NEXUS BETWEEN INCOME INEQUALITY AND CARBON DIOXIDE EMISSIONS IN KENYA

BY

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DECLARATION

This is my authentic research.

30th November 2021

…………………………………….. ……………………………………...

Signature Date

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This study has been submitted for examination with my supervisor's approval.

30th November 2021

Signature Date

Dr. Michael Ndwiga

ABSTRACT

Disparities in income and degradation of the environment are issues that have given rise to international debates and await immediate resolution. This paper scrutinized the nexus between income inequality and carbon dioxide discharges in Kenya. We examined the applicability of the EKC hypothesis in Kenya. We employed time series secondary data from World Bank Development Indicators for the years 1987 to 2018 and employed the ARDL model to determine a possible nexus in the series. The study included Energy consumption, Urbanization rate and Trade Openness to avoid omission of variables. According to the ARDL test results, the long-run nexus between Carbon dioxide discharges and inequitable distribution of income is inconclusive. The study reveals that inequitable distribution of income has positive but statistically insignificant impact on carbon dioxide emissions in Kenya. The outcome of this research is in accordance with the theory of Marginal propensity to emit, arguing that equality harms the environment. The study finding also indicate that EKC hypothesis is not applicable in Kenya. This finding is supported by the fact that Kenya is still developing and is yet to get to the turning point of EKC.

The study findings recommend that government should come up with policies that advocate for consumption of solar, wind and geothermal energy. The findings discourage the use of fossils fuel as it leads to increased levels of Carbon dioxide emissions.

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DEDICATION

I dedicate the research to Albert Otieno and Mary Atieno. Your prayers kept me going.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ARDL	Auto-Regressive Distributed Lag
CUSUM	Cumulative Sum of Recursive Residuals
CUSUMSQ	Cumulative Sum of Squares of Recursive Residuals
ECT	Error Correction Term
EKC	Environmental Kuznets Curve
GEMS	Global Environment Monitoring System
GHG	Green House Gases
GMM	Generalized Method of Moments
GoK	Government of Kenya
ICDEC	International Cooperation and Development European Commission
MPC	Marginal Propensity to Consume
MPE	Marginal Propensity to Emit.
OLS	Ordinary Least Squares
PWSDR	Power Weighted Social Decision Rule
SBC	Schwarz Bayesian Criterion
SDG	Sustainable Development Goal
SID	Society for International Development
UREC	Unrestricted Error Correction Model

CHAPTER ONE

INTRODUCTION

1.0 Background

Globally, the trend of income inequality has been rising. The rising trend of inequitable distribution of income is, however, not uniform across all the regions (UNDP, 2013) Europe has experienced an increase at the lowest speed while the Middle East has the highest speed of increase. Global statistics reveal that the richest 10% of the global population control a total of 40% of universal income while the poorest 10% enjoy up to 7% only (United Nations Development Programme, 2020). In equal measure, global environmental degradation is accelerating at an alarming rate. This is a clear indication that if we do not take necessary caution then there is a looming risk of massive and irreversible environmental degradation.

Key strategies of the growth plan for African countries include promoting zero levels of poverty, sustainable economic growth, and environmental sustainability. However, how best to achieve economic development while ensuring a sustainable environment remains an elusive goal and a daunting challenge to policymakers. According to (UNFCCC, 2006) Africa is exceptionally susceptible to the global warming effects that are likely to arise. To reduce greenhouse gas emissions in Africa, UN agencies have embarked on projects that promote alternative fuels, sustainable construction, use of hydro and solar power (UNFCCC, 2006).To achieve long-term sustainable growth African countries, need to embrace the use of renewable energy sources (Economic Commission for Africa, 2015).

Sub-Saharan African countries are in a crucial position of development. These countries are embracing swift urbanization and growth of population. Consequently, the region is faced with the mounting risk of appalling global climate change that poses a risk on systems responsible for food production through increased force and the occurrence of droughts and floods (Hogarth et al, 2015). Despite their low per capita GHG emissions levels, the region must join the worldwide effort in the fight against climate change. (Hogarth et al, 2015) explored that sectors like energy (electricity), Transport and manufacturing lead to high carbon intake. It is therefore important that the region implement policies that induce low carbon intake.

Kenya, like all Sub-Saharan African countries, has laid down stringent strategies to eradicate poverty, perhaps due to the vulnerability levels of its populations but also due to the assumption that poverty rather than distribution mattered. For a long time now, countries have held the belief that to achieve the goal poverty eradication they only need to have achieved economic growth, thinking that as the country grew richer, the wealth will spill over to improve the livelihoods of the poorest of its population. Inequality, therefore, has had a very low profile whenever poverty eradication policies were being formulated. Income inequality best presents itself when minorities of wealthy individuals capture the lion's share of income. In the year 2015, Kenya's top 20% controlled 47.5% of total income while the country's bottom 20% controlled 6.2% of total income (World Bank, 2020). These statistics paint a picture of how Kenya's income distribution is skewed towards the direction of the rich. Inequality affects society in many ways. It hurts growth, poverty reduction, and social stability.

When income distribution is skewed to only favor the rich over a while those that are consistently excluded from gains of development will contest the progress thereby leading to a rise in crime in society (UNDP, 2013) when inequality is excessive it becomes divisive and inefficient as it encourages the poor to take part in illegal activities and riots (SID, 2004) resources are diverted to solve civil unrest instead of being put into productive use.

Over the years, Kenya has experienced economic growth, negatively affecting the quality of Environment and equitable distribution of income. The growth of the Economy has resulted to increased use of fossil fuels, increased pollution levels and global warming. World Resources Institute Climate Analysis Indicators Tool showed that in the year 2013, Kenya's agricultural sector emerged as the top source of GHG discharges in Kenya the energy division is second, each leading to 62.8% and 31.2% of the total emissions respectively (USAID, 2017). As a associate of the UNFCCC, Kenya has onboarded various initiatives geared towards mitigation of climate change (Gok, 2015)

1.1 Problem Statement

The GoK has established various plans and strategies to incorporate environmental concerns into Planning and Development in the country (UNEP, 2014). Key examples include the Green Kenya Initiative whose aim is to encourage the manufacture of eco-friendly goods and environment management, Vision 2030, the nation's long term growth design whose aim is to change the nation into a freshly developing, a middle-income nation, offering a good value of living to all its people in sustainable surroundings', (The Constitution of Kenya, 2010) Article 42 which provides for a clean and healthy environment for all the citizens. Also, the Strategy of the Kenya Green Economy and its enactment plan (2016-2030), was directed towards the realization of the subsequent Medium-Term strategy for the year 2013-2017. (UNEP, 2014). Despite the above efforts, Kenya is still facing several pressing environmental challenges. Ranging from climate change and depletion of natural resources to extreme and harsh weather to rising temperatures (GoK, 2010). Through ratification of the Paris Agreement under UNFCCC, Kenya plans to decrease GHG discharges by 30 % by the year 2030 (GoK, 2018). Kenya is 15 % short of achieving its goal of being fully powered by green energy by the year 2020, and this is attributed to continued operations of coal-fired power plant construction plans and a lack of political will (New Climate Institute, 2020).

