CHAPTER - 2

REVIEW OF LITERATURE

The literature related to the current study titled "**Relationship between Greenhouse Gas Emissions, Trade Openness and Economic Growth- A Comparative Study between India and China**", are discussed under the following heads in this chapter:

2.1 Theoretical Framework

The theoretical ground on the subject of economic growth and environmental degradation is presented below. The most common theories used to describe the relationship between economic growth and environmental damage are examined.

2.1.1 The Limits to growth theory

In 1968, a group of about seventy five persons belonging to the Club of Rome believed that the possibilities of continuous growth have been exhausted and immediate action is required to avoid a planetary collapse. Jay Forester of MIT devised a model investigating the relationship between the world population, industrial world production, food supply, pollution and natural resources. The model is based on the thesis that the continued growth leads to infinite quantities that just do not fit into a finite world. Among these relationships, there are

“feedback loops” that register the effects of changes in one variable such as food production on another variable like population growth. The model assumes that population increase is affected by crowding, food intake, pollution and the material standard of living which depends on the level of capital, its productivity and the size of population. The model also assumes that non-renewable resources are used up by production process; agricultural production depends on land and on capital investments in agriculture, pollution is generated by the production process and gradually absorbed into a harmless form by the environment.

Limits to Exponential Growth

Food, resources and a healthy environment are sufficient conditions for growth which may be stopped by social factors. Before the crisis point is reached symptoms will appear like prices will rise, people will shift to lower quantity diets thus becoming malnourished. The model registers a tradeoff between production of more food and other goods. If priority would be given to food production, continuous population increase will leave no possibility of expansion. Further how much of CO2 or thermal pollution can be released without damaging the earth’s climate and how much lead, mercury, pesticides etc. can be absorbed by plants, fishes or human beings is not known

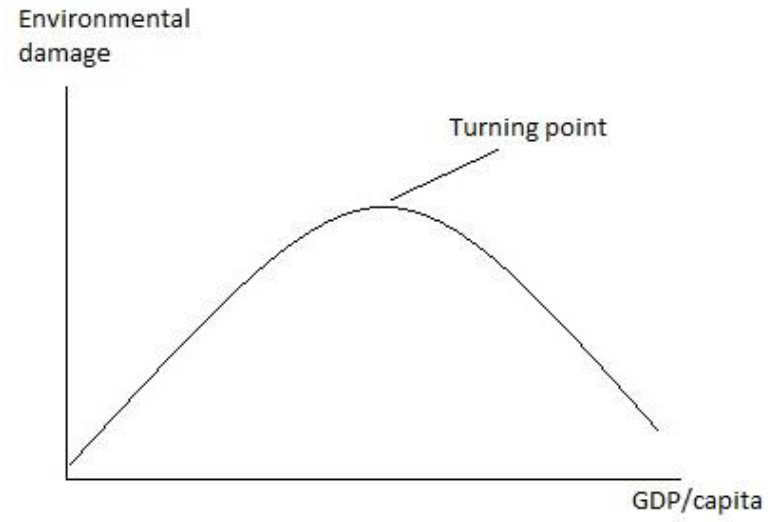
Thus Limits to growth report has been useful for defining what should be prevented. It emphasizes that pollution, high population growth rate, food and resources shortage will lead to catastrophic results. Hence people should understand that the resources are finite and must be used economically to save the world from collapse

2.1.2 The Environmental Kuznets Curve hypothesis

The World Development Report (1992) familiarized the Environmental Kuznets Curve (EKC) establishing the relationship between ambient concentrations of sulphur dioxide and per capita GDP in 47 cities spread over 31 countries. The EKC has an inverted U-shape where per capita income and sulphur dioxide concentration are positively correlated to a particular point at which the trend turns and the opposite relationship can be seen. The EKC was later applied to general environmental degradation globally.

The theory of the EKC says that as the industrial production becomes more severe, pollution increases. As time and income grows, the production is more

technological and service-centralized and also consumers start demanding a clean climate and these factors tend to counteract the increase in pollution and in due course cause the pollution levels to drop (Dinda, 2004).

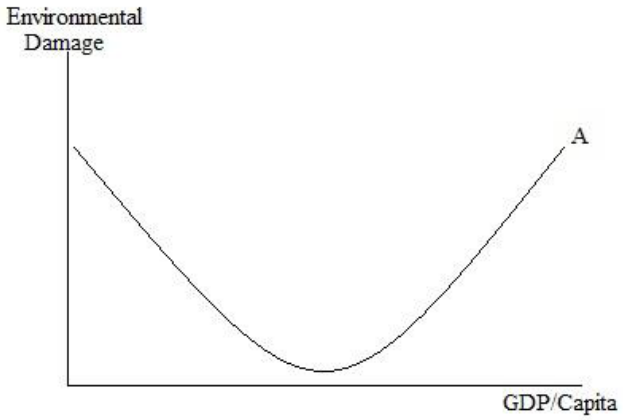


Source: Kuznets(1955)

Figure 2.1: The Environmental Kuznets Curve (EKC)

2.1.3 The Brundtland curve hypothesis

Like the Environmental Kuznets Curve, the Brundtland curve also describes the environmental effects of economic development. The WCED report (World Commission on Environment and Development) from 1978 named “Our Common future”, also known as the Brundtland report, presents another view of the relationship between GDP and environmental damage. The authors of the report argue that poor countries cause high levels of environmental degradation at the beginning stages of development followed by a decrease in environmental degradation when the economies grow further until a turning point is reached, at which environmental degradation increases. Unlike the EKC, the Brundtland curve is U-shaped.



Source: Cederborg.J & Snöbohm.S.(2016)

Figure 2.2: The Brundtland Curve

The level of environmental damage follows a U-shaped curve, where the lowest environmental damage is caused by middle-income economies. According to the Brundtland Curve hypothesis, poor countries cause much damage to the environment as they do not priortise environmental welfare when they concentrate only on the development of the country. The developing countries require massive cutting down of trees and over usage of sensitive land by citizens living in high poverty in order to make a living.

As the economy grows, environmental damage decreases mainly because when people come out of poverty and they become aware of the effects of environmental damage. When the turning point is reached, the pollution is thought to increase with economic growth and eventually get as maximum as original point. Increase in consumption as a result of increase in production brings a positive trend in environmental degradation as per the Brundtland Curve hypothesis. This damage on environment due to increased production is as dangerous to the environment as the ill effects of poverty according to the theory (Field and Field, 2013).

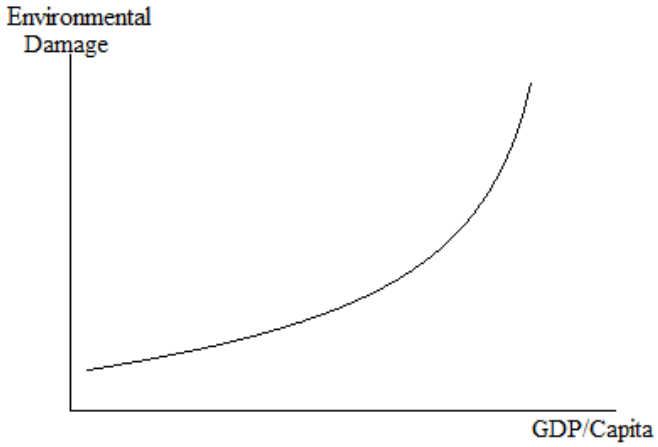
2.1.4 The Environmental Daly curve hypothesis

Daly in his book “Toward a steady state economy” written in 1973 describes the nexus between economic growth and environmental damage. Daly argues that today’s economy driven by increased production is disaster-prone and a steady-state type of economy could be the alternative (Daly, 1973). Daly writes about the subject again in 2004 in “Ecological Economics: Principles and

Applications", where Daly asks about the impact of human creativity and innovation and argues that the incentives for green technology is not sufficient to lower pollutions. Some natural resources are non-renewable, and others are being used at a higher pace than what is required. Daly argues that green development is not enough to counter balance the usage of scarce natural resources and the overall environmental damage.

All the measures taken to create a green production and a sustainable consumption will not be adequate to decrease the environmental degradation. As the economy grows, the environmental damage will increase against the willingness of the citizens and policymakers (Daly and Farley, 2004).

The Daly curve does not show a turning point at any level of wealth, such as the EKC and the Brundtland Curve (Bratt, 2012).



Source: Daly (1973)

Figure 2.3: The Environmental Daly Curve

2.1.5 The Pollution Haven hypothesis

The pollution haven hypothesis means that, when large industrialized nations plan to set up factories or offices abroad, they will always look for the cheapest option in terms of resources and labor that offers the land and material access they require. However, this often comes at the cost of environmentally unsafe practices. Developing nations with cheap resources and labor tend to have less harsh environmental regulations, and conversely, nations with stringent environmental set of laws become more expensive for companies as a result of the costs associated with meeting these standards. Thus, companies that choose

to physically invest in foreign countries tend to (re)locate to the countries with the lowest environmental standards or weakest enforcement.

2.2 Environment Kuznets curve theory based studies

2.2.1 Relationship between carbon emissions and economic growth

Grossman and Krueger(1991) used three air pollutants, sulphur dioxide, dark matter and suspended particles, in a cross-section of urban areas located in 42 countries, to study the relationship between the air quality and economic growth in the context of liberalization of trade between the United States and Mexico. The authors stated that with the liberalization of trade, industrialization processes could not be controlled which generally affects the environment. This is the classical theory of the relationship between the economic growth and environmental indicators, which is known as the EKC.

Shafik and Bandhopdhyaay (1992) in their study examined 149 countries using panel regression over the period 1960-90 to find that the environmental quality was monotonically improving. The reason for this improvement was due to the reduction of the amount of pollutants except for the amount of the dissolved oxygen in rivers and CO_2 when the level of income was rising. An unidentified income turning point was found as CO_2 emissions per capita had been increasing monotonically during the income growth. The report emphasized that development will be diluted without environmental protection and when no development happens, investment resources would be insufficient and as a result environmental protection will fail.

Selden and Song (1994) studied the relationship between the environmental quality and the development using the quadratic regression equation to integrate into a single model, the emissions per capita, real GDP per capita and an additional variable, the population density and assumed that industrialization and agricultural modernization might lead to increased pollution, while other factors might cause its decrease. The authors emphasized the role of the following factors: positive income elasticity for the environmental quality, the changes in the patterns of production and consumption, as well as the increasing levels of education and environmental awareness and the development of more open political systems. Only the air quality indicators (sulphur dioxide, suspended

particulates, oxides of nitrogen and carbon monoxide) were used in the study and global emissions for various scenarios of income and population growth were forecasted. The distribution of global income, the pattern of income growth rates among various nations and the pattern of the population growth rates among the nations were highlighted as the important factors for future global pollution. The authors found a meaningful Kuznets relationship between the emissions and GDP was expressed via possible signs of regression coefficients.

