a unit root with a drift that eliminates any structural break, whereas hypothesis α<0 indicates that the sequence is a trend-stationary procedure with each break at an unspecified moment in time. The Zivot and Andrews technique considers each point to be a potential break-date (Tb) and runs a regression for each possible break-date consecutively. The approach chooses the break-date (Tb) that minimizes the one-sided t-statistic for testing α̇ (=α-1) =1 from among all feasible breakpoints (*Tb*).

3.7.4 Determination of Optimum Lag Length

The optimum lag length was determined because utilizing additional lag lengths limits the degrees of freedom. Furthermore, the use of minimal delays caused autocorrelation and multicollinearity (Agboola & Bekun, 2019; Vrieze, 2012). The model form that was calculated using the AIC and BIC is as follows (Equation 3.7);

$$IC_P = lnln\ ln\ \left(\frac{\varepsilon^1 \varepsilon}{T - P_{max+k^x}}\right) + \left(P + K^X\left(\frac{A^X}{T - P_{max-k^x}}\right)\right) \ldots \ldots (Eq\ 3.7)$$

Where;

K^X Represents,

X=1, Random Walk with Trend

X=2, Random Walk with Trend and Drift.

X=3, Random Walk with Drift

A^X Is for AIC

$lnln\ ln\ (T - P_{max-k^x})$ Is for BIC

3.8 Co-Integration Analysis

In economics, several co-integration testing procedures are used, including the system-based tests of Johansen (1988) and the residual-based test of Engle and Granger (1987). Banerjee et al. (1998) and Boswijk (1994) proposed error-correction-based testing to enhance the findings of prior tools. The choice of the best tool among these robust tests is left to the user. However, more often, at least one test rejects the hypothesis while at least another one contradicts, complicating the interpretation of the results. Therefore, a suitable combination of these tools would yield more robust power performance than using each separately. Bayer and Hanck's co-combined co-integration techniques were improved gradually (2008-2013) to accommodate more robustness (Bayer & Hanck, 2013).

The Johansen Multivariate Co-Integration method was used to assess Co-Integration and determine if the model's variances are Co-Integrated (Johansen, 1988). The following is the model to be estimated (Equation 3.8).

$$\Delta Y_t = \alpha\beta Y_{t-1} + \sum_{i=1}^{P} \phi_i^x \Delta Y_{t-i} + \delta_0 + \varepsilon_t \ldots \ldots (Eq\ 3.8)$$

Where; ΔY_t forms the Dependent Variable.

α reflects the degree of (or magnitude of) long-term relationship convergence.

β' Indicates the long-term relationship coefficient.

ϕ_i^x represents the n-by-n vector and will demonstrate a short-term correlation.

3.9 Vector Error Correction Model

If variables were co-integrated and integrated, the model warranted for vector error correction which is needed for fitting, estimating, and interpreting the established size of short- and long-term associations (Agboola & Bekun, 2019). The following model was estimated (Eq 3.11).

$$\Delta Y_t = P_i \varepsilon_{t-i} + \sum_{i=0}^{p} \beta \Delta Y_{t-i} + \sum_{i=0}^{p} \alpha \Delta X_{t-i} + \cdots + \sum_{i=0}^{p} \lambda \Delta G_{t-i} \ldots \ldots (Eq\ 3.11)$$

Where; ΔY_t forms the Dependent Variable (CO_2) measured in $MtCO_2e$.

ΔX_t forms the vector of regressors (FDI, AgGDP, inflation and trade openness)

$P_i \varepsilon_{t-i}$ is the conditional Error Correction term

The lagged values of ΔY_t and ΔX_t determine the short-run relationship.

$\sum_{i=0}^{p} \lambda \Delta G_{t-i}$ determines the long-run relationship

ε represents the error term.

3.10 Granger-Causality

The Granger causality test is a statistical hypothesis used to determine any prediction possibilities that may be exhibited by the time series variables (Lopez & Weber, 2017). The model that was estimated to show precedence is shown below (Equation 3.12).

$$\{X\ Y\ Z\} = \{\alpha_1\ \alpha_2\ \alpha_3\} + \{\alpha_{11}\ \alpha_{12}\ \alpha_{13}\ \alpha_{21}\ \alpha_{22}\ \alpha_{23}\ \alpha_{31}\ \alpha_{32}\ \alpha_{33}\}\{X_{t-1}\ Y_{t-1}\ Z_{t-1}\}\{\varepsilon_1\ \varepsilon_2\ \varepsilon_3\} \ldots \ldots (Eq\ 3.12)$$

Where;

X, Y and ***Z*** represent the variables or time series data to be used.

X_{t-1} Represents the previous record of the data variable in consideration.

ε_i Represents the error term or white noise.

3.11 Ethical Considerations

When conducting research, ethical considerations should be a top priority for researchers to ensure that their research is conducted in an ethical and responsible manner. This is true even when researchers use secondary data sources. The current study utilized secondary data sources from the World Bank, the Kenya National Bureau of Statistics (KNBS), and the Environmental Performance Index (EPI). While no participants were directly involved in this research, there are still several ethical considerations that should be taken into account.

Respect for Privacy and Confidentiality

When using secondary data sources, it is important to respect the privacy and confidentiality of the individuals or entities that provided the data. In this study, the data sources used were publicly available, and no personally identifiable information was used. However, care was taken to ensure that the data was used only for the purpose of this study and was not shared with any unauthorized individuals or entities.

Use of Data

The use of data is a crucial ethical consideration. In this study, the data used was publicly available, and the authors ensured that the data was used only for the purpose of this study. It is also important to note that the data used was not manipulated or falsified in any way. The authors took care to analyze the data accurately and to draw conclusions based solely on the data presented.

Researcher Bias

Another important ethical consideration is the potential for researcher bias. Researchers should strive to remain impartial and avoid allowing their personal biases to influence the interpretation of the data. In this study, the authors took care to remain impartial and to present the data accurately and objectively.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.0 Overview

This chapter focused on the data analysis and the discussions of results. The chapter contains the results of unit root test, structural breaks, co-integration, VECM, and diagnostic tests.

4.1 Unit Root Test Results

The univariate plots presented in the appendix indicated all the DGP expected in time-series data (Appendix A). These charts demonstrated that the underlying data was non-stationary. To give proof, however, statistical estimate was used. As a result, the stationarity test was carried out utilizing the ADF and PP tests. The ADF and PP test findings showed that FDI and INF were stationary at a statistically significant level of $p < 0.01$. (Tables 4.1 and 4.2). CO_2, AgGDP, and TROP, on the other hand, were not stationary.

If the data is not stable, a unit root in time-series may result in misleading regression, according to Agboola and Bekun (2019). Agovino et al. (2019) proposed that unit root might be avoided using differencing or natural logs of the dataset utilized. As a result, the current study used first differencing to establish if the variables would be stationary.