(Al-mulali et al, 2015), (Lin et al, 2016) and (Osabuohien et al, 2014) completed several studies to examine the causes of ecological degradation in Africa. For Kenya, (Al-mulali et al, 2015) used the ARDL model to inspect how the EKC hypothesis is applicable. The findings of this study revealed that GDP increases pollution, thereby asserting the applicability of the EKC hypothesis in Kenya. (Baek & Gweisah, 2013) stated that early studies downplayed other variables of income that are relevant determinants of environmental challenges. Thus, a majority of the early EKC projects underwent a bias in variable omission (Iwata et al, 2010). Despite the mounting concern over the rising trend of income inequality and unsustainable environment, from what I have studied and learnt, there are very few empirical studies in Kenya that attempt to study the interrelationship of revenue variation and CO_2 emissions. The aim of this research is to incorporate Revenue variation in the EKC hypothesis thus bridging this gap in EKC literature.

1.2 Objectives

1.2.1 General Objective

To inspect the nexus between income inequality and Carbon dioxide emissions in Kenya.

1.2.2 Specific Objectives

i. To examine the short-run and long-run relationship between Carbon dioxide emissions and income inequality in Kenya.
ii. To investigate the applicability of the environmental Kuznets curve theory in Kenya.
iii. To draw policy implications from study findings.

1.3 Study Hypotheses

The null hypotheses are:

i. Carbon dioxide emissions and income inequality lack short and long-run association.
ii. Environmental Kuznets Curve hypothesis is not applicable in Kenya.
iii. Income inequality does not affect Carbon dioxide discharges in Kenya.

1.4 Contribution of the Study

Reduced income inequality and a clean sustained environment are fundamental drivers of the sustainable development agenda. Achievement of SDGs 10 and 13 promote the realization of other vital development goals such as elimination of poverty and hunger, sustainable production and consumption as well as ensuring that our cities and communities are safe and sustainable. The GoK long term blueprint, Vision 2030 has put more emphasis on the need to create wealth opportunities and enhance equity for the underprivileged in society (GoK, 2007). The Kenyan government together with organizations concerned with development have made a concerted effort in coming up with policies and strategies to combat carbon dioxide emissions and reduce inequality. However, the gap between incomes is still growing and levels of carbon dioxide emissions are increasing.

While expanding the prevailing EKC literature by examining whether revenue variation is a factor of environmental dilapidation in Kenya, the study will also form a knowledge database for decision-making in Green economy initiatives and guide project managers to allow effective and efficient execution of these initiatives. Past studies did put more emphasis on economic growth as a factor of environmental degradation. Introduction on revenue variation as a determinant of environmental quality in this study, therefore, offers a different perspective of solving the catastrophic issue of climate change.

1.5 Organization of the Study

Chapter two: "Literature review" gives a summary of the theoretical footings and appropriate studies regarding link between income inequality and ecological quality. Chapter three "Methodology" defines data and the sources of the data while also presenting the econometric approach of the study. The discussion of the experiential results is highlighted in chapter four. Chapter five then presents the " Conclusion" encapsulates the paper and gives an insight when it comes to policymaking.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The first part of this section presents the theoretical underpinnings explaining how income inequality affects environmental quality, then experiential literature and lastly a review of previous Works.

2.1 Theoretical Literature Review

Different theoretical underpinnings try to elucidate how income inequality affects environmental quality. These theories include the Environmental Kuznets Curve Hypothesis, Political Economy Approach, Marginal Propensity to Emit Approach, and the Emulation Theory.

2.1.1Environmental Kuznets Curve Hypothesis

The theory was first argued by Simon Kuznets in 1955. The theory posits that initially growth of the economy causes harm to the environment but after some level of income per capita the trend changes such that the growth of the economy mends the value of the surroundings (Kuznets, 1955). Thus, the presence of an upturned U-shaped association between financial and economic growth. The theory assumes a normal distribution of income and that causality runs from income inequality to environmental degradation. However, these assumptions have been proven to be erroneous. Some shortcomings of the EKC hypothesis include endogeneity bias which might arise from simultaneity as it is evident that environmental degradation can also cause income inequality. The mainstream EKC hypothesis considers economic growth as the only independent variable to explain environmental degradation. (Baek & Gweisah, 2013) noted that neglect of other variables that are key determiners of environment degradation results in omitted variable bias. Through this theory, the study will be able to establish the existence of an upturned U- shaped association regarding income and carbon dioxide emission in Kenya.

2.1.2 Political Economy Approach

This theory was first introduced by James Boyce in 1994. This theoretical point of view postulates that the protection of the environment is highly dependent on utility derived by a specific social class. The theory assumes that the environment is a normal good. According to (Boyce J. K., 1994) the wealthy class in the society have tendency of compromising the quality of the environment as most of them benefit from economic activities that generate pollution. He specifically demonstrates under the power-weighted decision rule (PWSDR) how the wealthy undermine environment protection policies. The wealthy enjoy the benefit of pollution-generating activities while the poor who are adversely affected bear the net costs. The power-weighted societal judgment rule hypothesis predicts as follows; In a society set up if the wealthy are more powerful than the poor, greater inequality will result in a deterioration in the eminence of the surroundings. On the other hand, if the less privileged have more power than the rich, inequality will thus reduce the level of environmental pollution. The political economy approach assumes that individuals with higher incomes generally have the power to influence policies. Therefore, ecological policies formulated will only benefit the privileged and not the society. (Wolde-Rufael & Idowu 2017). Boyce further explains that the power disparity among the have's and tha have not results in financial advantages to the rich and degradation of the surroundings for the impoverished (Boyce J. K., 1994) thus the marginal social cost is higher than the marginal social benefit. Boyce's model however assumed that causality runs from inequality to pollution yet it is known that pollution can also cause income inequality. This study aims to establish whether increased income inequality leads to increased levels of carbon dioxide emissions

2.1.3 Marginal Propensity to Emit (MPE).

This hypothesis was proposed by (Scruggs, 1998) . The main assumption underlying this theory is that environmental value is a luxurious feature. Therefore, its claim surges with demand in revenue. The theory is based on the keynesian MPC model that assumes that MPC reduces with an increase in income. This theory suggests that when incomes are distributed equally in society, low-income earners will intensify their energy and carbon-intensive goods use as they passage headed to the intermediate class hence a higher marginal propensity to emit. The theory argues that lesser being's utilization of supplementary units of revenue results in larger ecological deterioration as compared to the extra unit of revenue spent by wealthy individuals. The theory provides a mechanism to describe the negative association between carbon discharges and revenue variation. Hence, equality harms the environment.