Eakin and Selden (1995) carried out the research with panel data covering 108 countries from 1957 to 1986 based on CO_2 and GDP concentrating their analysis on two emission functions: the first one is quadratic in levels, while the second one is quadratic in the natural logarithms. They determined that endogenous variables could be the composition of output, regulations and taxes, as well as patterns of urbanization and some country–specific factors, including climate, geography, resources, and land area were mentioned as exogenous variables of emissions. The estimation results established an inverted–U shape. The estimated relationship was used to forecast the global emissions due to fossil fuel consumption and cement manufacturing over the period of 1986–2100.

Grossman and Krueger (1995) studied the effect of economic growth on ecological problems assuming that the development gave rise to structural changes in production, and the societies could find ways to conserve scarce resources. The authors examined the reduced form relationship between per capita income and various environmental indicators, such as urban air pollution, the state of the oxygen regime in river basins, the faecal contamination and heavy metal contamination of river basins. The authors found that for the most indicators, the pollution increased at the initial stage, but in the course of the economic growth, a subsequent phase of improvement as a result of the increased demand and supply for environmental protection at higher levels of national income could be observed. In general, the research demonstrated that national income was an important determinant of local air and water pollution.

Roberts and Grims (1997) presented the research covering the data from 1962 to 1991 for the groups of the high, middle and low level countries as referred by the World Bank. The authors used national carbon intensity as the log

dependable variable in the quadratic regression analysis to check if there had been an inverted U – curve relationship for CO_2 emissions per unit of GDP over the period of 30 years and tracked the changes in the selected groups of the countries. According to them the existence of the inverted U – curve for CO_2 emissions intensity would suggest that the reduction of pollution might be expected to occur as a natural by-product of economic development, improving the efficiency, particularly, of energy consumption. The results showed that the relationship between national carbon intensity and GDP changed from the essentially linear in 1965 to strongly curvilinear in 1990 for all countries. Hence, they proved the existence of the inverted– U relationship and also noticed that the higher income countries demonstrated a decrease in CO_2 emission, while other groups showed its increase

Unruh and Moomaw (1998) analysed the EKC behaviour raising a question whether the event of the decreasing pollution in the countries with higher income was due to economic growth or some other underlying changes. The researchers could not find any convincing evidence of such a happening in all other countries and they also questioned whether EKC was a useful model for the analysis of policy determining the development purposes. In an effort to evaluate whether income was the determining variable, the authors had applied the techniques of nonlinear dynamical analysis. The authors generated phase diagrams for sixteen countries. The analysis showed that there was a group of countries that demonstrated EKC-like behaviour because the emissions first rose and then stabilized around an attractor in the period from 1970 to 1980, or declined as the income grew. The authors concluded that it was not right to choose a single income turning point because CO_2 emissions originated almost entirely from fossil fuel usage.

Galeotti and Lanza (1999) estimated the relationship between CO_2 and GDP using a panel data model for 110 countries and forecast emissions in the period from 1971 to 1996. The sample covered 88 percent of the CO_2 emissions generated by fuel combustion. The estimated results of the study confirmed the EKC hypothesis and researchers forecasted the level of emission until 2020 using environmental Kuznets curve which showed that the future global emissions would grow in some cases and would be lower in many cases.

Bradford et al (2000) used a new specification to re-analyse the data on worldwide environmental quality investigated by Gene Grossman and Alan Krueger in a well-known paper on the environmental Kuznets curve (which postulates an inverse U shaped relationship between income level and pollution). In this paper the new specification enables us to draw conclusions from fixed effects estimation. In general, the report found support for the environmental Kuznets curve for some pollutants and for its rejection in other cases. The fresh specification offers some promise for analysis of such phenomena.

Hettinge et al. (2000) states that pollution grows unless environmental regulations like emission charges and subsidies, emission standards and property rights are strengthened. In a democratic country regulations are decided by politicians and since people have a higher demand for a clean environment when income grows, politicians are motivated to attract the voters by strengthening environmental regulations. This is as per the median voter theorem, introduced by Black (1948).

Dinda (2004) emphasized, that many researchers found the EKC for local pollutants, which have local impacts. There is no single policy, which can reduce pollution levels with rising economic growth and evidence for the existence of EKC is inconclusive. The author opined that good economic models reflecting physical and ecological basis of economic activity are required. Researchers should priortise on finding the factors explaining EKC, use decompositional analysis to find the dominant combinations of explanations, employ time series analysis to find the relationship between pollution and development in individual countries. Stringent policy measures are needed to ensure economic sustainability

Li et al. (2007) in their study aimed to use meta-analysis and investigated empirical EKC studies between 1992 and 2005. The study analyses and investigates the evidence from 77 studies and a total of 588 observations and implemented two new modeling approaches. Used a multinomial logit model and control for various modeling and studied the relationships between environmental degradation and economic growth. Also by applying Tobit model estimated income turning points (ITPs). Due to the global climate change, study focused on the estimation of ITPs for categories of greenhouse gases. Meta-analysis is used

to investigate systematic variation across Environmental Kuznets Curve (EKC) studies. Based on 588 observations, modeling results indicate that data characteristics, study methods, estimation techniques, and the chosen environmental quality degradation measures significantly affect the absence or presence of the EKC and any predicted income turning points (ITPs). The results also show that with respect to anthropogenic activity-related greenhouse gases, the evidence does not support the presence of an EKC.

Huanget al. (2008) studied 38 industrialized countries in order to test their connection to the Kyoto Protocol in this respect. The selected sample was divided into two parts, including the transition economies (for example Russia, the Baltic States) and the developed countries (for example Norway, Austria) using time series linear, quadratic and cubic equations. A hockey stick curve trend was seen between the economic development and GHG in transition economies. The results of the developed countries did not provide any evidence to support the EKC hypothesis for GHG. The author stressed that the countries should limit the greenhouse gas emissions to stop climate change and as a result can achieve the Kyoto Protocol objectives.

Jalil and Mahmu (2009) made an attempt to evaluate the long-run relationship between carbon emissions and energy consumption, income and foreign trade in the case of China by employing time series data of 1975–2005. The study also targeted at testing whether environmental Kuznets curve (EKC) relationship between CO2 emissions and per capita real GDP holds in the long run or not. Empirical analysis has been done using Auto regressive distributed lag (ARDL) methodology. A quadratic relationship between income and CO2 emission has been found for the sample period, supporting EKC relationship. The results of Granger causality tests indicated that one way causality runs through economic growth to CO2 emissions. The results indicated that the carbon emissions are mainly determined by income and energy consumption in the long run. Trade has a positive but statistically insignificant impact on CO2 emissions

Alstine and Neumayer (2010) addressed the aspects of economic growth and benefit of the environment. The results suggest that economic value needs to be decoupled from resource depletion and environmental destruction. However

from the theoretical discussion no conclusive answer is found that explains how this decoupling will occur. The authors have critically reviewed the theoretical and empirical literature on the EKC. Explanations for the inverted U-shaped relationship between income and environmental degradation are complex and perhaps context specific, but recent improvements in empirical methods address a number of past criticisms, which adds robustness to the EKC results for certain environmental pollutants. In this paper authors tried to analyse the ways in which countries manage to reduce their pollution load, which can suggest alternative explanations of the income-pollution relationship through variables such as energy price shocks, democracy, literacy, income inequality and ENGOs.

Richard Carson (2010) analysed the literature on the EKC hypothesis and pointed out the aspects that were not widely cited in other literature. According to the author, the pollution control context was largely ignored by economists while explaining EKC. The pollution data which was poor in quality used in the EKC studies were not as comparable across countries as one might hope because different methods and procedures could have been used in each country. The theory made everyone believe that the developing countries might grow out from the environmental problems, while, in reality, the developing countries can take many active actions to improve the environmental conditions. Very few researchers took a serious look at the problem of how changes in regulatory systems will be used to improve the environmental quality and keep away environmental degradation.

Tsurumi and Managi (2010) examined the environmental Kuznets curve hypothesis for carbon dioxide for sample covering 30 OECD countries classified into three groups for the period 1960–2003, using generalized additive models with a generic flexible functional form, allowing for a potentially non-linear non monotonic relationship. For the chosen countries with the dependent variables taken as the log of CO_2 and independent variables as the real log of GDP per capita it was found that economic growth was not sufficient to decrease CO_2 emissions. The first group had a negative slope for the high income levels, while the second group demonstrated a monotonically increasing trend at all income levels, and the third group displayed other trends or had confidence intervals which were too wide to interpret.

Bo (2011) attempted to address the relationship between environmental protection and economic development. The authors state that this has been a long time controversial issue. This paper provides a literature survey on Environmental Kuznets Curve (EKC), which includes genesis, explanations and empirical evidence of EKC. The results of the study say that income elasticity of environmental quality demand, scale, technological and composition effects, international trade, FDI and history accidents, etc. are key reasons to EKC.

Tzeremes & Halkos(2011) in their paper investigated China's carbon emissions during 1960- 2006, with particular focus on the direct role of growth and in connection to trade and the value added by various sectors like agriculture, industry and services. Their empirical results indicated the presence of an inverted U-shaped curve between CO_2 emissions and growth represented by the GDP per capita. Trade seems to be an important determinant in this relationship.

Fosten et al.(2012) analysed the EKC based on the relationship between the emissions of CO_2 and SO_2gases and GDP per capita covering samples from 1830 to 2003 for the CO_2 model and from 1850 to 2002 for the SO_2 model. The results supported the EKC hypothesis with per capita CO_2 and SO_2emissions, having an inverse U relation with real GDP per capita. It can be inferred that reducing greenhouse gases depends on legislations than reduction in economic growth and incorporating technological changes should be used to estimate EKC model.

Esteve and Tamarit (2012) attempted to find EKC evidence in Spain, using a linear integrated regression model with multiple structural changes using time series data spanning from 1857 to 2007. The turning point in Spain was found during 1986 due to the aftermath of the oil crisis of the 70s, the political instability in Spain in 1975–78, and by the shift in the energy mix that took place only at the beginning of the 80s. The results showed that even if the shape of the EKC does not follow an inverted U, it shows a decreasing growth path, pointing to a potential turning point.

Franklin and Ruth (2012) used the log squared regression equation with the U.S emission data of CO_2 to explain the possible impact of population and the economic structure on it. The existence of the inverted U shaped EKC was

confirmed by a data for a hundred year period with the variables divided by the population size. The results showed significant relationships between the population and the productive structure of the economy and CO_2 emissions. The authors advised the adoption of consumption choices that would strongly assure the sustainable way.

Alsayed and Sek (2013) tested the EKC hypothesis about the existence of the relationship between the environmental quality (i.e. CO_2, SO_2, BOD, SPM10, and GHG) and GDP among the developed and developing countries in the period from 1961 to 2009 using panel data and the cubic regression model. The results demonstrated the existence of the EKC and showed that CO_2 and SPM10 were the environmental indicators. The results also revealed that the developed countries had higher turning points than those of the developing countries and therefore the authors conclude that a higher economic growth might produce diverse effects on the environmental quality in different countries.