Table 4.1 Initial ADF Tests

VARIABLE	TEST STATISTICS	P-VALUE	CONCLUSION
LNCO_2	1.337	0.9968	At Level
LNAGGDP	-0.758	0.8311	At Level
LNTROP	-0.759	0.8310	At Level
LNFDI	-5.183	0.0000***	At Level
LNINF	-3.815	0.0028***	At Level

Note: $p < 0.01$***.

Source: Data Analysis Using Stata 13 (2021).

Table 4.2 Initial PP Tests

VARIABLE	TEST STATISTICS	P-VALUE	CONCLUSION
LNCO_2	1.540	0.9977	At Level
LNAGGDP	-1.283	0.6371	At Level
LNTROP	-0.912	0.7840	At Level
LNFDI	-5.237	0.0000***	At Level
LNINF	-3.921	0.0019***	At Level

Note: $p < 0.01$***.

Source: Data Analysis Using Stata 13 (2021).

Notably, following the initial differencing, all variables were stationary, as demonstrated by the ADF and PP subsequent findings (Tables 4.3 and 4.4). At $p < 0.01$ the results were statistically significant. As a result, the null hypothesis was rejected at this level since there was sufficient statistical evidence to demonstrate that all the time-series data was stationary.

Table 4.3 ADF Subsequent Tests

VARIABLE	TEST STATISTICS	P-VALUE	CONCLUSION
DCO_2	-4.375	0.0003***	first difference
DAGGDP	-4.399	0.0003***	first difference
DTROP	-5.669	0.0000***	first difference
DFDI	-9.801	0.0000***	first difference
DINF	-8.802	0.0000***	first difference

Note: $p < 0.01$***.

Source: Data Analysis Using Stata 13 (2021).

Table 4.4 PP Subsequent Tests

VARIABLE	TEST STATISTICS	P-VALUE	CONCLUSION
DCO_2	-4.298	0.0004***	first difference
DAGGDP	-4.400	0.0003***	first difference
DTROP	-5.666	0.0000***	first difference
DFDI	-16.387	0.0000***	first difference
DINF	-9.268	0.0000***	first difference

Note: $p < 0.01$***.

4.2 Structural Break Results

The study used Z-Andrews' first model, which allows for a break within the series intercepts. The findings of structural breaks revealed different dates for each variable. Notably, AgGDP experienced a statistically significant structural break in 2008 at $p < 0.01$ (Figure 4.1) and (Table 4.5). These results concurred with Agboola and Bekun (2019) and Kong'o *et al.* (2018). Similarly, Özokcu & Özdemir (2017) and Stern (2018) observed that structural breakdowns in 2008 and 2009 were heavily ascribed to the global financial crisis, which affected all economic production globally.

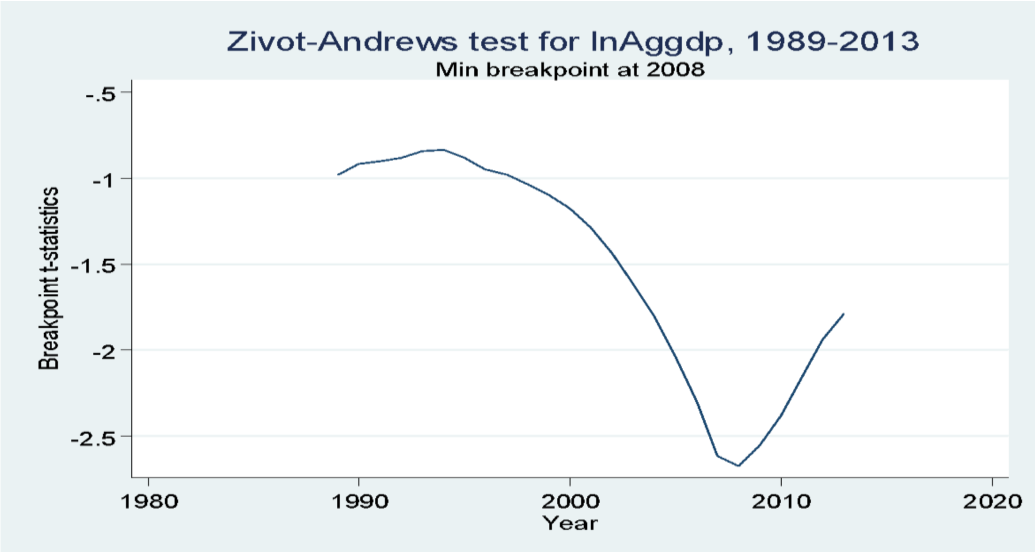

Figure 4.1 Zivot-Andrews Test Allowing for Break in Intercept

Source: Data Analysis Using Stata 13 (2021).

Table 4.5 Summary of Z-Andrews Allowing Break in Intercept

VARIABLES	OBSERVATIONS	[LAGS]	T-STATISTICS	BREAK YEAR
DCO_2	17	2	-3.887	1999
DAGGDP	26	0	-5.320***	2008
DTROP	18	0	-6.110	2000
DFDI	32	2	-8.790	2014
DINF	21	1	-8.342	2003

Source: Data Analysis Using Stata 13 (2021).

Critical values: 1%: -5.34 5%: -4.80 10%: -4.58.

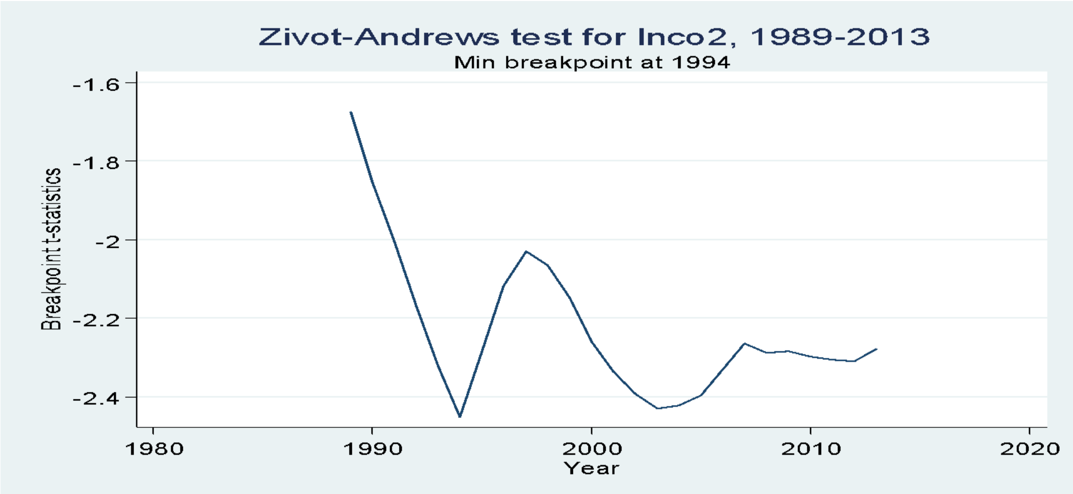

Figure 4.2 Zivot-Andrews Test Allowing for Break in Trend

Source: Data Analysis Using Stata 13 (2021).