2.1.4 The Emulation Theory

The theory was first argued by Veblen in 1899. The theory posits that in a more unequal society consumption is motivated by the desire for social standing. He stated that the standards of living of society are dictated by a group of people known as the leisure class. Therefore, individuals tend to emulate the consumption patterns of the immediate superior class. Thus, more unequal societies are highly susceptible to consumption of more polluting goods. With an increase in income, the poor will want to purchase big cars, etc. therefore, leading to more pollution. This theory, therefore, suggests that the reduction of the income inequality gap is not likely to enhance environmental quality but could otherwise lead to deterioration of the environment.

2.2 Empirical Literature Review

The series of investigation studies carried out in the works varies. Some of the investigation studies concentrated on cross-country analysis whereas others are country-specific. Since the pioneering works of (Boyce J. K., 1994) the empirical literature has had contrasting findings. The first strand of studies argue that increased income variation hints to increased carbon dioxide discharges, while the second group posited that increased gaps in income in the society develops the value of the surroundings and the last strand of studies deduced that inequality in incomes does not affect the quality of the environment.

(Golley & Meng, 2012) Investigated the disparities in carbon dioxide discharges in different homes by means of China's urban household revenue and outflow review (2005) data. The variables included in the model were per capita real income, income distribution, and per capita carbon dioxide emission. They found out that the distribution of revenue from the rich to the deprived is a possible remedy for the reduction of aggregate household emissions.

(Boyce, 1994), (Magnani, 2000), (Wilkinson & Pickett, 2010) and (Hao et al, 2016) are among noteworthy studies that explain the negative link regarding income variation and the value of the surroundings. (Baek & Gweisah, 2013) explored the outcome of income variation on carbon dioxide discharges in USA. Their study confirmed a positive relationship. Suggesting that equal distribution of income, as a possible remedy for environmental degradation. By use of time-series figures for the years 1995 to 2012 (Hao et al, 2016) examined the link between these two variables. The study findings indicated a positive link.

The second strand of literature argues of an exisyence of a negative association between the two variables. The studies include (Hübler, 2017),(Heerink et al, 2001) and, (Borghesi, 2006) using the Pooleds OLS model (Ravallion et al, 2000) explored the association of variations in incomes and discharges of carbon using a third-order polynomial of revenue, a time drift, and populace magnitude. It employed sectional figures gathered for 42 countries in the year 1975-1992. The results validated the existence of a trade-off between dropping C02 discharges and decreasing income variation. They concluded that disparities in income levels cause a decrease of carbon emissions in advanced and evolving nations. Similarly, (Heerink et al 2001) used cross-sectional statistics to study this link for 65 countries. The findings asserted that equal distribution of income leads to the deterioration of environmental quality. (Hübler, 2017) employed a quantile regression approach to investigate this relationship. The study findings revealed an adverse association concerning income variation and carbon dioxide discharges. The study further revealed that global trade and global ventures are clearly linked to discharges.

(Grunewald et al, 2017) explored the ambiguous link between the two variables. The study employed sectional figures for 158 nations for the years 1980- 2008. The sample data comprised of low, middle, and upper-revenue nations. To examine the linkage regarding the variables the study employed a static-effects model and group fixed effects model. The study's findings established that this relationship is dependent on the income grouping. Existence of higher revenue variation in average income markets results in lesser carbon dioxide discharges. However, in higher income markets, higher income variation results to an upsurge in per capita carbon dioxide discharges.

2.3 Overview of the Literature Review

The existing empirical literature reveals lack of definite nexus between revenue variation and carbon emission. Some studies indicate that greater income variation leads to reduced carbon discharge, the second strand of studies argue that higher income variation causes improvement of environmental quality while the third strand of studies argue that income inequality does not affect carbon emission. This difference in findings is a result of the application of different econometrics approaches, studies on different regions and types of data employed. Most of the studies use Carbon dioxide emissions, arguing that it is the main source of pollution.

None of these studies account for endogeneity that would be caused by simultaneity and exclusion of pertinent variables. This research complements the existing works in two ways; the first one, the study specifically focuses on Kenya only thereby expecting country-specific results. Secondly, will address the endogeneity which may be due to simultaneity between income inequality and Carbon dioxide emissions. Given the mentioned inadequacies in current literature, this study tries to cover the missing bits in the current works in terms of assessment methods.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This segment of the paper describes the theoretical structure and the Econometric approach. It defines the target population, datasets, and sources of the data.

3.1 Theoretical Framework

This study will employ the extended Stochastic Effects by Regression on the Populace, Affluence, and Technology identity. Ehrlich and Holdren (1971) introduced IPAT identity to elucidate the effect of the human population on the surroundings. IPAT states that impacts on the environment (I) are the products of Population size (P), Affluence (A), and Technology. Such that:

$$I = P * A * T \qquad (1)$$

However, this model specification has various shortcomings, the specification indicates that a change in one factor affects the impacts directly, whereas the other factors affect the impact through the scale effect (York et al, 2002). This model has also been criticized to assume proportionality in the functional relationship. The association of P, A, and T is multiplicative rather than additive thereby making it impossible for a monocausal explanation of impact (York et al, 2002). (Dietz & Rosa, 1994) argued that the model did not provide an adequate framework to examine the determinants of environmental degradation.