Fujii and Managi (2013) chose to estimate the EKC relationship separately considering particular types of industry and fuel and also taking into account the factors influencing the shape of EKC like scale, technology and composition. The authors opined that the existence of the EKC relationship between CO2 and economic growth would be possible for industries which do not use fossil fuels like the wood and paper industries, as well as pulp and printing industries but may not be for other industries, particularly to steel and metal, which use coal as their main intermediate fuel where the emission of CO_2 would increase proportionally with the production growth. Panel regression analysis based on quadratic or cubic relationship between CO_2 and GDP was used by the authors. Based on the availability of data from the International Energy Agency, the industries were chosen. There was the N-shape trend found for overall CO_2 emissions. Wood Industries, paper and pulp, printing and construction industries supported the EKC hypothesis. The CO_2 emissions from burning coal and oil increased with economic growth in upstream industries. Hence, a conclusion was made that three industries of the nine ones analysed with respect to CO_2 emissions were greener than the others.

Liao and Cao (2013) examined the relationship between the economic development and carbon dioxide emission in 132 countries for the period of 1971–2009 and evaluated the strength of the results based on data sources, model specification and estimation methods. The factors such as urbanisation, population density, trade and energy mixes were used in the analysis. The linear spline econometric model was used. The results were tested for sensitivity to a different number of segments of income elasticity of CO_2 and few other factors in order to check the vigor of the income effect. The author concluded that while the CO_2 emission was driven by economic development, urbanization, population density, trade and energy mix, these factors also would potentially contribute to the reduction of the absolute level of CO_2 per capita emission. The results of the study just described the trend observed in high income segments but did not support the inverted U shape concept. The author suggested that the economic policies helping to cultivate green technology development and the additional CO_2 emission reduction measures should be implemented to make up for a negative stage of income and CO_2 relationship.

Lopez et al. (2014) tried to determine the possibility of stabilizing CO_2emissions under a rapid increase of gross domestic product. The paper was an effort to study in detail how changes in the driving forces of the economy affect CO_2 emissions in Venezuela for the period 1980-2025, using the methodology proposed by Robalino-L´opez et al., (2008) an extension of the Kaya identity and on a GDP formation approach that includes the effect of renewable energies. The environmental Kuznets curve (EKC) hypothesis was tested in a coming future under different economic scenarios not only on past data but also on projections for the coming years. The cointegration techniques and the Jaunky specification were used to test the existence of the EKC hypothesis in Venezuela. The predictions of the study showed that Venezuela does not fulfill the EKC hypothesis, but however, the country could be on the way to achieve environmental stabilization in the medium term.

Cederborg and Snobohm (2016) observed the possible influence of economic growth on environmental degradation by studying relationship between per capita GDP and per capita emissions of the greenhouse gas carbon dioxide in 69 industrial countries as well as 45 poor countries using cross sectional data.

The cross sectional study analysed empirically found that there is in fact a positive relationship between per capita GDP and per capita carbon dioxide emissions. The researchers did not observe any turning point at which emissions start to decrease when reaching a peak GDP, as EKC theory claims. Stringent legal regulations are required to avoid further environmental damage and market economy mechanisms alone are not sufficient.

Mikayilov et al. (2018) investigated the relationship between the economic growth and CO_2 emissions in Azerbaijan using cointegration analysis for the period 1992 to 2013. The study employed Johansen, ARDLBT, DOLS, FMOLS and CCR methods to explore cointegration and estimate long-run coefficients. The study found that the results from the different cointegration methods were consistent with each other and that the economic growth has a positive and statistically significant impact on the emissions in the long-run implying that the EKC hypothesis does not hold for Azerbaijan. The paper concluded that measures to increase energy efficiency, carbon pricing instruments in production and international-domestic trade activities, and nationwide social awareness programs to instruct about the negative consequences of pollution can be considered as relevant environmental policies aimed at reducing carbon emissions.

Ru et al. (2018) analyzed the historical relationship between per capita income and emissions of SO_2, CO_2, and black carbon (BC) utilizing widely-used global, country-level emission inventories for the following four sectors: power, industry, residential, and transportation. They found that emissions of SO2 from the power and industrial sectors, as well as CO_2 from the industrial and the residential sectors largely follow an EKC pattern but income-emission trajectories for SO_2 andCO_2 from other sectors, and those for BC from all sectors, did not show an EKC. The results demonstrated that long-term income-emission trajectories of air pollutants are both sector and pollutant specific. Users of future emission scenarios derived using EKC assumptions should consider the underlying uncertainties in such projections in light of this historical analysis

Pilatowska and Wlodarczyk (2018) studied the long-run equilibrium relationship between CO_2 emissions and economic growth (the EKC hypothesis) in an asymmetric framework using the non-linear threshold cointegration. In order

to avoid the problem of omitted variables bias, the dynamic relationship between pollutant emissions, economic development and energy consumption were also examined (the extended EKC model). The empirical study was carried out for the European Union countries (EU-14) dividing into three groups depending on a category of knowledge-advanced economies in order to explain the differences in the dynamic linkage between CO_2 emissions and economic growth, as well as in the energy consumption impact on this co-integrating relationship. The study found that the EKC hypothesis is valid for the most high-level and some middle-level knowledge advanced economies. The addition of energy consumption to the standard EKC model has improved the results in terms of the presence of linear or threshold cointegration for all low-level knowledge based economies. Moreover, the causality pattern between CO_2 emissions and income has changed after adding energy consumption to the EKC model and some similarities are found in the countries belonging to the same category of knowledge-advanced economies.

Schroder and Storm (2018) developed a prognosis of climate-constrained global growth for 2014-2050 using the Kaya sum rule and secondly used the Carbon-Kuznets-Curve (CKC) framework to empirically assess the effect of economic growth on CO_2 emissions using measures of both territorial (production-based) emissions and consumption-based (trade adjusted) emissions. The authors ran panel data regressions using OECD ICIO CO_2 emissions data for 61 countries during 1995-2011 to check the robustness of the findings. The result showed decoupling of production-based CO_2 emissions and growth but consumption-based CO2emissions were monotonically increasing with per capita GDP.

Xu et al. (2018) investigated the relationship between economic growth and carbon emission in China with data of 30 provinces of China during the period of 2000 to 2012. Results showed that the relationship between carbon emission and economic growth in China during the recent decade has the development tendency toward an inverse U-shaped curve, approximately confirming the carbon emissions Kuznets curve hypothesis in China. The study also confirmed a significant spatial correlation between carbon emission and economic growth,

Zhou et al. (2018) investigated the impact of economic growth and energy consumption on carbon emissions in top ten selected countries contributing to the total carbon emissions in the world with an aim to test the validity of the Environmental Kuznets Curve (EKC) hypothesis, including five developing countries (China, India, Brazil, Mexico and South Africa) and four developed countries (European Union, the United States of America, Canada and Japan). Authors have adopted a panel quantile regression model that takes unobserved individual heterogeneity and distributional heterogeneity into consideration. The empirical results from the study show that the effect of the independent variables on carbon emissions is heterogeneous across quantiles. Energy consumption increases the carbon dioxide emissions, with the strongest effects occurring at different quantiles for sample group data. But the effects of energy consumption on carbon emissions for developed countries are greater than developing countries. The study findings were supporting inverted U-shaped curve in the selected countries

Beyene and Kotosz (2019) in their paper on "Testing the environmental Kuznets curve hypothesis: an empirical study for East African countries" tested the EKC hypothesis for 12 East African countries using the Pooled Mean Group (PMG) approach for the period from 1990 to 2013. The result showed that the relationship between per capita income and CO_2 emissions (a proxy for environmental degradation) is bell shaped and thus is an extended version of the original inverted U-shaped curve relationship between economic activities and environmental degradation. Hence the authors concluded that the economic activities in East African countries do not lead to CO_2 emissions. Therefore, environmental conservation policies, technological advancement and modern industrial policies are required to make the economic growth of East African countries effective in reducing CO_2 emissions.

Hao et al. (2019) explored the relationship between China's carbon emissions and economic growth based on panel data of 29 provinces from 2007 to 2016 by combining the Tapio decoupling model and the environmental Kuznets curve (EKC) framework. The paper quantitatively estimated the nexus of carbon emissions and economic development for the whole nation and the decoupling status of individual provinces. The authors found empirical evidence for the

conventional EKC hypothesis, showing that the relationship between carbon emissions and per capita gross domestic product (GDP) is an inverted U shape and that the inflection point will not be attained soon. Moreover, following the estimation results of the Tapio decoupling model, there were significant differences between individual provinces in decoupling status.

Iskandar (2019) tried to investigate the existence of EKC (Environmental Kuznets Curve) hypothesis and the dynamic relationship between CO_2 emission and economic growth in Indonesia for 1981-2016. Authors followed the Autoregressive Distributed Lag (ARDL) cointegration framework methodology. Study utilized data from World Bank Development Indicators. The results indicated that EKC hypothesis does not exist. In addition, the long run model shows that economic growth appears to have a significant positive impact on CO_2 emission, especially from electricity and heat production. The findings suggest that Indonesian government should shift towards a service-intensive economy and develop an alternative renewable energy source to mitigate environmental degradation as well as promote economic development.

Sun et al. (2019) examined the interaction between trade and an environmental pollution proxy of carbon dioxide (CO_2) emissions by integrating economic growth and energy usage as major potential determining factors in this relationship for 49 high-emission countries in Belt and Road regions over the period of 1991–2014 using current panel cointegration approaches. The results of the panel cointegration tests revealed that the four variables were stationary in the long run and also indicated that trade openness had both positive and negative impacts on environmental pollution, but the effect varied in these different groups of nations. The results of the vector error correction model (VECM) causality also showed a long-run causal effect between trade, economic growth, energy consumption, and environmental pollution in the Belt and Road, Europe, high-income, middle-income, and low-income panels. The environmental Kuznets curve (EKC) results further indicated the existence of an inverted U-form relationship between trade and carbon emissions.

Very few studies had Carbon emissions as explanatory variable influencing economic growth. They are as follows.

Mesih and Mesih (2009) attempted to study the impact of carbon emissions from gas flaring or gas fuels and solid fuels on economic growth. The results revealed that a unit rise in the emissions of these fuels lead to 0.34 and 0.52 units increase in GDP, respectively and so concluded that emissions have positive impact on economic growth. They also found that the major sources of carbon emission in Asia are gas fuels and solid fuels.

Ejuvbekpokpo (2014) studied the impact of carbon emissions on economic growth in Nigeria for the period 1980 to 2010. The variables used were carbon emissions from fossil fuels, gas fuels, liquid fuels, solid fuels and gross domestic product. Ordinary Least squares method was used for the analysis and the results revealed that carbon emissions have a negative impact on the economy of Nigeria.

Azam et al. (2015) had the prime aim to look into the impact of environmental degradation proxied by CO_2 emission per capita on economic growth in selected higher CO_2 emissions economies' namely China, the USA, India, and Japan for the period between 1971 and 2013. The author identified that empirical studies on the impact of environmental degradation on economic growth in the context of higher CO_2 emission countries are yet scanty in the available literature. The panel fully modified ordinary least squares (FMOLS) method is employed as an analytical technique for parameter estimation and the results show that almost all variables are statistically significant rejecting the null hypotheses of non cointegration and indicating that all variables play an important role in affecting the economic growth across countries. Where two explanatory variables namely CO_2 emissions and energy use show significantly negative impacts on economic growth, trade and human capital showed the significantly positive impact on economic growth. But, for the individual analysis across countries, the panel estimate suggests that CO_2 emissions have a significant positive relationship with economic growth for China, Japan, and the USA, while it is found significantly negative in case of India. The study found that suitable and practical policies are required in order to regulate pollution rising from areas other than liquefied fuel consumption. Thus reduction in pollution ultimately will guarantee sustainable economic growth and maturation and also improve welfare of the country.