Table 4.6 Summary of Z-Andrews Allowing Break in Trend

VARIABLES	OBSERVATIONS	[LAGS]	T-STATISTICS	BREAK YEAR
LNCO_2	10	2	-2.451***	1994
LNAGGDP	24	0	-2.674***	2008
LNTROP	9	0	-5.948	1991
LNFDI	10	2	-7.125	2006
LNINF	8	1	-6.392	1993

Source: Data Analysis Using Stata 13 (2021).

Critical values: 1%: -4.93 5%: -4.42 10%: -4.11.

The second model used allowed for a break in the trend on each series. The analysis discovered a statistically significant CO_2 break in 1994 at $p < 0.01$ (Table 4.6 and Figure 4.2). During this time, the Kenya Forestry Working Group (KFWG) was formed primarily to campaign against excisions, raise public awareness, and keep a record of all Kenyan forest resources (JICA, 2002). In addition, the Tsunza Conservation and

Development Programme (TCDP) was developed in the coastal region to preserve vegetation and wildlife in mangrove ecosystems (JICA, 2002).

Figure 4.3 Zivot-Andrews Test Allowing for a break in Both Trend and Intercept

Source: Data Analysis Using Stata 13 (2021).

Table 4.7 Summary of Z-Andrews Allowing Break in Both Trend and Intercept

VARIABLES	OBSERVATIONS	[LAGS]	T-STATISTICS	BREAK YEAR
DCO_2	12	2	-4.252	1994
DAGGDP	26	0	-5.652	2008
DTROP	13	0	-6.221	1995
DFDI	32	2	-8.651	2014
DINF	21	1	-8.194	2003

Source: Data Analysis Using Stata 13 (2021).

Critical values: 1%: -5.57 5%: -5.08 10%: -4.82.

Finally, the study determined structural breaks using the third model by allowing a break in both trend and intercept. However, all series exhibited statistically insignificant breaks at $p < 0.05$ (Table 4.7 and Figure 4.3).

4.3 Selection Criteria

A maximum of four lags were used to determine the ideal lag length. The ideal lag length was determined by the LR test findings to be four. However, the FPE, AIC, HQIC, and SBIC tests determined that the best lag length was one, which was statistically significant at $p < 0.05$. (Table 4.8). This study specifically depended on the AIC and SBIC test findings. As a result, the optimal lag duration for this investigation was one.

Table 4.8 Selection of Optimal Lag Length

Selection-Order Criteria

Sample: 1987 - 2019 Number of obs = 33

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-65.427				0.000	4.268	4.345	4.495
1	40.875	212.600	25.000	0.000	3.6e-07*	-.659065*	-.201311*	.701397*
2	58.823	35.896	25.000	0.073	0.000	-0.232	0.608	2.263
3	79.828	42.010	25.000	0.018	0.000	0.010	1.231	3.638
4	111.603	63.55*	25.000	0.000	0.000	-0.400	1.202	4.361

Note: Endogenous: $lnCO_2$ lnAggdp lntrop lnfdi lninf; Exogenous: _cons

4.4 Co-Integration Test Results

Johansen's multivariate Co-integration test was used, with the assumption that the data had a linear trend and constant variance. The trace and max-eigenvalues tests were used in this investigation. The results revealed at least two co-integrating equations at $p < 0.05$ (Table 4.9). The model's results revealed a long-run link, which is explained by the co-integrating relationship. The results are shown below.

Table 4.9 Johansen Tests for Cointegration

Trend: constant					Number of obs =	36
Sample: 1987 - 2019					Lags =	1
maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value	1% critical value
0	5	-1.2066		101.4661	68.52	76.07
1	14	21.0062	0.7089	57.0404	47.21	54.46
2	21	37.2473	0.5944	24.5583*1*5	29.68	35.65
3	26	46.1624	0.3906	6.728	15.41	20.04
4	29	48.8353	0.138	1.3821	3.76	6.65
5	30	49.5264	0.0377			
maximum rank	parms	LL	eigenvalue	max statistic	5% critical value	1% critical value
0	5	-1.2066		44.4257	33.46	38.77
1	14	21.0062	0.70889	32.4821	27.07	32.24
2	21	37.2473	0.59436	17.8302	20.97	25.52
3	26	46.1624	0.3906	5.3459	14.07	18.63
4	29	48.8353	0.138	1.3821	3.76	6.65
5	30	49.5264	0.03766			

Note: p < 0.05** and p < 0.01***.

Source: Data Analysis Using Stata 13 (2021).

Allowing for structural break (one break) checks between the dependent and independent variables allowed for cointegration to be examined. In 2008, the test found a regime shift in agricultural output. This was attributed to the global financial crises experienced on last quarter of 2008 and the first quarter of 2009. Agricultural output is projected to have decreased dramatically over that period. However, the subsequent regime showed that the industry gradually recovered owing to increased agricultural production.

4.5 Vector Error-Correction Results

Since there were co-integrating variables, the study used the VECM to estimate the error correction term. The study of time series models in this context entailed fitting, estimating, evaluating, and deriving conclusions from an unconstrained VEC model. The VECM was estimated with a one-lag length and one co-integrating equation. The computed parameters are presented below (Table 4.10).

Table 4.10 Vector Error-Correction Model

Sample: 1984 - 2019					No. of obs. = 36
				AIC	= -.3892343
Log likelihood = 21.00622				HQIC	= -.1742991
Det (Sigma_ml) = 2.14e-07				SBIC	= .2265786
Equation	Parms	RMSE	R-sq.	chi2	P>chi2
D_lnCO_2	2	0.1483	0.1879	7.8693	0.0196**
D_lnaggdp	2	0.0545	0.0241	0.8392	0.6573
D_lntrop	2	0.1029	0.0242	0.8444	0.6556
D_lnfdi	2	1.1911	0.5580	42.9201	0.0000***
D_lninf	2	0.8451	0.0166	0.5724	0.7511

Note: $p < 0.05$** and $p < 0.01$***.

Source: Data Analysis Using Stata 13 (2021).

Table 4.11 Short-Run Relationship among the Selected Variables

		Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
D_lnCO_2							
	_ce1 L1.	-0.037	0.038	-0.970	0.333	-0.113	0.038
	_cons	-0.066	0.025	-2.660	0.008***	-0.114	-0.017
D_lnaggdp							
	_ce1 L1.	0.012	0.014	0.820	0.413	-0.016	0.039
	_cons	0.004	0.009	0.430	0.665	-0.014	0.022
D_lntrop							
	_ce1 L1.	0.013	0.027	0.480	0.630	-0.039	0.065
	_cons	-0.013	0.017	-0.770	0.442	-0.047	0.020
D_lnfdi							
	_ce1 L1.	-2.022	0.309	-6.550	0.000***	-2.627	-1.417
	_cons	-0.001	0.199	-0.010	0.996	-0.390	0.388
D_lninf							
	_ce1 L1.	0.159	0.219	0.730	0.468	-0.270	0.588
	_cons	-0.028	0.141	-0.200	0.845	-0.304	0.249

Note: $p < 0.1$*, $p < 0.05$** and $p < 0.01$***.