In this regard (Dietz & Rosa, 1994) altered the model into a stochastic arrangement to accommodate random errors in the estimation of the parameter and also to correct the above-mentioned shortcomings.The STIRPAT model is specified as a Cobb Douglas function:

$$I_i = aP_i^b A_i^c T_i^d e \qquad (2)$$

Where I, P, A, and T denote the environmental effect, population size, affluence, and technology respectively. a,b,c and d are parameters while e is the error term. (Shahbaz et al 2015) Argued that compared to simple linear modeling, log-linear specification yields reliable and efficient empirical results. We, therefore, transform the equation into natural logs, equation 2 yields:

$$lnI_i = lna + blnP_i + clnA_i + dlnT_i + e \quad (3)$$

3.2 Model Specification

This paper adopts STIRPAT model with a slight alteration to include other variables that affect environment quality. According to (York et al, 2002) and (Dietz & Rosa, 1994) the model can include other units of analysis provided they theoretically fit into the model. In this regard,

This study will estimate the following model:

$$\Delta ln\text{CO2emissions}_t = a_0 + \sum_{i=1}^{n} a_{1i}\Delta ln\text{CO2emissions}_{t-1} + \sum_{i=1}^{n} a_{2i}\, \Delta ln\text{GDPpercapita}_{t-1} + \sum_{i=1}^{n} a_{3i}\Delta ln\text{Ginicoefficiet}_{t-1} + \sum_{i=1}^{n} a_{4i}\Delta ln\text{Energyuse}_{t-1} + \sum_{i=1}^{n} a_{5i}\Delta ln\text{Urbanization}_{t-1} + \sum_{i=1}^{n} a_{6i}\Delta ln\text{TradeofGDP}_{t-1} + \mathrm{a}_1 ln\text{CO2emissions}_{\,t-1} + \mathrm{a}_2\, ln\text{GDPpercapita}_{t-1} + \mathrm{a}_3 ln\text{Ginicoefficient}_{t-1} + \mathrm{a}_4 ln\text{Energyuse}_{t-1} + \mathrm{a}_5\, ln\text{Urbanization}_{t-1} + \mathrm{a}_6\, ln\text{TradeofGDP}_{t-1} + \mu_t \quad (4)$$

Model 1 represented by equation 4 is used to examine the effect of Economic growth, Gini coefficient, Energy use described in kg of oil equivalent per capita, Urbanization rate and Trade Openness on CO2 discharges (metric tons per capita).

$$\Delta ln\text{CO2emissions}_t = a_0 + \sum_{i=1}^{n} a_{1i}\Delta ln\text{CO2emissions}_{t-1} + \sum_{i=1}^{n} a_{2i}\, \Delta ln\text{GDPpercapita}_{t-1} + \sum_{i=1}^{n} a_{3i}\Delta ln\text{GDPpercapita}^2_{t-1} + \sum_{i=1}^{n} a_{4i}\Delta ln\text{Ginicoefficient}_{t-1} + \sum_{i=1}^{n} a_{5i}\Delta ln\text{Energyuse}_{t-1} + \sum_{i=1}^{n} a_{6i}\Delta lnU_{t-1} + \sum_{i=1}^{n} a_{7i}\Delta ln\text{TradeofGDP}_{t-1} + \alpha_1 ln\text{CO2emissions}_{t-1} + \alpha_2\, lnGDPpercapita_{t-1} + \alpha_3 ln\text{GDPpercapita}^2_{t-1} + \alpha_4 ln\text{Ginicoefficient}_{t-1} + \alpha_5\, ln\text{Energyuse}_{t-1} + \alpha_6\, ln\text{Urbanization}_{t-1} + \alpha_7\, ln\text{TradeofGDP}_{t-1} + \mu_t \quad (5)$$

Model 2 represented by equation 5 investigates the applicability of EKC hypothesis per capita GDP and CO2 emissions. According to the literature if the EKC hypothesis applies in Kenya: γ_2 *is* expected to be greater than zero and γ_3 to be less than zero and statistically significant.

Model 3 represented by equation 6 examines the impact of inequality of income on carbon dioxide discharges while holding the other variables as additional variables.

$$\Delta ln\text{CO2emissions}_t = a_0 + \sum_{i=1}^{n} a_{1i}\Delta ln\text{CO2emissions}_{t-1} + \sum_{i=1}^{n} a_{2i}\,\Delta ln\text{GDPpercapita}_{t-1} + \sum_{i=1}^{n} a_{3i}\Delta ln\text{GDPpercapita}_{t-1}^2 + \sum_{i=1}^{n} a_{4i}\Delta ln\text{Ginicoefficient}_{t-1} + \sum_{i=1}^{n} a_{5i}\Delta ln\text{Energyuse}_{t-1} + \sum_{i=1}^{n} a_{6i}\Delta ln\text{Urbanization}_{t-1} + \sum_{i=1}^{n} a_{7i}\Delta ln\text{TradeofGDP}_{t-1} + \alpha_1 ln\text{CO2emissions}_{t-1} + \alpha_2\, ln\text{GDPpercapita}_{t-1} + \alpha_3 ln\text{GDPpercapita}_{t-1}^2 + \alpha_4 ln\text{Ginicoefficient}_{t-1} + \alpha_5\, ln\text{Energyuse}_{t-1} + \alpha_6\, ln\text{Urbanization}_{t-1} + \alpha_7\, ln\text{TradeofGDP}_{t-1} + \mu_t \quad (6)$$

The test of long-run association between the variables in the system is carried out. The null hypothesis is tested against alternative hypothesis. If the computed F-statistic is higher than the upper bound of the critical value we reject the null hypothesis but if the computed F-statistic is below the (Pesaran et al, 2001) lower bound we do not reject the null hypothesis. If the computed F-statistic is in between the upper and the lower bounds the outcome is indecisive.

The analysis of the short-run and long-run associations among the variables is done by using the ARDL model. The ARDL model is selected because unlike other cointegration tests it can estimate cointegration among variables that are I(0) and/or I(1). Furthermore, ARDL can be used to estimate small samples. Moreover, it can attenuate the problem of omitted variables as well as autocorrelation (Narayan & Narayan, 2004). Also, ARDL is advantageous as it adopts only one equation (Pesaran et al, 2001).

Δ is the differenced operator, μ_t is the error term. a_1 to a_7 represent the short-run parameters whereas the long-run dynamic coefficients of ARDL are represented by α_1 to α_7.

3.3 Variables Measurement and Definition

Table 3. 1 Summary of the variables.

Variable	**Measurement**	**Expected sign**
CO2 emissions	Carbon dioxide emissions (metric tons per capita)	
Economic growth	Real GDP per capita	Positive

Income Inequality	Gini coefficient	Negative
Energy consumption per capita	Energy use (kg of oil equivalent per capita)	Positive
Urbanization	The ratio of urban population to the total population	Positive
Trade openness	Sum of exports and imports as a %age of GDP per capita	Positive

3.4 Diagnostic Tests

To verify the credibility and correctness of the ARDL model. The study will apply various diagnostic tests. Stationarity test is a process of testing that the statistical characteristics of time series including mean, and variance are not altered over a given period of time. This study utilized the Augmented Dickey Fuller Test to check for stationarity within the model.

The Normality test determines whether the sample data has been drawn from a population that is normally distributed and that the residual of the response variable has a normal distribution around the mean. Since the observation were less than 50 0bsevations then the Shapiro-Wilk test was the appropriate test to measure for normality. Therefore, the study employed the Shapiro-Wilk Test.