2.2.2 Relationship between carbon emissions, trade openness, energy consumption, FDI, population, technology, tourism and economic growth

Essien (2010) investigated the effects of the short run and long run causal link (Granger causality relationship) between energy consumption, economic growth and carbon emissions in Nigeria (using Nigerian data over the period 1980 – 2009) including labour, investment in gross fixed capital formation, trade openness, total expenditure on education and labour force in the model. The study employed Augmented Dickey Fuller (ADF) and Philip Perron (PP) Test to examine the stationary state of the data and Johansen cointegration test to determine if there exists a long run relationship among the variables before estimating the model. The stationary test results indicated that none of the variables are stationary at levels in both tests while the cointegration results indicated that there are four co-integrating equations associated with our variables. The study applied the techniques of VECM version of Granger causality to find whether there exist a bi-directional or uni-directional causality between energy consumption, economic growth and carbon emissions in the short and long run. The statistical findings indicated that a neutral hypothesis holds in the short run (economic growth and energy consumption and carbon emissions are not related) and a bi-causal relationship holds in the long run between economic growth and energy consumption. This result did not suggest the existence of an EKC hypothesis in the long run, however, the standard polynomial functions (linear, quadratic and cubic) were estimated to confirm the existence of the EKC (‘‘U’’) curve or ‘‘N’’ shape curve and to find the main driving forces affecting carbon emissions patterns and the relationship between economic growth and carbon emissions. The study concluded that although in the short run no causality is found between economic growth, energy consumption and carbon emissions, there is a strongly interdependent relationship between economic growth and energy consumption in the long run.

Ahmed and Long (2012) investigated the relationship between CO_2 emission, economic growth, energy consumption, trade liberalization and population density in Pakistan with yearly data from 1971 to 2008 based on EKC hypothesis. The cointegration analysis using Auto Regressive Distributed Lag

(ARDL) bounds testing approach was incorporated. The results supported the hypothesis both in short-run and long-run and an inverted U-shaped relationship was found between CO2 emission and growth. Interestingly the authors found trade support the environment positively but population contributes to environmental degradation in Pakistan. The energy consumption and growth are the major explanatory variables which contribute to environmental pollution in Pakistan. Moreover, the time series data analysis was used and the stability of variables in estimated model was also assessed.

Linh and Lin (2014) examined the dynamic relationships between CO_2 emissions, energy consumption, FDI and economic growth for Vietnam in the period from 1980 to 2010 based on Environmental Kuznets Curve (ekc) approach, cointegration, and Granger causality tests. The empirical results did not support the EKC theory in Vietnam. However, the cointegration and Granger causality test results indicated a dynamic relationship among CO_2 emissions, energy consumption, FDI and economic growth. The short run bidirectional relationship between Vietnam's income and FDI inflows implied that the increase in Vietnam's income will attract more capital from overseas. Inversely, FDI inflow is also driver of national income growth.

Ali et al. (2015) attempted to analyze the impact of energy consumption, economic growth, financial development, economic globalization along with poverty incidence measured by poverty head count ratio on carbon emissions in Pakistan economy for the period 1972-2011. Johansen's cointegration test was applied to explore the long run association amongst the variables. A long run equilibrium association was found between carbon emissions and regressors in the carbon emission model. Long run and short run causality was found between the variables. The study also confirmed the existence of Environment Kuznets Curve hypothesis in Pakistan.

Dogan et al. (2015) analysed the long-run dynamic relationship of carbon dioxide emissions, real gross domestic product (GDP), the square of real GDP, energy consumption, trade and tourism under an Environmental Kuznets Curve (EKC) model for the Organization for Economic Co-operation and Development (OECD) member countries applying second-generation unit root tests,

cointegration test and causality test which can deal with cross-sectional dependence problems. The tests indicated that the analysed variables become stationary at their first differences and the cointegration test showed the existence of a long-run relationship between the analysed variables. The dynamic ordinary least squares (DOLS) estimation technique indicated that energy consumption and tourism contribute to the levels of gas emissions, while increases in trade lead to environmental improvements. The EKC hypothesis was not supported as the sign of coefficients on GDP and GDP^2 was negative and positive, respectively and the Dumitrescu–Hurlin causality tests explained a variety of causal relationship between the analysed variables.

Ameer and Munir (2016) examined the impact of trade openness, urban population, technology and economic growth on environment of Asian economies from 1980 to 2014. The study utilized panel unit root, panel cointegration, DOLS estimator and causality tests in order to establish the association between environment and selected macro-economic variables. The results obtained from carbon dioxide emissions model show the significant impact of growth and technology on carbon emissions. While results of sulfur dioxide emissions model indicates the existence of inverted U-shaped EKC hypothesis. The study concluded that there should be research and development programs at public and private level to control pollution through new technologies.

Khateeb (2016) studied the effect of financial development, income, energy consumption, and trade openness on carbon emissions in Jordan during the period 1980 to 2011 using the time-series data collected from the World Bank and UNCTAD databases. The long-run elasticity of CO_2 emissions with respect to energy consumption was positive. Furthermore, the relationship between CO_2emissions and GDP in the long run was positive, and negative with respect to square of GDP. In addition to that, the foreign trade has positive impact on CO_2 emissions. The findings showed that financial development has a long-run negative impact on per capita CO_2 emissions, suggesting that financial development does not increase environmental degradation. Causality tests clearly justify the long run effects of energy consumption, GDP, squared GDP, financial development and foreign trade Granger-cause on CO_2 emissions which explains the existence of a unidirectional long-run causality from per capita GDP, the

square of per capita GDP, per capita energy use and financial development to per capita carbon emissions. The results of the bound F-test for cointegration test showed the existence of a long-run relationship between per capita energy consumption, per capita income, the square of per capita income, trade openness, financial development and per capita carbon emissions. Findings also indicated that a per capita carbon emission have a positive relationship with foreign trade to GDP ratio and with energy consumption, while financial development, has a negative and significant impact on per capita carbon emissions in the long- run. The results also supported the validity of EKC hypothesis in Jordan's economy.

Ozturk and Oz (2016) explored the relationship between the energy consumption, income, foreign direct investment (FDI) inflows, and CO_2 emission in Turkey, for the period 1974-2011 using cointegration method and Granger causality analysis. The cointegration method results indicated that there is a long term relationship among the variables. Results also showed that, both in the short and long run, Environmental Kuznets Curve (EKC) hypothesis is supported in Turkey. In addition, the pollution halo hypothesis, meaning that FDI has positive effects on environment was found valid for Turkey in the short and long run since there is bilateral causality relationship between CO_2 emission and FDI inflows, and also negative coefficients of FDI. The Granger causality test showed that there is a unilateral causality relation from energy consumption to economic growth in Turkey.

Aye and Edoja (2017**)** used the dynamic panel threshold framework to examine the effect of economic growth on CO_2 emission based on data from a panel of 31 developing countries The results showed that economic growth has negative effect on CO_2 emission in the low growth regime but positive effect in the high growth regime with the marginal effect being higher in the high growth regime. The finding did not support the Environmental Kuznets Curve (EKC) hypothesis; rather a U-shaped relationship is established. Energy consumption and population were also found to exert positive and significant effect on CO_2 emission whereas financial development indicator in the model did not change the conclusion about EKC hypothesis. The study found evidence of noteworthy causal relationship between CO_2 emission, economic growth, energy consumption and financial development employing panel causality methods. The findings stressed

the need for alteration of low carbon technologies aimed at reducing emissions and sustainable economic growth.

Lu (2017) investigated the co-movement and causality relationships between greenhouse gas emissions, energy consumption and economic growth for 16 Asian countries over the period 1990–2012. Bidirectional Granger causality was found between energy consumption, GDP and greenhouse gas emissions and between GDP, greenhouse gas emissions and energy consumption in the long run. The results showed a non-linear, quadratic relationship proving the existence of the environmental Kuznets curve for these 16 Asian countries and a subsample of the Asian new industrial economy. Short-run relationships are dependent on the regions across the Asian continent. From the viewpoint of energy policy in Asia, various governments support low-carbon or renewable energy use and are reducing fossil fuel combustion to sustain economic growth, but in some countries, evidence suggested that energy conservation might only be marginal.

Hasson and Masih (2017) investigated the interplay between economic growth, energy consumption, electricity consumption, carbon emission and trade by employing recent South African trade and energy data during the period from 1971 to 2013. The ARDL bounds testing approach to cointegration has been used to test the long run relationship among the variables, while short run dynamics has been investigated by applying error correction method (ECM). The authors found a positive relationship between energy consumption and economic growth but electricity prices have a negative impact on economic growth. The results further evidenced that trade openness and electricity consumption are leading variables, while the rest are lagging. Furthermore empirical results were found to be consistent with the existence of environmental Kuznets curve.

Makarabbi et al. (2017) made an attempt to evaluate the existence of EKC in Indian context. The time series data from 1978 to 2015 has been used. The following variables are applied CO_2 emission per capita, real GDP per capita, energy consumption per capita and FDI. Data has been collected from World Bank Development Indicators and World Energy Statistics database. ARDL Bound test and Granger causality test were applied to test cointegration or long run

relationship between variables. In order to validate the existence of EKC hypothesis, OLS (Ordinary Least Square) regression was used. The results indicated the existence of long run relationship between CO emission per capita, GDP per capita, FDI inflows and energy consumption per capita. VECM granger causality results highlighted the bi-directional causality between CO emission per capita and FDI, CO emission per capita and energy consumption. But, found unidirectional granger causality running from GDP per capita to CO emission per capita. With the regression results it is concluded that inverted U-shaped curve does not exist between GDP per capita and CO emission per capita in India's context.

Solarin et al. (2017) made an attempt to study the link between CO_2 emissions, hydroelectricity consumption, urbanisation and real GDP in China and India during the period between 1965 and 2013. The autoregressive distributed lag (ARDL) used to investigate to long term cointegration bounds testing approach, which is augmented with structural breaks. Study used the ARDL cointegration test to establish long run relationship in the variables and showed that real GDP and urbanisation have long-run positive impact on emission, while hydroelectricity consumption exerts long-run negative impact on emission in both countries. The results indicated the existence of environmental Kuznets curve (EKC) hypothesis in China and India. In addition to this the paper also assesses the causal link between the variables by using Granger causality procedures and the results show that there is long-run bidirectional relationship between the variables in both countries

Sterpu et al. (2018) analysed the relationship between per capita greenhouse gas (GHG) emissions, gross domestic product, gross inland energy consumption, and renewable energy consumption for a panel of 28 countries of European Union in the period 1990–2016. Two theoretical models, a quadratic and a cubic one, were used to estimate the shape of the environmental curve and to test the Kuznets hypothesis. The panel cointegration approach proved the existence of long-run equilibrium relations among the four macroeconomic indicators. Empirical estimations, using panel data techniques, as well as heterogeneous regression for each individual country in the panel, showed non-conclusive evidence for the environmental Kuznets curve (EKC) hypothesis. The

least square estimates, with the variables in log per capita form, revealed that the inverted U-shaped EKC hypothesis is verified for the panel and for 17 of the 28 EU countries. Estimates of the cubic model showed that the environmental curve has an inverted N-shaped form. These results do not hold when the values are in non-logarithmic form. In addition, the estimations for all models show that an increase of gross energy consumption leads to an increase of GHGs, while an increase of renewable energy consumption leads to a reduction in GHG emissions.