Source: Data Analysis Using Stata 13 (2021).

Notably, only FDI was statistically significant at $p = 0.00$ during the short-run computation (Table 4.11). All other variables were statistically insignificant at $p < 0.05$ (Table 4.11). These findings are consistent with those of Nyberg et al. (2020). According to their study, terracing and agroforestry enhanced agricultural production. However, the total effect was minor to the Kenya Agricultural Carbon Project (KACP) (Nyberg et al., 2020).

Table 4.12 Co-Integrating Equations

Equation	Parms	chi2	P>chi2
_ce1	4	43.4662	0.000***

Note: $p < 0.01$***.

The estimated error correction term (_ce1) was statistically significant with a chi-square value of 43.4662 at $p < 0.05$, as shown in the co-integrating equation above (Table 4.12). It denotes the rate by which the response variable approaches equilibrium. As a result, the system adjusts disturbance towards the long-run relationship at a speed proportional to the magnitude of the coefficient to converge at equilibrium of less than 1% (Maddala & Kim, 2021). The error term was used to estimate the variables' short-run (Table 4.11) and long-run relationships (Table 4.13).

These findings were consistent with those of several studies that have utilized the error correction model to analyze the long-run relationship between economic growth and environmental degradation, such as CO_2 emissions. For instance, Keho and Alimi (2020) used the error correction model to explore the long-run relationship between economic growth and environmental quality in Nigeria. Similarly, Ozturk and Acaravci (2013) employed the error correction model to examine the relationship between economic growth, energy consumption, and CO_2 emissions in Turkey. These studies, among others, show that the error correction model is a reliable econometric technique for analyzing the long-run relationship between economic growth and environmental degradation.

Table 4.13 Johansen Normalization Restriction Imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_ce1						
lnCO_2	1	.	.	.	.	.
lnaggdp	-2.6712	0.7321	-3.65	0.000***	-4.106	-1.236
lntrop	-1.8773	0.5504	-3.41	0.001***	-2.956	-0.799
lnfdi	0.6064	0.0572	10.61	0.000***	0.494	0.718
lninf	-0.3183	0.1021	-3.12	0.002***	-0.518	-0.118
_cons	18.7223	.	.	.	.	.

Note: $p < 0.01$***.

Source: Data Analysis Using Stata 13 (2021).

There were two co-integrating associations, according to the results of Johansen's co-integration test. While the variables strayed from a certain trajectory in the short to medium term, there were long-term trend linkages to which they reverted in the long run, according to these findings.

The co-integrating relationships indicated that CO_2 emission was the dependent variable to which the macroeconomic drivers were aligned by modifying any variances. Table 4.13 revealed that, in the long term, a 1% increase in agricultural GDP reduced roughly 2.67% of carbon dioxide in the atmosphere at *Ceteris paribus*. Furthermore, a one percent rise in inflation and trade openness reduced carbon dioxide in the atmosphere by 0.32% and 1.88%, respectively at *Ceteris paribus*. The findings suggested that agricultural GDP, inflation, and trade openness had a long-term negative and substantial influence on carbon dioxide emissions.

Additionally, the study discovered a negative link between trade openness and CO_2 emissions. These findings differ from those of Rahman (2013). The study discovered that trade openness has a considerable and favorable influence on carbon dioxide emissions in Bangladesh (Rahman, 2013). However, the results for FDI and CO_2 emissions agreed with Zhu et al (2016). According to their findings, FDI had a negative impact on carbon emissions in the Association of Southeast Asian Nations (ASEAN) except at the 5th quantile and became significant at higher quantiles (Zhu et al., 2016). Furthermore, the study concluded that enhanced trade openness might aid in the reduction of carbon emissions, particularly in low- and high-emissions nations (Zhu et al., 2016).

However, a one percent rise in FDI increased around 0.61% of CO_2 in the atmosphere at *Ceteris paribus*. The findings suggested that FDI inflows had a long-term beneficial and substantial influence on carbon dioxide emissions. These findings agreed with those of Islam et al (2021), Wamalwa et al. (2018) and Ondieki et al. (2020). Their research discovered that carbon emissions have a detrimental impact on Saudi Arabia's economic growth. However, inflation, which contributed to economic growth unpredictability, had a favorable short-run effect. Furthermore, temperature and rainfall (which are mostly influenced by carbon emissions) have an impact on the country's economic growth, both favorably and adversely (Islam et al., 2021). Furthermore, Azam et al. (2016) discovered a positive and substantial association between carbon emissions and economic growth in the United States, China, and Japan.

4.6 Hypotheses Testing

H_{01}: The null hypothesis is that there is no significant relationship between agricultural output and Carbon dioxide emissions in Kenya, while the alternative hypothesis is that there is a significant relationship between the two variables.

The long-run relationship results showed that there was a negative and statistically significant link between agricultural output and CO_2 emissions in Kenya at z = -3.65, p = 0.000 (Table 4.13). Therefore, the study rejected the null hypothesis. However, the short-run adjustment indicated a positive and insignificant results at p = 0.413 (Table 4.11).

H_{02}: The regression coefficient between Trade Openness and Carbon dioxide emissions in Kenya is equal to zero.

The long-run results revealed a negative and substantial link between trade openness and CO_2 emissions at z = -3.41, p = 0.001 (Table 4.13). Furthermore, their short-run relationship was negative and statistically insignificant at p = 0.630 (Table 4.11). Therefore, the study rejected the null hypothesis.

H_{03}: The regression coefficient between Foreign Direct Investment and Carbon dioxide emissions in Kenya is equal to zero.

Similarly, the short-run results revealed a negative and significant link between FDI and CO_2 emissions at z = -6.550, p = 0.000 (Table 4.11). On the other hand, the long-run link between the two was positive and statistically significant at z = 10.61, p = 0.000 (Table 4.13). Therefore, the study rejected the null hypothesis.

H_{04}: The regression coefficient of Inflation is not statistically significant in the model with Carbon dioxide emissions in Kenya as the dependent variable.

Finally, the short-run data revealed a positive but insignificant link between inflation and CO_2 emissions at p = 0.468 (Table 4.11). Furthermore, the two variables' long-run association was positive and statistically significant at z = -3.12, p = 0.002 (Table 4.13). Therefore, the study rejected the null hypothesis.