Multicollinearity happens when a number of independent variables within the model, either two or more are intercorrelated. The Presence of collinearity among variables results in large values of variance and standard error thereby undermining the statistical significance of independent variables. Additionally, multicollinearity results in wide confidence intervals thereby increasing the chances of committing type II error. The used pairwise correlation to test for multi-collinearity.

Autocorrelation is the measurement of the degree of similarity between the values of similar variables over successive time intervals. Presence of autocorrection results in wider confidence intervals leading to inefficient estimators. The study used the Durbin-Watson d Test to test for autocorrelation. The d statistic is the proportion of the sum of squared differences in sequential residuals to the RSS. The closer the d is to zero the higher the chances of positive serial correlation (Gujarati & Porter, 2009).

Heteroscedasticity is the variance that is non-constant among the residuals. The presence of Heteroscedasticity violates the OLS assumption of the constant variance of the error thus leading to a biased estimator. This study utilized the Breusch-Pagan Test.

3.5 Data Sources

This study utilized time series dataset for the period 1987-2018. The data on carbon dioxide emissions, Gross Domestic Product per Capita, Trade openness, Gini coefficient, Urbanization, energy consumption was retrieved from World Bank Development Indicators Database.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSION

4.0 Introduction

This segment presents empirical results and discussions with an aim to analyze the short and long-run nexus regarding Carbon Dioxide discharges and income inequality in Kenya, and the applicability of the EKC hypothesis. Time series data for the period 1981-2018 was used in this study. Section one analyzes tabular descriptive Statistics. Section two presents diagnostic tests. Section three presents the optimal lag length selection criteria whereas sections four and five look at various tests for Unit Root and Cointegration Respectively.

4.1 Descriptive Statistics

This segment describes the basic features of the variables applied in the research. The Standard deviation shows the dispersion of the series relative to its mean while the Min and the Max represent the smallest and the largest values in the series. We expressed all the variables in the models into their natural logarithm (ln) form so at to minimize the chance of the heteroscedasticity issue that comes from the model estimation.

Table 4.1 below shows that during the 32 years of study lnCarbon Dioxide Emissions had an average of 0.2618, SD of 0.0510 and Minimum and Maximum values stood at 0.1883 and 03827 respectively. lnGross Domestic Product per capita had a mean of 920.0676, SD of 107.3276, Min and Maximum values of 809.9616 and 1201.466 respectively. The average of lnGini coefficient was 50.0391 and recorded a standard deviation of 13.72515 with least and extreme values of 40.80 and 93.50 correspondingly. lnEnergy use recorded a mean of 465.4814, Standard Deviation of 55.8003, the minimum and maximum values of 423.7141 and 655.4366 respectively. lnUrbanization rate presented an average of 21.0244 and a Standard Deviation of 3.3233 whereas 16.2810 and 27.0300 were the least and supreme values respectively. Lastly, lnTrade openness recorded a mean of 54.1593, Standard Deviation of 8.6099, Minimum and Maximum values of 36.1493 and 72.8585 respectively.

Table 4. 1: Summary Statistics

Variable	Obs	Mean	SD	Min	Max
lnCarbon dioxide emissions	32	0.2618	0.0510	0.1883	0.3827
lnGross Domestic Product per capita	32	920.0676	107.3276	809.9616	1201.466
lnGini coefficient	32	50.0391	13.72515	40.80	93.50
lnEnergy use	32	465.4814	55.8003	423.7141	655.4366
lnUrbanization rate	32	21.0244	3.3233	16.2810	27.0300
lnTrade openness	32	54.1593	8.6099	36.1493	72.8585

Source: Data generated using Stata 14.

4.2 Diagnostic Test Results

4.2.1Normality Test Result

The concept of Normality test for variables gives an indication of whether the variables are normally distributed. One characteristic of a normal variable is that its statistical properties are equal. The original Shapiro Wilk Test (1965) Wald Test was ran for normality for this study. Shapiro Wilk Test is an extra suitable technique for small sample sizes (if it is less than 50 samples)

Table 4.2 below reveal that all the variables except one variable (lnUrbanization rate) are non-normal.

Table 4. 2 Shapiro Wilk Test for Normality

Variable	**Obs**	**W**	**V**	**Z**	**Prob>z**	**Verdict**
lnCarbondioxideemissions	32	0.90585	3.141	2.376	0.00876	Non-normal
lnGrossDomesticProductpercapita	32	0.86554	4.485	3.116	0.00092	Non-normal
lnGinicoefficient	32	0.69837	10.062	4.793	0.00000	Non-normal
lnEnergyuse	32	0.67274	10.917	4.962	0.00000	Non-normal
LnUrbanizationrate	32	0.95043	1.654	1.044	0.14820	Normal
lnTradeopenness	32	0.91963	2.680	2.046	0.02036	Non-normal

Source: Data generated using Stata 14.

4.2.2 Multicollinearity Test

Multicollinearity was examined based on pairwise Pearson correlation. High correlation among explanatory variables themselves and with the residual term would lead to inflated coefficient of determination.

The results show that multicollinearity was not a major problem given that the explanatory variables adopted in the study did not present close to perfect correlation among themselves. This implies that the coefficient of determination was not inflated. The study dropped the variable Gross Domestic Product per capita because it was highly correlated with Energy Use given that Energy consumption is included in the summation of Gross Domestic Product per capita.

Table 4.1: Pairwise Correlation Coefficients

	lnGross Domestic Product per capita	lnGini coefficient	lnEnergy use	lnUrbanization rate	lnTrade openness
lnGross Domestic Productper capita	1	-	-	-	-
lnGinicoefficient	0	1	-		
lnEnergyuse	0.9172	-	-	1	-
lnUrbanizationrate	0.7093	-0.7258	0.6235	1	-
lnTradeopenness	-0.6783		-0.7907	-0.4671	1

4.2.3 Optimal Lag Selection Criteria

In time series econometrics, optimal lag selection is very crucial as it helps to reduce residual correlation. Presence of a lot of lags into the model causes degrees of freedom loss, while the use of too few lags results in misspecification of the model. The research used AIC to inform on the best lag length to use as it is robust over other criteria especially when dealing with annual data.

Table 4. 4 Selection Order Criteria based on AIC and SBC

Lag	**AIC**	SBC
0	-13.9899	-13.9026
1	-32.6125	-32.0015
2	-323938	-31.2593
3	-35.6315	-33.9733
4	-152.042*	-149.86*

Source: Data generated using Stata 14.

The two Information Criteria are in agreement that the optimal lag length for this study is Four (4). In case of inconsistency about the optimal lag length among the information criteria results, this study would have chosen AIC.

4.2.3 Unit Root Test Results

This study used ARDL Model approach. Before employing this approach, we must check for stationarity condition for all the variables in the series. The validity of the ARDL approach dictates that the series is stationary at I(0) or/and I(1).