Darwanto et al. (2019) in their paper on “The Damaging Growth: An Empiric Evidence of Environmental Kuznets Curve in Indonesia” examined the short-run and long-run relationships between economic growth, carbon dioxide (CO_2) emissions and energy consumption within a sample period of 1990-2016 using autoregressive distributed lag approach to test the cointegration relationship and Granger vector error correction model causality test to investigate the direction of causality. This study did not support the hypothetical relationship (environmental Kuznets curve) for a significance level of 5 percent but the long-run test of Granger causality showed a two-way causal relationship of economic growth, CO_2 emissions, and energy consumption. The authors concluded that a reduction in energy consumption is an effective way to control CO_2 emissions but will simultaneously impede economic growth.

Kong and Khan (2019) analyzed the core energy consumption among countries’ specific variables by Environmental Kuznets Curve hypothesis (EKC), for a panel data of 29 (14 developed and 15 developing) countries during the period of 1977–2014. By assessing Generalized Method of Moments (GMM) regressions with first generation tests such as common root, individual Augmented Dickey-Fuller (ADF), and individual root-Fisher-PP, the results confirm the EKC hypothesis in the case of emissions of solid, liquid, gases, manufacturing industries and also construction. Hence, they computed the cointegration test by Pedroni Kao. Since the variables are co-integrated, a panel vector error correction model is estimated in GDP per capita emission from manufacturing industries, arms import, commercial service export, and coal rent, in order to perform Pairwise Granger Causality test and indicate Vector Error Correction (VEC), with cointegration restrictions. Moreover, the statistical finding confirmed the VEC

short-run unidirectional causality from GDP per capita growth to manufacturing industries and coal rent, as well as the causal link with manufacturing industries and commercial service export. Additionally, there occurred no causal link among economic growth, arm import and coal rent.

Osiobe (2019) aimed to establish a long-run and the Granger causal relationship between economic growth, CO_2emissions, international trade, energy consumption, and population density in Malaysia. The study used the annual data covering from 1970 to 2014 and used the Auto-Regressive Distributed Lag ($ARDL$) model to examine the Environmental Kuznets Curve. The empirical results of the analysis indicated that a long-run relationship between per capita CO_2emissions and the explanatory variables existed. The findings of this study reveals that several factors, such as changes in energy composition, level of international trade, population density, output, introduction of cleaner production technology, environmental policies and environmental awareness play a significant role in making the decoupling between economic growth and environmental degradation.

Ssali et al. (2019) explored the nexus among environmental contamination, economic growth, energy use, and foreign direct investment in 6 selected sub-Saharan African nations for a time of 34 years (1980–2014). Panel unit root (CADF and CIPS, cross-sectional independence test), panel cointegration (Pedroni and Kao cointegration test, panel PP, panel ADF), Hausman poolability test, and an auto-regressive distributed lag procedure in view of the pooled mean group estimation (ARDL/PMG) were applied. The variables were altogether integrated at the same order I(1). Findings revealed that there is a confirmation of a bidirectional causality between energy use and CO_2 in the short-run and one-way causality running from energy use to CO_2 in the long run and also additionally a significant positive outcome and unidirectional causality from CO_2 to foreign direct investment in the long run yet no causal relationship in the short run. An increase in energy use by 1 percent caused an increase in CO_2 by 49 percent. An increase in economic growth by 1 percent caused an increment in CO_2 by 16 percent and an increase in economic growth squared by 1 percent diminished CO_2 by 46 percent. The positive and negative impacts of economic growth and its square approve the EKC theory.

Deekor et al. (2020) employed the Autoregressive Distributed Lag (ARDL) method which allows for the combination of variables with mixed order of integration in a single regression model to test the hypothesis that energy consumption matters in the carbon dioxide effect of economic growth. Using Nigerian dataset, the findings of the study suggested that there is probable cointegrating relationship among the variables of interest. However, the estimation results refute the Environmental Kuznets Curve (EKC) in the context of the Nigerian economy. Essentially, the study found the relationship between carbon dioxide (CO_2) emissions and gross domestic product (GDP) per capita to be monotonically increasing and the response of CO_2 emission to energy consumption to vary for different energy-mix.

Manta et al. (2020) estimated the nexus between CO_2 (carbon dioxide) emissions, energy use, economic growth, and financial development for ten Central and Eastern European countries (CEEC) over the 2000–2017 period, starting from Environmental Kuznets Curve (EKC) theory. The study used the Fully Modified Ordinary Least Squares (FMOLS) method for testing the cointegration relationship and Granger causality estimation based on the Vector Error Correction Model (VECM) and Pair wise Granger causality test to identify the causality relationships between the variables and to identify the direction of causality. The study found that in the long run, the levels of CO_2 emissions and energy use did not have any influence on economic growth and there is bidirectional causality among economic growth in terms of GDP and financial development variables. The study concluded that increasing financial development will generate more CO_2 emissions and more energy use, and increasing economic growth will lead to rising financial development and also, bidirectional causality was revealed between financial development and CO_2 emissions which indicated that financial development may help to reduce CO_2 emissions.

Trade openness is a significant contributor to carbon emissions. Several authors have studied the specific relationship between trade openness and carbon emissions

Hao and Liu (2014) in their paper on “Has the development of FDI and foreign trade contributed to China’s CO_2 emissions? An empirical study with provincial panel data” investigated the relationship between FDI, foreign trade and Carbon Dioxide emissions in China using a two-equation model adapted from Halkos and Paizanos (2013). The results suggested that the increase in per capita FDI helps to restrain the growth of China's per capita CO_2 emissions. The authors observed that the dominating direct effect of FDI on carbon emissions was negative and the indirect effect was positive but for foreign trade, both direct and indirect effects on CO_2 emissions were insignificant.

Dellink et al. (2015) offered an analysis of how climate change damages may affect international trade in the coming decades and how international trade can help reduce the costs of climate change. It also analyses the impacts of climate change on trade considering both direct effects on infrastructure and transport routes and the indirect economic impacts resulting from changes in endowments and production. A qualitative analysis with a thorough literature review is used to present the direct effects of climate change. The study highlights the important regional differences in the effects that climate change will have on regional and sectoral economic activities and on competitiveness. The study suggests that by being aware of how climate impacts may affect its economy through trade, countries can design climate and trade policies that are aligned and thus avoid the worst climate damages at least cost.

Fernandez et al. (2016) made an attempt to analyse the evolution of emissions, the development of carbon efficiency of the global economy, and the role of international trade. Authors tried to present a new dataset of geographical production, final production, and consumption-based carbon dioxide emission inventories, spanning 78 regions and 55 sectors between 1997 and 2011.They primarily used the Global Trade Analysis Project database which had relevant energy volume, trade, and input–output data. The authors opined that carbon emissions increased substantially during 1997–2011, driven by the evolution of the global economy. The developing countries have added importance as global providers of goods and services and will also become more relevant as global consumers as they grow, putting extra pressure on the relationship between human activities and the environment.

Bernard and Mandal (2016) examined the impact of trade openness on environmental quality using a dynamic panel data model for 60 emerging and developing economies. The study attempted to examine the trade-environment relationship for the period 2002 to 2012, employing Environmental Performance Index (EPI) and CO_2 emissions as the two indicators of environmental quality. The paper tried to fill in the lack of dynamic panel data models investigating trade-environment relationship in emerging economies. The fixed effects model elicited that trade openness improves EPI, albeit it increases CO_2 emissions. When corrected for endogeneity, trade openness was found to have no significant impact on EPI, though it escalated CO_2 emissions. GMM findings with EPI highlighted that political factors improve environmental quality, whereas income and population have detrimental effects. In the GMM estimations with CO_2emissions, trade openness, income, energy consumption and population were found to have deleterious effects on environmental quality. The empirical findings imparted support to the contentions over the impact of trade on environmental quality.

Shahbaz (2016) explored the relationship between trade openness and CO_2 emissions by incorporating economic growth as an additional and potential determinant of this relationship for three groups of 105 high, middle and low income countries. The study applied the Pedroni (1999) and Westerlund (2007) panel cointegration tests and found that the three variables are cointegrated in the long run and observed that trade openness impeded environmental quality for the global, high income, middle and low income panels but the impact varied in these diverse groups of countries. The panel VECM causality results highlighted a feedback effect between trade openness and CO_2 emissions. Trade openness Granger caused CO_2 emissions for the high income and low income countries.

Shapiro (2016) quantified how international trade affects CO_2 emissions and analyzes the welfare consequences of regulating the CO_2 emissions from shipping. The paper described a model of trade and the environment, compiled new data on the CO_2 emissions from shipping, and estimated key parameters using panel data regressions. Results of the study showed that the benefits of international trade exceed environmental costs due to CO_2 emissions by two orders of magnitude. While proposed regional carbon taxes on the CO_2 emissions

from shipping would increase global welfare and increase the implementing regions GDP, they would also harm poor countries.

Vale et al (2017) investigated the mechanics of international trade and CO_2 emissions in two blocs of countries ('North' and 'South') by analyzing data from the World Input–Output Database. The study adapted the Miyazawa technique to estimate the linkages between international trade and the environment at a global scale. The results suggest that both the North and the South have become less pollution-intensive (technique effect) over the years. Interestingly and in contrast to much of the literature, the study also found support to the hypothesis that the South has specialized in relatively more pollution-intensive activities (composition effect).

Hasanov et al. (2018) investigated the role of the trade in CO_2 emissions using a panel of nine oil exporting countries. The results from cointegration and error correction modeling showed that exports and imports have statistically significant impacts of opposite signs on consumption-based CO_2 emissions in both the long- and short-run and that the effects of changes in the trade-CO_2 emissions relationship will fully be absorbed around three years. However, the study found that the exports and imports are statistically insignificant for territory-based CO_2 emissions.

Pie et al. (2018) evaluated the influence of imports and exports of goods and services on greenhouse gas (GHG) emissions in a data panel composed of 30 countries over 21 years. The study included as control variables the gross domestic product per capita, employment, an indicator of the economic crisis, and a non-linear trend and inferences were performed using a Bayesian framework. The results showed that it was the exports and imports of goods, rather than services that were related to CO_2equivalent levels. The study found that more a country imports, the higher their GHG emission levels are and also that when employment rates are higher more energy is consumed and GHG emissions are greater. In richer countries, GDP per capita is the factor that best explains why their emissions are so high.