4.7 Diagnostic Test Results

Table 4.14 Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	19.0394	25	0.7952
2	21.3753	25	0.6715

H_0: no autocorrelation at lag order

Table 4.15 Jarque-Bera Test

Equation	chi2	df	Prob > chi2
D_lnCO_2	0.062	2	0.9697
D_lnaggdp	0.892	2	0.6401
D_lnfdi	0.72	2	0.6977
D_lninf	0.459	2	0.7947
D_lntrop	0.438	2	0.8032
ALL	2.571	10	0.9898

Source: Data Analysis Using Stata 13 (2021).

The Lagrange-multiplier test was used in the study to perform a diagnostic analysis on the variables. The analysis with both the first and second lags of the variables yielded an insignificant result at $p > 0.6715$ (Tables 4.14). As a result, the study did not reject the null hypothesis and concluded that no autocorrelation existed at lag orders one and two.

The Jarque-Bera test was also used to examine if the disturbances were distributed normally in multiple dimensions. The test showed that all study variables followed the normal distribution at $p > 0.05$ (Tables 4.15).

Explicitly, diagnostic tests were performed before drawing the conclusions of the computed VECM model. The initial diagnostic check was the stability test. The results of the stability tests showed that the predictions from the unconstrained VECM were stable, and all of the companion matrix roots were inside the unit cycle (Figure 4.4).

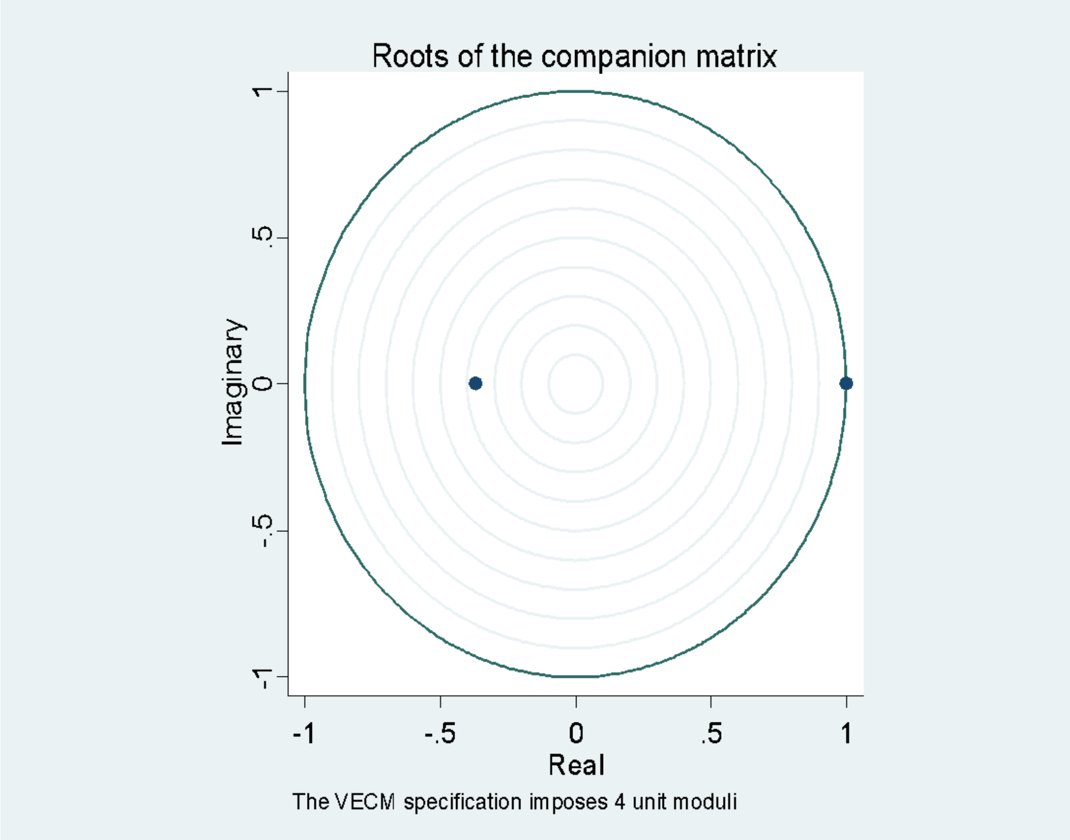

Figure 4.4 Stability Test Companion Matrix

Source: Data Analysis Using Stata 13 (2021).

4.8 Granger Causality Test

The granger causality test findings are displayed below, along with comments on rejection and acceptance of the null hypothesis. Null hypothesis: $H_0 = 0$

Table 4.16 Granger Causality Test Results

Equation	Excluded	chi2	df	Prob > chi2	Remarks
lnCO_2	lnAggdp	13.122	4	0.011**	**Reject**
lnCO_2	lnfdi	6.0526	4	0.195	Accept
lnCO_2	lntrop	18.255	4	0.001***	**Reject**
lnCO_2	lninf	5.7009	4	0.223	Accept
lnCO_2	lntrop	18.255	4	0.001***	**Reject**
lnCO_2	ALL	47.26	16	0.000***	**Reject**
lnAggdp	lnCO_2	13.361	4	0.010***	**Reject**
lnAggdp	lntrop	22.234	4	0.000***	**Reject**
lnAggdp	lnfdi	1.936	4	0.748	Accept
lnAggdp	lninf	11.433	4	0.022**	**Reject**
lnAggdp	ALL	87.509	16	0.000***	**Reject**
lntrop	lnCO_2	15.927	4	0.003***	**Reject**
lntrop	lnAggdp	16.234	4	0.003***	**Reject**
lntrop	lnfdi	3.5545	4	0.470	Accept
lntrop	lninf	9.4914	4	0.050**	**Reject**
lntrop	ALL	56.155	16	0.000***	**Reject**
lnfdi	lnCO_2	42.041	4	0.000***	**Reject**
lnfdi	lnAggdp	14.939	4	0.005***	**Reject**
lnfdi	lntrop	36.881	4	0.000***	**Reject**
lnfdi	lninf	20.967	4	0.000***	**Reject**
lnfdi	ALL	82.277	16	0.000***	**Reject**
lninf	lnCO_2	10.869	4	0.028**	**Reject**
lninf	lnAggdp	3.0328	4	0.552	Accept
lninf	lntrop	19.563	4	0.001***	**Reject**
lninf	lnfdi	4.1269	4	0.389	Accept
lninf	ALL	38.693	16	0.001***	**Reject**

Note: $p < 0.05$** and $p < 0.01$***.

Source: Data Analysis Using Stata 13 (2021).

The study employed Granger's causality approach to address for heterogeneity concerns in time series data, as Maziarz (2015) did. The model was used to demonstrate precedence among variables using a matrix. The first set of the equations in the matrix indicate that CO_2 was used as the dependent variable. The results indicated that both agriculture and trade openness granger cause CO_2 emission in Kenya. These results are consistent with previous studies that have identified the relationship between economic growth and CO_2 emissions (Hussain et al., 2020; Zhang et al., 2019).