Table 4. 5 Stationarity test of variables using ADF

		Stationarity of all variables at levels		Stationarity of all variables at first difference	
Variables	Lags	Without trend	With trend	Without trend	With trend
lnCarbondioxidemissions	1	-	-	-4.082***	-4.197**
lnGrossDomesticProductper capita	0	-	-	-2.916**	-4.449***
lnGinicoefficient	2	3.840***	-3.429**	-	-
lnEnergyuse	1	-	-	-	-3.129*
lnUrbanizationrate	1	-	-	-46.524***	-43.894***
lnTradeopenness	1	-	-	-3.759***	-4.055**

*Note: ***, ** and * denote stationarity at 1%, 5% and 10% levels of significance in that order*.

Source: Stata 14.

The results show that the variable lnGini coefficient was stationary at level. All the other variables obtained stationarity status at first difference.

4.3 Estimated Coefficients using ARDL

Table 4. 6 Test results of estimated ARDL model Coefficients

	ARDL MODEL			
Long run Coefficients				
Variable	Coefficient	Standard Error	t-statistic	P-value
lnGross Domestic Product per capita	1.87596**	0.7036	2.67	0.014
lnGini coefficient	-0.2631	0.2346	-1.12	0.274
lnEnergy use	-1.06122	0.9075	-1.17	0.254
lnUrbanization rate	-0.3502	0.4348	-0.81	0.429
lnTrade openness	-0.1628	0.2476	-0.66	0.517
Short Run Coefficients				
Δ lnEnergy use	2.0792**	0.8433	2.47	0.022
Constant	-2.5122	2.6550	-0.95	0.517
ECT	-0.5086**	0.1955	-2.60	-0.016
R-Squared	0.5553			
Adj R-Squared	0.4199			
Loglikelihood	47.8052			
Root MSE	0.0601			
Observations	31			

*Note: ***, ** and * denote stationarity at 1%, 5% and 10% levels of significance in that order.*

The results in table 4.5 above reveal a progressive association between economic growth and Carbon dioxide emissions in the long run. The coefficient is elastic and has a 5% significance level. To be more specific 1% rise in Gross domestic product per capita in the long run rises Carbon dioxide discharges by 1.88%. This finding concurs with (Al-mulali et al, 2015) who also found a significant and positive relationship between Gross Domestic Product and ecological footprint in Lower-Middle Income countries. (Baek & Gweisah, 2013) also confirmed that a rise Gross domestic product lead to improved environmental quality in the United States.

Income inequality is highly inelastic and has a deleterious nexus with Carbon dioxide emissions, 1% rise in disparity in incomes leads to a 0.26 % decline in Carbon dioxide discharges in Kenya. This outcome is in agreement with the strand of the studies that argue that an increased gap in income leads to the improved clean environment. This finding affirms the findings of (Heerink et al, 2001) and (Ravallion et al, 2000). However, it contrasts the findings of (Gweisah, 2013) whose findings indicated that equitable distribution of income both in the long and short run in the United States actually promotes the quality of the environment,and (Magnani, 2000) who found out that greater equality of income improves the environment by reducing Carbon dioxide emissions. (Yemane Wolde-Rufael, 2017) findings contradicts this study's finding that inequitable distribution of income has a statistically significant relationship with carbon dioxide discharges but asserts that reducing income inequality in China has a beneficial effect on the environment while improving income distribution in India has no environmental benefits.

The findings show that Energy use is elastic, but has a negative relationship with Carbon dioxide emission in the long-run and a positive relationship in the short run. In particular, a 1% increase in energy use in the long run results in a 1.06% decrease in Carbon dioxide emissions. However, in the short-run a 1% rise in Energy use results to a 2.08% upsurge in Carbon dioxide discharges with a 5% level of significance. The short run results of this study are consistent with (Al-mulali et al, 2015) who confirmed a positive nexus between energy consumption and Carbon dioxide emissions.They further argued that environmental damage is caused by increased consumption of energy. (Baek & Gweisah, 2013) while studying whether equality harms the environment in the united states: just like this study found out that increased use of energy is harmful to environment. While conducting a comparative between China and India (Yemane Wolde-Rufael, 2017) also established that energy use is a determining factor of Carbon dioxide emissions in both countries. The study findings of (Lin et al, 2016) also found out that for African countries energy use is a determining factor of Carbon dioxide emissions. The study's results revealed presence of a negative but statistically insignificant long run relationship between Carbon dioxide emissions and Urbanization rate. This study shows that the relationship is inelastic and that a 1% rise in the movemement of the people to the urban areas in the long run, reduces the amount of Carbon dioxide emitted in the environment by 0.35%. (Al-mulali et al, 2015) reiterated that urbanization rate has insignificant effect of environment in lower income countries.

The study results also reveal the presence of a negative nexus between trade openness and Carbon dioxide emissions in the long run. The relatioship is highly inelastic but insignificant. A 1% rise in Trade openness leads to a 0.16% decline in Carbon dioxide emissions in Kenya.This finding also concurs with the finding of (Al-mulali et al, 2015) that indicated an insignificant but negative nexus between ecological footprint and trade openness of lower-middle income countries. The finding of (Ozturk et al, 2016) are consistent with this study whose results indicated that increased trade is advantagious to environment.

The Error Correction Term is negative as expected and significant at a 5% level of significance. It indicates that disequilibrium from the long run in the previous period is corrected in the current period at a speed of convergence of 50.86%.

The results of R^2 reveal that 55.53% of the variations in Carbon dioxide emissions are explained by explanatory variables in the model.

4.4 Cointegration Test

To test for the long run and short-run relationships within the model the study employed the Bounds Cointegration test.

The below table demonstrate that the computed F-statistic is smaller than the critical F-statistic for the I (1) regressors and greater than critical F-statistic for the I (0) regressors at all levels of significance. As a result, we are unable to make conclusive decision. In this regard, the findings are inconclusive. From this result, the study is unable to validate the existence or non-existence of a long-run and short–run nexus in the series.

Table 4. 7 Bounds Cointegration Test Results

	Critical F-Values			
F-Statistic 3.155	0.10 [I_0] [I_1]	0.50 [I_0] [I_1]	0.25 [I_0] [I_1]	0.01 [I_0] [I_1]
Model	2.26 3.35	2.62 3.79	2.96 4.18	3.41 4.68

4.3 Estimated Coefficients using ARDL.

To explore whether EKC exists in Kenya, we generated the natural log of Gross Domestic Product per capita squared. Due to high collinearity the study dropped Gross Domestic Product per capita.