Huang et al. (2019) in this paper discussed about the environmental impacts of foreign direct investment (FDI) and foreign trade using panel quantile

regression to explore the effects of FDI and foreign trade on Chinese provincial CO2 emissions between 1997 and 2014. The results indicated that the effect of FDI on CO_2 emissions is negative and significant except at the $5^{th}$and 10^{th} quantiles. Foreign trade has a significant negative effect on CO_2 emissions at upper quantiles, and the degree of the effect increases gradually with the increase of CO_2 emissions. The results also indicated that the inverted U-shaped environmental Kuznets curve (EKC) is valid only in the least and most polluted provinces. The paper suggests that the total effects are positive. Authors have recommended, several policy implications for China based on the empirical results obtained.

Jun et al. (2020) attempted to find the impact of trade openness on pollution in China by applying wavelet-coherence analysis, phase-difference technique and Breitung and Candelon (2006) causality test. The results indicated that trade openness has increased pollution in China especially after 2001 when China became member of WTO. It also suggested that “pollution haven hypothesis” exists in China. The authors argue that the trade openness has increased exports which have increased domestic production by increasing the scale of industries, which in turn has increased pollution in the country. The findings also show that trade openness causes carbon emission both in short, medium and long runs. The results suggested that China should take suitable measures while following trade openness policy to avoid pollution.

The factors determining trade openness and its determinants are discussed in the following studies:

Richards and Guttmann (2006) aimed to understand Australia’s low openness by analysing the empirical determinants of aggregate country trade and estimated a standard gravity model of bilateral trade. The authors found that countries with larger populations trade less, as do countries that are relatively more remote. After controlling for trade policy there was little evidence of a positive correlation between openness and economic development. Thus the authors found that population and economic location to potential trade partners as the most crucial determinants of trade openness.

Jafari et al. (2011) in a study on the determinants of trade flows among D8 countries observes crucial factors that affect the volume of export flows among member countries. The results from a gravity model estimated using Panel Correlated Standard Errors (PCSE), demonstrate that the trading partners' gross domestic product (GDP), exchange rate, population of exporter country, border and distance are the notable factors affecting the volume of export flow among the countries in the D8 group. The authors suggested that the countries would do better if they focus on exporting more to their neighbouring countries which can reduce the cost of transportation.

Mbogela (2015) conducted an empirical examination of the factors of trade openness in Africa and the determinants of bilateral trade flows between Africa and the BRIC and OECD member countries. The study also examined the impacts of trade openness on the economic growth in Africa. The study also made an attempt to empirically examine and provide explanations on the relatively lower trade levels that these countries have been experiencing ever since their political independence. The panel data analysis methods has been used to capture the relationships between the variables of interest over a prolonged time period and extricate the time invariant country specific effects that are very relevant particularly in examining bilateral trade flows. The author has used Hausman test for selection of models and econometric estimations of the coefficients for the regressions were made through the application of either random effects or fixed effects models. The research study results indicate that trade openness and diversification of trade are vital for enhancing African economic growth.

Sare et al. (2018) examined the determinants of international trade measured by openness and exports in Africa relying on data for 46 countries over the period 1980–2015. Results from their system generalized method of moments suggest that financial development proxied by private credit does not promote openness, while domestic credit positively affects international market integration. Further evidence shows a U-shaped relationship between private credit and trade. While inflation and gross fixed capital formation robustly improve openness, savings, population and real GDP per capita are far from being robust determinants.

Tahir et al. (2018) made an attempt to find the significance of trade openness in the growth process of countries and also examined the impact of macroeconomic determinants on the trade openness of countries. By keeping South Asian Association for Regional Cooperation (SAARC) member countries in focus, the data between 1971 and 2011 has been analysed using panel data econometrics and two stages least square method (TSLS). The results highlight that the macroeconomic determinants such as investment both in physical and human capital and per capita gross domestic product (GDP) positively impact trade openness. Further, the size of labour force and currency exchange rate has also impacted trade openness negatively and significantly. It suggests the developing countries to pay favourable attention to macroeconomic variables if they want to grow in the long run through outward-oriented policies.

Osei et al. (2019) made an attempt to re-evaluate the drivers of trade openness in Africa depending on panel data with special focus on the role of economic growth. They performed a comparative analysis of the factors affecting trade openness for low-income and lower– middle-income countries using the system generalized method of moments. The results indicated that, while economic growth enhances openness in low-income countries, in the case of lower–middle-income countries, the impact is not robust and largely negative suggesting that higher growth is associated with less openness.

Mallick and Behera (2020) The authors made an attempt to investigate the long-run equilibrium relationship between economic growth and trade openness in India between 1960 and 2018. Asymmetric error-correction model with threshold cointegration has been used to evaluate the impact of trade openness on economic growth under different regimes such as the pre-trade reforms period 1960–1990, and post-trade reforms period 1991–2018. The results showcase the evidence of asymmetric cointegration between economic growth and trade openness in India during the period under evaluation. The estimated asymmetric error-correction model exhibits a different speed of adjustment in trade openness. It is also indicated that during the pre-reforms period, deviations from the long-run equilibrium due to a relative increase in economic growth have a lower speed of adjustment in comparison to deviations caused by a corresponding dip in economic growth in India.

2.3 Other related Studies

Tapio (2005) made an attempt to provide a theoretical framework for decoupling, highlighting the difference between decoupling, coupling and negative decoupling. The author also tried finding the weak, strong and expansive/recessive degrees of decoupling, laying emphasis on the absolute increase or decrease of the variables. The study focused in EU region and the case of road traffic in Finland between 1970 and 2001. They identified the relationships of GDP, traffic volumes and CO2 emissions in the EU15 countries, including of Finland road traffic. Four hypothetical suggestions of the Finnish phenomenon were shared in this article: policy towards sustainable mobility, green urban lifestyle, increasing income differences, and statistical misinterpretation.

Parikh et al. (2007) evaluated the consequences of various carbon emission mitigation measures on economic development and analysed the implications for the poor by empirically implementing an economy-wide model for India over a 35-year time period. The methodology used was a multi-sectoral, inter-temporal model in the activity analysis framework. The results indicated that carbon dioxide (CO_2) emission reduction imposes costs in terms of lower gross domestic product (GDP) and higher poverty. In fact, the effects of environmental constraints are found to be virtually equivalent to a major oil shock, lending credence to the belief that constraining carbon emissions of developing countries without providing adequate compensation imposes large costs on these economies and denies them access to legitimate avenues of development. Article concludes stating there is no reason for India to agree to any binding emission constraints and the focus must be firmly on achieving domestic economic and social goals viz. poverty eradication, a problem that, as the model points out, does persist to the end of the time period considered.

Halicioglu (2008) attempted to examine empirically dynamic causal relationships between carbon emissions, energy consumption, income, and foreign trade in the case of Turkey using the time series data for the period 1960-2005. This research tested the interrelationship between the variables using the bounds testing to cointegration procedure. The bounds test results indicated the

existence of two forms of long-run relationships between the variables. In the case of first form of long relationship, carbon emissions are determined by energy consumption, income and foreign trade. In the case of second long-run relationship, income is determined by carbon emissions, energy consumption and foreign trade. An augmented form of Granger causality analysis was conducted amongst the variables. The long-run relationship of CO2 emissions, energy consumption, income and foreign trade equation was also checked for the parameter stability. The empirical results suggested that income is the most significant variable in explaining the carbon emissions in Turkey which is followed by energy consumption and foreign trade.

Everett et al. (2010) attempted to draw an analysis of their experience across the world as an environmental policy department addressing the complementarities and trade-offs between economic growth and protecting the environment. They claim that economic and environmental performance must go hand in hand. The natural environment is central to economic activity and growth, providing the resources we need to produce goods and services, and absorbing and processing unwanted by-products in the form of pollution and waste. The paper highlights that the UK and the global economy faces significant environmental challenges, from averting dangerous climate change to halting biodiversity loss and protecting our ecosystems. There has been debate over whether it is possible to achieve economic growth whilst also tackling these challenges. This paper does not try to answer the question of what the sustainable level of economic growth might be, but instead evaluates the link between economic growth and the environment, and the role of environmental policy in managing the provision and use of natural assets. The paper concludes with a suggestion of having a consistent, coherent and effective environmental policy framework to maintain a natural environment and long-term economic growth and development.

Hossain (2012) examined the dynamic causal relationship between carbon dioxide emissions, energy consumption, economic growth, foreign trade and urbanization using time series data for the period of 1960-2009. Short-run unidirectional causalities are found from energy consumption and trade openness to carbon dioxide emissions, from trade openness to energy consumption, from

carbon dioxide emissions to economic growth, and from economic growth to trade openness. The test results also supported the evidence of existence of long-run relationship among the variables which also confirmed the results of bounds and Johansen cointegration tests. The study also found that over time higher energy consumption in Japan gives rise to more carbon dioxide emissions as a result the environment will be polluted more. But in respect of economic growth, trade openness and urbanization the environmental quality was found to be normal good in the long-run

Kohler (2013) employed trade and energy data and modern econometric techniques to investigate the relationship between CO_2 emissions, energy consumption, income and foreign trade in South Africa and found the existence of a long run relationship between environmental quality, levels of per capita energy use and foreign trade in SA. The study revealed that per capita energy use has a significant long run effect in raising the country's CO_2 emission levels and higher levels of trade acted to reduce these emissions. Granger causality tests confirmed the existence of a positive bidirectional relationship between per capita energy use and CO_2 emissions, between trade and income per capita and between trade and per capita energy use. It appeared for the authors that SA trade liberalisation has not contributed to a long run growth in neither pollution-intensive activities nor higher emission levels.

Kulionis(2013) tested the causal relationship between renewable energy consumption, gross domestic product (GDP) and carbon dioxide (CO_2) emissions in Denmark using multivariate framework for the annual data from 1972-2012. The causal relationship between variables was examined using Granger causality test in VAR framework. Results of unit root tests showed that all variables are non-stationary in their level form and stationary in first difference form. Cointegration analysis following Johansen (1992) approach showed that there is no evidence of cointegration among the test variables. The empirical results from Granger causality Toda-Yomamoto test and Granger causality test using first differences strongly supported a unidirectional causality coming from renewable energy consumption to CO_2 emissions. The results of this study also indicated that there is no statistically significant causality between the economic growth and renewable energy consumption, which supports the neutrality hypothesis and

implies that energy conservation policies do not have a significant impact on economic growth. The empirical results also revealed that there is no causality between economic growth and CO_2 emissions. This may be due to the fact that Denmark has one of the lowest energy intensities in the world, which allows achieving one unit of GDP with a minimum input of energy and minimum CO_2 emissions

Sbia et al. (2014) in their paper “A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE” investigated the relationship between foreign direct investment, clean energy, trade openness, carbon emissions and economic growth in case of UAE covering the period of 1975Q1-2011Q4. They tested the unit properties of variables in the presence of structural breaks and applied the ARDL bounds testing approach to examine the cointegration by accommodating structural breaks stemming in the series. The VECM Granger causality approach was also applied to investigate the causal relationship between the variables. Their empirical findings confirmed the existence of cointegration between the series and also found that foreign direct investment, trade openness and carbon emissions decline energy demand. Economic growth and clean energy has positive impact on energy consumption.