Agriculture is a significant sector in Kenya, contributing to over a third of the country's GDP and employing over 70% of the population (World Bank, 2021). However, it is also a significant contributor to Carbon dioxide emissions. The findings suggest that policies aimed at promoting agricultural development in Kenya need to consider the environmental impact of such growth. Trade openness, which is essential for economic growth and development, can also lead to increased CO_2 emissions. The results suggest that policymakers in Kenya need to consider the environmental impact of increased trade openness and implement policies aimed at reducing CO_2 emissions associated with international trade.

Additionally, the study results showed that both FDI and trade openness granger caused agricultural GDP in Kenya. The findings suggest that an increase in FDI and trade openness leads to an increase in agricultural GDP in Kenya. These results are consistent with previous studies that have identified the relationship between economic growth and FDI (Chen & Feng, 2020; Ghazali & Lean, 2018; Kastratović, 2019) and trade openness (Jena & Grote, 2020; Wan, et al., 2019) with agricultural GDP. According to these studies, FDI in agriculture had a direct influence on the volume of carbon dioxide equivalent emissions in developing countries.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter covers the results summary, conclusions, and suggestions. The concluding portion of the chapter presents a framework for future research on new findings that may reveal additional implications not discussed in this study.

5.1 Summary of Findings

The univariate graphs demonstrated that the structure of the data was not constant over time (non-stationary). Similarly, the findings of the ADF and PP tests suggested that FDI and INF were stable at level. CO_2, AgGDP, and TROP, on the other hand, were not stationary. Notably, following the initial differencing, all variables became stationary.

Furthermore, AgGDP had a fundamental break in 2008. According to Stern (2018) and Özokcu & Özdemir (2017), structural breaks in 2008 and 2009 were mainly attributable to global financial crisis which impacted all industries globally. The analysis also discovered that CO_2 emissions peaked in 1992. In that year, there was a dramatic regime shift in CO_2 emissions, which was coupled with the growth of radical environmental groups. Most Kenyan environmental organisations, such as TCDP and KFWG, were formed to campaign against excisions, raise public awareness, and keep a record of all Kenyan forest resources.

The interaction term coefficient was found to be significant, indicating that economic growth mitigates the influence of Foreign direct investment on Carbon dioxide emission. According to the EKC theory, income has an inverting U-shaped association with environmental pollution, just as economic advancement has an inverted U-shaped link with carbon emissions. When a country reaches high levels of economic growth, it will prioritize green and sustainable development, introducing eco-friendly FDI and reducing carbon emissions. The findings agreed with those of Owusu-Brown (2017).

The findings also revealed that as the inflation rate falls, so do the prices of agricultural input supplies, while the value of agricultural output rises. From the standpoint of the farmer, the connection appears appealing, yet it poses a significant concern in terms of CO_2 emission especially during the short run. The increased agricultural productivity in unsustainable technology has a direct influence on environmental sustainability as depicted by Musarat et al. (2021). On the other hand, there is no direct link between inflation and carbon emission. However, an increase in inflation is expected to increase economic activities including agricultural production, construction, and other manufacturing industries. Consequently, a surge in the amount carbon dioxide emitted from all these sectors is expected to increase.

According to Konar, Dang, and Debaere (2018), a significant increase in trade openness would decrease the natural resources and ecosystem services by approximately 5 per cent. Moreover, the study shows that as the countries become more open to trade and more investments flow into them, the agricultural produce would increase significantly. The current study results indicated similar findings.

A long-run relationship between trade openness and Carbon dioxide emissions was identified by Le et al. (2016). According to the study, the relationship differs according to the income of countries. A feedback effect between trade openness is also expected. Kong’o et al. (2015) also found a negative effect between trade openness and Carbon dioxide emission.

Notably, because of the co-integrating variables, the study calculated the error correction term using the VECM. In this context, time series model analysis entailed fitting, estimating, evaluating, and deriving conclusions from an unconstrained VEC model. The VECM was computed with a two-lag length and one co-integrating rank. The short-run relationship indicated that Carbon dioxide emission, inflation and trade openness had a statistically insignificant relationship at $p > 0.05$. However, the long-run relationship indicated that after adjustment AgGDP, inflation and trade openness converged towards equilibrium at $p < 0.01$. However, FDI diverged from the equilibrium at $p = 0.000$.

Therefore, the study did not reject the null hypotheses and concluded that there was enough statistical evidence to prove a relationship between the selected macroeconomic variable and CO_2 emission during the short and long run.

5.2 Conclusions of the Study

The study's first objective was to examine the direction and strength of the relationship between agricultural output and Carbon dioxide emissions in Kenya using statistical models. The results revealed a negative and statistically significant association between the two variables in the long term. However, before fitting and correction with the ECT, the association was minor in the short term. As a result, the study determined that there was a link between agricultural output and CO_2 emissions in Kenya.

The second objective was to assess the extent to which trade openness affects Carbon dioxide emissions in Kenya through an econometric model that incorporates relevant variables. In the short term, the association was positive and negligible, but after the ECT adjustment, it turned negative (indirect) and statistically significant. As a result, the study determined that there is a link between trade openness and CO_2 emissions in Kenya.

The study's third objective was to determine the impact of Foreign Direct Investment on Carbon dioxide emissions in Kenya using inferential statistics. The study discovered that the association between the two variables was statistically significant in the short term. Furthermore, the link was positive and statistically significant over time. As a result, the study determined that there exists a direct link between FDI and CO_2 emissions in Kenya.

The final objective was to investigate the association between inflation and Carbon dioxide emissions in Kenya using time series data analysis methods. In the ideal world, the analysis discovered a positive but statistically insignificant link between inflation and CO_2 emissions in the short run. However, after applying the ECT to modify the association, it turned negative and statistically significant. As a result, the study determined that there exists an indirect link between inflation and CO_2 emissions in Kenya.

5.3 Study Recommendations

The research indicates that agricultural activities have a significant adverse effect on CO_2 emissions in Kenya. While the current emission rate is relatively insignificant, it is anticipated to increase if agricultural activity is intensified. Given the negative and statistically significant relationship between agricultural output and carbon dioxide emissions in Kenya, the study recommends that policymakers explore opportunities to promote sustainable agricultural practices that reduce carbon dioxide emissions. This could involve incentivizing the adoption of climate-smart agricultural techniques such as precision farming, conservation agriculture, and agroforestry that have been shown to improve productivity while mitigating carbon dioxide emissions. Additionally, the government could consider investing in research and development of low-emission technologies for farming and supporting farmers to adopt environmentally-friendly practices. Encouraging the use of renewable energy and developing sustainable energy policies could also contribute to reducing carbon emissions from the agricultural sector in Kenya.