Table 4. 8 EKC test results

	ARDL MODEL			
Long run Coefficients				
Variable	Coefficient	Standard Error	t-statistic	P-value
lnGross Domestic Product squared	0.93798**	0.35181	2.67	0.014
lnGini coefficient	-0.2631	0.2346	-1.12	0.274
lnEnergy use	-1.06122	0.9075	-1.17	0.254
lnUrbanization rate	-0.3502	0.4348	-0.81	0.429

lnTrade openness	-0.1628	0.2476	-0.66	0.517
Short Run Coefficients				
Δ lnEnergyuse	2.0792**	0.8433	2.47	0.022
Constant	-2.5122	2.6550	-0.95	0.517
ECT	-0.5086**	0.1955	-2.60	-0.016
R-Squared	0.5553			
Adj R-Squared	0.4199			
Loglikelihood	47.8052			
Root MSE	0.0601			
Observations	31			

*Note: ***, ** and * denote stationarity at 1%,5% and 10% levels of significance in that order.*
Source: Stata 14

For EKC hypothesis to be applicable in Kenya we expect a negative coefficient of Gross Domestic Product per capita squared. Table 4.8 above indicates a positive and statistically coefficient. The study results have therefore established that EKC hypothesis is not applicable in Kenya. This result is consistent with the finding of (Ozturk et al, 2016). Most of other SubSaharan Africa & Africa studies have reported invalidity of this hypothesis. (for instance,(Al-mulali et al, 2015), (Lin et al, 2016) and (Shahbaz et al, 2015). This trend is attributed to the fact that Kenya and Africa as a whole are still developing.

4.6 Post Estimation Diagnostic Tests

The model was subjected to diagnostic tests. Table 4.8 below represents the results of Serial Correlation and Heteroscedasticity tests whereas the CUSUM and CUSUMQ plots for the model is displayed in figures below.

Table 4. 9 Diagnostic Test Results.

Model	Normality	Autocorrelation	Heteroscedasticity
1	0.47683	0.7349	0.4154

As shown in Table 4.9 above, the ARDL Model applied in this study held no diagnostic problems. This was concluded after statistical tests were done at a 0.05 significance level which indicated this Model satisfied the assumptions of normality, autocorrelation and homoscedasticity.

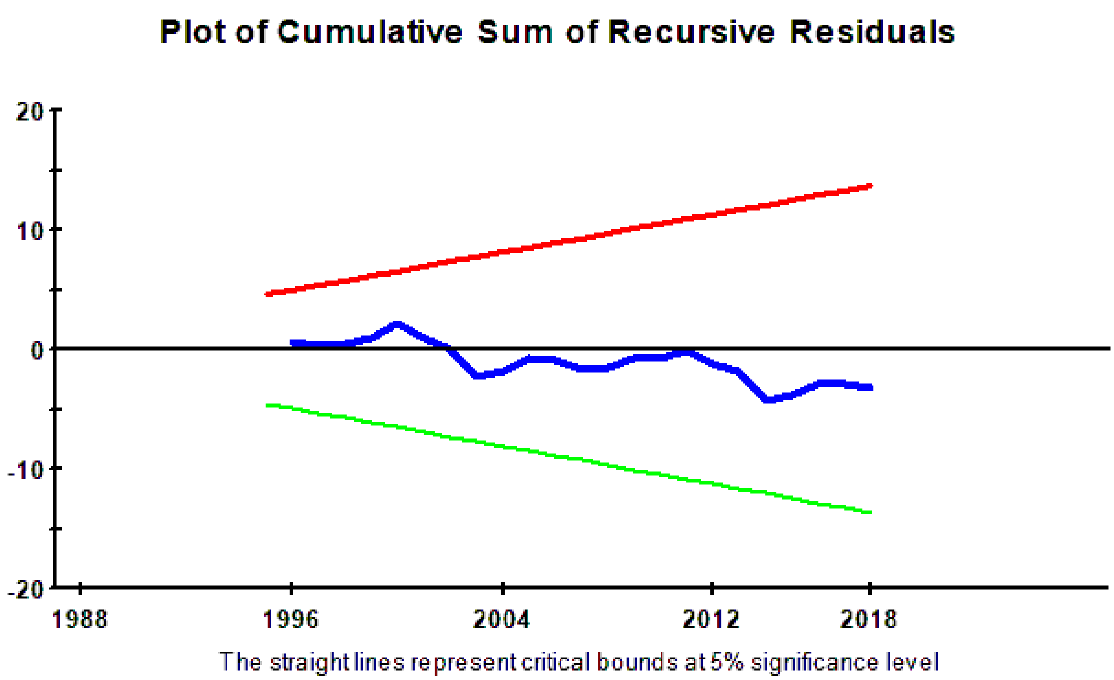

Figure 4. 1 CUSUM plot

Plot generated from Microfit 5.0

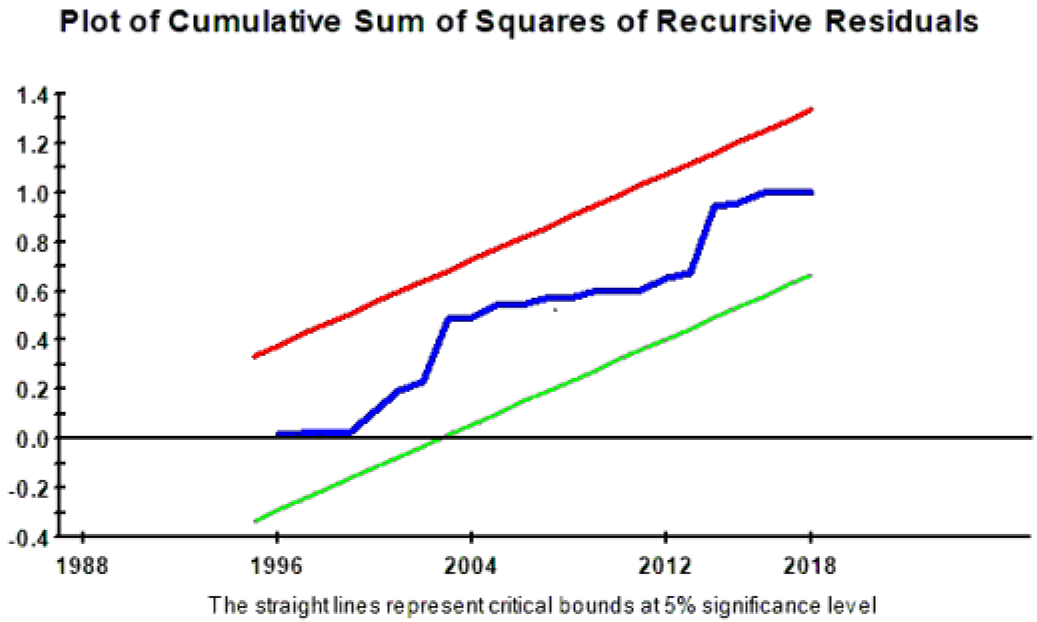

Figure 4. 2 CUSUMSQ plot

Plot generated from Microfit 5.0

The plots of CUSUM of Recursive Residuals and CUSUMSQ of Recursive Residual presented above confirms stability of the model at a 5% level of significance.