Kasperowicz (2015) probed the relationship between CO_2 emissions and economic growth for 18 EU Member Countries from 1995 to 2012 employing Panel data approach. Using basic ECM estimation the study established that the long-run relationship between GDP and CO_2 emissions is negative. The reason is the development of novel low-carbon technologies which helps in attaining the same production level at lower CO_2 emissions in the long run. The short-run relationship between GDP and CO_2 emissions is positive as in the race to development there would be a faster increase in production which can be reached due to more exhaustive energy use by the existing technologies and as a result the capacity increases as well CO_2 emissions.

Lin et al. (2015) analysed the occurrence of decoupling of CO_2 emissions from gross domestic product (GDP) in South Africa (SA) for the period of 1990 to 2012 by using the Organization for Economic Cooperation and Development

(OECD) and Tapio methods, and found the primary CO_2 emissions causing forces by the Kaya identity. A strong decoupling during the period of 2010–2012 was seen which is said to be the best development situation. In 1994–2010 SA had a weak decoupling while during the period 1990–1994, the development in SA showed an expansive negative decoupling state. The results of Kaya identity showed that the increase in population, GDP per capita and deteriorating energy efficiency were the chief driving forces for the increase of CO_2 emissions. The author suggested that SA can increase the share of renewable energy and encourage green energy technology as well as better strategies of the demand side management (DSM) to raise the competence of energy consumption as well as CO_2 emission reductions.

Maji (2015) tried evaluating the impact of clean energy on economic growth in Nigeria. Cointegration was determined among the variables using Autoregressive distributed lag (ARDL) approach. The study results indicated a significant negative relationship between two indicators of clean energy (alternative and nuclear energy and electric power consumption) and economic growth. The result further highlights a significant positive relationship between combustible renewable waste and economic growth and concluded that Nigeria has potentials of clean energy to be reaped in near future. The author also argues that Nigeria economy has not fully developed its renewable energy sources. There is also the absence of separate legal and institutional framework for clean energy in the country.

Palamalai et al. (2015) in their study on “Relationship between energy consumption, CO_2 emissions, economic growth and trade in India” examined the causal nexus between various sources of energy consumption, viz. coal, crude oil, electricity and natural gas, CO_2 emissions, economic growth and trade in India using the Perron unit root test, Gregory and Hansen cointegration test and Vector Error Correction Model. The study exhibited a long-run relationship between various sources of energy consumption, economic growth, CO_2 emissions and trade in India. The findings revealed that increase in CO_2 emissions leads to achieve high level of economic activity in India and also found that foreign trade influences the various sources of non-renewable energy consumption in the long-

term. But energy consumption did not significantly contribute towards promoting foreign trade, except crude petroleum, in the short-run.

Zakarya et al. (2015) in their paper on “Factors affecting CO_2 Emissions in the BRIC Countries: A Panel Data Analysis “ analyzed the interactions that may exist between the total energy consumption, FDI, economic growth, and the emission of CO_2in the BRICS countries, using the cointegration tests and panel Granger causality. The results showed significantly that there is a cointegration relationship between CO_2 emissions and economic variables. The results also indicated the existence of a unidirectional causality from CO_2 to the independent variables.

Sadeghieh (2016) aimed to investigate the causal connection between financial development and ecological degradation in Turkey through a multivariate framework that uses economic growth and fuel consumption as additional determinants of environmental degradation from 1960–2011. The study used Zivot and Andrews (1992) unit root test to check the integration order of data. Because variables were integrated at the same order (I[1]), cointegration analysis was applied in order to check the possible long-run equilibrium relationship between variables. Then, the Johansen cointegration test revealed that the variables under investigation are co-integrated in the long run. After establishing the long-run relationship between variables, error correction modeling was applied to identify the long-run and short-run coefficients of the variables. The findings showed that in the long-run, economic growth has negative and significant effect on carbon emissions while fuel consumption has positive and elastic impact on carbon emissions. Granger causality test based on ECM was conducted to reveal the existence and direction of the causality among variables. The results show that there is uni-directional causality running from financial development and economic growth to carbon emissions and fuel consumption, and from carbon emissions to fuel consumption.

Sikdar and Mukhopadhyay(2016) developed an econometric model to clarify the causal relationship between carbon dioxide (CO_2) emission and population, given the structure of population, structure of industries and economic growth in India. Based on this modeling exercise, the paper predicted the energy

consumption and generation of CO_2 emission in 2050. The study anticipated that the total CO_2 emission in India will be 3.5 million metric tons in 2050.

Yeh and Liao (2016) employed an analytic tool of Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) to see how well population and economic growth can describe their individual possible impact on global warming in Taiwan. The study proposed seven scenarios of STIRPAT model and tested statistically for the implication of each proposed model using the past national data in the period 1990 to 2014. The result suggested two models to foresee the effect of carbon emission due to population and economic growth by the year 2025 in Taiwan. Positive logarithmic polynomial coefficients with respect to population show an up-pulling force to carbon emission, as Taiwan's total population continues to increase. Contrarily, the coefficients for per capita GDP in logarithmic form are negative indicating that economic forces will lower the carbon emissions in 2025 bringing an inverted U-shape.

Obradović and Lojanica (2017) examined the causal relations between energy use, CO_2 emissions and economic growth, using the examples of Greece and Bulgaria. The study used Vector Error Correction model with annual data from 1980 to 2010 in order to determine potential causality between the variables. The empirical findings indicated that, in the long run there is causality from energy and CO_2 emissions to economic growth in both countries. In the short run, there is no causality between energy and economic growth neither on Greece nor on Bulgaria. Based on the results of the analysis certain recommendations can be presented considering energy policy in the long run, though the orientation to saving energy could have negative impact on economic growth.

Wang et al. (2017) investigated the non-linear relationship between provincial economic growth and carbon emissions by using panel smooth transition regression (PSTR) models. The research indicated that, on the condition of separately taking gross domestic product per capita (GDP pc), energy structure (Es), and urbanisation level (Ul) as transition variables, three models all reject the null hypothesis of a linear relationship, i.e., a non-linear relationship exists. The three models applied in the study all favourably describe the non-linear relationship between economic growth and CO_2 emissions in China. The study

also showed that the conversion rate of the influence of UI on per capitaCO_2emissions is significantly higher than those of GDP pc and Es on per capita CO_2 emissions.

Cetin et al. (2018) discussed the impact of economic growth, energy consumption, trade openness, and financial development in Turkey. Annual time series data has been used for the period of 1960 to 2013 and conducted the Lee and Strazicich test which suggested that the variables are suitable for applying the bounds testing approach to cointegration. Through a cointegration analysis they found that there is a long-run relationship between the per capita real income, per capita energy consumption, trade openness, financial development, and per capita carbon emissions in the presence of structural breaks. The results indicated that in the long run, carbon emissions are mainly determined by economic growth, energy consumption, trade openness, and financial development. The VECM Granger causality analysis indicates a long-run unidirectional causality running from economic growth, energy consumption, trade openness, and financial development to carbon emissions.

Fan and Hossain (2018) examined and compared the long and short-run relationships between technological innovation, trade openness, CO_2 emission and economic growth of China and India over the period of 1974-2016 by utilizing the ARDL Bounds Test methodology and Toda-Yamamoto Granger Causality test. The obtained results revealed that technological innovation, trade openness and CO_2 emission have a significant positive impact on Economic growth in the long-run but mixed effect in the short-run in China. For India, On the other hand, trade openness and CO_2 emission have a significant positive impact in the long-run but CO_2 emission has a negative impact in the short-run on economic growth. Technological innovation is not significant in the long-run and both technological innovation and trade openness are not significant on economic growth for India in the short-run. The Toda-Yamamoto Granger causality test reveals that bi-directional causality is running between Economic growth and trade openness, between technological innovation and CO_2 emissions as well as a unidirectional causality is running from technological innovation and CO_2 emissions to trade openness for China. On the other hand, our obtained results express that there is a unidirectional causality running from economic growth, technological innovation

and trade openness to CO_2 emissions as well as from technological innovation to trade openness for India. The results obtained from this empirical analysis have an important policy implication for China and India.

Kazakopoulos (2018) conducted a study on the relationship between Carbon dioxide emissions and economic growth in Greece and Bulgaria for the period 1980 to 2010. In this study, an attempt was made to reveal the issues of environmental degradation among the countries worldwide. By comparing carbon emissions based on both territorial-based production and on final consumption, it was suggested that emissions are concentrated mainly in few developed countries, where consumption-based emissions are larger than production based. The global CO_2 emissions, the energy mix and the effects of renewable are also analysed. Fossil fuels combustion contributes approximately 90 percent of the total global CO_2 emissions. Renewable resources have increased significantly and supply as much as 16.7 percent of the global final energy consumption. Further regulations are needed though, to avoid the possible merge of pollution levels, according to the N-shaped curve. The energy sector is a key factor towards influencing emission levels.

McGee and Greiner (2018) made an attempt to uncover the socioeconomic drivers of CO_2 emissions by evaluating how the distribution of income impacts the relationship between economic growth and CO_2 emissions in 35 most developed nations. The authors found that from 1985 to 2011, increase in income inequality led to a tighter coupling between economic growth and CO_2 emissions in developed nations. Also the authors found that increases in the top 20 percent of income earners' share of national income have resulted in a larger association between economic growth and CO_2 emissions, while increases in the bottom 20 percent of income earners' share of national income reduced the association between economic growth and CO_2 emissions. Author's finding recommends that income inequality in developed countries with small economies may help reduce CO_2 emissions.

Saqib (2018) examined the relationship between greenhouse gas (GHG) emissions, energy consumption and economic growth with panel data of the six gulf cooperation council (GCC) countries - Saudi Arabia, Kuwait, United Arab

Emirates, Qatar, Bahrain, and Oman over the period 1996–2017. The empirical results showed the existence of bidirectional causal relationship between energy consumption and economic growth. The results supported the occurrence of unidirectional causality from energy consumption to GHG emissions without any feedback effects, and the existence of bidirectional causal relationship between economic growth and GHG emissions for the region as a whole. The study suggested that environmental and energy policies should recognize the differences in the relationship between energy consumption and economic growth in order to maintain sustainable economic growth in GCC region.

Akadiri et al. (2019) discussed about carbon emissions, energy consumption and economic growth. They opined that there has been a growing interest on environmental issues, due to climatic-based problems associated with escalated levels of pollution and degradation of the environmental quality. The authors examined the causal and long-run relationship between carbon emissions, energy consumption and economic growth for Iraq. They used bounds test for cointegration and Toda-Yamamoto for a Granger causality test using annual data for the period between 1972 and 2013. Findings reveal that there are no feedback relationships between economic growth, carbon emissions and energy consumption of Iraq.

Caporale et al. (2019) examined the relationship between the logarithms of CO2 emissions and real GDP in China by applying fractional integration and cointegration methods. The univariate results indicated that the two series are highly persistent, whilst the cointegration tests (using both standard and fractional techniques) implied that there exists a long-run equilibrium relationship between the two variables in first differences, i.e. their growth rates are linked together in the long run. This suggests the need for environmental policies aimed at reducing emissions during periods of economic growth.