According to the findings, increasing trade openness will indirectly raise CO_2 emissions. Notably, trade liberalization encouraged FDI. Based on the negative and statistically significant relationship between trade openness and carbon dioxide emissions in Kenya, it is recommended that policymakers pursue a balanced approach to economic development that promotes sustainable trade and environmental conservation. This could involve implementing policies that encourage investments in cleaner and more sustainable technologies, like renewable energy and energy-efficient production methods. Additionally, the government could strengthen environmental regulations and standards for industries that have a high potential for carbon emissions, while promoting sustainable practices and incentives for businesses that prioritize environmental conservation. Encouraging the use of green technologies and sustainable practices in the trade sector, such as reducing transportation emissions and promoting sustainable logistics, could also contribute to mitigating carbon dioxide emissions while promoting trade openness. Ultimately, a comprehensive and integrated approach that balances economic development with environmental conservation is needed to achieve sustainable development in Kenya.

Notably, the relationship between FDI and CO_2 emissions in developing countries is complex and depends on various factors. While FDI can contribute to increased CO_2 emissions, it can also promote sustainable development practices that mitigate CO_2 emissions and promote economic growth. Given the positive and statistically significant relationship between Foreign Direct Investment (FDI) and carbon dioxide emissions in Kenya, it is recommended that policymakers promote sustainable investment practices that prioritize environmental conservation while attracting foreign investment. This could involve creating incentives for foreign investors to invest in clean and sustainable technologies and industries, while implementing policies and regulations that encourage the adoption of environmentally-friendly practices. Additionally, the government could prioritize investment in renewable energy and other green technologies that reduce carbon emissions, while promoting energy efficiency and conservation measures. Furthermore, the government could collaborate with foreign investors and development partners to promote sustainable infrastructure development that prioritizes environmental conservation and mitigates carbon dioxide emissions. Ultimately, a balanced approach that attracts foreign investment while promoting sustainable development practices that mitigate carbon dioxide emissions is necessary to achieve sustainable economic growth in Kenya.

Lastly, most research revealed that inflation had a beneficial impact on economic growth. Notably, higher economic development in middle - and low-income nations has been associated with increased CO_2 emissions. Based on the negative and statistically significant relationship between inflation and carbon dioxide emissions in Kenya, it is recommended that policymakers prioritize measures that target reducing inflation to mitigate carbon dioxide emissions. This could involve implementing sound macroeconomic policies, like maintaining price stability and managing inflation expectations, while promoting sustainable development practices that align with the country's socio-economic goals. Additionally, investing in renewable energy and exploring alternative energy sources could offer potential long-term solutions to reducing carbon emissions and mitigating the adverse impacts of inflation on the environment.

5.4 Suggestions for Further Study

The study recommends future research to evaluate the regime shifts in CO_2 emission and agricultural output to unearth the underlying concepts in the structural breaks. Additionally, the studies should also evaluate impacts of CO_2 emission on other macroeconomic variables like economic growth and development.

Finally, the study did not cover on other emissions from the agricultural sector like methane from livestock industry. The increased livestock production in the country would also need to be evaluated to ensure sustainable practices in the sector to minimize CO_2 emission to the environment.

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APPENDICES

Appendix A: Plots of Time-series Data

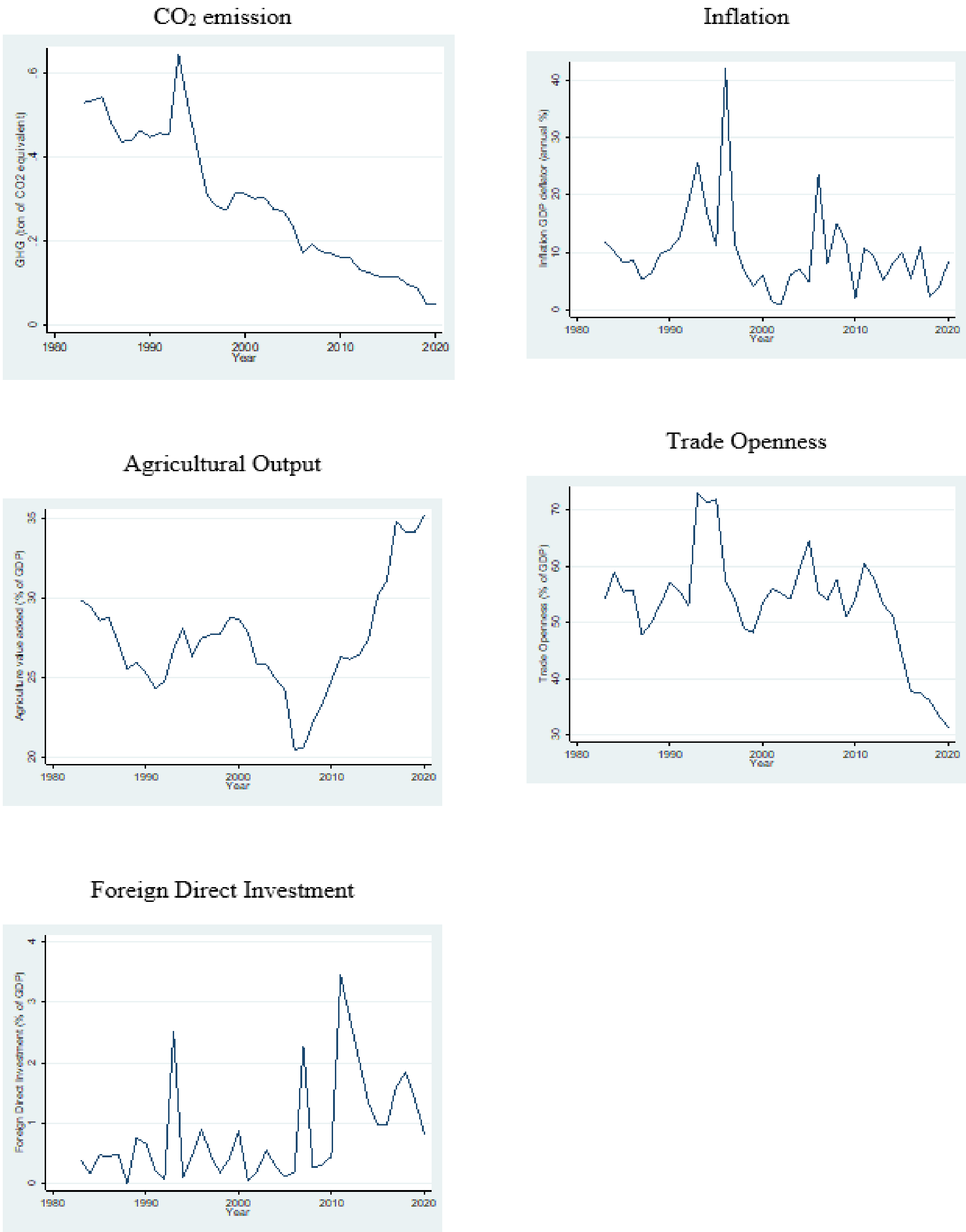

Figure 7.1 Univariate Graphs

Source: Data Analysis Using Stata 13 (2021).