CHAPTER FIVE

SUMMARY,CONCLUSION AND RECOMMENDATIONS.

5.1 Introduction

This segment of the paper summarizes the results of the research; inferences made and policies recommended given the empirical findings.

5.2 Summary and Conclusion

The study objective was to evaluate the link between Carbon dioxide emissions and Income inequality in Kenya. We also explored whether Environmental Kuznets Curve exists in Kenya.

So as to achieve the study objectives; the study collected data on Carbon dioxide emissions, Gini coefficient,Gross Domestic Product per capita, Urbanization rate, Energy Consumption and Trade openness for the period 1987-2018 from the World Bank Development Indicators Database. ARDL model was employed and to enable us study the short run and long run link among the series we used Bounds test.

This study's first objective was to investigate the short-run and long-run link between Carbon dioxide emissions and income inequality in Kenya. This study findings reveal presesence of a negative but statistically insignificant long run relationship between Carbon dioxide emissions and income inequality in Kenya. The study suggests that increase in income gaps in Kenya results to reduction of emissions into the environment. The study results for Bounds test are inconclusive. We therefore cannot conclusively establish existence of a long run and short run relationship of the variables used in the series. The findings validate the Marginal Propensity to emit theory that proposes that equality harms the environment quality.

The second objective sought to explain whether the EKC hypothesis is applicable in Kenya. The results established that EKC hypothesis isn't applicable in Kenya. The study therefore accepts the null hypothesis of absence of Environmental Kuznets Curve in Kenya.

5.3 Policy Recommendations

This paper recommends the need for a energy efficient projects that promote the role played by renewable sources of energy in lessening amount of emissions into the environment and promote use geothermal, solar and wind Energy. This study further encourages the government to fast-track construction of Olkaria geothermal power plants so as to ensure the country has attained its full geothermal resource potential of around 10,000 MW. This move will result to reducing the consumption of fossil fuel.

Further we recommend the government to be cautious about constructing Coal powered plant in Lamu as it will derail efforts put across to bring down consumption of fossil fuels. There should be a check by the government on the cost and benefits that come along with constructing the coal plant. Thorough research and Environmental impact assessment should be undertaken before implementing this particular project.

Additionally,the political measure should be taken to promote democracy as a better governance will promote free flow of information in matters environment thereby promoting public awareness and environment legislation.

Given that the Ecological Kuznets hypothesis is not applicable in Kenya, then it means that it is not a sound basis of Environmental policy for the country. Policymakers should instead put more emphasis on promoting sustainable, environmentally friendly developments as opposed to expectations that economic growth will automatically lead to a clean environment. This study recommends that effort be geared towards ensuring pro-poor growth as it will result in reduced cases of degradation of the environment.

5.4 Limitations of the Study

The main shortcoming of this research was inadequacy of data. To be more precise the data for gini coefficient is wanting in all African countries and Kenya not being an exception. However,the study addressed this limitation by using linear extrapolation and interpolation based on the available gini coefficient data. It is believed that this data is reliable and policy recommendation can be made from the results of the data.

5.5 Areas of Further Research

This study didn't utilize granger causality to probe the causal nexus between disparity of incomes and carbon dioxide discharges. The study recommends that in order to understand the interrelationship between the two variables: there is need for future studies to further investigate the Granger causality of the two variables and as a result get full picture of the overall damage caused into the environment.

The study findings show that the nexus between inequality in income and carbon dioxide discharges is inconclusive. Future studies should further examine why this relationship is inconclusive.

APPENDIX

Appendix 1: Data used in the Analysis

Year	Carbon dioxide emissions	Gross Domestic Product per Capita	Gini coefficient	Energy use	Urbanization rate	Trade Openness
1987	0.2420	878.6819	93.5	461.227591	16.281	47.7028
1988	0.2162	900.6872	86.30	456.491464	16.383	49.9750
1989	0.2264	910.8062	79.10	457.222757	16.485	53.1564
1990	0.2588	917.4080	71.90	451.511405	16.748	57.0209
1991	0.2402	900.3525	64.70	445.035567	17.043	55.5977
1992	0.2349	864.7870	57.50	442.239418	17.342	52.9309
1993	0.2242	840.9411	50.30	439.21997	17.645	72.8585
1994	0.2178	837.0037	43.10	430.639855	17.952	71.2661
1995	0.2294	848.1478	43.73	437.930077	18.263	71.7457
1996	0.2438	857.9482	44.37	440.892132	18.579	57.3121
1997	0.2257	837.8107	45.00	433.613199	18.898	54.0571
1998	0.2367	841.4944	45.19	437.403423	19.222	48.8972
1999	0.2408	837.4119	45.38	434.808504	19.55	48.1923
2000	0.2575	819.6154	45.56	437.965932	19.892	53.3090

2001	0.2317	827.7052	45.75	431.981532	20.239	55.9468
2002	0.2198	809.9616	45.94	426.016479	20.591	55.1727
2003	0.1883	811.4266	46.13	423.714082	20.948	54.1323
2004	0.2085	829.9529	46.31	433.506427	21.31	59.4770
2005	0.2274	855.2250	46.50	436.927096	21.675	64.4789
2006	0.2470	885.8096	45.17	443.165486	22.045	55.2365
2007	0.2421	920.6492	43.83	440.465146	22.42	53.8948
2008	0.2490	897.6019	42.50	443.54017	22.8	57.5786
2009	0.2863	902.1245	42.26	456.949612	23.183	50.8636
2010	0.3007	951.6880	42.01	464.413492	23.571	54.2269
2011	0.3018	982.9808	41.77	461.465825	23.969	60.4487
2012	0.2735	1000.8292	41.53	454.836356	24.376	57.7651
2013	0.3098	1032.2773	41.29	468.637588	24.794	53.1330
2014	0.3218	1060.0950	41.04	505.997401	25.221	51.2983
2015	0.3569	1093.1342	40.80	543.3572	25.658	44.1786
2016	0.3827	1129.7132	48.50	580.7170	26.105	37.7002
2017	0.3761	1156.4253	42.70	618.0768	26.562	37.3948
2018	0.3580	1201.4664	41.60	655.4367	27.03	36.1494

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