Jian et al. (2019) examined the effects of economic growth, financial development and energy consumption on carbon dioxide emission (CO_2) in China from 1982 to 2017. The study applied Johansen cointegration test and vector error correction model (VECM) to investigate the long-term equilibrium and short-term causality relationship among the four variables. The causality was also checked

by using the innovative accounting approach (IAA). The empirical results showed the long-term cointegration relationship between them. Evidence showed a unidirectional Granger causality running from energy consumption to financial development. Financial development and energy consumption had a statistically significant positive impact on CO2 emissions.

Liu et al. (2019) decomposed the factors that affect the CO_2 emissions of China's manufacturing industry into eight effects. Authors have used the extended LMDI decomposition model to investigate the factors that affected China's manufacturing CO_2 emissions from 1995 to 2015.The results of the study confirms that China's manufacturing CO_2 emissions increased from 1.91 billion tons in 1995 to 6.25 billion tons in 2015, and during the research period, the industrial activity effects were the most important factor leading to increased CO_2 emissions in manufacturing, and energy intensity was the most important factor in promoting the reduction of CO_2 emissions from manufacturing. It is also found that there were differences in the driving factors of CO_2 emissions in the manufacturing industry in different periods that were closely related to the international and domestic economic development environment and the relevant policies of the Chinese government regarding energy conservation and emission reduction.

Liu et al.(2019)employed multispatial convergent cross mapping (CCM) to revisit the energy-carbon-economy causation for China, India and the G7 countries using both aggregate data and per capita data based on nonlinear dynamics. The findings indicated that there are significant differences between developing countries and developed countries. A bidirectional nexus between energy consumption, carbon emissions and economic growth was found in China and India, but various causal relationships are identified in the G7 countries, including bidirectional, unidirectional and neutral nexus. The results confirmed that the decoupling phenomenon is common in most G7 countries.

Maji et al. (2019) estimated the impact of renewable energy on economic growth in West African countries using panel dynamic ordinary least squares (DOLS) by employing a sample of 15 West African countries covering the 1995-2014 period. The results of the study indicated that renewable energy consumption slows down economic growth in these countries mainly due to the nature and source of renewable energy used in West Africa, which is majorly

wood biomass. The study observed that the use of clean energy sources like solar, wind and hydropower which does not have a side effect on human health and the environment is less in West Africa. The study recommended that (1) cleaner technologies should be employed to optimize the benefits of wood biomass as a renewable source of energy while minimizing its adverse effects; (2) the share of other renewable energy components such as solar, wind and geothermal should be increased in the renewable energy mix of the sub-region of West Africa and (3) greater commitment to achieving sustainable renewable energy by West African authorities is needed.

Pandey and Rastogi (2019) empirically investigated the impact of energy consumption (electricity consumption) and economic growth (in terms of real gross domestic product) on the environmental degradation in form of CO_2 emissions. The study aimed to identify the interrelationship among the three variables viz. real GDP, electricity consumption and CO_2 emissions. The analysis was based on the time series annual data for the period of 1971-2017.The authors tested the stationarity for the variables by applying Dicky Fuller test and examined the short run and long run causal relationships among electricity consumption, real GDP and CO_2 emissions using Johansen Cointegration and Granger causality approach. The Johansen cointegration test ascertained that some combinations of the two variables are cointegrated which concluded the long-term relationship among the defined variables. The results also indicated for a short run causality from electricity consumption to economic growth and to the CO_2 emissions. The results concluded that India should take stringent measures to curb the surging emissions of greenhouse gases in which CO_2 has a major portion.

Waheed et al. (2019) examined the survey of earlier literature that deals with economic growth, energy consumption and carbon emission, both single country studies as well as multi-county studies that covers the period till 2019. The main focus of this survey was on the coverage of countries, modeling methodologies, periods as well as empirical conclusions. The authors found that the earlier studies have reported economic growth and energy consumption as significant sources of carbon emission but the role of economic growth in carbon emission was highly reported in highly developing countries. They also found that

in case of developed countries, carbon emission is not linked with economic development and in case of developing countries, higher energy consumption leads to increase the economic growth and for developed countries, there are no such evidences of dependence between energy consumption and economic growth. The study concluded that in both developing and developed countries, higher energy consumption was the main perpetrator for carbon emission.

Yang et al. (2019) studies the impact of carbon emission reduction on improving economic performance with a special focus on China. The research indicates that China is the world's largest carbon dioxide emitter, and China's Low-Carbon Pilot (CLCP) policy has significantly condensed carbon dioxide emissions and achieved expected results. Authors analysed panel data from 286 Chinese prefecture-level cities and from Chinese micro-industrial enterprises from 2001 to 2013. The article also focuses on the causal effect of environmental policy on regional economic growth and the benefits and changes in the behaviour of enterprises through a quasi-natural experiment and the difference-in-differences (DID) method. The research results indicate that the CLCP policy significantly promotes regional economic growth. Although the CLCP policy significantly increases various production costs, it also promotes the growth of enterprises' output and benefits.

Yazdi and Dariani (2019) empirically examined the dynamic causal relationships between CO_2 emissions, energy consumption, economic growth, trade openness and urbanisation for the period 1980–2014 using the pooled mean group (P.M.G.) approach and panel Granger causality tests for Asian countries. Using panel unit root tests we found that all variables integrated of order 1. From the Pedroni panel cointegration test, there is a long-run relationship among the variables. The results showed that urbanisation increases energy consumption and CO_2 emissions. Environmental quality is considered a normal good in the long run. The Granger causality test results support that there is a bidirectional causal relationship between economic growth, urbanisation and CO_2 emissions. Consumption is greater than the impact on CO_2 emissions in the eastern region and some evidence supports the compact city theory. These results contribute not only to advancing the existing literature, but also deserve special attention from policymakers and urban planners in Asian countries.

Akorede and Afroz (2020) examined the trend analysis of the relationship between energy consumption and carbon dioxide on one hand and the trend analysis of the relationship between economic growth and CO_2 emission on the other hand for the period of 1970-2017. The study also determined the long-run relationship and direction of causality among the variables using Granger causality test and the results showed a bi-directional causality between urban population and Energy consumption. The third objective was to examine the impact of urbanization, energy consumption, economic growth on carbon dioxide emission in Nigeria by employing autoregressive distributed lag (ARDL) test approach. The results showed that in the short run, energy consumption and the previous lag of economic growth have a positive and significant impact on carbon dioxide emission in Nigeria. Only urban population had a negative but significant impact on CO_2 emission in Nigeria. In the long run however, urbanization was still statistically significant but negative while energy consumption and economic growth still had a positive and significant impact on CO_2 emission. The major reason was that the bulk of the country's energy consumption was from non-renewable means.

Chontanawat (2020) examined the dynamic relationship between energy consumption, CO_2 emissions and economic output in ASEAN for the period 1971–2015 using cointegration and causality models. The empirical results from the models suggest that there is a long-run relationship and there is causality between these variables, indicating that energy consumption and output are related to CO_2emissions. The results provide useful information in terms of policy implications. Policies aiming to reduce or conserve energy consumption could be implemented as it would help to reduce the level of CO_2 emission, without having much effect on economic growth.

Khan and Majeed (2020) reviewed the decoupling relationship between economic growth and carbon emissions for the Association of Southeast Asian Nations (ASEAN) countries as a region. Authors used Tapio decoupling indicator along with decomposition techniques to analyse the decoupling status and the drivers of carbon emissions. The results shows that the overall ASEAN region experienced expansive negative decoupling (END) status, followed by weak decoupling (WD) status, It also suggest that population, affluence, and energy

structure significantly contributed to the carbon emissions at both regional and national levels. The study also highlights the key drivers of carbon emissions and gives extensive insights for emission mitigation.

Khan et al (2020) investigated the nexus between energy consumption, economic growth and CO_2 emission in Pakistan by using annual time series data from 1965 to 2015. The estimated results of ARDL indicated that energy consumption and economic growth increase the CO_2 emissions in Pakistan both in short run and long run. Based on the estimated results it was recommended that policy makers in Pakistan should adopt and promote such renewable energy sources that will help to meet the increased demand for energy by replacing old traditional energy sources such as coal, gas, and oil. Renewable energy sources are reusable that can reduce the CO_2 emissions and also ensure sustainable economic development of Pakistan.

Shaheen et al. (2020) studied whether gross domestic product (GDP), energy consumption and urbanization affect Carbon dioxide (CO_2) emissions covering the time span 1972-2014 in Pakistan. The empirical estimates of autoregressive distributed lag (ARDL) affirmed that energy consumption and GDP are the main drivers of the pollutant environment in Pakistan, and also quantitatively determine the definite impact percentage of each dynamic force in Pakistan. Specifically, the empirical findings determine that in the long run, energy consumption and GDP intensify CO_2 emissions showing significant impact; however, industrialization and urbanization were found to be insignificant.

Tong et al. (2020) examined the cointegration and causality relations between economic growth, energy consumption, and carbon dioxide (CO_2) emissions in the E7 countries using a bootstrap autoregressive distributed lag (ARDL) bound test with structural breaks. The study found that there is no cointegration between economic growth, energy consumption, and CO_2 emissions for People's Republic of China, Indonesia, Mexico, and Turkey. Evidence of cointegration was found for Brazil when CO_2 emissions are the dependent variable and for India and Russia when energy consumption is the dependent variable. For all of the E7 countries except Indonesia, short-run Granger causality was found to exist from energy consumption to CO_2 emissions and from economic growth to CO_2 emissions for Brazil, India, Mexico, and People's Republic of

China. Short-run Granger causality was also found from economic growth to energy consumption for Brazil, India, Indonesia, Mexico and People's Republic of China, and from CO_2 emissions to energy consumption for all E7 countries. The results consistently showed that energy consumption is the main cause of CO_2 emissions which has led to the emergence of global warming problems.

Wu et al. (2020) attempted to study the relationship between carbon emissions and industrial development in four countries with different development levels from a global perspective. They used Tapio decoupling model and the overall dependence of countries of various development levels on carbon emissions was analysed. They included a panel data model to study the contributing factors of carbon emissions in countries with different development levels between 2015 and 2019 and examined the relationships between carbon emission and economic growth in different countries. The results indicated that the added value of industry and agriculture has a significant positive effect on carbon emissions in countries of various development levels, and forest area has a significant negative effect on carbon emissions. It is found that developed countries are still the largest emitters and industrial and agricultural productions are still the most important factor affecting carbon emissions, and the increase in forest area helps reduce the impact of carbon dioxide.

Zou and Zhang (2020) published a research paper bringing a spatial Durbin model with economic growth, energy consumption equation, and CO_2 emissions and analysed the dynamic relationship and spatial spill over among economic growth, energy consumption, and CO_2 emissions effects. They reviewed panel data of 30 regions in China between 2000 and 2007. The results indicated that the economic growth can expressively improve carbon dioxide emissions, and China's economic growth level has become a positive driving force for carbon dioxide emissions. However, economic growth will not have an impact by the reduction of carbon dioxide emissions. They identified a two-way relationship between energy consumption (ENC) and carbon dioxide emissions (CO_2). Energy consumption and carbon emissions are interrelated, which has a negative spatial spillover effect on the carbon dioxide emissions of the surrounding provinces and cities.