Appendix B: Research Data Used

Year	CO_2	AgGDP	FDI	INF	TROP
2019	0.050845	34.14965	1.395177	3.961055	33.40144
2018	0.089806	34.09859	1.852298	2.422471	36.14939
2017	0.097195	34.83123	1.603416	10.94193	37.39484
2016	0.114975	31.07233	0.981089	5.550868	37.70021
2015	0.115595	30.19241	0.968195	10.02498	44.17859
2014	0.116147	27.45094	1.335981	8.068286	51.29831
2013	0.124218	26.44333	2.030645	5.168744	53.13301
2012	0.131772	26.16995	2.737734	9.379781	57.76508
2011	0.159892	26.3046	3.45731	10.79392	60.44867
2010	0.16175	24.82622	0.44516	2.091676	54.22686
2009	0.170387	23.3604	0.314032	11.6373	50.86364
2008	0.174564	22.19634	0.266289	15.15117	57.5786
2007	0.191907	20.58666	2.281276	8.129486	53.89479
2006	0.172426	20.51969	0.19622	23.53013	55.23649
2005	0.235138	24.23627	0.113202	4.89965	64.47887
2004	0.271445	24.92904	0.286194	7.126842	59.477
2003	0.275554	25.80444	0.548413	6.197313	54.13227
2002	0.304995	25.85397	0.210062	0.933206	55.17267
2001	0.301863	27.84926	0.040833	1.57312	55.94684
2000	0.312309	28.72178	0.872896	6.079848	53.30904
1999	0.315834	28.74408	0.402864	4.193939	48.19227
1998	0.273592	27.74491	0.188366	6.931403	48.89724
1997	0.282942	27.69394	0.473451	11.43522	54.05712
1996	0.308737	27.49252	0.90216	41.98877	57.31211
1995	0.416191	26.34962	0.467474	11.22107	71.74574
1994	0.521954	28.11536	0.103977	17.01641	71.26613

1993	0.644147	26.80801	2.532351	25.69848	72.85848
1992	0.453763	24.78129	0.077513	18.89723	52.93087
1991	0.456972	24.32015	0.231013	12.53196	55.5977
1990	0.449001	25.31413	0.665874	10.6372	57.02091
1989	0.463365	25.96381	0.750804	9.769009	53.15638
1988	0.440522	25.5402	0.004721	6.455624	49.97498
1987	0.438115	27.17165	0.494069	5.401952	47.70277
1986	0.479003	28.77758	0.452068	8.711724	55.74139
1985	0.543587	28.60623	0.470184	8.305783	55.44543
1984	0.535743	29.5099	0.173684	10.19072	58.8039
1983	0.52964	29.86876	0.397024	11.83804	54.16271

Appendix C: Study Area

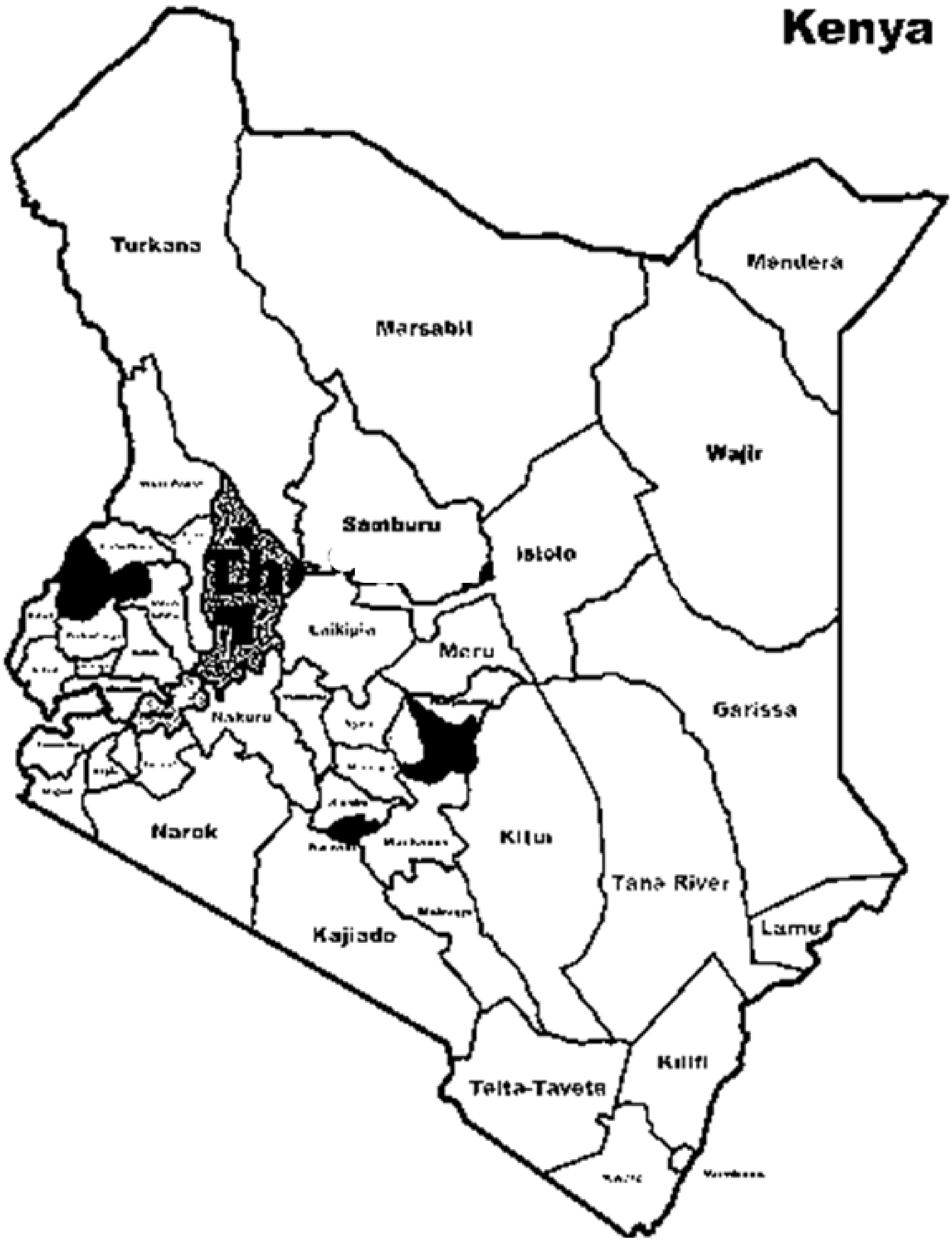

Figure 7.2 Study Area

Sourced from OnTheWorldMap.com